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MFN 08-844

Docket No. 52-010

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

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 256 Related to ESBWR Design Certification Application – Electrical Power - RAI Number 8.2-14 S01**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC Letter No. 256, dated September 16, 2008 (Reference 1).

Enclosure 1 contains GE Hitachi Nuclear Energy (GEH) response to RAI 8.2-14 S01. This RAI was originally responded in Reference 2, as requested by the NRC in Reference 3.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

References:

1. MFN 08-714 - Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 256 Related To ESBWR Design Certification Application*, dated September 16, 2008
2. MFN 08-595 - *Response to Portion of NRC Request for Additional Information Letter No. 205 Related to ESBWR Design Certification Application - Electrical Power - RAI Number 8.2-14*, dated July 29, 2008
3. MFN 08-495 - Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 205 Related To ESBWR Design Certification Application*, dated May 21, 2008

Enclosure:

1. MFN 08-844 -Response to Portion of NRC Request for Additional Information Letter No. 256 Related to ESBWR Design Certification Application – Electrical Power - RAI Number 8.2-14 S01

cc: AE Cubbage USNRC (with enclosure)
RE Brown GEH/Wilmington (with enclosure)
DH Hinds GEH/Wilmington (with enclosure)
RM Wachowiak GEH/Wilmington (with enclosure)
eDRF 0000-0093-5427

Enclosure 1

MFN 08-844

Response to Portion of NRC Request for Additional

Information Letter No. 256 Related to ESBWR

Design Certification Application

Electrical Power

RAI Number

8.2-14 S01

NRC RAI 8.2-14 S01

We have reviewed your response to RAI 8.2-14 and we have the following additional questions:

(1) You have stated that detailed dynamic calculations have not been completed. The staff requests that GEH provide their schedule for completing detailed dynamic calculations.

(2) The staff requests that GEH provide a detailed explanation (include diagrams) regarding how the rectifier and battery chargers will be tripped by internal means due to excessive high bus voltage. In addition. please explain how the rectifier and inverter trip are coordinated. Please also specify if the battery charger, rectifier, and inverter trip devices have an adjustable setting for coordination purposes.

(3) The staff requests that GEH explain the impact of excessive high bus voltage on safety-related loads when fed from the regulating transformer during islanding mode of operation.

GEH Response

GEH provides the following information in response to the reviewer questions. The response to item (3) results in a revision to the DCD as described.

(1) The current schedule for preparation of the dynamic calculations indicates they will be completed December, 2009 (preliminary) and December, 2011 (final), these dates however are subject to change based on project needs.

(2) The UPS is designed with certain functional requirements as needed to protect the supplied electrical loads. The details of how this equipment performs the required functions are specific to the equipment supplier. GEH has consulted with a leading safety-related UPS vendor to determine how their equipment functions as an example for the reviewer. As background, this vendor uses a thyristor based rectifier stage and an Insolated Gate Bipolar Transistor (IGBT) based inverter stage. For a battery charger or UPS input rectifier high DC output voltage condition, this vendor blocks the firing pulses to the thyristor bridges and the thyristors naturally commutate off at the next zero crossing. For an inverter trip, the firing pulses to the IGBT bridges are blocked and the inverter output is cut off immediately.

The safety-related battery chargers and UPS input rectifier high DC voltage trips are coordinated such that the associated inverters do not trip on high DC input voltage during voltage transients on the AC distribution system. The trips are coordinated such that the inverter high DC input voltage trip setpoint is greater than the associated battery charger and UPS input rectifier high DC output trip setpoints. In addition, the time delay for the inverter high DC input voltage trip is greater than the time delay for the battery charger and UPS input rectifier high DC output voltage trips. In this way, the high DC voltage protection is coordinated in both magnitude and time so the battery charger and UPS input rectifier always trip before their DC output voltage reaches the level that would cause an inverter trip on high DC input voltage. This is a functional requirement for the battery charger and UPS equipment; the actual trip magnitude and time margins are a function of the vendor specific equipment design. The trip setpoints may be coded in the UPS and battery charger firmware or may be field adjustable depending on the vendor specific design. GEH is also addressing the referenced setpoint coordination in response to RAI 14.3-413 (MFN 08-881, dated November 17, 2008).

The battery chargers, Uninterruptable Power Supply (UPS) rectifiers and UPS inverters will be tripped as designed by the equipment manufacturer. This equipment has not been purchased so no specifics are available at this time. GEH expects to select this equipment by December 2011; this date however is subject to change based on project needs. The diagrams and drawings depicting how the rectifier and battery chargers will be tripped by internal means will be available at that time.

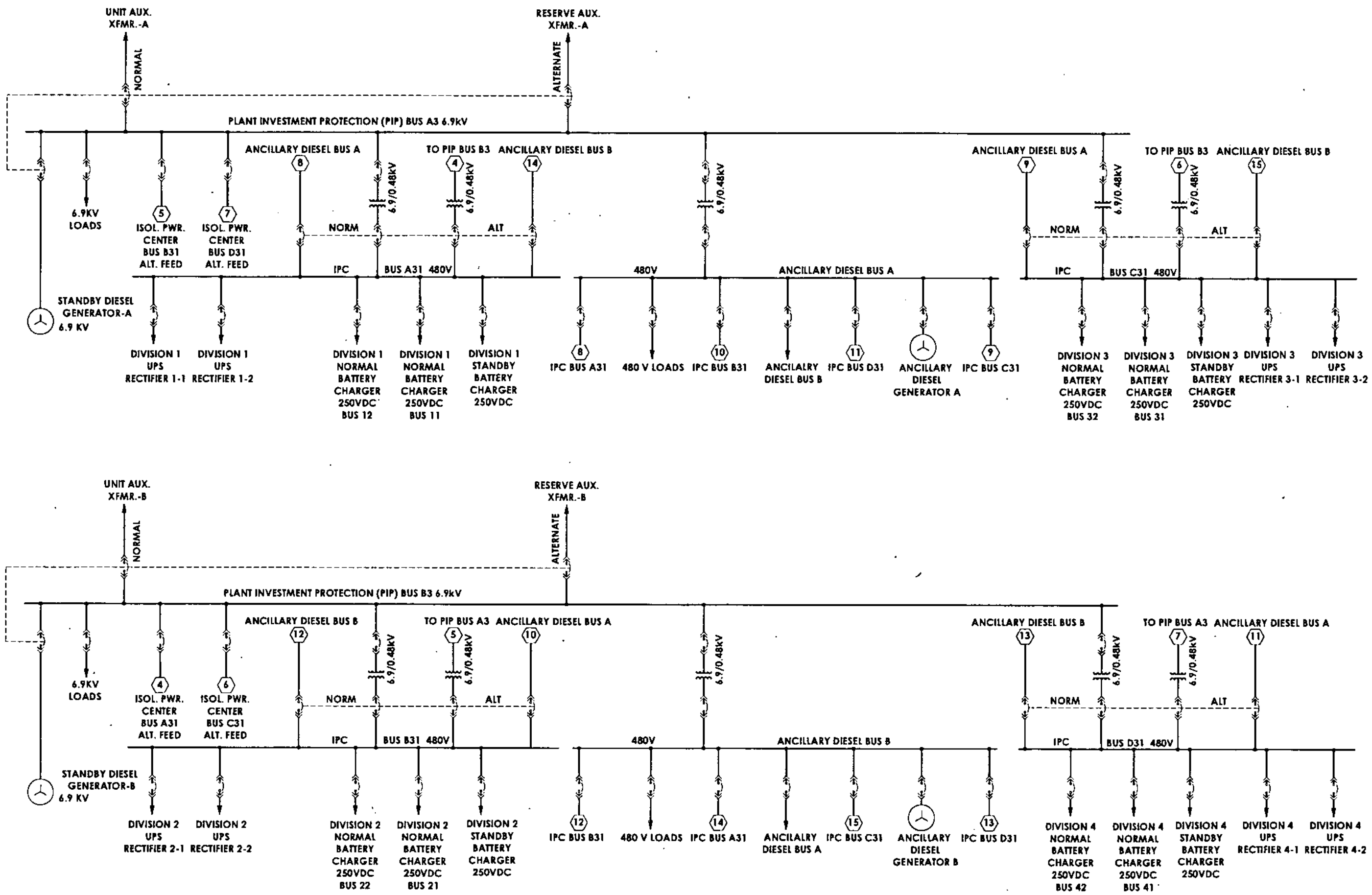
(3) Due to the potential for disruptive voltages and frequencies reaching the safety related loads, the safety-related UPS bypass transformers are eliminated from the ESBWR design. The 100% redundant UPS rectifiers and inverters within each division negate the need for a bypass transformer as was used in previous designs using only a single UPS rectifier and inverter. The battery chargers and UPS will be designed to have the required fault clearing and load inrush current capability without the need to switch to a bypass source. Each inverter within a division can be taken out of service for maintenance without the need to de-energize the UPS bus, however the division will be inoperable per the Technical Specifications due to the reduced battery capacity in this configuration. DCD Tier 1 and Tier 2 will be revised to reflect removal of the safety-related UPS bypass transformer.

DCD Impact

DCD Tier 1, Figures 2.13.1-1 sh. 2 and 2.13.5-1, and Tier 2 Subsections 1.2.2.13.5, 8.1.1, 8.1.5.2.2.1, 8.3.1.1.2, 8.3.1.1.3, 14.2.8.1.67, 16B.3.8.4, 16B.3.8.5, 16B.3.8.6, Figures 8.1-4, 8.3-1, 8.3-3 and Table 8.3-4 will be revised in Revision 6 as noted in the attached markup.

DCD Markups for

RAI 8.2-14 S01


UNIT AUX. XFMR.-A
NORMAL
RESERVE AUX. XFMR.-A
ALTERNATE
PLANT INVESTMENT PROTECTION (PIP) BUS A3 6.9kV
6.9KV LOADS
ISOL. PWR. CENTER BUS B31 ALT. FEED
ISOL. PWR. CENTER BUS D31 ALT. FEED
STANDBY DIESEL GENERATOR-A 6.9 KV
ANCILLARY DIESEL BUS A
TO PIP BUS B3
ANCILLARY DIESEL BUS B
6.9/0.48kV
NORM
ALT
IPC
BUS A31 480V
480V
ANCILLARY DIESEL BUS A
BUS C31 480V
DIVISION 1 UPS RECTIFIER 1-1
DIVISION 1 UPS RECTIFIER 1-2
DIVISION 1 NORMAL BATTERY CHARGER 250VDC BUS 12
DIVISION 1 NORMAL BATTERY CHARGER 250VDC BUS 11
DIVISION 1 STANDBY BATTERY CHARGER 250VDC
IPC BUS A31
480 V LOADS
IPC BUS B31
ANCILALRY DIESEL BUS B
IPC BUS D31
ANCILLARY DIESEL GENERATOR A
IPC BUS C31
DIVISION 3 NORMAL BATTERY CHARGER 250VDC BUS 32
DIVISION 3 NORMAL BATTERY CHARGER 250VDC BUS 31
DIVISION 3 STANDBY BATTERY CHARGER 250VDC
DIVISION 3 UPS RECTIFIER 3-1
DIVISION 3 UPS RECTIFIER 3-2
UNIT AUX. XFMR.-B
RESERVE AUX. XFMR.-B
PLANT INVESTMENT PROTECTION (PIP) BUS B3 6.9kV
ISOL. PWR. CENTER BUS A31 ALT. FEED
ISOL. PWR. CENTER BUS C31 ALT. FEED
STANDBY DIESEL GENERATOR-B 6.9 KV
ANCILLARY DIESEL BUS B
TO PIP BUS A3
ANCILLARY DIESEL BUS A
BUS B31 480V
BUS D31 480V
DIVISION 2 UPS RECTIFIER 2-1
DIVISION 2 UPS RECTIFIER 2-2
DIVISION 2 NORMAL BATTERY CHARGER 250VDC BUS 22
DIVISION 2 NORMAL BATTERY CHARGER 250VDC BUS 21
DIVISION 2 STANDBY BATTERY CHARGER 250VDC
IPC BUS B31
IPC BUS A31
ANCILALRY DIESEL BUS A
IPC BUS C31
ANCILLARY DIESEL GENERATOR B
IPC BUS D31
DIVISION 4 NORMAL BATTERY CHARGER 250VDC BUS 42
DIVISION 4 NORMAL BATTERY CHARGER 250VDC BUS 41
DIVISION 4 STANDBY BATTERY CHARGER 250VDC
DIVISION 4 UPS RECTIFIER 4-1
DIVISION 4 UPS RECTIFIER 4-2

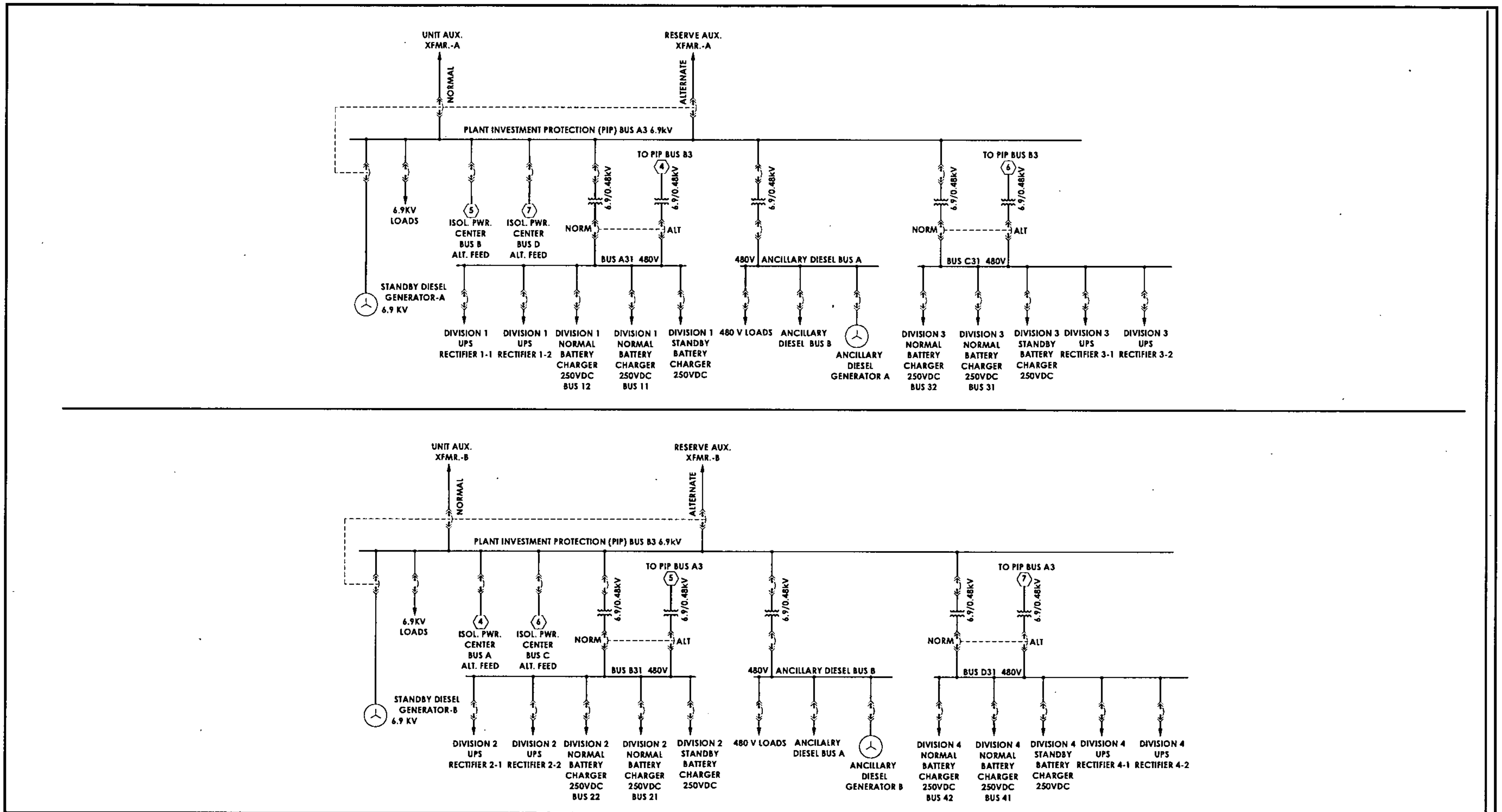
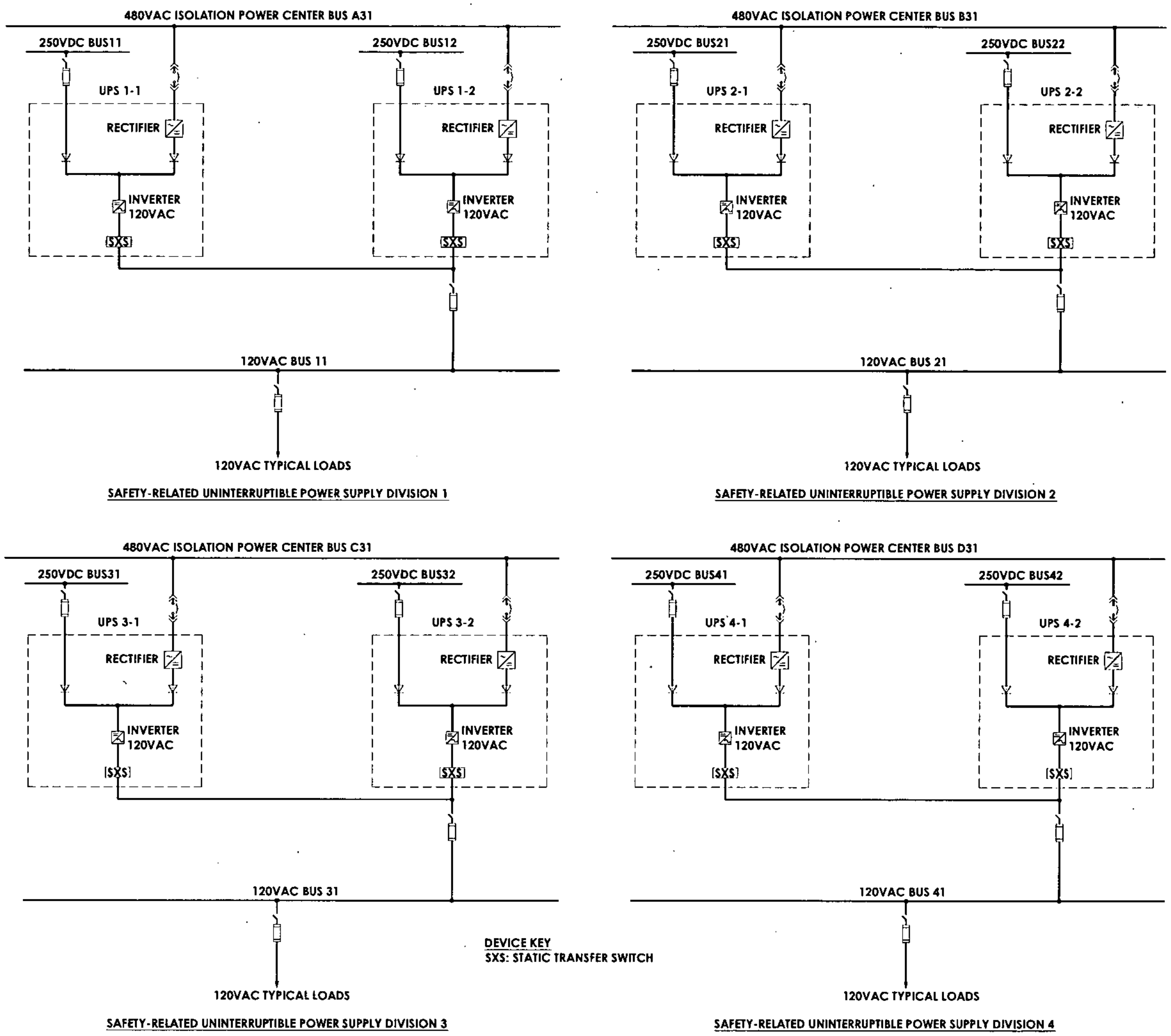


Figure 2.13.1-1 Sh 2.
Onsite AC Power System Functional Arrangement


480VAC ISOLATION POWER CENTER BUS A31
250VDC BUS11
250VDC BUS12
UPS 1-1
UPS 1-2
RECTIFIER
INVERTER
120VAC
SXS
120VAC BUS 11
120VAC TYPICAL LOADS
SAFETY-RELATED UNINTERRUPTIBLE POWER SUPPLY DIVISION 1
480VAC ISOLATION POWER CENTER BUS B31
250VDC BUS21
250VDC BUS22
UPS 2-1
UPS 2-2
120VAC BUS 21
SAFETY-RELATED UNINTERRUPTIBLE POWER SUPPLY DIVISION 2
480VAC ISOLATION POWER CENTER BUS C31
250VDC BUS31
250VDC BUS32
UPS 3-1
UPS 3-2
120VAC BUS 31
SAFETY-RELATED UNINTERRUPTIBLE POWER SUPPLY DIVISION 3
480VAC ISOLATION POWER CENTER BUS D31
250VDC BUS41
250VDC BUS42
UPS 4-1
UPS 4-2
120VAC BUS 41
SAFETY-RELATED UNINTERRUPTIBLE POWER SUPPLY DIVISION 4
DEVICE KEY
SXS: STATIC TRANSFER SWITCH

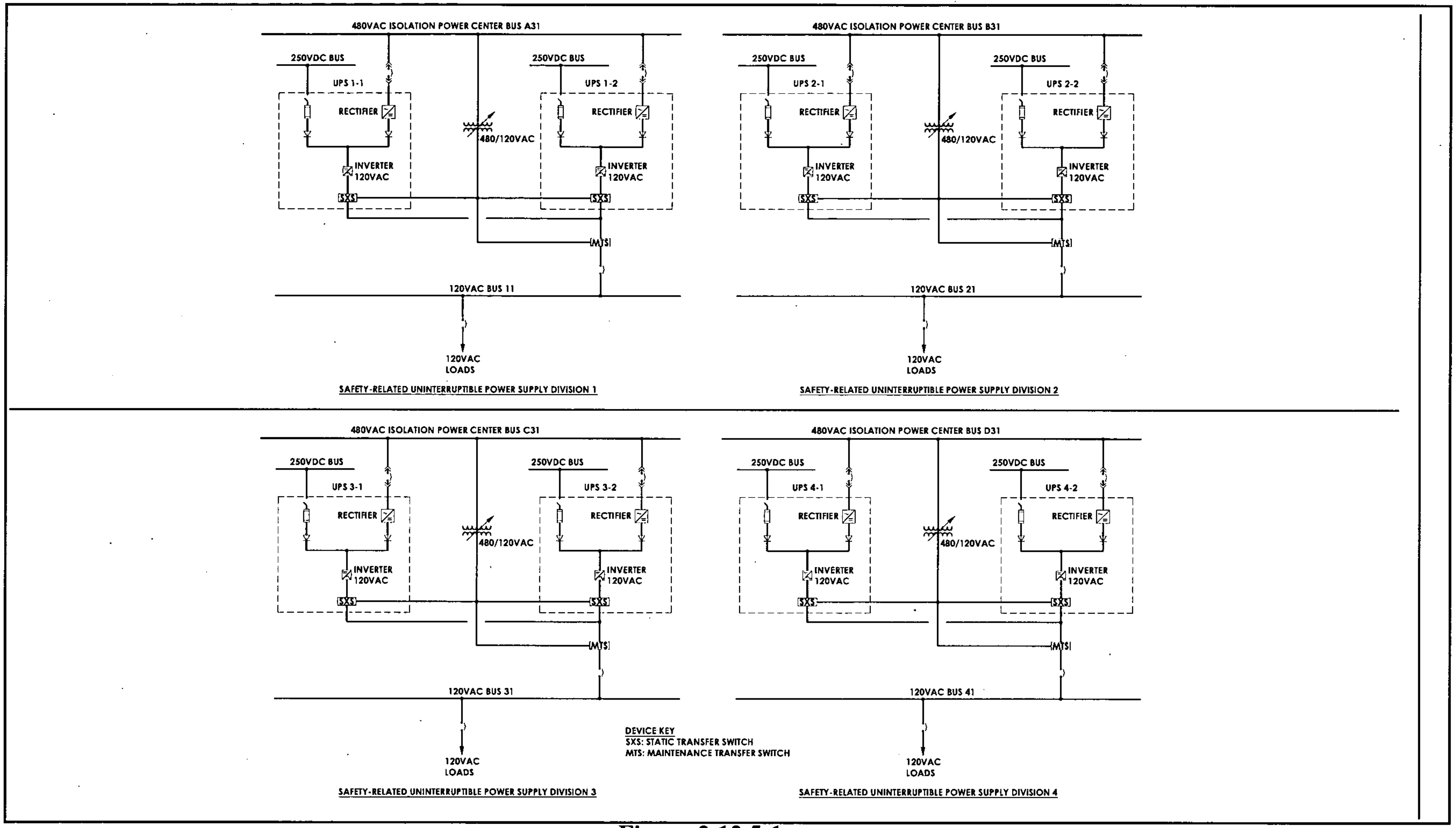


Figure 2.13.5-1.
Safety-Related UPS System Functional Arrangement

are not available. The standby on-site AC power supply system is configured to provide power to the permanent nonsafety-related buses.

Either the main generator or the normal preferred off-site power source normally energizes the plant buses. Transfer to the on-site standby diesel generators is automatic when all other power supplies capable of feeding the buses are not available. Should these power supplies fail, their supply breakers trip and the standby on-site power supply (diesel generators) is automatically signaled to start. After the standby voltage and frequency reach normal values, the standby supply breakers close. After bus voltage is reestablished, large motor loads are sequentially started.

On a defense-in-depth basis, the Standby On-Site AC Power Supply system can provide power to important safety-related loads. However, these loads are powered by uninterruptible power supplies (for AC loads) or safety-related DC power from safety-related station batteries if the preferred power supply or the Standby On-Site AC Power Supply is not available.

1.2.2.13.5 Uninterruptible AC Power Supply

The safety-related uninterruptible power supply (UPS) provides redundant, reliable power to the safety-related logic and control functions during normal, upset and accident conditions.

Each of the four divisions of this safety-related uninterruptible power is separate and independent. Each division is powered from an inverter supplied from the divisional Isolation Power Center and the safety-related DC bus. The DC bus receives its power from a divisional battery charger and battery.

~~A static bypass switch is provided for transferring the UPS AC load through a direct feed from the UPS inverter to the Isolation Power Center through a regulating transformer. A manual bypass switch is provided for maintenance purposes.~~

The nonsafety-related uninterruptible power supply system for the two power-distribution load groups in the plant is supplied from the 480 V AC power center in the same group. In addition, there is another uninterruptible power supply system used to supply the N-DCIS loads.

Two dedicated uninterruptible power supply systems supply the TSC.

1.2.2.13.6 [Deleted]

1.2.2.13.7 Communications System

The Communications System includes a plant page/party-line (PA/PL) system, the private automatic branch telephone exchange (PABX), a sound-powered telephone system, an in-plant radio system and the evacuation alarm and remote warning system.

1.2.2.13.8 Lighting Power Supply

The lighting systems include: the normal, standby, emergency, security and MCR emergency lighting systems. The normal lighting system provides illumination under all normal plant conditions, including maintenance, testing, and refueling operations. It is powered from the nonsafety-related buses. The standby lighting system supplements the normal lighting system

8. ELECTRIC POWER

8.1 INTRODUCTION

8.1.1 General

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 sources are designed to provide reliable power 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 onsite AC power system consists of safety-related and nonsafety-related power systems. The two offsite power sources 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 (main generator continues to provide AC power to site loads upon loss of offsite power sources), two onsite independent nonsafety-related standby diesel generators are provided to power the Plant Investment Protection (PIP) nonsafety-related loads and safety-related loads through battery chargers~~,~~ and rectifiers~~, or regulating transformers~~. Two nonsafety-related ancillary diesel generators are capable of supplying power to the ancillary buses when no other sources of AC power are available (see Subsection 8.3.1.1.9). 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 switchyard and the high voltage tie lines to the high-side Motor Operated Disconnects (MODs) of the main generator circuit breaker, the high-side 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 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.

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 inverter power supply. The UPS normal AC power from the inverter is synchronized in both frequency and phase with the alternate AC bypass supply, so that unacceptable voltage spikes are avoided in case of an automatic transfer from normal to alternate supply.~~

8.1.5.2.2.2 Nonsafety-Related Uninterruptible AC Power Supply

Each load group of the nonsafety-related Uninterruptible AC Power Supply is powered through separate and independent nonsafety-related inverters connected to the nonsafety-related DC bus and from their 480 VAC Power Center (Figure 8.1-5). Separate nonsafety-related batteries also power each DC bus.

Upon loss of AC power supply, the nonsafety-related UPS is powered by its respective nonsafety-related battery, and switching from the AC to the DC source is transparent to UPS loads. Provision is made for automatic switching to the alternate bypass supply from a 480 VAC Power Center, in case of a failure of the inverter power supply. The inverter normal AC power supply is synchronized in both frequency and phase with the alternate AC bypass supply, so that unacceptable voltage spikes are avoided in case of an automatic transfer from normal to alternate supply. The onsite standby diesel-generators provide backup for the normal and alternate 6.9 kV AC power sources that supply the 480 VAC power centers from the PIP buses.

8.1.5.2.3 Nonsafety-Related I&C Power Supply System

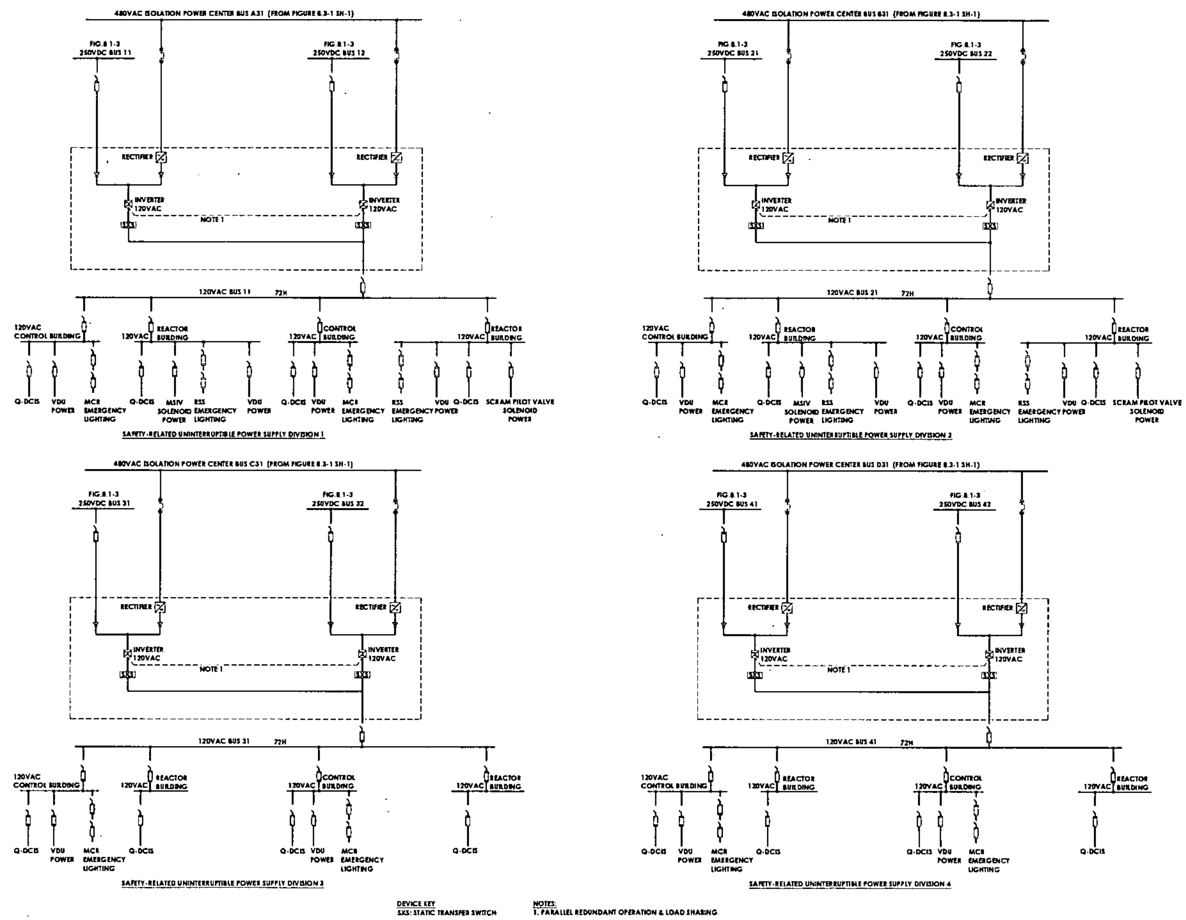
System deleted.

8.1.5.2.4 Regulatory Requirements

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

General Design Criteria:

- GDC 2, "Design Bases for Protection Against Natural Phenomena"
- GDC 4, "Environmental and Dynamic Effects Design Bases"
- GDC 5, "Sharing of Structures, Systems, and Components" – The ESBWR does not share any safety-related structure, system or component with any other unit. Therefore, this GDC is not applicable.
- GDC 17, "Electric Power Systems" - Safety-related DC power sources are provided to support passive core cooling and passive containment integrity safety-related functions. No offsite or diesel-generator-derived AC power is required for 72 hours after an abnormal event. However, the ESBWR standard design complies with GDC 17 with respect to two independent and separate offsite power sources and standby onsite power sources. Subsection 3.1.2.8, "Criterion 17 – Electric Power Systems," provides ESBWR electric power source availability requirements and conformance with Regulatory Guide 1.93.


480VAC ISOLATION POWER CENTER BUS A31 (FROM FIGURE 8.3-1 SH-1)
FIG.8.1-3
250VDC BUS 11
FIG.8.1-3
250VDC BUS 12
RECTIFIER
INVERTER
120VAC
NOTE 1
SXS
120VAC BUS 11
72H
120VAC
CONTROL BUILDING
REACTOR
BUILDING
CONTROL
BUILDING
Q-DCIS
VDU
POWER
MCR
EMERGENCY
LIGHTING
MSIV
SOLENOID
POWER
RSS
EMERGENCY
LIGHTING
SCRAM PILOT VALVE
SOLENOID
POWER
SAFETY-RELATED UNINTERRUPTIBLE POWER SUPPLY DIVISION 1
480VAC ISOLATION POWER CENTER BUS C31 (FROM FIGURE 8.3-1 SH-1)
FIG.8.1-3
250VDC BUS 31
FIG.8.1-3
250VDC BUS 32
SAFETY-RELATED UNINTERRUPTIBLE POWER SUPPLY DIVISION 2
SAFETY-RELATED UNINTERRUPTIBLE POWER SUPPLY DIVISION 3
SAFETY-RELATED UNINTERRUPTIBLE POWER SUPPLY DIVISION 4
DEVICE KEY
SXS: STATIC TRANSFER SWITCH
NOTES:
1. PARALLEL REDUNDANT OPERATION & LOAD SHARING.

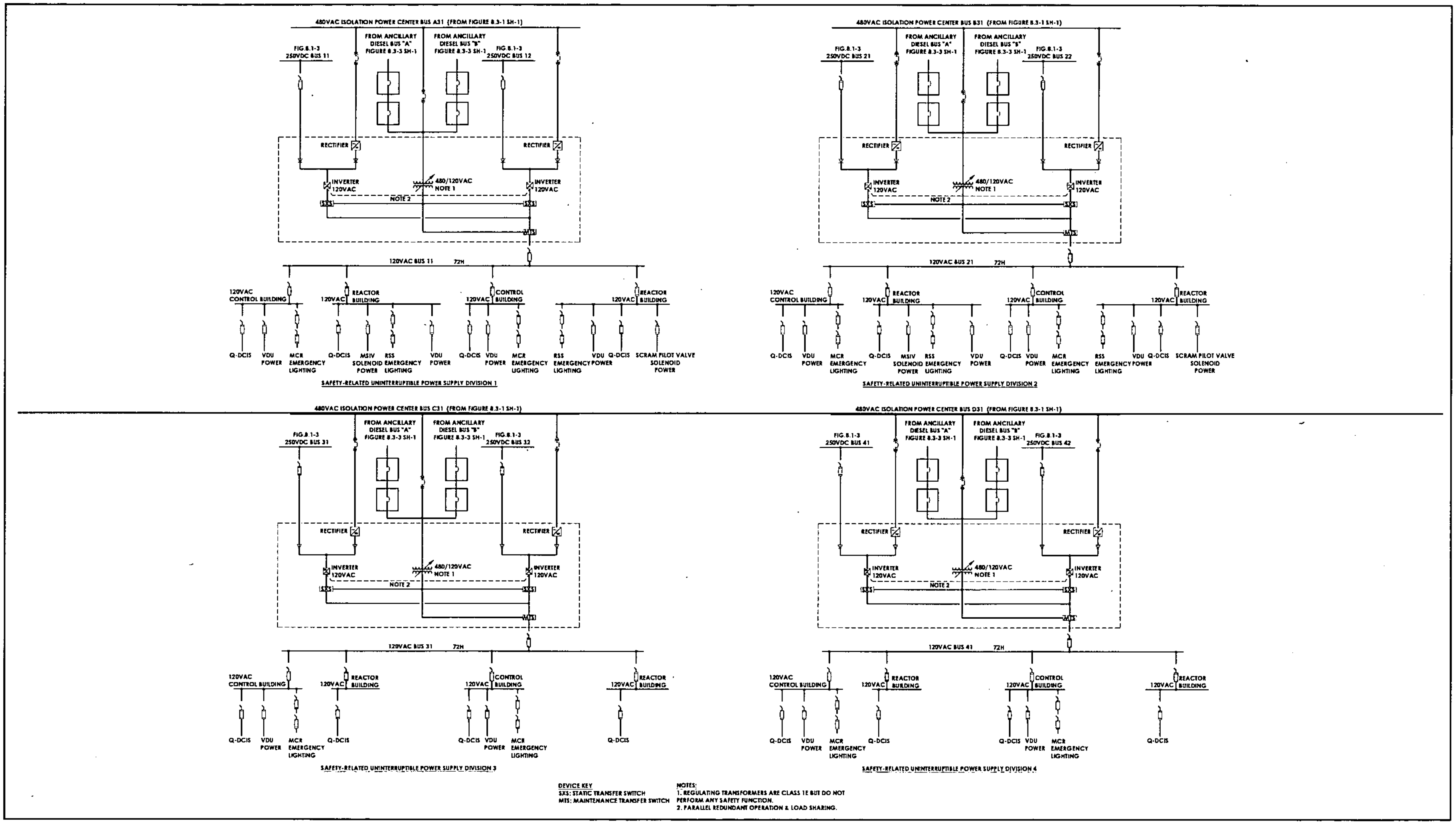


Figure 8.1-4. Uninterruptible AC Power Supply (Safety-Related)

Sh 1 of 1

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 Divisions 1, 2, 3 and 4. Each Isolation Power Center is double-ended and can be powered from either of the PIP load group buses. The normal and alternate source main breakers of each Isolation Power Center are electrically interlocked to prevent powering the Isolation Power Center from the normal and alternate sources simultaneously. The Isolation Power Centers are shown in Figure 8.3-1.

The Isolation Power Centers supply power to safety-related loads of their respective division. These loads consist of the safety-related battery chargers, and rectifiers, and regulating transformers as discussed in Subsections 8.3.2 and 8.3.1.1.3. In addition, there is no safety-related lighting that operates directly from the 480 VAC in the ESBWR design. The lighting system is discussed in Chapter 9.

Isolation power centers are protected against degraded voltage and frequency conditions by way of voltage and frequency relays installed in each Isolation Power Center to prevent tripping of all Isolation Power Center loads, in accordance with BTP PSB1. The four safety-related Isolation Power Centers are located in the Seismic Category I Reactor Building in their respective divisional areas.

Motor Control Centers

MCCs supply power to motors, control power transformers, process heaters, motor-operated valves and other small electrically operated auxiliaries, including 480 - 208/120V and 480 - 240/120V transformers. MCCs are assigned to the same load group as the power center that supplies their power.

8.3.1.1.3 Uninterruptible AC Power Supply System

Safety-Related Uninterruptible AC Power Supply System

Figure 8.1-4 shows the overall safety-related Uninterruptible AC Power Supply (UPS) system. The safety-related UPS for each of the four divisions is supplied from a 480V Isolation Power Center in the same division. The Isolation Power Centers are connected to PIP nonsafety-related buses, which are backed by standby diesel-generators. Divisions 1, 2, 3 and 4 each have two rectifiers, two batteries and two inverters. Each rectifier receives 480 VAC normal power from the Isolation Power Center of that division and converts it to 250 VDC. The 480 VAC/250 VDC rectifier and a safety-related 72-hour battery of that division supply 250 VDC power through diodes to a common inverter with an output of 120 VAC single phase.

The safety-related UPS inverter high DC input voltage trip setpoint and time delay are greater than the associated battery charger and UPS rectifier high DC output voltage trip setpoint and time delay. This arrangement prevents safety-related UPS inverter trips as a result of fast transients on the AC supply that may occur during the ESBWR islanding transient or as a result of generator voltage regulator failures, for which protective relaying and breaker operations may not otherwise prevent safety-related UPS inverter trips.

Power is distributed to the individual safety-related loads from associated 120 VAC distribution panels, which supply power to the Reactor Building and the Control Building.

The plant design and circuit layout of the UPS provide physical separation of the equipment, cabling, and instrumentation essential to plant safety. Equipment of each division of the safety-related UPS distribution system is located in an area separated physically from the other divisions. No provisions exist for the interconnection of the safety-related UPS buses of one division with those of another division or nonsafety-related power. All components of safety-related UPS AC systems are housed in Seismic Category I structures.

Refer to Subsection 8.3.1.1.5 for a discussion of physical separation and independence.

Four divisions of safety-related UPS provide 120 VAC power for the Q-DCIS loads/logic components (reference Section 7.1 for Q-DCIS description) and other safety-related loads requiring uninterruptible power (see Figure 8.1-4). Two divisions (1 and 2) of safety-related power supply the RPS scram pilot valve solenoids and the same two divisions supply power to the MSIV solenoids (see Figure 7.2-1 and Figure 8.1-4).

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. The two inverters in each safety-related division will be configured for parallel redundant operation to allow load sharing and the equal discharge of the division's safety-related batteries. ~~A static transfer switch is provided for each inverter for transferring safety-related UPS AC load from the safety-related inverter outputs to a direct AC feed from the divisional Isolation Power Center through a safety-related regulating transformer should failure of the division's inverters occur. A manual maintenance transfer 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 failure of each of the division's inverters; and

~~□One manual bypass switch for inverter or rectifier maintenance;~~

~~□One 480/120 VAC regulating transformer to supply a direct AC feed during inverter(s) or rectifier(s) maintenance or failure; and~~

- Power distribution panel boards to provide power to all safety-related loads requiring uninterruptible 120 VAC power.

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 inverters is the same division's Isolation Power Center, which provides AC power to the rectifiers. Transfer from the 480 VAC power supply to the 250 VDC buses is done automatically and passively in case of loss of the normal power source. Each inverter normally carries approximately 50% of the load, if one inverter fails, 100% of the load is picked up by the remaining inverter. If both inverters in a division are lost, the associated 120 VAC UPS bus is de-energized ~~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 failure of both of the division's inverters~~. 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 five load groups (load groups A, B, C, TSC-A, and TSC-B). UPS load groups A and B each include two solid-state inverters, two solid-state rectifiers, two solid-state transfer switches, two manual transfer switches, and two regulating transformers with associated distribution panels (Figure 8.1-5). UPS load group C includes one solid-state inverter, one solid-state rectifier, one solid-state transfer switch, one manual transfer switch, and one regulating transformer with associated distribution panels.

The normal power supply for the 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. 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.

A third nonsafety-related UPS is provided to supply additional nonsafety-related loads (load group C) 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 through the 480/480 VAC regulating transformer, which also supplies power during maintenance of the inverter and its associated components.

Two dedicated nonsafety-related UPS (Figure 8.1-5) 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 case of failure of the 480 VAC power supply, transfer from the 480 VAC power center to the nonsafety-related 125 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.

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.

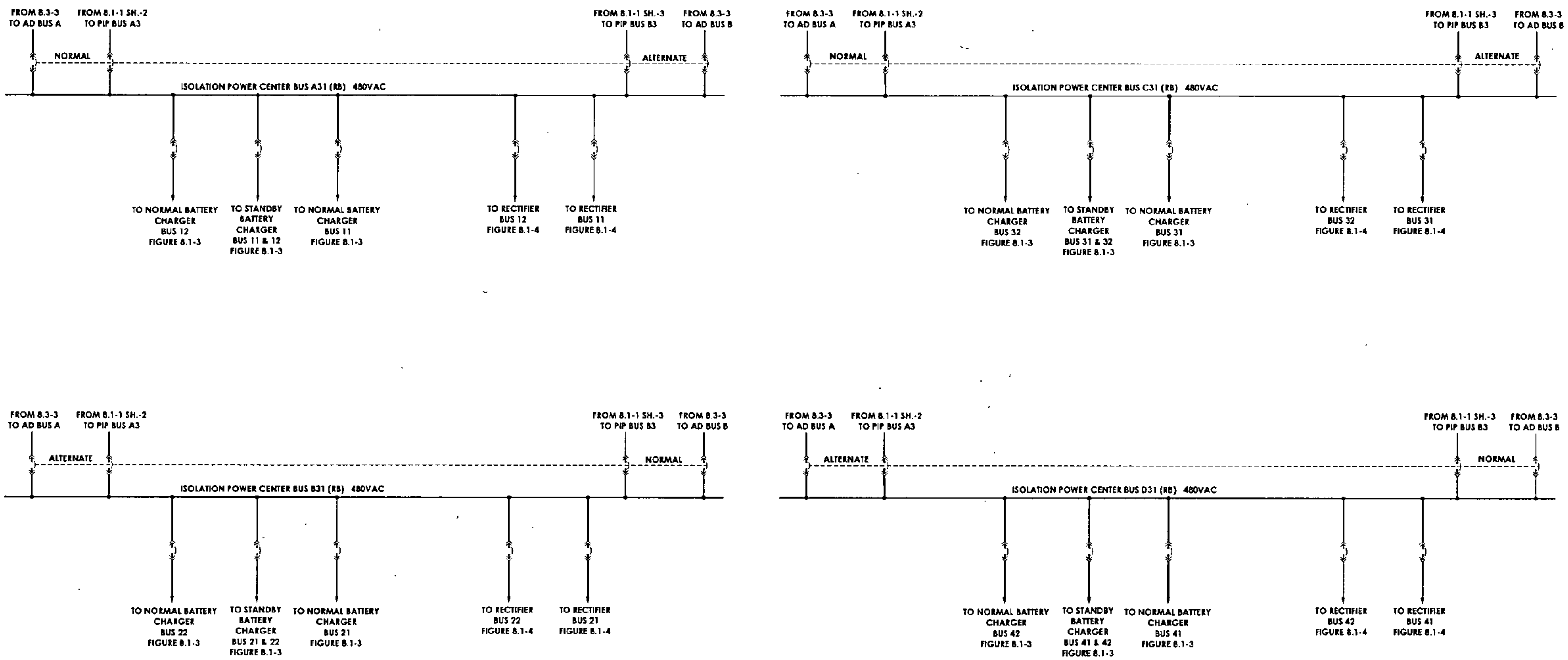
Table 8.3-4

Safety-Related DC and UPS Nominal Component Data

a. Batteries Two 250 VDC batteries per division, 120 valve regulated lead acid cells per battery, 6000 Ah. per battery (8 hour rate to 1.75 V/cell @77°F)
b. Charger AC input - 480 VAC, 3-phase, 60 Hz DC output - 250 VDC, 500 A continuous - float voltage 2.20 V/cell @90°F or above to 2.35 V/cell @40°F or below (temperature compensated from 2.24 V/cell @77°F) - maximum equalizing charge voltage 2.35 V/cell @77°F
c. Uninterruptible Power Supply (UPS) i) Inverter - 40 kVA with 250 VDC input and 120 VAC, 60 Hz output - AC output voltage regulation of ±1% steady state - output frequency variation within ±0.1% of nominal 60 Hz - total harmonic distortion <5% ~~ii) Regulating Transformer~~(Deleted) ~~40 kVA 480/120 VAC, ±1%~~(Deleted)

Notes:

(1) See Figures 8.1-3 and 8.1-4 for the configurations of the safety-related DC and UPS systems.



SAFETY-RELATED 480 VOLT ISOLATION POWER CENTERS

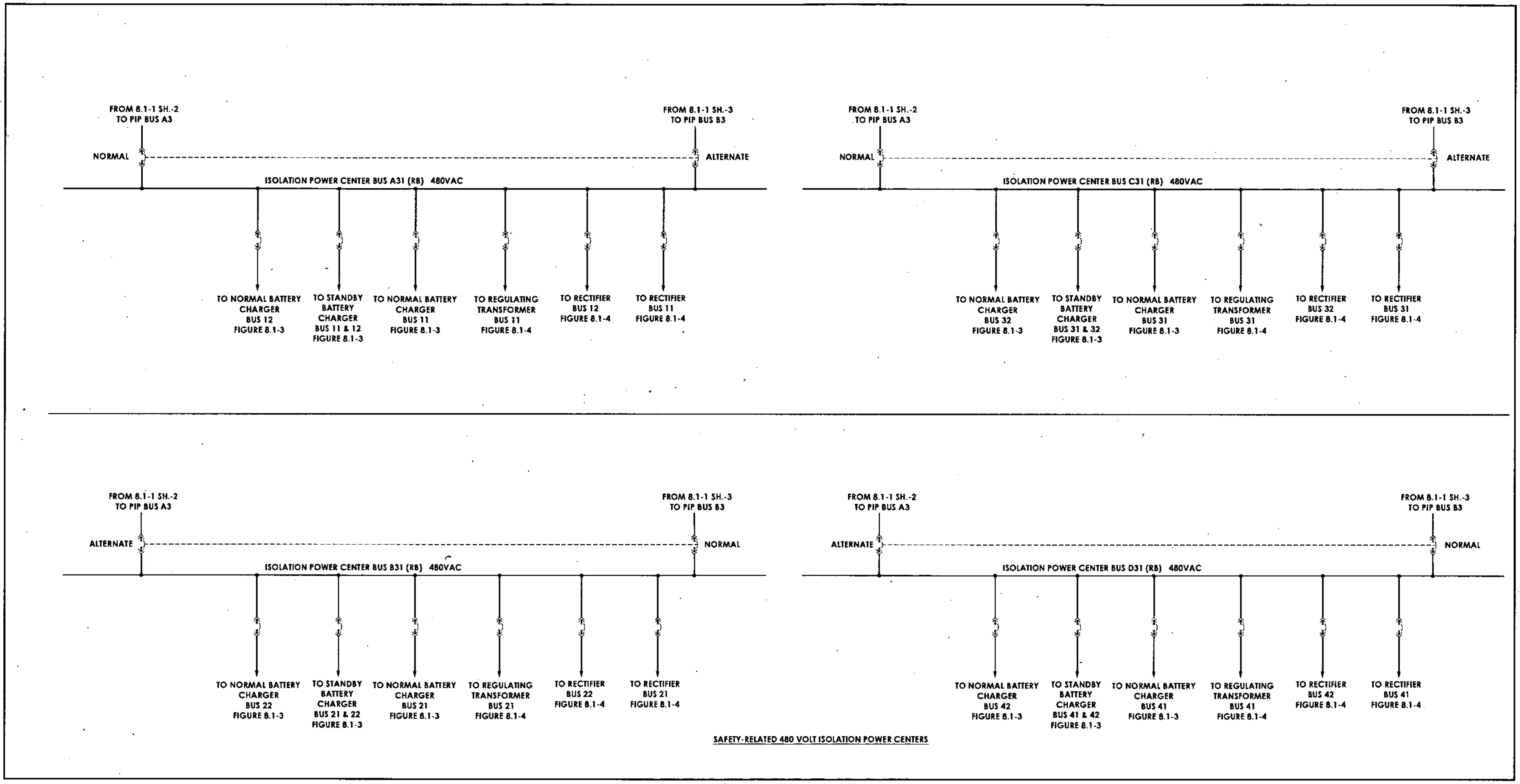
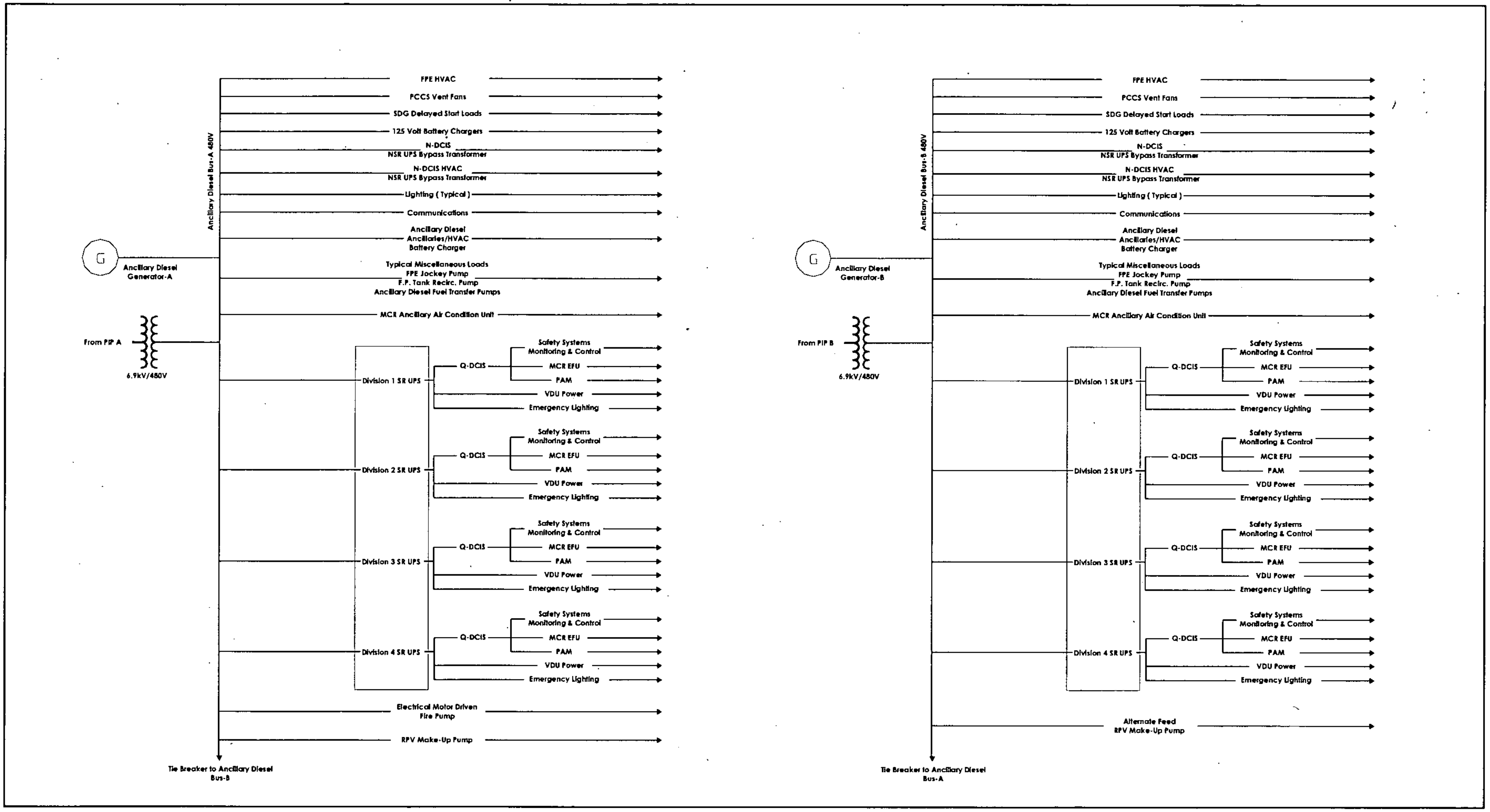


Figure 8.3-1. Safety-Related 480 Volt Power Centers

Sh 1 of 1


Ancillary Diesel Bus-A 480V
FPE HVAC
PCCS Vent Fans
SDG Delayed Start Loads
125 Volt Battery Chargers
N-DCIS
NSR UPS Bypass Transformer
N-DCIS HVAC
NSR UPS Bypass Transformer
Lighting (Typical)
Communications
Ancillary Diesel
Ancillaries/HVAC
Battery Charger
G
Ancillary Diesel
Generator-A
Typical Miscellaneous Loads
FPE Jockey Pump
F.P. Tank Recirc. Pump
Ancillary Diesel Fuel Transfer Pumps
MCR Ancillary Air Condition Unit
From PIP A
6.9kV/480V
Division 1 SR UPS
Division 2 SR UPS
Division 3 SR UPS
Division 4 SR UPS
Q-DCIS
Safety Systems
Monitoring & Control
MCR EFU
PAM
VDU Power
Emergency Lighting
Electrical Motor Driven
Fire Pump
RPV Make-Up Pump
Tie Breaker to Ancillary Diesel
Bus-B
Ancillary Diesel Bus-B 480V
Ancillary Diesel
Generator-B
From PIP B
Alternate Feed
RPV Make-Up Pump
Tie Breaker to Ancillary Diesel
Bus-A

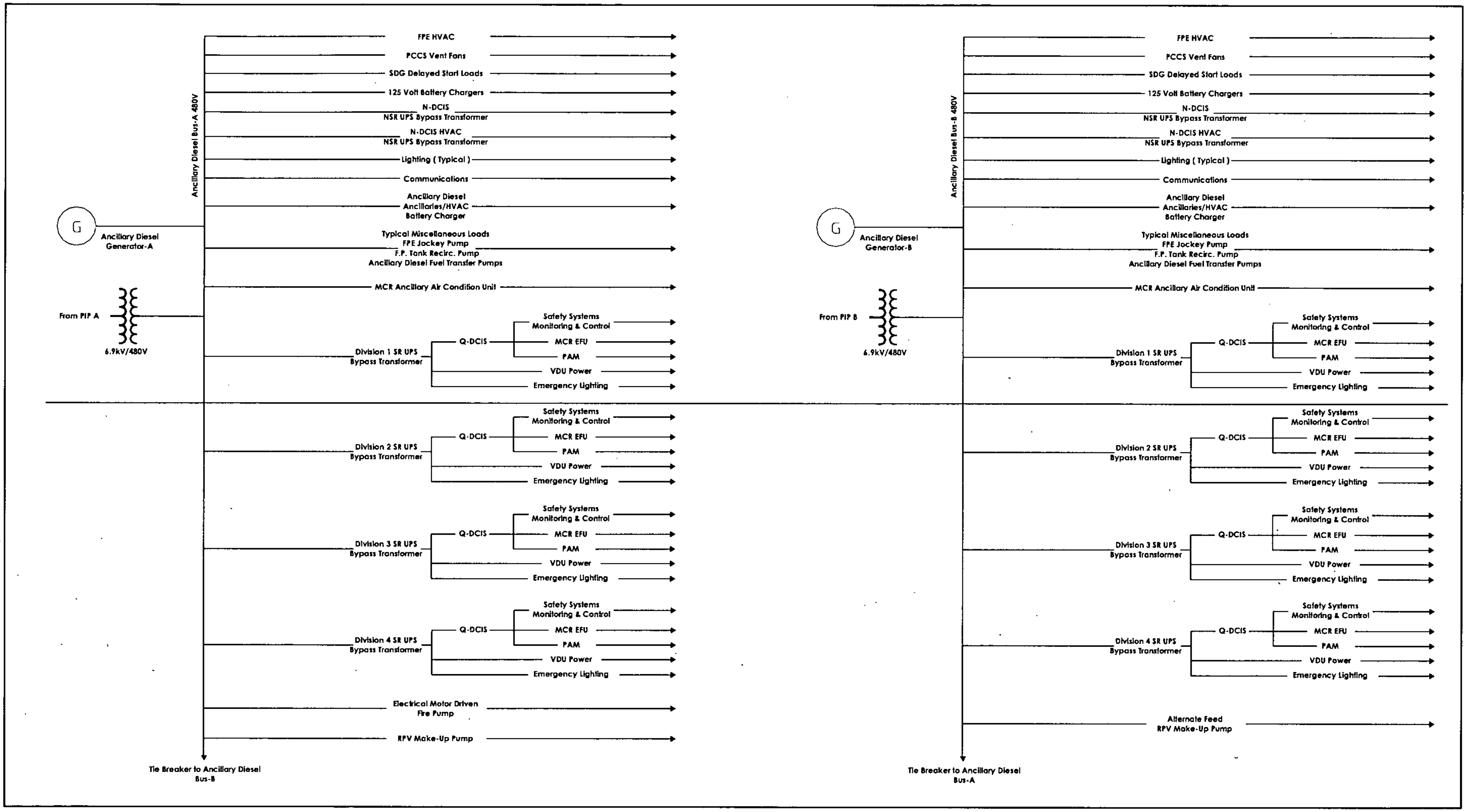


Figure 8.3-3. Ancillary Power Functional Figure

Sh 1 of 1

- Proper automatic startup of the ADGs upon detection of a low temperature in the room where the diesel generator is located;
- Proper operation of the ADGs when manually connected to their ancillary electrical bus. The testing will include verification that voltage and frequency are maintained within design limits when connection to the bus is made and/or interrupted. That overspeed limits are not exceeded when the diesel generator is unloaded;
- The ADGs are tested at full load and rated power factor for a period of 24 hours. This ensures diesel cooling and room HVAC systems perform their design functions;
- The rate of fuel consumption determined in the load testing at full load, is used to confirm that fuel capacity of the associated day tank meets the design operational requirement;
- The rate of fuel consumption determined in the load testing with the proper operation of the fuel oil transfer pumps, meets the requirement for 7-day minimum storage inventory without refueling for each ancillary diesel generator;
- Testing includes verification of the setting of the low level alarm in the day tanks and proper operation of the fuel oil transfer pumps are consistent with the design requirements;
- The proper function of the ADG protective devices;
- That permissive and prohibit interlocks, controls, and alarms operate in accordance with design specifications;
- Proper operation of auxiliary systems such as those used for starting, cooling, heating, ventilating, lubricating, and fueling the ADGs; and
- Capability of the system to allow use of the ADGs to supply power to the safety-related 120-volt Uninterruptible buses through ~~480/120 regulating step-down transformers~~the Isolation Power Center buses.

14.2.8.2 General Discussion of Startup Tests

Those tests proposed and expected to comprise the startup test phase are discussed in this subsection. For each test, a general description is provided for test purpose, test prerequisites, test description and test acceptance criteria, where applicable.

Because additions, deletions, and changes to these discussions are expected to occur as the test program is developed and implemented, the descriptions remain general in scope. In describing a test, however, an attempt is made to identify those operating and safety-oriented characteristics of the plant, which are to be explored and evaluated.

The ESBWR, because it is a natural circulation reactor, has unique characteristic during startups and especially during the initial startup. The CRD cooling flow provides a steady supply of cold water into the bottom of the RPV and core heat warms the upper part of the RPV (that is, there is a designed-in tendency for temperature stratification until natural circulation is established). This can be overcome with the RWCU/SDC system (See Subsection 14.2.8.2.17).

B 3.8 ELECTRICAL POWER SYSTEMS

B 3.8.4 Inverters - Operating

BASES

BACKGROUND

The DC to AC inverters are the preferred source of power for the Uninterruptible 120 VAC Power during all modes of operation because of the stability and reliability they achieve in being powered from the associated safety-related DC sources. Uninterruptible 120 VAC Power supplies all safety-related loads, including the Safety-Related Distributed Control and Information System (Q-DCIS) and the control power for safety-related systems.

Each of the four divisions of DC and Uninterruptible AC Electrical Power includes two separate DC to AC inverters, one associated with each of the DC Sources. Each inverter receives DC power from either the associated safety-related rectifier or the associated 250 VDC bus that is supported by the battery and charger. The output diodes for the battery chargers and safety-related rectifiers isolate the output of each required battery from an associated 480 VAC IPC bus that is de-energized or has degraded voltage.

~~Power to the Uninterruptible 120 VAC Power buses can also be supplied directly from the associated Isolation Power Center (IPC) bus using the safety-related regulating transformer. The regulating transformer bypasses the inverter and both the DC source and the rectifier that support the inverter. A static transfer switch on the output of each inverter will automatically energize the Uninterruptible 120 VAC Power bus from the regulating transformer should an inverter failure occur; however this feature is not a credited safety function that is required for OPERABILITY of either the inverter or distribution system. A manual maintenance transfer switch on the output of the inverter is provided for transferring the source of power for the Uninterruptible 120 VAC buses from the inverter to the regulating transformer for maintenance without removing UPS AC loads from service.~~

APPLICABLE SAFETY ANALYSES

The initial conditions of design basis transient and accident analyses in Chapter 6, "Engineered Safety Features," (Ref. 1) and Chapter 15, "Accident Analyses," (Ref. 2) assume Engineered Safety Feature (ESF) systems are OPERABLE. The 250 VDC power system provides normal and emergency 250 VDC power to DC to AC inverters, which are used to provide Uninterruptible 120 VAC Power during all modes of operation.

ACTIONS

A.1

With one or both inverters inoperable on one required division, ~~the associated Uninterruptible AC Electrical Power Distribution bus may be powered from the regulating transformers but the overall reliability of the associated Uninterruptible AC Electrical Power Distribution bus is reduced. With inverters in one required division inoperable,~~ the Uninterruptible AC Electrical Power Distribution buses in the two remaining required divisions are capable of supporting the minimum safety functions necessary to shut down the reactor and maintain it in a safe shutdown condition.

Required Action A.1 allows 24 hours to fix the inoperable inverter and return it to service. The 24 hour limit is based upon engineering judgment, taking into consideration the time required to repair an inverter and the additional risk to which the plant is exposed because of the inverter inoperability. This risk has to be balanced against the risk of an immediate shutdown, along with the potential challenges to safety systems that such a shutdown might entail. ~~When the AC Vital Bus is powered from the regulating transformer, it is relying upon interruptible AC electrical power sources (offsite and onsite). The uninterruptible inverter source to the Uninterruptible AC Electrical Power Distribution buses is the preferred source for powering safety-related devices.~~

Required Action A.1 is modified by a Note stating that applicable Conditions and Required Actions of LCO 3.8.6 must be entered with any Uninterruptible AC Electrical Power Distribution bus de-energized. This Note is necessary to ensure that the ACTIONS for an inoperable Uninterruptible AC Electrical Power Distribution bus are taken if that bus cannot be energized from either ~~the~~ inverter ~~or the safety-related regulating transformer~~. Otherwise, pursuant to LCO 3.0.6, these actions would not be entered even if the AC Vital Bus were de-energized. Therefore, the ACTIONS are modified by a Note stating that ACTIONS for LCO 3.8.6 must be entered immediately. This ensures the Uninterruptible AC Electrical Power Distribution bus is re-energized within 8 hours.

B.1 and B.2

When one or both inverters on two or more required divisions are inoperable, the remaining inverters may not have the capacity to support a safe shutdown and to mitigate an accident condition, especially if power is lost to the supporting IPC buses. If the Required Actions for restoration of a required inverter cannot be met within the specified Completion Time,

BASES

APPLICABILITY

The inverters required to be OPERABLE in MODES 5 and 6 provide assurance that:

a. Required features to provide adequate coolant inventory makeup are available for the irradiated fuel assemblies in the core in case of an inadvertent draindown of the reactor vessel,

b. Required features necessary to mitigate the effects of events that can lead to core damage during shutdown are available, and

c. Instrumentation and control capability is available for monitoring and maintaining the unit in a cold shutdown condition or refueling condition.

Inverter requirements for MODES 1, 2, 3, and 4 are covered in LCO 3.8.4, "Inverters - Operating."

ACTIONS

A.1, A.2.1, A.2.2, A.2.3 and A.2.4

If one or more required inverters are inoperable, the remaining OPERABLE inverters may be capable of supporting sufficient required feature(s) to allow continuation of CORE ALTERATIONS and/or operations with a potential for draining the reactor vessel. By allowing the option to declare required feature(s) associated with an inoperable inverter inoperable, appropriate restrictions are implemented in accordance with the affected required feature(s) of the LCOs' ACTIONS. In many instances this option may involve undesired administrative efforts. Therefore, the allowance for sufficiently conservative actions is made (i.e., to suspend CORE ALTERATIONS and any activities that could potentially result in inadvertent draining of the reactor vessel).

Suspension of these activities shall not preclude completion of actions to establish a safe conservative condition. These actions minimize the probability of the occurrence of postulated events. It is further required to immediately initiate action to restore the required inverters and to continue this action until restoration is accomplished in order to provide the necessary inverter power to the plant safety-related systems. The Completion Time of Immediately is consistent with the required times for actions requiring prompt attention. The restoration of the required inverters should be completed as quickly as possible in order to minimize the time the unit's safety-related systems may be without power ~~or powered from a constant voltage source transformer~~.

B 3.8 ELECTRICAL POWER SYSTEMS

B 3.8.6 Distribution Systems - Operating

BASES

BACKGROUND

The DC Electrical Power Distribution system provides the normal and emergency power to the DC to AC inverters, which are used to provide Uninterruptible 120 VAC Power during all modes of operation. Uninterruptible 120 VAC Power supplies all safety-related loads, including the Safety-Related Distributed Control and Information System (Q-DCIS) and the control power for safety-related systems. The DC and Uninterruptible 120 VAC Electrical Power Distribution system is designed to have sufficient capacity, independence, redundancy, and testability to perform its safety functions, assuming a single failure, when any three of the four divisions are available.

Each of the four divisions of DC and Uninterruptible AC Electrical Power distribution includes two 250 VDC Electrical Power Distribution buses and two Uninterruptible 120 VAC Power buses.

Each of the two 250 VDC Electrical Power Distribution buses in each division is powered from an associated DC source consisting of a battery and a battery charger that is powered from an Isolation Power Center (IPC) bus. The output of each 250 VDC Electrical Power Distribution bus is the safety-related and uninterruptible source of power to an associated DC to AC inverter. A safety-related rectifier powered from the IPC bus provides the normal source of power to the inverter. If there is loss of power to the IPC bus or the safety-related rectifier fails, the 250 VDC Electrical Power Distribution bus will transparently continue to supply power to the Inverter. The Bases for Specification 3.8.1, "DC Sources - Operating," provides a more detailed description of the DC Sources and the 250 VDC Electrical Power Distribution buses.

Each of the two Uninterruptible 120 VAC Electrical Power buses in each division is powered from an associated inverter. The inverter, which receives its power from a 250 VDC Electrical Power Distribution bus as described above, is the safety-related, uninterruptible source of power to an associated Uninterruptible 120 VAC Electrical Power bus. ~~A safety-related regulating transformer, powered from the IPC bus, provides an alternate source of power to each Uninterruptible 120 VAC Electrical Power bus. A static bypass switch on the output of each inverter will automatically energize the Uninterruptible 120 VAC Power bus from the regulating transformer should an inverter failure occur; however this feature is not a credited safety function that is required for~~

BASES

BACKGROUND (continued)

OPERABILITY of either the inverter or distribution system. A manual bypass switch on the output of the inverter is provided for transferring the source of power for the Uninterruptible 120 VAC buses from the inverter to the regulating transformer for maintenance without removing UPS AC loads from service. The Bases for Specification 3.8.4, "Inverters - Operating," provides a more detailed description of the inverters and the Uninterruptible 120 VAC Electrical Power buses.

The DC and Uninterruptible AC Electrical Power Distribution buses are listed in Table B 3.8.6-1. Two divisions (1 and 2) of safety-related power supply the reactor protection system (RPS) scram pilot valve solenoids and the same two divisions supply power to the main steam isolation valve (MSIV) solenoids.

APPLICABLE SAFETY ANALYSES

The initial conditions of design basis transient and accident analyses in Chapter 6, "Engineering Safety Features," (Ref. 1) and Chapter 15, "Accident Analyses," (Ref. 2) assume ESF systems are OPERABLE. The DC Electrical Power Distribution system provides the normal and emergency power to the DC to AC inverters, which are used to provide Uninterruptible 120 VAC Power during all modes of operation. Uninterruptible 120 VAC Power supplies all safety-related loads, including the Q-DCIS and the control power for safety-related systems.

The OPERABILITY of the DC and Uninterruptible AC Electrical Power Distribution is consistent with the initial assumptions of the accident analyses and is based upon meeting the design basis of the unit. This includes maintaining OPERABILITY of three divisions of Uninterruptible AC Electrical Power so that at least two divisions remain OPERABLE during accident conditions in the event of:

a. An assumed loss of all offsite AC electrical power and all onsite AC electrical power; and

b. A worst-case single failure.

The DC and Uninterruptible AC Electrical Power Distribution system satisfies Criterion 3 of 10 CFR 50.36(d)(2)(ii).

BASES

ACTIONS (continued)

safety-related rectifiers and regulating transformers that are also capable of powering the required loads.

With one or both 250 VDC Electrical Power Distribution buses inoperable on one required division, the two remaining required divisions of DC and Uninterruptible AC Electrical Power have the capacity to support a safe shutdown and to mitigate an accident condition even if power is lost to the supporting IPC bus. Since a subsequent worst-case single failure could, however, result in the loss of minimum necessary DC electrical subsystems, continued power operation should not exceed 24 hours. The 24 hour Completion Time for restoration is based upon engineering judgment.

B.1

Condition B represents one or both Uninterruptible 120 VAC Electrical Power buses inoperable in one required division. In this condition, the voltage and frequency of the power being supplied to the safety-related loads for that division, including the Q-DCIS and the control power for safety-related systems, cannot be maintained within required limits even when the associated IPC bus remains energized. The two remaining divisions with OPERABLE 120 VAC Electrical Power buses still have the capacity to support a safe shutdown and to mitigate an accident condition even if power is lost to the supporting IPC buses. Since a subsequent single failure could, however, result in the loss of minimum necessary Uninterruptible 120 VAC Electrical Power buses, continued power operation should not exceed 8 hours. The 8 hour Completion Time is based on engineering judgment.

C.1

Condition C represents two or more required divisions with one or both DC and Uninterruptible AC Electrical Power Distribution buses inoperable, or the Required Action and associated Completion Time of Condition A or Condition B is not met. When one or more DC or Uninterruptible AC Electrical Power Distribution buses (i.e., any combination) on two or more required divisions are inoperable, the remaining DC Sources may not have the capacity to support a safe shutdown and to mitigate an accident condition, especially if power is lost to the supporting IPC buses. If the Required Actions for restoration of a required DC or Uninterruptible AC Electrical Power Distribution bus cannot be met within the specified Completion Time, the plant remains vulnerable to a single failure that could impair the capability to reach safe