Millstone Power Station Unit 2
Safety Analysis Report

Chapter 8

CHAPTER 8–ELECTRICAL SYSTEMS

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D-18767-416-131	05		
D-18767-416-401	03		
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D-18767-416-470	03	1	
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E-18767-411-003	04		
E-18767-411-011	03		
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E-18767-411-102	02		
E-18767-411-103	02		
E-18767-411-302	03		
E-18767-411-310	03		
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8.1 ELECTRIC POWER

8.1.1 INTRODUCTION

This chapter describes the utility grid and its interconnections to other grids and to the Millstone Nuclear Power Station 345 kV switchyard. The on site electric system is also described. Definitions used in this chapter are given below.

Transmission System

The transmission system includes all transmission lines coming to the Millstone Nuclear Power Station complex up to, but not including, the point of connection to the 345 kV switchyard.

Off Site System

The off-site system includes the transmission system and the 345 kV switchyard and extends up to, but does not include, the main transformer bank. Included in the off site system are the reserve station service transformers, Millstone Units 2 and 3.

On Site System

The on-site system includes the Millstone Unit 2 electric power systems out to, and including, the main transformer bank (Figure 8.2–1); this includes the normal station service transformer.

Portable generator connection points have been provided on several plant electrical buses. These connections are defense-in-depth features available for coping with an extended loss of AC power (ELAP) event. The connections are shown on Figure 8.2–1, “Main Single Line Diagram” and Figure 8.5–1, “Single Line Diagram”.

Normal Operation

Normal operation is when the main generator is transmitting electrical power through the main transformer bank and when plant auxiliaries are being supplied from the normal station service transformer.

Normal Power System

The normal power system includes that equipment required to support the main turbine generator, plant systems, and equipment associated with the reactor.

Emergency Power System

The emergency power system includes that electrical distribution equipment required to support the safe shutdown and post-accident operations of Millstone Unit 2. Included in the emergency power system are the emergency 4160 V switchgear and all extensions except those going to the normal switchgear and the reserve station service transformer and Unit 3 (Figure 8.2–1). The emergency power system and equipment is Class 1E and safety related.

Standby Power System

The standby power system includes the Class 1E emergency diesel generators, which are referred to as the on-site emergency power supply.

Preferred Power System

The preferred off site power supply is from the 345 kV switchyard and the reserve station service transformer.

Alternate Off Site Source

The alternate off site source is the 4160-V tie to Millstone Unit 3 via bus 34A or 34B.

8.1.1.1 Design Criteria

The 345 kV switchyard and the associated transmission lines provide the off site sources that are the preferred power supplies, as outlined in Section 5.2.3 of IEEE Standard 308-1971 and Criterion 17 of Appendix A of 10 CFR Part 50. The conventional and accepted design of these facilities has been shown to be conservative and reliable.

Transmission facilities connecting the Millstone generating units to the main transmission grid are designed in accordance with the “Design and Operation of the Bulk Power System,” developed by the Northeast Power Coordinating Council (NPCC).

8.1.1.2 Utility Grid

The utility electrical system consists of interconnected diverse energy sources including fossil fueled, hydro-electric and nuclear fueled plants supplying electric energy over a 345/115 kV transmission system (Figure 8.1–1C).

ISO-New England is the regional transmission organization which has authority over the operation of the transmission system in Connecticut. The main transmission system fed by Millstone Power Station is part of the New England power system. The Connecticut Valley Electric Exchange (CONVEX) is one of the local control centers in New England and assists ISO-New England in running the power system in Connecticut.

The electrical output of Millstone Unit 2 is delivered to the 345 kV switchyard (Figure 8.1–1D). Four 345 kV transmission lines feed power to the 345 kV system. Two of these lines feed the eastern part of Connecticut by connecting respectively to the Card and Montville substations. The remaining two lines feed the central part of Connecticut by connecting to the Beseck, Haddam, and Manchester substations.

8.1.1.3 Interconnections

Millstone Power Station is connected to the Eversource Energy, Inc. transmission system which is closely integrated with transmission systems of several other utilities and operating companies. The New England power system is part of the larger northeast interconnection power grid and is tied through various connections points throughout New England. These interconnections include 345kV, 230kV, 138kV, 115kV, 69kV, and DC lines. The New England power system is also tied to neighboring grids such as New York, Hydro Quebec and New Brunswick, which are under the control of other reliability coordinators within the NPCC region.

8.1.1.4 345-kV Switchyard System at Site

The 345 kV switchyard is designed in an arrangement as shown on Figure 8.1–1D. The switchyard consists of ten 345 kV breakers, four 345 kV transmission Units 2 and 3 lines, two 345 kV tie lines to the generator step-up transformers, and two 345 kV tie lines to the reserve station service transformers. The Millstone 1 generator step-up transformer and reserve station service transformer are no longer in service.

The breakers and motor-operated disconnect switches are controlled primarily from CONVEX via the Supervisory Control and Data Acquisition System (SCADA) and from the Millstone Unit 1 Control Room. Millstone 2 Operations is responsible for the switching and tagging of equipment located in the Millstone 1 Control Room. Via the Millstone Unit 1 Control Room Millstone 2 Operations has primary control of breakers 8T, and 9T, as well as indication only of the remaining breakers and motor-operated disconnect switches. The Millstone Units 2 and 3 Control Rooms are equipped with remote panels that show the status only of the breakers and motor-operated disconnect switches in the switchyard. Through the operation of control switches, all breakers can be operated at the switchyard, if necessary.

Each element of the Millstone bus and associated line terminations are protected by redundant sets of primary and backup relays. The primary and backup relays are supplied from separate DC sources, separate current transformers, separate coupling capacitor voltage transformers, and communication channels.

The DC power is supplied by two independent batteries, one primary and one backup. Each battery is equipped with its own charger and distribution panel. A manual transfer scheme is provided to allow one battery and charger to carry the DC load upon the failure of the other battery and charger.

8.1.2 OFF SITE POWER SYSTEM

8.1.2.1 Description

The off site power system is designed to provide reliable sources of power to the on site AC power distribution system adequate for the safe shutdown of the unit. Details of the 345 kV switchyard are shown on Figure 8.1–1D.

The switchyard, which is configured in a combination breaker-and-a-half and double breaker-double bus arrangement, buses together four 345 kV transmission line circuits, two generator circuits and two station service circuits. The Millstone 1 generator and station service circuits are no longer in service.

The four transmission line circuits terminated at the switchyard are:

a. Millstone to Beseck (Line Number 348)

b. Millstone to Card (Line Number 383)

c. Millstone to Montville (Line Number 371, this line includes Line 364)

d. Millstone to Manchester (Line Number 310)

These circuits connect the station to the 345 kV system transmission grid and follow a common right-of-way from Millstone to Hunts Brook Junction (9.0 miles).

These four circuits are individually mounted on separate structures which are installed across a 415-500 foot wide Right of Way to provide adequate physical independence of the transmission lines. The transmission towers, which support the four lines, consist of a combination of steel and wooden mono-pole structures, and steel and wooden H-frame structures. The towers are designed to the National Electric Safety Code Part C2, and Eversource Overhead Transmission Line Standards, which have both strength and overload design factors to provide for conservative designs. The towers for all four transmission lines are periodically inspected for proper physical condition.

With four lines feeding the Millstone Switching Station in service, the offsite power source complies with GDC-17 with no reasonable failure that can affect all circuits in such a way that none of the four circuits can be returned to service in time to prevent fuel design limits or design conditions of the reactor coolant pressure boundary from being exceeded. In particular, a sequence of cascading events from a particular tower falling in a specific manner, at one of only a few specific locations, or a line falling at Hunts Brook Junction, the worst case would be the loss of two circuits.

All four of the 345 kV lines leaving Millstone cross over two 115 kV circuits which supply the Waterford Substation, and constitute the off site source for Millstone Unit 1. However, the mechanical failure of a single 345 kV line, and the consequential failure of the 115 kV circuits will not affect the preferred source of off site power to Millstone Units 2 and 3.

At Hunts Brook Junction, the four transmission line circuits diverge along three separate rights-of-way (Figure 8.1–1B). The 348 line turns west to the Beseck Substation, the 383 and 310 lines continue north to the Card Street and Manchester Substations, respectively, and the 371 line turns east to Montville Substation. At this junction, aerial crossover of lines exist (line 383 and line 310 cross over line 371/364); however, at worst, only two of the four circuits from the Millstone Switching Station would be removed from service should a structure collapse or a conductor drop.

The main transformer bank and reserve station service transformer circuits, connecting the generating station to the 345 kV switchyard, are 0.35 mile long and each circuit is installed on separate structures. These circuits are supplied from different bus positions in the switchyard, so placed that no single equipment or component failure would remove both circuits from service at one time.

The inspection and testing of the 345 kV circuit breakers and the transmission line protective relaying are done on a routine basis, without removing the transmission lines from service. The insulating oil for the transformers (main step up, normal station service transformer (NSST), reserve station service transformer (RSST)) is sampled and tested on a routine basis. During these routine inspections and tests, the operability and functional performance of the electric systems are verified.

8.1.2.2 Analysis

The possibility of power failure due to contingencies in the connections to the system and the associated switchyard is minimized by the following arrangements:

a. The connections to the system have been designed to comply with the NPCC “Design and Operation of the Bulk Power System” and the ISO New England “Reliability Standards for the New England Area Bulk Power Supply System.” Compliance with these criteria ensure that the supply of off-site power will not be lost following contingencies in the interconnected transmission system. Transient stability studies have been performed to verify that widespread or cascading interruptions to service will not result from these contingencies. In addition, the loss of Millstone Unit 2 or the loss of any other unit in the system will not result in cascading system outages and thus will not cause loss of off-site power to units 2 and 3.

   The 345 kV circuit breakers are SF6 puffer type and are pneumatically operated. Electrical controls are provided for both local and remote Millstone 1 control room or CONVEX operation. Each power circuit breaker has a separate pneumatic supply unit capable of operating the breaker for a minimum of three close-open operations after the loss of its pneumatic supply unit. The essential AC station service for the power circuit breaker pneumatic supply units and the other switchyard requirements is supplied by an off site 23 kV line which has transfer capability to a source from Millstone Unit 3. The circuit breakers are equipped with a closing solenoid and two independent trip solenoids. A standard anti-pump and trip-free control scheme is used.

Two 125 VDC batteries are located in the switchyard control and relay enclosure for switchyard relaying and control. Each battery has its own charger and DC distribution panel. The redundant batteries and protective relaying systems are physically and electrically separate.

b. The 345 kV system is protected from lightning and switching surges by overhead electrostatic shield wires, earth grounding at most structures, surge arrestors on the switchyard main buses, surge arrestors at the transformer high voltage bushings, and rod gaps on the line terminals.

c. Each 345 kV transmission line is protected from phase to phase and phase to ground faults by two sets of diverse protective relays, one primary and one back-up, both of which are high speed schemes.

The primary line protection consists of a distance relaying package in a directional comparison blocking scheme communicating with the remote terminal over a carrier current channel.

The backup line protection consists of step-distance relays operating independently from the remote terminal. This equipment is used with a transfer trip channel to provide a high speed permissive over-reaching scheme. A second transfer trip scheme provides tripping of the breakers at the remote terminal in the event of a stuck breaker at Millstone as well as tripping Millstone breakers following the reception of a trip signal from the remote end.

Pilot wire relaying is used for primary protection of the 345 kV tie lines between the switchyard and the main step-up transformers. Backup protection consists of directional distance, single zone and directional ground overcurrent relays located in the switchyard and for transfer tripping to the plant dual channel audio-tone equipment is used.

Tripping of the switchyard breakers following the operation of the generator or main step-up transformer bank primary and backup relays is accomplished by the means of the transfer trip via pilot wire and audio-tone.

The Millstone 2 RSST 345 kV tie line is protected by two sets of protective relays, one primary and one backup. The directional distance relays detect phase-faults, and the directional ground overcurrent relays detect ground-faults. Operation of these relays will trip the appropriate 345 kV circuit breakers on the A switchyard bus, and send a transfer trip signal via digital teleprotection system with fiber optics communications medium to trip the transformer's low side circuit breaker at the plant. The operation of any of the RSST transformer protective relays at the plant will trip the low side breaker, and send a transfer trip signal via digital teleprotection system with fiber optics communications medium to trip the appropriate switchyard breakers.

Breaker failure relays are provided for each of the 345 kV circuit breakers to trip adjacent breakers in the event that the primary breaker fails to trip. The DC power for breaker failure operation is supplied from the backup battery system.

A breaker failure timing relay is initiated every time a main breaker is signaled to trip by primary or backup relays. If the breaker has not tripped before the time period has expired, tripping of the adjacent breaker will take place.

Phase angle sensitive impedance relays are also included in the backup protection of the main step-up transformer bank tie lines to protect the generator.

Automatic reclosing of 345 kV breakers is allowed following the protective relay tripping of the 345 kV transmission lines. The reclosing is designed for time delay reclosure from the remote ends only. At the switchyard, the breakers will close via synch-check relays.

A synch-check relay is also provided for each circuit breaker to supervise both manual closing and automatic reclosing of the breaker.

d. Primary and backup relaying is provided for each circuit breaker along with breaker failure backup protection. These provisions permit the following:

1. Any circuit can be switched under normal or fault conditions without affecting another circuit.

2. Any single circuit breaker can be isolated for maintenance without interrupting power or protection of any circuit.

3. Short circuits on any section of a bus are isolated without interrupting service to any element other than those connected to the faulty bus section.

4. The failure of any circuit breaker to trip within a set time initiates the automatic tripping of the adjacent breakers and thus may result in the loss of a line or generator for this contingency condition; however, power can be restored to the good element in less than eight hours by manually isolating the fault with appropriate disconnect switches.

Complete battery failure is considered highly unlikely since two independent 125 VDC battery systems are provided. Failure of a single battery system results only in a momentary loss of one set of protective relays until the DC is manually transferred to the other battery. Therefore, no single failure could negate the effectiveness of the relaying to clear a fault.

The Millstone design provides two off site circuits between the switchyard and the 4.16 kV Class 1E buses. The immediately available off site supply is the Millstone Unit 2 RSST while the alternate supply is the Millstone Unit 3 bus 34A or 34B.

The normal supply to the plant with the plant on line is the NSST. If this source is lost due to a plant trip, a fast bus transfer scheme connects the plant electrical system (6.9 kV and 4.16 kV) to the RSST. The second or alternate source of off site power is available by manual controls to Millstone Unit 3 bus 34A or 34B for 4.16 kV power.

Physical separation of the off site power sources, switchyard protection, redundancy, and the transmission system design based on load flow and stability analyses minimize the possibility of simultaneous failure of all power sources (reserve station service supply, standby AC emergency generators, and Millstone Unit 3 bus 34A or 34B.

The 345 kV transmission system supplying off site power to Millstone is normally operated at 357 kV at Millstone. This system voltage is controlled by varying the reactive power generation on the Millstone Power Station units. The Millstone Units 2 and 3 operators control the unit excitation as specified by CONVEX Operation Instruction Number 6913. The unit operators are required to balance the reactive power output of the units.

The CONVEX system operator supervises the system reactive power dispatch. The CONVEX operator directs the loading of all the reactive power sources in CONVEX to balance the reactive supply. The CONVEX operator keeps the Millstone Power Station reactive power generation in balance with the Eastern Area requirements so that the effect on the system of voltage variations is minimized when a unit is lost.

One objective of the reactive power dispatch is to prevent the voltage at the Millstone Power Station from going below the minimum required to support actuation of the Engineered Safety Features equipment. A switchyard voltage of 345 kV will assure successful actuation and operation of all necessary safeguards loads in the unlikely event Millstone Unit 2 experiences a Loss-of-Coolant Accident and trips off the transmission system. CONVEX operates the system to assure that this minimum voltage requirement will be met, following the loss of the unit. When in Reactor Modes 5 or 6, with the auxiliary electrical system lightly loaded, Millstone Unit 2 can assure successful actuation and operation of all necessary safeguards loads with a switchyard voltage of 335 kV. The maximum allowable voltage at Millstone Station is 362 kV based on equipment ratings.

If abnormal system conditions result in voltages approaching minimum levels, system operating instructions and procedures direct the CONVEX operator to take specific corrective actions to restore voltage.

Actual experience and system simulations show that the CONVEX operator is able to control the system voltages within the desired limits.

The Millstone plant is connected to the transmission system by four 345 kV circuits (described in Section 8.1.2.1). Transmission operating procedures are in place to ensure that no more than the minimal number of circuits would ever intentionally be taken out of service, except in an emergency, when both Millstone generating units are on-line.

If both Millstone units 2 and 3 are on line at full output, certain contingencies on the transmission system as determined by CONVEX result in procedural restrictions on the station's net output, in order to assure that system synchronous and voltage stability will be maintained.

By careful design of the switchyard and protective relays, the possibility of the simultaneous loss of both units 2 and 3 at Millstone has been significantly reduced. The system has been computer modeled for both light load and heavy load conditions. The stability analysis indicates that the rest of the system remains in synchronism after the loss of any one Millstone unit. The probability of losing both on-line units simultaneously is extremely small because of the preventive measures discussed in the following paragraphs. Accordingly, the Licensee believes it is reasonable to count upon on site power sources to supply the necessary station service power requirements in the very remote event that both Millstone units 2 and 3 should be lost at once accompanied by the total loss of the transmission supply to the station.

A primary objective in designing the connection of the Millstone Nuclear Power Station to the 345 kV transmission network in Connecticut has been to prevent the loss of the entire station output. The reliability criteria of NPCC and ISO New England are a fundamental part of this design process. The most severe outage which the system has been designed to survive in order to minimize the possibility of a total plant outage is as follows:

With any one of the four Millstone 345 kV transmission circuits out of service the plant remains stable for any three-phase fault normally cleared (four cycles) or any one-phase fault with the delayed clearing (eight cycles).

The Millstone units are connected to the large interconnected transmission system in the eastern half of the United States. The interconnected system frequency is maintained at 60 ± 0.03 Hz in accordance with NPCC standards for the bulk power system. The system is designed and operated such that the loss of the largest single supply to the grid does not result in the complete loss of preferred power. The system design considers the loss, through a single event, of the largest capacity being supplied to the grid, removal of the largest load from the grid, or loss of the most critical transmission line. This could be the total output of a single Millstone reactor unit, the largest generating unit on the grid, or possibly multiple generators as a result of the loss of a common transmission tower, transformer, or a breaker in a switchyard or substation.

In order to ensure the interconnected system will remain stable and offsite power circuits meet GDC-17 requirements, the following technical requirement actions and generation output restrictions will be implemented when both Millstone Power Station Unit 2 and Unit 3 are at power:

With any of the 345 kV offsite transmission lines (310, 348, 371 (includes 364 line), and 383) out of service or nonfunctional, the nonfunctional transmission line shall be restored to functional status within 72 hours or total station output shall be reduced to ≤ 1650 MWe net within the next 6 hours; or, alternatively, within 7 days for Lines 310, 348, and 383 or 14 days for Line 371/364 with the following action requirements in place:

a. Once per shift, verify the remaining lines are functional,

b. Once per shift, perform a weather assessment,

c. Once per 24 hours, verify the EDGs are operable and the SBO diesel is available.

If any of the above actions cannot be met or if a weather assessment predicts adverse or inclement weather will exist while a transmission line is nonfunctional (i.e., out of service), total station output shall be reduced to ≤ 1650 MWe net within the next 6 hours to ensure the stability and availability of the electrical grid is maintained.

With two 345 kV offsite transmission lines nonfunctional, total output shall be reduced to ≤ 1650 MWe net within the next 30 minutes.

The allowed outage times (AOT) for Lines 310, 348, 371/364, and 383 are based on the configuration of the transmission lines at Hunts Brook Junction where Lines 383 and 310 cross over Line 371/364 and Line 348 runs to the west of the crossover. With Line 348, 310, or 383 nonfunctional, the possibility exists that either Line 383 or 310 could drop on Line 371/364 and result in three lines nonfunctional. This condition would impact grid stability and therefore, a 7-day AOT is allowed with the specified action requirements in place. When Line 371/364 is nonfunctional, if either Line 310 or 383 drops, two transmission lines remain functional. Therefore, a 14-day AOT is allowed with the specified action requirements in place.

8.1.2.3 Extreme Contingency Events

The design of the switchyard protective relay schemes and circuit breaker installations is such that at most only one pole or phase of a three-phase circuit breaker will fail to clear a fault. Breakers which are designed to meet this criteria are classified as having independent pole tripping. Independent pole tripping is ensured by installing breakers with mechanically independent poles and two separate methods of tripping the circuit breaker. These installations include two sets of relays, trip coils, and two sets of current and potential transformers. The wiring for the relay packages are installed in separate duct banks, the relay packages are physically separated in the control house and two separate DC supplies are provided.

The 345 kV switchyard at Millstone is designed so that the loss of more than one transmission circuit due to a failure of a breaker to trip requires at least two circuit breakers to simultaneously fail to operate. The failure of even one circuit breaker is very unusual. At least three circuit breakers would have to fail before three transmission lines would be lost due to malfunctions in the switchyard.

8.1.3 STATION BLACKOUT (SBO)

On July 21, 1988, the Code of Federal Regulations 10 CFR Part 50, was amended to include Section 50.63 entitled "Loss of All Alternating Current Power," (Station Blackout [SBO]). The SBO rule requires that each light-water-cooled nuclear power plant be able to withstand and recover from a SBO event of specified duration, requires licensees to submit information as defined in 10 CFR Part 50.63, and requires licensees to provide a plan and schedule for conformance to the SBO rule. The SBO rule further requires that the baseline assumptions, analyses and related information be available for NRC review. Guidance for conformance to the rule is provided by (1) Regulatory Guide (RG) 1.155, Station Blackout; (2) NUMARC 87-00, Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors; and (3) NUMARC 87-00 Supplemental Questions/Answers and Major Assumptions dated December 27, 1989 (issued to the industry by Nuclear Management and Resources Council, Inc. [NUMARC], dated January 4, 1990).

8.1.3.1 Station Blackout Duration

Millstone Unit 2 has the ability to cope with a loss of preferred and emergency on-site AC power sources for up to eight hours. Unit 2 must provide decay heat removal during the event. It is assumed that there will be no AC power available during the first hour of the SBO except for battery backed power supplies (i.e., vital 120V AC). Within the first hour, Millstone Unit 2 will have an alternate AC power source available from Millstone Unit 3 Alternate AC (SBO) diesel generator.

Millstone Units 2 and 3 each have two emergency diesel generators in addition to the Unit 3 Alternate AC (SBO) diesel generator. In accordance with the SBO Rule and NUMARC 87-00, one of the four emergency diesel generators would be available and a Station Blackout is postulated to occur at one unit only at any one time. In the event of a Unit 2 station blackout, the Unit 3 AAC diesel will be made available within one hour by Unit 3 operator action and connected to Unit 2 Bus 24E by Unit 2 operator action.

8.1.3.2 Ability to Cope with a Station Blackout

Eight-hour coping assessments were performed for the 1) condensate inventory available for decay heat removal, 2) Class 1E battery capacity, 3) compressed air capability, 4) effects of loss of ventilation, 5) containment isolation, 6) emergency lighting, 7) communications, and 8) heat tracing. The results of these assessments are summarized below.

Condensate Inventory Available for Decay Heat Removal

A calculation was performed to determine the available volume in the Condensate Storage Tank (CST) for decay heat removal during SBO. The necessary condensate inventory required for decay heat removal plus cooldown is less than the Technical Specification minimum requirement for the CST, including consideration of required turbine driven auxiliary feedwater pump NPSH. Therefore, the Millstone Unit 2 condensate inventory would be adequate for decay heat removal during an 8 hour station blackout.

Class 1E Battery Capacity

An assessment was performed to ensure that the unit has adequate battery capacity to support required DC loads during a SBO. It is assumed that one battery charger will be returned to service within one hour when the alternate AC source is available. The DC power requirements for a station blackout were calculated using the methodology of IEEE-STD-485, “Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations.” This standard incorporates design margins for aging and temperature correction that are addressed in various other industry standards such as IEEE-STD-450, “Recommended Practice for Maintenance, Testing, and Replacement of Large Stationary Type Power Plant and Substation Lead Storage Batteries.” This methodology calculates battery load requirements for various sections of time. The magnitude of DC loads for each section of time is referred to as the section size. Various section sizes are calculated in order to construct a battery duty cycle.

The assessment concluded that the Class 1E batteries have adequate capacity to supply the required DC loads for eight hours during a station blackout.

Compressed Air Capability

No Millstone Unit 2 air operated valves are relied on to cope with a station blackout for eight hours. Long term decay heat removal will be accomplished by manual operation of the atmospheric dump valves. The auxiliary feedwater regulating valves will fail open on loss of air, and auxiliary feedwater flow will be controlled by varying the speed on the auxiliary feedwater pump turbine.

The Effects of Loss of Ventilation

Detailed room heat-up calculations were performed for different areas of the unit containing station blackout equipment which would have post-SBO 8 hour steady state ambient air temperatures greater than 120°F. An area containing SBO equipment with a final temperature in excess of 120°F would be considered a dominant area of concern.

NUMARC 87-00 calculation methodologies were utilized to the maximum extent possible to facilitate compliance with the SBO requirements. However, in most cases different methods had to be used. These methods used either a computer generated calculation of room/area temperatures over time, or a manual calculation of steady state temperatures. Either method is more conservative than the NUMARC methodology.

For dominant areas of concern, the SBO equipment contained in the area is either qualified for the environment, or a reasonable assurance of operability has been provided.

Containment Isolation

Containment isolation valves have been reviewed to verify that valves which must be capable of being closed or that must be operated (cycled) under SBO conditions can be positioned (with indication) independent of the Millstone Unit 2 preferred or Class 1E AC power supplies. No plant modifications nor associated procedure changes were required to ensure that appropriate containment integrity can be provided under SBO conditions.

Emergency Lighting

Emergency lighting was evaluated to ensure that the unit has sufficient emergency lighting for personnel to safely perform the operations required for an orderly safe shutdown of the unit during SBO. The Station Blackout Safe Shutdown Scenario credits the Appendix R lighting fixtures (self-contained battery units and the security lighting) for providing eight-hour lighting to areas where operators maintain safe plant operations; areas where operators maintain the plant in a safe shutdown conditions; and access/egress routes to accomplish these functions. The 1.5-hour rated, life safety battery units provide additional portable emergency lighting for ingress / egress into plant areas during a SBO Event.

Communications

An assessment was performed to ensure that the unit has sufficient reliable effective communications systems available to plant personnel during SBO.

Heat Tracing

An evaluation was performed to determine the effects of a loss of electric heat tracing to systems essential to plant shutdown during SBO and to systems that are returned to service when power is restored. Existing electric heat tracing is adequate for coping with the eight hour SBO for systems required for safe shutdown excluding the local level instrumentation on the CST. However, an alternative method is available for determining CST level.

FIGURE 8.1–1A DELETED BY FSARCR MP2-UCR-2016-007

Figure deleted by FSARCR MP2-UCR-2016-007

Withheld under 10 CFR 2.390 (d) (1)

FIGURE 8.1–1B HUNTS BROOK JUNCTION

[redacted]

[redacted]

FIGURE 8.1-1C
345KV TRANSMISSION MAP OF CONNECTICUT AND WESTERN MASSACHUSETTS
Withheld under 10 CFR 2.390 (d)(1)

MPS-2 FSAR

FIGURE 8.1-1D 345KV SWITCHYARD

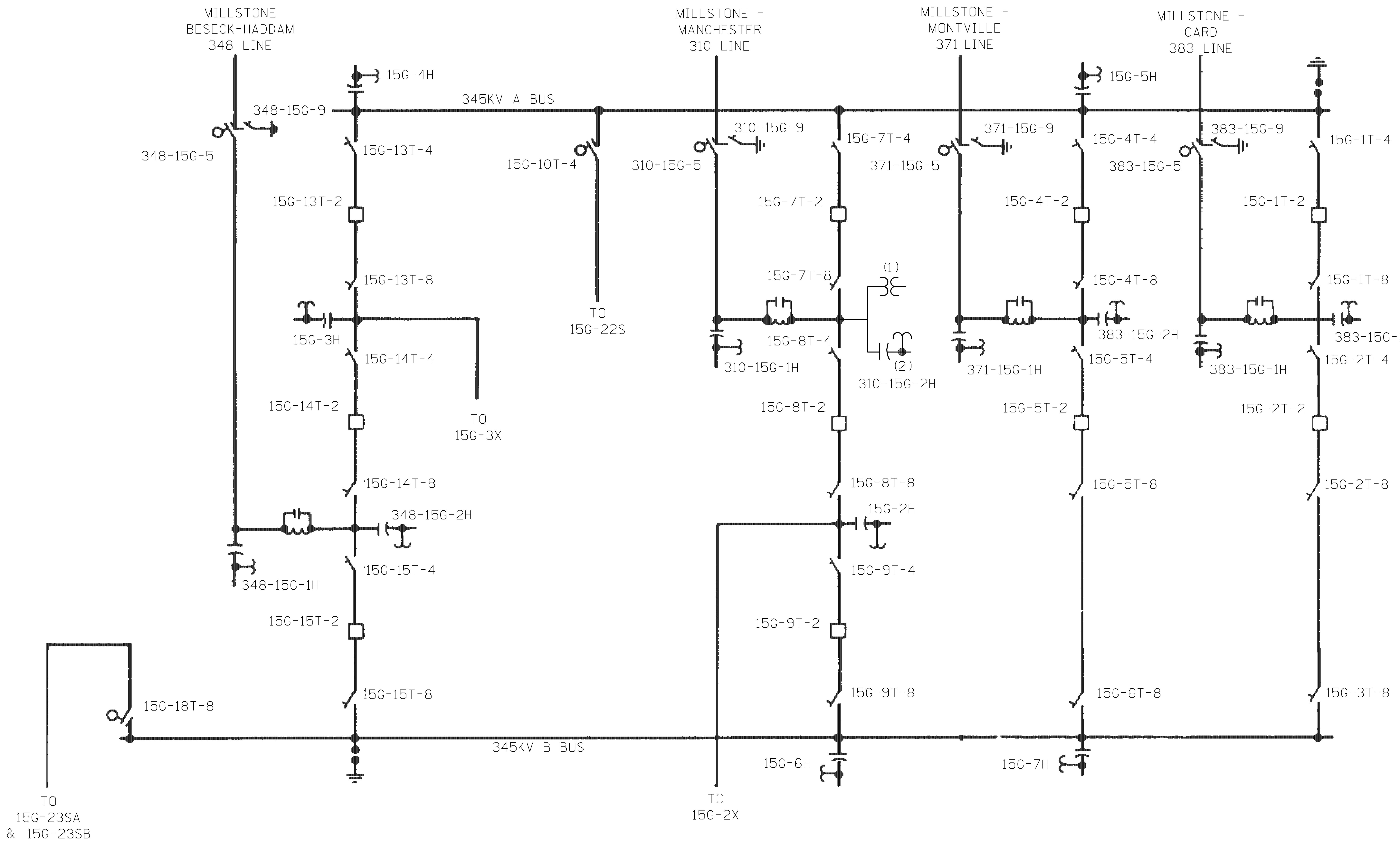

FIGURE 8.1–2 DELETED BY PKG FSC MP2-UCR-2011-010

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8.2 4160-VOLT AND 6900-VOLT SYSTEMS

8.2.1 DESIGN BASES

8.2.1.1 Functional Requirements

From either of two full capacity station service transformers, power is supplied to two 6900 volt buses and to six 4160 volt station service buses. The 6900 volt switchgear feeds motors of 3000 horsepower and larger. The 4160 volt switchgear feeds large (250 to less than 3000 hp) motors and supplies power to 480 volt load center transformers. Additional sources of 4160 volt power are from the emergency diesel generators, and from the Unit 3 reserve station service transformer or Unit 3 Normal Station service transformer (backfeeding).

8.2.1.2 Design Criteria

None of the 6900-volt equipment is required for safety related services, but three of the 4160-volt switchgear groups are part of Class 1E systems as defined in IEEE Standard 308, 1971. The Class 1E switchgear has been designed, built and tested in accordance with Sections 4 and 5.2 of IEEE Standard 308, 1971, Criteria 1, 2, 3, 17 and 18 of Appendix A of 10 CFR Part 50, seismic criteria as defined in Sections 5.8.1 and 5.8.1.1 of this report, and Safety Guide 6.

8.2.2 SYSTEM DESCRIPTION

8.2.2.1 System

The 6900 volt system, shown in Figure 8.2–1, is a reliable source of power for the reactor coolant and condensate pumps. The system consists of two buses, 25A (H1) and 25B (H2) each capable of being fed from the 6900 volt winding of either the normal or the reserve station service transformer. The 6900 volt winding of each transformer is sized to supply the full-load requirements of both buses.

The 4160-volt system, shown in Figure 8.2–1, consists of five buses, 24A (A1), 24B (A2), 24C (A3), 24D (A4), and 24E (A5), each consisting of a metal-clad switchgear assembly with vertical lift air circuit breakers. The 4160-volt system provides a reliable source of power to large AC motors and to 480-volt load centers. During plant operation, power is supplied to buses 24A (A1) and 24B (A2) from the normal station service transformer. Bus ties connect buses 24A (A1) and 24B (A2) to buses 24C (A3) and 24D (A4), respectively. During other periods, such as startup and shutdown when the normal station service transformer is not used, power is supplied from the reserve station service transformer directly to buses 24C (A3) and 24D (A4) and via the bus ties to buses 24A (A1) and 24B (A2). The 24E (A5) bus may be fed from either bus 24C (A3) or 24D (A4), or from Unit 3 reserve station service transformer or Unit 3 normal station service transformer (backfeeding). All auxiliary loads (other than the 6.9 kV motors detailed above) are supplied from the 4.16-kV buses. Motors of 250 horsepower and larger are connected directly to the 4.16 kV system; other loads are supplied at 480 volts from 4160-480 volt unit substations; 120/208 volt sources are available by stepping down from 480 volts.

8.2.2.2 Components

The 6900 volt switchgear for buses 25A (H1) and 25B (H2), and 4160 volt switchgear for buses 24A (A1) through 24E (A5) and Unit 3 buses 34A and 34B consist of indoor, free standing, metal clad units containing vertical lift air circuit breakers and necessary auxiliaries; all located in a Class I structure. Overcurrent and motor overload protection is provided by an overcurrent relay with instantaneous attachment, and a ground fault sensor relay on each feeder.

The equipment is all of General Electric Company manufacture, and its principal components are rated as follows:

6900 Volts

Component	Amperes Continuous	MVA Interrupting
Bus	2000	
Feeder breakers, main	2000	500
Feeder breakers, motor	1200	500

4160 Volts

Component	Buses 24A (A1) - 24D (A4)	Bus 24E (A5)	Buses 34A, B, C, D
Bus (amp cont)	2000	1200	3000/2000
Main feeder breakers (amp cont)	2000	1200	3000
Other feeder breakers (amp cont)	1200	1200	1200
All circuit breakers (MVA inter)	250	250	350

Buses 24C (A3), 24D (A4), and 24E (A5) are emergency buses that supply power to equipment required for a LOCA or other transient and conform to the requirements for Class 1E equipment.

Where means exist for manually connecting together redundant load groups, interlocks are provided as directed by Safety Guide 6 to prevent an operator error that would parallel the standby power sources. In addition to electrical interlocks, a Kirk Key Interlock System is utilized on the feeder breakers to bus 24E (A5). This operates on the principle that the key required to close one breaker can be removed from the second breaker only when its locking bolt is in a predetermined (breaker open) position. The key must be removed from one lock before another lock can be operated.

A test report, dated June 14, 1971, from General Electric on the 4160 volt emergency switchgear contains the following summary of seismic test results:

a. The stresses developed from combined seismic and normal loads do not exceed normal design stresses and are less than the allowable values specified in the American Institute of Steel Construction, Steel Construction Manual.

b. The deflections in structural members under combined horizontal and vertical acceleration forces are not large enough to introduce the possibility of breaker dropout.

c. The lowest natural frequency in the breaker support system is 19 hertz.

d. The breaker operating mechanism will withstand acceleration forces up to 44 g without false tripping or closing.

e. When vibrated in the frequency range of 0 to 37 hertz, door mounted LAC 66 relays tested on the factory floor were found to function normally; that is:

   The contacts did not close due to vibration when the relay was not energized, and

   The relays operated correctly when energized above their pickup setting.

8.2.3 SYSTEM OPERATION

8.2.3.1 Normal Operations

During normal operation, the source of electric power for plant auxiliaries is from the normal station service transformer. This transformer is a forced oil/air-cooled three-winding unit rated 45 MVA, with its primary connected to the generator isolated phase bus. One secondary winding feeds the 4160 volt system and the other supplies the 6900 volt system.

During a normal startup the reserve station service transformer is used. After the main generator is synchronized with the system, the operator will manually initiate live transfer of the auxiliary load from the reserve station service transformer to the normal station service transformer. The circuit is interlocked and arranged to permit only a momentary parallel. Prior to shutdown, the operator will reverse the procedure before unloading and disconnecting the main generator from the system.

8.2.3.2 Abnormal Operation

The reserve station service transformer is a similar 60 MVA three-winding unit with its primary fed directly from the 345 kV station switchyard. It is the preferred source during startup and periods when the main turbine generator is off-load.

An automatic transfer scheme is provided to ensure continuity of auxiliary power from the preferred source. The transfer scheme will sense conditions resulting in, or leading to, a loss of voltage from the normal station service transformer and will initiate a transfer for conditions such as a turbine or generator trip.

The transfer is high speed and considered simultaneous. It is not a supervised scheme. That is, the secondary breakers for both the normal station service transformer and reserve station service transformer receive essentially simultaneous signals to open and close, respectively. It should be noted there exists an interposing relay that provide a close permissive in the reserve station service transformer secondary breaker closing circuit, and starts an 8 cycle timer. The timer's function is to verify that all breaker close permissives have been accomplished within the specified 8 cycle time frame. In the unlikely event that these permissives have not been met within the allowed 8 cycle time frame, the fast transfer scheme will NOT be permitted. In the unlikely case that a phase displacement in excess of a predetermined value exists between the normal and alternate source voltages, PRIOR to the fast transfer signal being generated, the automatic transfer is also prohibited. The transfer to the reserve station service transformer is further prohibited if there is no voltage on its secondary side, or if the source is faulted. The fast transfer scheme has been demonstrated by test to result in a total dead bus time of less than six cycles.

The RSST has an on load tap changer (OLTC) that allows for changing the 4.16kV winding tap without taking the transformer out of service. When the RSST connects to the plant electrical system, this allows for changing the voltage on the 4.16kV bus and maintaining design system bus voltage.

Undervoltage protection for the emergency buses is provided via the Engineered Safety Features Actuation System (ESAS), which is discussed in FSAR Section 7.3. Undervoltage protection consists of two independent schemes (one for each 4160 Volt emergency bus 24C (A3) and 24D (A4)). Relay contacts from the ESAS undervoltage actuation logic provide outputs to control circuits for automatic bus load shedding, and start of emergency diesel generators.

A Level 1 undervoltage actuation (loss of voltage) provides a trip signal to the RSST supply breaker to the emergency bus and the normal to emergency bus tie breaker, initiates breaker trips for automatic load shedding, and provides a start signal for the emergency diesel generator associated with that bus.

A Level 2 undervoltage actuation (degraded voltage) provides a trip signal to the RSST supply breaker to the bus. When a 4160 Volt emergency bus is fed from the RSST during degraded voltage conditions, this breaker trip results in a loss of power to the bus and a subsequent Level 1 undervoltage actuation.

A Level 2 undervoltage actuation does not initiate a trip of the normal to emergency supply breaker and, as such, does not isolate the power supply from the NSST. When a 4160 Volt emergency bus is fed from the NSST during degraded voltage conditions, operator actions are used to prevent damage to safety-related equipment, in accordance with operating procedures.

Both transformers have their low-voltage windings grounded, the 6.9 kV winding has its wye neutral grounded through a resistance and the delta 4160 volt winding through a grounding transformer and resistor. Both are effective low-impedance grounds which will limit ground fault currents to less than 400 and 200 amperes, respectively. All load feeders and bus feeders are provided with ground fault trip protection.

8.2.3.3 Emergency Conditions

When off site power is not available, redundant emergency diesel generators are available to supply power to the emergency 4160 volt buses. A full description of this power source is given in Section 8.3.

It could be postulated that on site emergency power is being used following an accident because of the lack of availability of power from the Unit 2 reserve station service transformer. To relieve the diesel generator of continued post-incident operation in such a case, it is possible (by operator control) to bring off site power to Unit 2 via Unit 3 bus 34A or 34B through the Unit 3 reserve station service transformer, or the Unit 3 normal station service transformer (backfeeding).

A 4160V crosstie from Unit 3 is provided to the 24E (A5) bus from the Unit 3 reserve station service transformer or Unit 3 normal station service transformer (backfeeding). This feeder is sized to provide sufficient power to place the unit in a safe shutdown condition or to provide required minimum post accident power requirements. The 24E (A5) bus also serves as a transferable power source for spare units of emergency equipment. It supplies power for the following components:

a. Service water pump P5B

b. Reactor building closed cooling water pump P11B

c. High-pressure safety injection pump P41B

The 24E (A5) bus is connected to either the 24C (A3) or 24D (A4) bus. However, both electrical and mechanically operated key interlocks prevent connecting bus 24E (A5) to both bus 24C (A3) and 24D (A4) simultaneously. The same interlock scheme is arranged to transfer the source of control power so that the control power for bus 24E (A5) is from the same redundant system as the control power for the bus to which it is connected. When a piece of equipment is out of service for maintenance, such as the service water pump P5A, its control switch on the main control board will be in the “LOCK-OUT” position (pull-to-lock), and the 24E (A5) bus will be connected to the 24C (A3) bus to allow the spare pump to be energized. The diesel generator load sequencer is so enabled through interlocks with the bus 24E (A5) tie breakers that pump P5B will start on a safety injection actuation signal (SIAS) in place of pump P5A.

8.2.3.4 Startup, Shutdown and Refueling

For conditions of normal startup, shutdown, or refueling of the unit, all station auxiliary power is supplied from the 345 kV network through the Unit 2 reserve station service transformer or through the NSST via the Main Generator Step up Transformer with the generator links removed.

8.2.4 AVAILABILITY AND RELIABILITY

8.2.4.1 Special Features

Safety related components are duplicated and their power supplies and distribution systems are arranged to ensure that neither a failure of a bus, nor the failure of equipment connected to a bus (including the diesel generator), will prevent proper operation of the safety related systems.

The normal and reserve station service transformers are physically separated. The Unit 3 reserve transformer and Unit 3 normal station service transformer are also physically isolated from the other two and are fed from different positions in the switchyard than the Unit 2 reserve transformer. When the Unit 3 RSST is out of service, the Unit 3 NSST connection must be credited as the Unit 2 alternate off site source. A single failure of breaker 13T in the 345 kV switchyard would cause simultaneous loss of both Unit 2 off site sources, and therefore breaker 13T and associated disconnect switches must be maintained “open” when this situation exists. The capacity and capability of the Unit 2 immediate off site source is unaffected by this action. An interconnecting 4160 volt crosstie between Unit 3 and Unit 2 bus 24E (A5) provides an alternate power source from Unit 3 reserve station service transformer or the Unit 3 normal station service transformer (backfeeding).

The 24A (A1) and 24B (A2) 4160 volt buses supply loads required for normal operations while 24C (A3) and 24D (A4) provide power to vital equipment including vital 480 volt AC load centers necessary for emergency shutdown or for incident conditions. Buses 24C (A3) and 24D (A4) serve redundant systems. The vital auxiliaries supplied from either bus are sufficient under all conditions to provide safety feature action or to safely shut down the plant.

8.2.4.2 Tests and Inspections

The 6900 and 4160 volt circuits and associated devices are given operational checks while individual equipment is shut down or not in service. Circuit breakers are withdrawn individually to the test position and their functions tested. The preventive maintenance program for switchgear breakers and protective relays is performed in accordance with Maintenance Procedures, based on industry, regulatory and vendor recommendations.

FIGURE 8.2–1 MAIN SINGLE LINE DIAGRAM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

8.3 EMERGENCY GENERATORS

8.3.1 DESIGN BASES

8.3.1.1 Functional Requirements

To provide a reliable onsite source of auxiliary power if the preferred source is lost, the unit has two onsite emergency generators. They are redundant, independent and separate, and are used for no purpose other than that described. Each is connected to a 4160 volt emergency bus as shown in Figure 8.2–1.

8.3.1.2 Design Criteria

The emergency generators and their associated devices are designed, built, and tested in accordance with Section 5.2.4 of IEEE Standard 308 1971, Safety Guides 6 and 9, and Criteria 1, 2, 3, 17 and 18 of Appendix A of 10 CFR Part 50. Seismic criteria are defined in Sections 5.8.1 and 5.8.1.1 of this report.

8.3.2 SYSTEM DESCRIPTION

8.3.2.1 System

Two physically and electrically separate, quick starting, skid-mounted diesel generators are provided. Each diesel generator set has the capability to initiate the engineered safety features (ESF) in rapid succession, and to supply continuously the sum of the loads needed to be powered at any one time for a loss-of-coolant accident (LOCA). Each diesel generator is rated as follows:

2750 kw Continuous

3000 kw 2000 hours

3250 kw 300 hours

The predicted loads listed in Tables 8.3-2 and 8.3-3 indicate that the continuous rating is not exceeded.

At no time during the loading sequence will the frequency and voltage decrease to less than 95 percent of nominal and 75 percent of nominal, respectively. During recovery from transients caused by step load increases or resulting from the disconnection of the largest single load, the speed of the diesel generator will not exceed rated speed plus 75 percent of the difference between rated speed (900 rpm) and the overspeed trip setpoint (value in the range of 1008 rpm to 1053 rpm). Voltage is restored to within 10 percent of rated voltage and frequency is restored to within two percent of 60 hertz in less than 40 percent of each load sequence time interval.

The adequacy of each diesel generator to perform its functions within the guidelines of Safety Guide 9 has been demonstrated by preoperational tests.

The recommendations of Safety Guide 6 are met as noted below:

a. Loss of one redundant load group (AC or DC) will not prevent the minimum safety functions from being performed.

b. Each vital AC load group can be connected to the preferred (off site) power source, or to a standby (on site) power source consisting of a diesel generator. Neither standby source can be automatically connected to any load group except the one it is normally associated with.

c. The two standby power sources cannot be automatically paralleled with each other nor with the power system.

d. One load group cannot be automatically connected to another load group.

e. Loads cannot be automatically transferred between the redundant standby power sources.

f. 4160 Volt bus A5 (see Figure 8.2–1) can be manually tied to either standby power source but only under the restrictions described in Sections 8.2.2.2 and 8.2.3.3.

8.3.2.2 Components

Each unit consists of a 12 cylinder 900 rpm opposed piston Fairbanks Morse diesel engine, a frame 966-40 generator, a high-speed solid state exciter-regulator unit, and associated control and auxiliary equipment. The unit has a continuous rating of 2750 kW, defined as 8760 hours of operation a year with an availability equal to or greater than 95 percent. This assures the opportunity for maintenance of the offload unit during post-accident operation.

The units can be started by injecting compressed air into every other cylinder between the opposed pistons, but for increased reliability in starting, compressed air is injected into every cylinder. The starting air system is shown on Figure 8.3–5. To further ensure starting reliability, the following features are incorporated in each diesel generator unit:

a. Two air flasks are provided, each having sufficient capacity for a minimum of three starts. Their characteristics are as follows:

Normal operating pressure: 150 psi (min) to 230 psi (max)

Tank design pressure: 250 psi

Design Code: American Society of Mechanical Engineers (ASME) VIII (1971)

b. The air flask valving is so designed that a rupture of one flask will not depressurize the other nor affect its capability to start the engine.

c. Both the lube oil and jacket water systems are provided with “stay warm” heaters and circulating pumps to maintain each unit at an elevated temperature to facilitate starting. An alarm alerts the operator if the heat fails.

d. A 480 volt AC motor-driven air compressor, supplied from an emergency bus and controlled by air flask pressure, is provided for each starting unit and is capable of recharging depleted flasks in one-half hour. The depleted flask pressure is considered at 150 psig since this corresponds to the pressure in the flask after three successive starts.

e. A DC motor-driven backup starting air compressor is provided for each diesel unit, manually operated or automatically controlled on flask pressure and supplied from the 125 volt DC vital system. It is annunciated when started.

f. An activated alumina desiccant air dryer, an oil coalescing prefilter, and a particulate after filter are provided in each line between the starting air compressor header discharge and the starting air flasks to provide clean dry air. The dryer is sized to accommodate the flow of both air compressors operating simultaneously.

g. The diesel engine lube oil system is so designed that the unit may be started from the main control board without priming the lube oil system.

A jacket water cooler, Tubular Exchange Manufacturing Association (TEMA) “R” shell and tube type, is provided for each emergency diesel generator. Cooling water is circulated in a closed loop through the diesel engine cooling water passages and the shell side of the cooler by an engine-driven jacket coolant pump. An electric motor-driven standby jacket coolant pump and a jacket coolant heater are provided to keep the cooling water heated while the diesel engine is not operating. The jacket cooling water system is shown on Figure 8.3–5. The cooling medium flowing through the tube side of the jacket water cooler is supplied by the service water system and is shown on Figure 9.7–1. The engines are capable of operating for approximately three minutes at full load without cooling water supply. This provides sufficient time for the initiation of flow in the service water system by pumps connected to the emergency bus. In an emergency, when service water is not available, one emergency diesel may be cooled with fire water cross-connected to the service water system from valve 2-FIRE-258.

Each diesel generator, its piping, and its auxiliaries are housed in its own Class I structure within the auxiliary building. Ventilation, emergency lighting, and fire protection are provided. The ventilating system is described in Section 9.9.12, and the fire protection is covered in Section 9.10.

Diesel fuel oil for the emergency diesel generators (EDGs) is stored in a 25,000 gallon (approximate capacity) above ground diesel oil storage tank (T - 148). The fuel oil is transferred from the storage tank by two 25 gpm diesel fuel oil transfer pumps to the two 13,500 gallon (approximate capacity), Class I, diesel oil supply tanks (T - 48A and T - 48B) which are located in the structure that houses the associate EDG. A minimum of 12,000 gallons of fuel oil is stored in each above ground diesel oil supply tank. The piping is arranged such that normally one diesel fuel oil transfer pump supplies diesel fuel oil to one diesel oil supply tank. However, there is an interconnection in the supply piping with a “locked closed” valve so that each transfer pump can supply diesel fuel oil to either supply tank. Diesel fuel oil is transferred by gravity from the supply tank to the engine-driven diesel fuel oil pump which supplies fuel oil to the diesel engine. The piping is arranged such that normally one supply tank provides diesel fuel oil to one EDG. However, there is an interconnection in the piping with a “locked closed” valve so that one EDG can be provided with diesel fuel oil from either or both supply tanks. The volume of fuel oil in each diesel oil supply tank is maintained at a level above the required Technical Specification volume by operation of the respective diesel oil transfer pump. Both diesel oil transfer pumps take a suction from the above ground diesel oil storage tank.

The volume of fuel oil is not expected to vary during normal plant operation because the diesel generators are in standby. When the EDGs are running, diesel oil supply tank level will go down until automatic makeup from the diesel oil storage tank occurs. Each diesel oil transfer pump is controlled by a level switch which is set above the required Technical Specification volume.

The required Technical Specification volume in the diesel oil supply tanks (T-48A and T-48B) will provide sufficient fuel oil for two EDGs to operate at 2750 KW for 24 hours, and then one EDG to continue operation at 2750 KW for a total of approximately 3.5 days, assuming the two tanks are cross-connected after securing one EDG. An EDG run time of approximately 3.5 days provides a significant margin of time for replenishment of EDG fuel oil. Replenishment can be accomplished from the non-safety related above ground diesel oil storage tank or offsite sources. The nonseismic above ground diesel oil storage tank provides the normal makeup path for fuel oil to the fuel oil supply tanks. It contains fuel oil which is fully qualified and tested regularly.

At least one diesel oil transfer pump will be available to supply fuel oil from the storage tank to the diesel oil supply tanks, since the pumps are supplied from vital power sources. If the volume of fuel oil in the above ground diesel oil storage tank is taken into consideration, the one remaining EDG will be able to continue operation at 2750 KW for an additional 3.5 days. This will increase the total time one EDG will be able to operate to approximately 7 days.

If a seismic event occurs, the fuel oil in the above ground diesel oil storage tank cannot be relied upon, because the above ground diesel oil storage tank is not seismically qualified. However, replenishment of fuel oil could be accomplished via an offsite source.

The required Technical Specification volume of 12,000 gallons in each diesel oil supply tank (T-48A and T-48B) is verified by the associated Technical Specification Surveillance Requirement. The required volume of fuel oil in the above ground diesel oil storage tank is 17,195 gallons plus a small volume increase to compensate for unusable fuel due to instrument inaccuracy and suction pipe stub height, is not required by Technical Specifications. It is required by the Technical Requirements Manual and is verified by a similar surveillance requirement. Also, the above ground diesel oil storage tank low level alarm is set above this required volume. The associated alarm response procedure provides the necessary guidance to restore the required above ground tank volume.

It is only necessary to maintain the required volume in the above ground diesel oil storage tank when the plant is operating in Modes 1 through 4. When the plant is in Mode 5 or below, the expected EDG loading will be significantly below rated load. Therefore, the Technical Specification requirement for diesel fuel oil will provide reasonable assurance that sufficient time will be available to obtain diesel fuel oil from an offsite source, if the above ground tank is not available.

In addition to the total volume of fuel oil maintained onsite, Millstone Unit Number 2 has a fuel oil supply contract for delivery of fuel oil to the unit. Emergency Plan procedures require an evaluation of the need to order additional fuel from offsite sources within 4 hours following a LOCA and LNP. The Emergency Plan procedures also require the Technical Support Center staff to provide load shedding recommendations within 24 hours of a LOCA and LNP. These load shedding recommendations may include securing one EDG, cross connecting the two diesel oil supply tanks, and securing any electrical loads not needed to support plant recovery. The specific recommendations will vary depending on the situation, and will be developed within the 24 hour time period. This time is sufficient to allow the Technical Support Center staff to develop the specific load shedding recommendations, and will allow an evaluation of the likelihood of fuel oil delivery to Millstone Unit Number 2. If fuel oil delivery is imminent, load shedding will not be necessary.

The EDG fuel oil system is shown on Figure 8.3–4. A failure mode analysis of the EDG fuel oil system is given in Table 8.3-1.

Each diesel engine is provided with a lubrication system which circulates lube oil through a filter, a cooler, a strainer, and then through the diesel engine by means of an engine-driven lube oil pump. An electric motor driven pre-lube pump is provided to be used for lubricating the engine before it is manually started.

An electric motor-driven standby lube oil pump and lube oil heater are provided to keep the lube oil heated while the diesel engine is not operating. The diesel lube oil system is shown on Figure 8.3–5.

Each diesel generator is tied to a 4160 volt emergency bus through a circuit breaker having provision for tripping as noted in Section 8.3.4.1. When the 4160 volt system is fed exclusively from the emergency diesel generators, the system ground is provided by a resistor loaded distribution transformer between each diesel generator neutral and ground. This grounding device limits ground current to one (1) ampere.

Seismic calculations for the diesel generator components were completed by the Fairbanks Morse Power Systems Division of Colt Industries on July 26, 1972. These calculations were made for the following eight items that were judged essential for continuous operation of the diesel generator:

Engine-generator skid assembly

Heat exchanger stack assembly

Lube oil filter

Lube oil strainer

Jacket water expansion tank

Air compressor skid assembly

Air receiver tank

Electrical control cabinet, plus relay test certification

Certified calculations have been submitted and independently verified, showing that the diesel generating unit and its accessories meet the seismic requirements as elsewhere defined for this project.

At a later date, a mathematical analysis was made of the overspeed governor and shutdown system, similar to the calculations for the above listed assemblies. This analysis showed that this assembly meets the seismic requirements with a safety factor of 2.3.

8.3.3 SYSTEM OPERATION

8.3.3.1 Emergency Operation

As discussed in Section 7.3, the diesel generator associated with a 4160 volt AC emergency bus receives an automatic start signal under either of the following conditions:

a. ESAS Level 1 Undervoltage Actuation from the associated 4160 volt AC emergency bus

b. An ESAS Safety Injection Actuation Signal (SIAS)

The generator field is automatically flashed by DC from the 125 volt DC vital system when the unit reaches 250 rpm. Within 15 seconds of the start signal, the diesel generator accelerates to 90 percent or greater of rated speed and 97 percent or greater of rated voltage.

If a loss of voltage occurs on a 4160 volt AC emergency bus (with or without a concurrent SIAS), the following items occur:

a. The tie between the applicable buses (bus 24A (A1) - bus 24C (A3) or bus 24B (A2) - bus 24D (A4)) and the feeder applicable breaker from the reserve station service transformer are tripped.

b. All load feeder breakers on the emergency bus except small permanently connected loads are tripped.

c. The diesel generator breaker is automatically closed.

d. The closure of the diesel generator breaker starts a load sequencer that closes load feeder breakers in discrete steps. During the application of load steps, the minimum generator voltage and frequency and the recovery time to within 10% of nominal voltage and 2% of nominal frequency are within Safety Guide 9 requirements.

If a SIAS occurs with no concurrent loss of voltage on a 4160 volt AC emergency bus, then the corresponding diesel generator starts but does not load. Consequently, if SIAS occurs with no concurrent loss of voltage to either 4160 volt AC emergency bus, both emergency diesel generators start but do not load.

A logic diagram outlining the operation of the diesel generator and its auxiliaries is shown in Figure 8.3–1, and the details of the control circuitry are shown in Figure 8.3–2. The load sequencers are located in the ESAS actuation cabinet, and their operation is fully described in Section 7.3.

Tables 8.3-2 and 8.3-3 provide a breakdown of the automatic loading sequence for EDG A and B, respectively. The “B” pumps on the A5 swing bus are swing pumps and can be powered from Facility Z1 (bus A3) or Facility Z2 (bus A4). The A5 swing bus can only be aligned to one facility at a time. When the A5 bus is aligned to a facility, that facility’s ESF signal will sequence the appropriate “B” pump into operation if the pump breaker is not in “pull-to-lock” or the breaker is not “racked-down.” By procedure, the “B” pump(s) are made available for service only if their corresponding “A” or “C” pump(s) are not available. Additional loads, such as the instrument air compressor, hydrogen recombiner, or auxiliary feedwater (AF) pump, may be added by operator control.

Total required loads for a LOCA with only one diesel operating, as shown in Tables 8.3-2 and 8.3-3, have been conservatively estimated. The values of brake horsepower (bhp) for large motors (over 100 hp) are based on the maximum operating requirements of the driven equipment for all modes of operation. When converting horsepower to kilowatts for these motors, the actual motor efficiencies are used. Equipment loads for motors rated 100 hp and less are based on the motor full load rating and motor efficiency values which are typical for the motor size and type are used. Battery charger load requirements are based on the maximum calculated output requirement. Transformer loads for supplying low voltage, instrumentation, and emergency lighting loads are 80 percent of the transformer full load rating, without application of a factor for diversity. Demand factors are applied for specific loads in cases where operation is controlled by process conditions, such as temperature, pressure or level.

8.3.3.2 Abnormal Operation

The usual mode of operation of the onsite emergency power system is for both diesels to operate, independently supplying emergency buses A3 and A4. However, if only one diesel will start, its load sequencer will operate as described in the preceding section.

8.3.4 AVAILABILITY AND RELIABILITY

8.3.4.1 Special Features

The diesel generator units are physically isolated and their feeders are run separately. The engines require no outside power for starting other than 125 volt DC for control logic, field flashing, and breaker control. One of the two station vital batteries supplies 125 volt DC to one diesel with the other battery supplying the second diesel via separated cable routings.

The starting air solenoid valves are fail-safe. That is, a loss of DC voltage or other de-energization of either of the solenoids admits starting air to the engine.

The fail-to-start relay functions to interrupt the starting of the diesel engine if a speed of 250 rpm is not reached or lube oil pressure is not established within 12 seconds of the start initiation. Operating experience has shown that a diesel which does not start within ten seconds is not likely to start at all. Therefore, the start is interrupted to conserve the air supply for later start attempts, subsequent to a system checkout and correction.

Each of the following alarm conditions of an emergency diesel generator (EDG) have a corresponding annunciator in the main control room but does not have an annunciator on the local control panel of the applicable EDG:

Diesel generator breaker trouble

Diesel automatic start

Diesel SIAS start

Diesel generator ready to load

Exciter not reset

Diesel control switch in maintenance position

Diesel generator auto voltage regulator not set at 4160

The following alarm condition of an EDG has a specific annunciator in the main control room and a duplicate annunciator on the applicable local control panel:

* Generator differential current

Each of the following alarm conditions of an EDG has: (1) either a specific or shared annunciator on the applicable local control panel, and (2) a shared common annunciator in the main control room, “Diesel Generator U12 (or U13) Trouble:”

* Lube oil pressure - low

* Engine overspeed

Loss of unit 4160 volt auxiliary power

Lube oil temperature - high - low

Lube oil level - low

Jacket water temperature - high - low

Service water coolant - low flow

Starting air pressure - low

DC air compressor - start

Engine start failure

Fuel oil supply tank - low

Generator underfrequency

Generator undervoltage

Loss of excitation

Generator neutral ground fault

Generator overvoltage

Generator bearing temperature - high

Jacket water level - low

Fuel oil supply valve - shut

Generator stator temperature - high

Loss of 480 volt auxiliary power

Loss of 125 volt DC control power

Pre-lube pump running

Key lock switch in slow start

Jacket water pressure - low (results in trip only when on test)

Crankcase pressure - high (results in trip only when on test)

Fuel oil pressure - low (results in trip only when on test)

Reverse power flow (results in trip only when on test)

Instantaneous overcurrent (results in trip only when on test)

Core balance ground fault (results in trip only when on test)

Any auxiliary control switch not in automatic position

The three devices marked * above are the only shutdown functions permitted during an emergency start. These three conditions, if allowed to continue, would rapidly result in the loss of the diesel generator. Hence, it is advantageous to remove it from service when the condition is first sensed and thereby minimize damage to the engine or the generator. These trip devices are all considered essential as noted below:

a. Low Lube Oil Pressure

This shutdown functions upon coincidence of two out of three signals when the normal pressure of over 20 psi has dropped to 16 psi or two out of two signals when normal pressure has dropped to 18 psi. The engine manufacturer considers this to be an essential feature.

b. Engine Overspeed

A centrifugal governor shuts down the engine at about 116% of rate speed. Full load rejection can be made without actuating this trip.

c. Generator Differential Current

This feature protects the generator in the event of an internal fault.

The Voltage Restraint Overcurrent relay protects the EDG generator from excessive current in the event of a 4160 VAC bus or load fault. This relay has the capability to trip open the EDG breaker during surveillance testing and during emergency operation. The operator has the facility to reset and close the EDG breaker should the fault clear or be isolated by a load breaker.

No single failure can prevent both diesel generators from functioning. Surveillance instrumentation will warn the operator during normal station operation of detectable inadequacies or failures which could lead to loss of function of the diesel generator and its power supply system. Components whose correct functioning can be verified only during operation of the diesel generator system will be tested periodically. An analysis of the effects of a single failure within the instrumentation or controls of one of the diesel generators under an emergency condition is given in the following:

Signal or Component	Malfunction	Comments and Consequences
Undervoltage signal or potential transformer on 4160 volt bus	Failure to detect undervoltage	Undervoltage sensors are redundant and arranged in two-out-of-four logic so single failure will have no consequences on operation of system.
Bus clearing circuitry	Failure to operate	Failure of bus clearing circuitry will lock out corresponding diesel generator feeder breaker. However, other diesel generator will not be affected; sufficient emergency equipment will remain in operation for safe shutdown.

Signal or Component	Malfunction	Comments and Consequences
Diesel engine or generator control circuitry	Failure to start engine or to close generator breaker	Failure of one diesel engine to start or generator breaker to close will leave one completely redundant emergency system available for operation.
Differential protection relay Engine overspeed Low lube oil pressure	Relay and/or contact failure	Will result in tripping diesel generator; other diesel generator will carry redundant load, so will not affect safety.
Voltage Restraint Overcurrent Relay	Relay and/or contact failure	Will result in tripping the diesel breaker. Indication of the fault will be provided by the “DIESEL GEN 12U 913U) BKR CLOSING CIRCUIT BLOCKED” alarm and DIESL GEN 12U (13U) BKR TRIP. If the fault has cleared or has been isolated the operator can attempt to reset the condition and close the breaker, otherwise, the other diesel will carry the redundant load and so safety will not be affected.
Ground fault relay	Relay and/or contact failure	Indication of fault will be provided on local annunciator with common (“diesel generator trouble”) alarm in main control room. Relay and/or contact failure will initiate false alarm but will have no effect on diesel generator operation.
Load sequencer	Failure to operate in proper sequence	Worst case will result in tripping corresponding diesel generator. Other diesel generator will not be affected, and sufficient emergency equipment will remain in operation for safe shutdown or other emergency action.
Emergency bus tie breakers	Failure of electrical interlocks to prevent closure of tie breaker	Mechanical interlocks will prevent paralleling of two main 4160 volt emergency buses.

Signal or Component	Malfunction	Comments and Consequences
DC supply	Loss of one station battery or its distribution system concurrent with loss of off site power	Could not open supply breakers nor shed loads; diesel generator voltage would not be established due to lack of field flashing; generator breaker would not close. Because of complete separation of redundant DC supplies, other diesel generator would function as required for safe shutdown or other emergency action.

8.3.4.2 Tests and Inspections

Diesel generator tests are designed to demonstrate that the diesel generators will provide adequate power for the operation of the equipment. They also assure that the emergency generator control systems for safety related equipment will function automatically in the event of a loss of all normal 4160 volt power, in accordance with Criterion 18.

Frequent tests are made to identify and correct any mechanical or electrical deficiency before it can result in a system failure. The fuel supply and starting circuits and controls are continuously monitored and faults are annunciated. An abnormal condition in these systems will be signaled without having to place the diesel generators on test (see Figure 8.3–2).

To verify that the emergency power system will properly respond within the required time limit when required, the following tests are performed:

a. EDG load testing, load rejection testing and start time testing is performed in accordance with Technical Specifications requirements.

b. Demonstration of the automatic sequencing equipment during normal unit operation. For details, see Section 7.3.

Monthly Surveillance Testing

To minimize the mechanical stress and wear on the diesel engine, each diesel engine will be started in slow speed using the Mechanical Governor.

During the slow start procedure, a key lock switch is used to block certain full speed function (i.e., excitation, jacket water low pressure) from occurring during reduced speed.

The protective devices that function to shut down the diesel generator are checked periodically for their trip setpoints. For the overspeed device, the diesel can be forced to increase in speed until trip occurs. Crankcase and lube oil pressure switches are disconnected and an outside pressure source applied until the trips occur. Periodically, the protective relays are inspected and their setpoints checked.

A sample of the fuel oil in the above ground storage tank will be taken manually and analyzed periodically.

TABLE 8.3-1 DIESEL FUEL OIL SYSTEM MODE ANALYSIS

COMPONENT	FAILURE MODE	MONITOR	DETRIMENTAL EFFECT	CORRECTIVE ACTION	RESULTANT STATUS
Diesel fuel oil supply tanks T-48A & T-48B	Rupture of one tank	Low level alarm	Loss of fuel oil	Isolate supply tank; open valve between lines to engines	Redundant diesel supply tank available
Supply header to diesel engine	Pipe break	Low level alarm	Loss of fuel oil and one diesel generator	Isolate break and repair	Redundant diesel generator in service (1)
Engine-driven fuel oil pump (one per engine)	Mechanical failure	Low pressure alarm	Loss of one diesel generator	Isolate pump and repair	Redundant diesel generator in service (1)
Diesel generators H7A & H7B	Loss of fuel oil for other reason	Low pressure alarm	Loss of one diesel generator	Isolate diesel generator	Redundant diesel generator in service (1)

Notes:

(1) One diesel generator has adequate capacity for emergency conditions.

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TABLE 8.3-2 “A” EMERGENCY DIESEL GENERATOR LOADING

CONNECTED LOADS

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
Battery Charger			X					X
TRF and Cable Losses			X					X
Motor Operated Valves			X					
Emergency Lighting			X					X
Reg Transformers			X					X
Computer UPS			X					X
Computer Room Air Conditioning			X					X
Miscellaneous Connected			X					X

SEQUENCE 1

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
Service Water	450	426		365				365
High Pressure Safety Injection	400	460		388				388

Description	Motor Rated HP	Actual Load BHP	0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	Post LOCA Loads
Containment Air Recirculation Fans (2)		Scenario		X				X

SEQUENCE 2

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
RBCCW	350	315			265			265
Charging (2)	200	Scenario		388	182			

SEQUENCE 3

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
Low Pressure Safety Injection	400	380				325		
Containment Spray (2)	250	230				195		195
Safety Related HVAC						X		X

SEQUENCE 4

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
Auxiliary Feedwater	350	360					306	268

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Safety Related HVAC							X	X

MANUAL LOADS

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
Spent Fuel Pool Cooling								X
Hydrogen Recombiner								
Instrument Air Compressor								X
Containment Sample								X
Post Incident Recirculation Fan								X

Emergency Diesel Generator (EDG) running load is less than 2750 KW at all steps, this is the continuous rating of the EDG.

Notes:

(1) At < 3 minutes following auto sequencing, Motor Operated Valve (MOV) loads will have reached their required position.

(2) At < 10 minutes following auto sequence, auxiliary feedwater pump load will be at normal LOCA flow.

(3) Auxiliary feedwater pump BHP value is different for pump run-out (360 BHP) and required flow (315 BHP).

(4) Load modeled with EDG at Technical Specifications maximum Hz frequency value.

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TABLE 8.3-3 "B" EMERGENCY DIESEL GENERATOR LOADING

CONNECTED LOADS

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
Battery Charger			X					X
480 Volt Load Center Transformer Losses			X					X
Motor Operated Valves			X					
Emergency Lighting			X					X
Reg Transformers			X					X
Computer UPS			X					X
Computer Room Air Conditioning			X					X
Miscellaneous Connected			X					X

SEQUENCE 1

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
Service Water	450	426		365				365

High Pressure Safety Injection	400	460		388				388
Containment Air Recirculation Fans (2)	75	Scenario		X				X

SEQUENCE 2

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
RBCCW	350	315			265			265
Charging (2)	200	Scenario		388	182			
Boric Acid (2)	50				X			X

SEQUENCE 3

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
Low Pressure Safety Injection	400	380				325		
Containment Spray (2)	250	230				195		195
Safety Related HVAC						X		X

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SEQUENCE 4

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
Auxiliary Feedwater	350	360					306	268
Safety Related HVAC							X	X

MANUAL LOADS

Description	Motor Rated HP	Actual Load BHP	Running KW for Loads Powered from EDG A for LOCA with LNP					
			Automatically Started Loads					Post LOCA Loads
			0 Sec	2 Sec	8 Sec	14 Sec	20 Sec	
Spent Fuel Pool Cooling								X
Hydrogen Recombiner								
Instrument Air Compressor								X
Turbine Auxiliaries								X
Containment Sample								X
Post Incident Recirculation Fan								X

Emergency Diesel Generator (EDG) load is less than 2750 KW, this is the continuous rating of the EDG.

Notes:

(1) At < 3 minutes following auto sequencing, Motor Operated Valve (MOV) loads will have reached their required position.
(2) At < 10 minutes following auto sequence, auxiliary feedwater pump load will be at normal LOCA flow.
(3) Auxiliary feedwater pump BHP value is different for pump run-out (360 BHP) and required flow (315 BHP).

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FIGURE 8.3–1 LOGIC DIAGRAMS DIESEL GENERATORS (SHEET A)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–1 LOGIC DIAGRAMS DIESEL GENERATORS (SHEET B)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 0A)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 1A)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 2A)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 2A)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 4)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 5)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 6)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 7)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 8)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 9)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 10)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 11)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 12)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 13)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 14)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 15)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 16)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 17)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 18)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 19)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 20)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 21)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 22)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 23)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 24)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 25)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 26)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 27)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 28)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 29)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–2 DIESEL GENERATOR RELATED (SHEET 30)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–3 NOT USED

FIGURE 8.3–4 DIESEL GENERATOR FUEL OIL SYSTEM/AUXILIARY STEAM CONDENSATE AND HEATER INDEX (SHEETS 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–4 DIESEL GENERATOR FUEL OIL SYSTEM/AUXILIARY STEAM CONDENSATE AND HEATER INDEX (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–4 DIESEL GENERATOR FUEL OIL SYSTEM/AUXILIARY STEAM CONDENSATE AND HEATER INDEX (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–5 DIESEL GENERATORS' ANCILLARY SYSTEMS (SHEET 1A)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–5 DIESEL GENERATORS' ANCILLARY SYSTEMS (SHEET 1B)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–5 DIESEL GENERATORS' ANCILLARY SYSTEMS (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.3–5 DIESEL GENERATORS' ANCILLARY SYSTEMS (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

8.4 480 VOLT SYSTEM

8.4.1 DESIGN BASES

8.4.1.1 Functional Requirements

The 480 volt system provides power for unit auxiliary loads below 250 horsepower. Those auxiliaries required for a safe shutdown of the unit or for maintaining it in hot standby condition are served by emergency load centers and emergency motor control centers. These emergency 480 volt sources feed battery chargers for the DC system and regulating transformers for 120 volt AC instrumentation.

8.4.1.2 Design Criteria

The 480 volt system, including emergency load centers and emergency motor control centers, is designed, built and tested in accordance with Sections 4 and 5.2 of the IEEE Standard 308-1971, Criteria 1, 2, 3, 4, 17, and 18 of Appendix A of 10 CFR Part 50, and Safety Guide 6.

All of the 480 volt equipment in safety-related services is designed for the seismic conditions described in Sections 5.8.1 and 5.8.1.1.

8.4.2 SYSTEM DESCRIPTION

8.4.2.1 System

The 480 volt system shown in Figure 8.2–1 consists of six buses; two double-ended and two single-ended load centers. The double-ended load centers supply normal station loads. Each consists of two transformers and two bus sections with a tie breaker. Each transformer is connected to a different 4160 volt bus and is sized to support the loads of both 480 volt bus sections for maintenance purposes. The double-ended load center feeder and tie breakers are interlocked to prevent simultaneous connection of both 4160 volt sources to a single bus. The interlock can be defeated through the use of sync selector switches which permit momentary paralleling of load center 22A with 22B or load center 22C with 22D across the respective tie breakers 22A-1T-2 or 22C-1T-2. The sequence allows: (1) paralleling across and closing of the tie breaker immediately followed by the automatic opening of one of the selected feeder breakers, or (2) paralleling across and closing of a selected feeder breaker immediately followed by the automatic opening of the associated tie breaker. The two single-ended load centers (B5 and B6) each consist of a single transformer and bus section and supply loads necessary for safe shutdown or post-incident conditions.

In addition, a portable generator connection point has been provided to back feed bus 22F. This connection is a defense-in-depth feature that is available for coping with an extended loss of AC power (ELAP) event. The connection is shown on Figure 8.2–1. “Main Single Line Diagram”.

Motor control centers, located throughout the unit, are fed from these load centers. Four of these are considered emergency motor control centers (B51, B52, B61, B62), and are fed from the emergency load centers. The loads carried by the emergency motor control centers include auxiliaries such as shown in Tables 8.3-2 and 8.3-3.

Normal station lighting is provided by 480-208/120 volt and 480-277 volt transformers located throughout the plant. Power for lighting of critical operating areas, such as the control room, diesel generator rooms, DC switchgear rooms, emergency shutdown panels and refueling areas is supplied as described above but has additional backup lighting panels fed from the emergency motor control centers.

In addition to the AC lighting design, Section 8.5.3.1 (Battery System/System Operation) describes how low-level DC lighting fixtures supplied by the unit main batteries and the turbine battery provide lighting throughout the station. On a loss of all AC sources, the life safety lighting requirements for egress are satisfied by the 1.5-hour rated, self-contained battery units installed throughout the station. In addition, the MP2 Appendix R Compliance Report, Section 6.3 credits 8-hour rated battery backed emergency lighting units (ELU's) and security lighting, which illuminate outdoor access and egress routes, to cope with a design basis fire. The security lighting power supply is backed by a security diesel generator. These Appendix R lighting fixtures (8-hour rated, self-contained battery units, and the security lighting) are credited by the Station Blackout Safe Shutdown Scenario. The 1.5-hour rated, life safety battery units provide additional portable emergency lighting for ingress / egress into plant areas during a SBO Event.

8.4.2.2 Components

All 480 volt power supply and utilization equipment in safety-related services is housed in Class I structures. These spaces are equipped with smoke and fire detection systems and portable fire extinguishers.

The 480 volt load centers are free standing, indoor type with dripproof enclosures containing drawout-type air circuit breakers, motor starters, and associated relays, instruments and fuses. Their rating is as follows:

Transformers	
Transformers	1500 kVA (AA), 2000 kVA (FA)
Temperature rise	80°C (40°C ambient)
Impedance	7.59 to 8.7%
Bus	2000 amp continuous
Circuit Breakers	
Main incoming feeders	3000 amp continuous
	65,000 amp interrupting (without instantaneous trip)
MCC feeders and ties	42,000 amp interrupting (without instantaneous trip)
Load feeders	600 amp continuous

30,000 amp interrupting (with instantaneous trip)

Overcurrent and motor overload protection are provided by overcurrent trip devices on each load center feeder breakers as follows:

Emergency MCC - short and long time elements on all phases

Mag-jack M-G - instantaneous on all phases; long-time element on two phases

Other feeders - instantaneous and long time elements on all phases

Vital 480V buses 22E & 22F are equipped with class 1E voltage monitoring devices. These devices initiate an alarm in the control room if the devices respective bus voltage exceeds 516 VAC. This warns operators to correct the situation using plant procedures to minimize the overvoltage conditions which increase the potential for long-term equipment degradation.

A test report dated July 21, 1970, from General Electric, describes the vibration and shock tests given to a prototype of this switchgear. The seismic qualification of the transformers was verified by a mathematical analysis. A summary of the results of the 480 volt switchgear tests is given below:

a. GE-type AKD-5 switchgear has been vibration tested in each of the three directions at 0.5 g over the frequency spectrum of 5 to 500 hertz.

b. AKD-5 switchgear has been shock tested to 40 g on a Navy medium-weight shock machine.

c. GE-types AK-50 and AK-25 breakers have been vibration tested in each of the three directions at 0.5 g over the frequency spectrum of 5 to 500 hertz.

d. AK-50 and AK-25 breakers remained operative during shock at accelerations up to 15 g on a Navy medium-weight shock machine.

e. The AK-50 breaker has been vibration tested without loss of function during vibration at its lowest resonant frequency of 29 hertz at 5.0 g input.

f. The AK-25 breaker has been vibration tested without loss of function during vibration at its lowest resonant frequency of 44 hertz at 3.0 g input.

The motor control centers are General Electric free standing types with dripproof indoor enclosures containing combination starters, molded case circuit breakers, individual starter control transformers, and associated relays and fuses. Two Emergency Control Centers, B51 and B61, are encapsulated in environmentally controlled enclosures due to their location in areas which could be subject to a steam environment resulting from a high-energy line break. The ratings for the motor control centers are as follows:

Bus (main) 600 or 800 amp continuous

(vertical)	300 amp continuous
Circuit breakers	22,000 amp interrupting (min.)

Overcurrent and motor overload protection are provided on each feeder as follows:

Thermal-magnetic circuit breaker

Three thermal overload relays in each motor starter (except for MOV)

A certification from General Electric, dated December 20, 1971, testifies that tests they made on August 21, 1970, were on a prototype of the emergency motor control centers furnished for this project. A summary of these tests is given.

a. The test article was swept in frequency from 5 to 500 hertz at a one-half octave per minute sweep rate at a constant 0.5 g input acceleration.

b. The equipment was vibrated in each of its three orthogonal axes; vertical, horizontal in-breadth, and horizontal fore and aft.

c. All vibration sweeps were made with a 480 volt AC, 60-hertz source connected to the control center main bus.

d. Vibration sweeps were made in two modes of functional status:

    1. With each starter unit disconnect in the ON position but starter not energized.

    2. With each starter energized.

e. The tests conducted indicate the equipment, as tested, is suitable for applications up to at least 0.5 g base input accelerations through a frequency band width from 5 to 500 hertz.

f. The resonant level of the equipment structure appears to be at 5 to 6 hertz, while component resonant levels are at higher frequencies.

g. Interchanging of starter units vertically within the equipment will not significantly alter the response of the individual components inasmuch as the structure is nonresonant at the frequencies at which components are resonant.

h. These tests indicate that the 7700 line motor control center is suitable to at least 0.5 g base input accelerations through a frequency band width from 5 to 500 hertz.

Each of the two control element assembly drive power sustainers is connected to a 480 volt emergency load center. The control element assembly drive power sustainer system consists of two ride-through flywheel motor generator sets. The motor generator sets have the ability to hold all the control elements and to sustain the motion of any element already being stepped during a one-second interruption in the station service voltage.

The only motors inside the containment required during a LOCA are those driving the containment air recirculation and cooling fans and the post incident recirculation fans noted in Section 8.4.1.2. The suitability of these motors to meet the environmental and seismic shock requirements is presented in Sections 6.5.4.2 and 6.6.4.2, respectively.

8.4.3 SYSTEM OPERATION

8.4.3.1 Normal Operation

Normally, each emergency load center transformer is fed from a corresponding emergency 4160 volt bus, which in turn receives power from a station service transformer as shown in Figure 8.2–1. There is no way in which these two load centers can be tied together. Each of these load centers feeds two emergency motor control centers.

8.4.3.2 Emergency Operation

Under emergency conditions, there is no change in the mode of operation of these load centers and motor control centers. The only changes are those associated with the means of supplying power to the 4160 volt emergency buses, as described in Sections 8.2 and 8.3.

8.4.4 AVAILABILITY AND RELIABILITY

8.4.4.1 Special Features

The load groups on each emergency load center and its associated motor control centers are redundant to each other and separate. Hence, a complete failure of power, or failure of components on one channel does not affect the availability of services to care for a LOCA.

One charging pump is fed from power source Z1 and one from Z2. The third charging pump can be aligned with either a channel Z1 or channel Z2 source. Two power selector switches with electrical and Kirk key interlocks prevent tying the two motor control center buses together, as shown in Figure 8.4–1. If one pump is out of service, the selector switches are positioned (under administrative control) to feed the third pump from the power source redundant to that which is feeding the operating pump. Thus, in case of an accident, two charging pumps are available, each fed from a separate and redundant power source.

As noted in Section 8.2.3.3 and in Figure 8.2–1, the third service water pump is fed from 4160-volt bus A5, which can be energized from either a channel Z1 or Z2 source. The service water strainer associated with this pump has a feeder from each of two 480 volt emergency motor control centers fed from these two vital sources. Two power selector switches (under administrative control) with electrical and Kirk key interlocks prevent tying the two motor control center buses together, as shown in Figure 8.4–2. If the selector switches are not positioned to complete the supply circuit, an alarm is given on the main control board. Interlocking also assures that the power supply for the third strainer is aligned to the same source as the power for the associated service water pump. Thus, two service water pumps and their related strainers are always available, each with a separate and redundant power source.

Shutdown Cooling Suction Header Containment Isolation valve 2-SI-651 also has the capability of being supplied power from either Facility Z1 or Facility Z2. This valve is not an installed spare unit of emergency equipment as discussed in Section 8.2.3.3. The alternate power provides a means to open 2-SI-651 post-LOCA for boron precipitation control and will not be utilized during normal plant operation. Therefore, this valve is not considered a Facility Z5 component. To prevent placing the plant in an unanalyzed condition for separation concerns, the cross connection of 2-SI-651 to Facility Z2 is limited to boron precipitation control post-LOCA combined with a loss of power to MCC B51 or for testing purposes. Emergency operating procedures provide guidance for aligning 2-SI-651 to its alternate power.

8.4.4.2 Tests and Inspections

The 480 volt circuit breakers, motor starters, and associated equipment are tested while individual equipment is shut down or not in service. Circuit breakers and starters are withdrawn individually and their functions tested. Accidental grounds on the load center buses or feeders are monitored continuously by ground detectors and are alarmed in the main control room.

Load center transformers are periodically given an insulation resistance test either on line or during a refueling outage in accordance with a preventive maintenance program.

FIGURE 8.4–1 CHARGING PUMP - POWER SUPPLY CROSSOVER P18B

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.4–2 SERVICE WATER STRAINER ML1B POWER SUPPLY CROSSOVER SCHEME

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

8.5 BATTERY SYSTEM

8.5.1 DESIGN BASES

8.5.1.1 Functional Requirements

Battery power is needed for a variety of uses, such as “trip” and “close” of electrically operated circuit breakers, certain solenoid operated valves, certain control systems, Auxiliary Building and Turbine Battery Room emergency lighting, and devices used during turbine coastdown. Through DC/AC inverters, the batteries also provide power to the reactor protective system, engineered safety features actuation, and to vital instrumentation.

8.5.1.2 Design Criteria

The components of the battery system are designed, built, and tested in accordance with the requirements of:

- Safety Guide 6
- Section 5.3 of IEEE Standard 308, 1971, with the exception of the requirements for the frequencies of battery discharge tests (battery service tests) and battery charger performance tests. (These tests are required to be conducted at intervals of at least once per 18 months, rather than the Standard’s stated yearly test interval.)
- Section 6.3.4 of IEEE 308, 1980
- Criteria 1, 2, 3, 17, and 18 of Appendix A of 10 CFR Part 50
- Section 4 of IEEE 279, 1971
- IEEE 650, 1979

Seismic criteria are defined in Sections 5.8.1 and 5.8.1.1 of this report.

8.5.2 SYSTEM DESCRIPTION

8.5.2.1 System

A 125 volt DC supply system consisting of two isolated switchgear bus sections (with key interlocked tie breakers) and associated distribution panelboards is provided. Each of the two DC switchgear bus sections is supplied by a separate 60 cell battery and two 400 amp battery chargers, normally connected in parallel to form a single 800 amp charger. Figure 8.5–1, Sheet 1, illustrates this system. An additional battery/charger/switchgear combination is provided for nonvital loads associated with the turbine and its auxiliaries, for certain Turbine Building emergency lights, and for backup of selected vital instrument AC panels through DC/AC inverters. Figure 8.5–1 Sheet 2 illustrates this system.

8.5.2.2 Components

The ratings of the principal components of the main (vital) battery systems are as follows:

Batteries—2 (C&D Type LCR-33)

Rating 8 hr (amp-hr)	2320
1 min (amp)	2240
Voltage, nominal (volts)	125
min	105
max	140

Chargers—2 pairs

Capacity, individually (amp)	400
Capacity, total each pair (amp)	800
Voltage (volts, DC)	110-140
Regulation (%)	±1.0
Ripple, max (%)	2.0
Current limit (%)	125

Switchgear—2 groups

Circuit breaker s	
Continuous (amp)	1600
Interrupting (amp)	50,000
Bus	
Continuous (amp)	2000

A separate 125 volt battery system has been provided to supply power to the DC emergency oil pumps associated with the main turbine and the turbine-driven feedwater pumps and to two separate nonvital DC/AC inverters for backup of the 120 VAC vital 1 and 2 instrument panels. The system consists of a 1500 amp-hr battery, two 200 ampere chargers, and a DC switchgear assembly that includes the required motor starters and 600 amp continuous, 25,000 amps interrupting air circuit breakers. A DC panelboard, fed from the turbine battery, supplies turbine generator control power and emergency lighting for the turbine building and the battery rooms.

Station battery rooms are in Class I structures and have continuous induced ventilation as described in Section 9.9.6.

A 400 Amp Charger System was subjected to a Seismic Simulation Test Program as required by the Cyberex Incorporated Purchase Order Number 12410 and Wyle Laboratories' Seismic Test Procedure Number 543/0173/DB dated February 13, 1992, Revision A dated June 18, 1992. This test program was performed on June 19, 1992, as documented in Test Report 42614-1.

The test program consisted of single axis Resonance Search testing and triaxial Random Multifrequency testing. The specimen was instrumented with accelerometers, electrically powered, loaded and monitored as directed by Cyberex during the test program.

It was demonstrated that the battery charger specimen possessed sufficient structural integrity to withstand, without compromise of structure or monitored functions, the prescribed simulated seismic environment.

Each station battery is contained in two 2-step free standing racks bolted to the floor. In the seismic calculations, the lower step was omitted in calculations of natural frequency and resisting frictional forces of top step cells were neglected. The system is symmetric about the mid-frame. Calculations included the determination of stresses due to horizontal motion in short direction, horizontal motion in longitudinal direction, vertical motion, and side rail stresses due to short motion. All checked out to indicate a conservative design.

A 2000A fused disconnect switch is used with each station battery. The fused disconnect switches are seismically qualified using the GIP-2 methodology for resolution of USI-46 as discussed in Report Number 03-0240-1367, Revision 0, dated December 14, 1995.

Two LCU-33 [(1)] battery cells were installed in a battery rack which was attached to the table of a vibration machine. The specimens were vibrated between 3.5 and 19.5 Hz along each of the two mutually perpendicular horizontal axes and the vertical axis simultaneously. Acceleration was applied at an angle of 36° from the horizontal. The two cells were connected in series and the output voltage monitored during the test. There was no evidence of electrical discontinuities or mechanical damage during or as a result of these dynamic exposures.

8.5.3 SYSTEM OPERATION

8.5.3.1 Normal Operation

The 125 volt DC vital system shown in Figure 8.5–1, sheet 1, provides a reliable power and control source for systems required for a safe shutdown and for post-incident operation. A typical protective scheme is shown in Figure 8.5–2, Reactor Trip Switchgear schematics.

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(1) The LCR-33 replacement cells are similar to the tested LCU-33 cells. See C&D Charter Power Systems, Inc., Environmental and Seismic qualification Report Number QR 163409-01, dated May 24, 1995.

The system includes two 60 cell lead calcium standby batteries and four 400 amp battery chargers. One pair of chargers is associated with each battery. The tie breakers are interlocked to prevent the paralleling of the two batteries but allow either battery to feed both buses, if necessary during cold shutdown or refueling operations. While in this alignment (one battery connected to both buses, each battery is sized to supply the total connected vital loads for one hour without charger support. In all other plant modes of operation, each battery is sized to supply the most severe postulated load conditions on its associated bus for an eight-hour duty cycle. During normal operation, the 125V DC load is supplied from the battery chargers with the batteries floating on the 125V DC bus. On loss of AC power to the battery chargers, the DC load is supplied from the battery. Power is available to these DC loads for a period of 8 hours. After 8 hours, it is assumed that AC power is restored to the chargers either from the system or the emergency generators.

Each 400 amp of charger is able to recharge a fully discharged battery in less than 12 hours while supporting the maximum continuous load of that battery. (A fully discharged battery is a battery where the cells are discharged to 1.75 volts per cell). Each battery/charger combination feeds its own independent and separate distribution channels via a main DC switchgear assembly. Each switchgear bus supplies two independent and physically separated 125 volt DC distribution panelboards for vital loads, two 125 volt DC panelboards for nonvital loads, and two separate 125 volt DC/120 volt AC static inverters for vital instrumentation. Each of the two inverter outputs is connected to an independent and physically separated 120 volt AC panelboard. Thus, four separate DC feeders and two separate AC feeders (via the inverters) are available from each battery for distribution within the plant.

Low-level DC emergency lighting in certain areas is provided throughout the station from the unit main batteries and the turbine battery, but does not satisfy Life Safety Code (NFPA) nor is it credited during a loss of power event such as Appendix R or Station Blackout. In the event of the loss of all sources of AC, minimal lighting requirements for egress per Life Safety Code (NFPA) are satisfied by 1.5-hour rated, self-contained automatically charged battery pack, lighting units.

8.5.3.2 Emergency Conditions

There is no change in the mode of operation of the battery system during emergency conditions except for the loads associated with loss of offsite power. On loss of AC power, vital battery loads include breaker tripping and closing circuits, continuous control circuits, emergency lighting, inverters, EDG air compressors and EDG field flash current. The battery service test profile shown in Table 8.5-1 envelopes the battery discharge current versus time profile for both vital batteries on loss of AC power.

8.5.4 AVAILABILITY AND RELIABILITY

8.5.4.1 Special Features

Each of the two 125 volt DC emergency power sources is equipped with the following instrumentation in the control room to enable continual operator assessment of emergency power source condition:

a. Direct current bus undervoltage alarm.

b. Battery current indication.

c. Bus current indication.

d. Charger malfunction alarm (including input AC undervoltage, output DC undervoltage and overvoltage, high temperature, low airflow, high and low output current).

e. Direct current bus voltage indication.

f. Direct current ground alarm.

The undervoltage relay is designed specifically to monitor the charging supply for a station battery and to sound an alarm if this supply fails. The setting of the relay is above 125 volts, and the equipment is capable of operating down to 95 volts.

The 125 volt switchgear circuit breakers have magnetic series trip elements for overcurrent protection as follows:

Battery charger - instantaneous, short-time and long-time elements

Other feeders - short-time and long-time elements

Auxiliary spray charging header supply valve 2-CH-517 and Loop 1A charging header supply valve 2-CH-519 have the capability of being supplied power from either Facility Z1 or Z2. These valves are not an installed spare unit of emergency equipment as discussed in Section 8.2.3.3. The alternate power provides a means to open 2-CH-517 and close 2-CH-519 post-LOCA for boron precipitation control and will not be utilized during normal plant operations. Therefore, these valves are not considered Facility Z5 components. To prevent placing the plant in an unanalyzed condition for separation concerns, the cross connection of 2-CH-517 and 2-CH-519 to Facility Z1 is limited to boron precipitation control post-LOCA, coincident with a loss of normal power, combined with a loss of Facility Z2 DC power, or for testing purposes. Emergency operating procedures provide guidance for aligning 2-CH-517 and 2-CH-519 to their alternate power.

8.5.4.2 Tests and Inspections

To ensure battery functional capability and to assure detection of battery degradation, the following tests and inspections are performed periodically:

a. Float voltage is measured.

b. Cells are checked for cracks or leakage.

c. The plates of cells are checked for buckling, discoloring, grid cracks and plate growth.

d. Specific gravity of each cell is measured.

e. Voltage of each cell is measured.

f. Electrolyte level of each cell is checked, and all water additions are recorded.

g. Temperature and specific gravity of the electrolyte of a pilot cell are measured.

h. Battery charger alarms and battery charger voltages are checked.

i. Bottoms of cells are visually inspected for flaking buildup and for abnormal cell plate deterioration.

j. Periodically a battery charger AC supply breaker will be opened to verify the load-carrying ability of the battery. During this test an undervoltage annunciator will indicate that the battery chargers are out of service.

Batteries will deteriorate with time, but precipitous failure is extremely unlikely. The surveillance specified is that which has been demonstrated over the years to provide an indication of cell degradation long before it fails. Battery replacement will be made when a capacity test indicates the battery capacity is at or below 80 percent of the manufacturer’s rating.

TABLE 8.5-1 BATTERY SERVICE PROFILE FOR BATTERIES 201A AND 201B

Discharge Step	Duration	Nominal Test Current (DC Amperes)
1	0 to < 1 Minute	311
2	1 to < 29 Minutes	224
3	29 to < 30 Minutes	242
4	30 to < 120 Minutes	221
5	120 to < 479 Minutes	197
6	479 to < 480 Minutes	243

FIGURE 8.5–1 SINGLE LINE DIAGRAM 125 VDC / VAC SYSTEMS (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–1 SINGLE LINE DIAGRAM 125 VDC / VAC SYSTEMS (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 4)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 5)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 6)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 7)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 8)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 9)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 10A)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 10B)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 10C)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 10D)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 11)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.5–2 REACTOR TRIP SWITCHGEAR CIRCUIT BREAKER CONTROL CIRCUITRY (SHEET 12)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

8.6 ALTERNATING CURRENT INSTRUMENTATION AND CONTROL

8.6.1 DESIGN BASES

8.6.1.1 Functional Requirements

The 120 volt AC instrument power for reactor protection, engineered safety features and vital instrumentation is supplied by four physically isolated and electrically independent vital instrument panels. Each vital instrument panel is powered by one of four physically isolated inverters. Two inverters are powered by each of the two redundant batteries.

8.6.1.2 Design Criteria

This power source is normally derived from the station battery system described in Section 8.5, hence the same criteria are met.

8.6.2 SYSTEM DESCRIPTION

8.6.2.1 System

This special 120 volt AC power supply and distribution system is shown in Figure 8.5–1, Sheets 1 and 2. It consists of two separate and redundant systems composed of four essential buses for vital instrumentation and control, and two regulated buses for nonvital instrumentation and control.

The four vital AC buses are normally supplied from DC/AC static inverters. The 120-volt regulated AC instrument panelboards supply the nonvital instrumentation requirements.

Each regulated panel is powered through a transfer switch from a normal or alternate source which includes one Uninterruptible Power Supply (UPS) fed by a nonemergency motor control center and one 480/208-120 volt regulating transformers fed by an emergency motor control centers. During normal operation, the transfer switch is in the normal position and power is fed from the normal MCC and UPS. Should this voltage drop to a predetermined low voltage setpoint, the transfer switch transfers to the alternate supply and power will be fed from the alternate MCC and regulating transformer.

In addition, portable generator connection points have been provided on 120VAC vital panels VA20 and VA40. These connections are defense-in-depth features that are available for coping with an extended loss of AC power (ELAP) event. The connections are shown on Figure 8.5–1, “Single Line Diagram”.

In addition, for increased flexibility during planned maintenance periods, the normal source UPS can be supplied with an administratively key controlled source, an emergency MCC.

To provide increased reliability, each of the four vital instrumentation panels has an alternate power supply via a “zero break” static transfer switch. Vital channels 1 and 2 are fed from separate DC/AC inverters whose source of DC is the turbine battery. Vital channels 3 and 4 are fed from one of the two regulated AC instrument power panels.

8.6.2.2 Components

In addition to the battery system components described in Section 8.5.2.2, four DC/AC static inverters with static transfer switches are required. These inverters and static switches are supplied by Cyberex, Inc., and their characteristics are as follows:

Rating 125 volts DC/120 volts AC, 15 kVA, any pf, 2 wire, ungrounded

Voltage regulation (%)	±1
Frequency stability (%)	±0.5

Overload capability (%) 125% of continuous rating for 5 minutes at any power factor

Transfer time of static switch	Zero break

A common inverter trouble alarm for each Inverter and Static Switch is provided in the Control Room. The following alarms with local alarm lights, except as noted, are tied to the common inverter trouble alarm:

- Synchronism Fail
- Input CB Tripped
- Output Undervoltage
- Alternate Line (light on static switch)
- AC Ground Fault
- Over Temperature (inverters only)
- Reverse Polarity
- Low Air Flow (static switches only/no local alarm light)
- Static Switch Bypassed (no local alarm light)

Active and passive components of the reactor protective system, engineered safety feature circuits and the emergency power system are designed to meet the seismic design requirements. The equipment and their components are designed to function before, during, and after an operating basis earthquake. In addition, they can sustain a design basis earthquake without any loss of protective function.

Seismic qualification of the Inverter and Static Switches was demonstrated by Wyle Laboratories in their Test Report Number 42384-1: “Seismic Simulation Test Program On A 15 kVA Inverter/ Static Switch Assembly for use in Northeast Utilities’ Millstone Unit 2 Nuclear Plant,” dated February 13, 1992. The details of qualification are also documented in the Seismic Qualification Review 92-034: DC/AC Inverter Replacement.

Seismic qualification tests were performed for five (5) Operational Basis Earthquakes (OBE’s) and one (1) Safe Shutdown Earthquake (SSE). The testing was performed to industry standard IEEE 344-75, which exceeds original qualification requirements for MP2. These were described as qualification to IEEE 344-71, supplemented by the requirement that simultaneous horizontal and vertical motions were required during testing. As such, the seismic qualification testing for the Inverter/Static Switch assembly was successfully performed in accordance with plant design requirements.

The distribution panels provide feeder protection by the use of molded case circuit breakers with thermal-magnetic trips. Three panelboards were tested under simulated seismic conditions; two of the well-mounted type and one floor mounted. These panelboards are representative of the eight being used. One was tested in five directions, and the other two in two biaxial positions. The seismic simulation was accomplished by utilizing a pulse amplitude modulated sine wave. The test specimens were subjected to five such pulses at each resonant frequency and the frequencies of the building resonances. The acceleration amplitudes were as required by the criteria of this project. All specimens were found satisfactory at even higher levels. Circuit breakers and an undervoltage relay were monitored and all performed satisfactorily.

8.6.3 SYSTEM OPERATION

8.6.3.1 Normal Operation

The power supplied by the above sources is used for essential control systems as illustrated in Figure 8.5–2.

8.6.3.2 Emergency Operation

No changes are required in this system to cope with any unit emergency situation.

8.6.4 AVAILABILITY AND RELIABILITY

8.6.4.1 Special Features

By means of a synchronizing signal, the inverter output is always in synchronism with its associated static switch's alternate source. Under this condition, transfer to the alternate source can be made at any time with no “bump” due to voltage difference or phase displacement. The static switch will transfer the AC load to the alternate source under any of the following conditions:

- Low AC voltage (108V)

- Inverter failure

8.6.4.2 Tests and Inspections

Each of the four vital inverters can be removed from service for inspection of its components, and for an operational test. These tests can be done individually by manually transferring the inverter load (zero break) to its associated alternate source. The static switch can be removed from service via a manual bypass switch. However, during this period of time, the associated alternate source is no longer available.

8.6.4.3 Additional Features

The backup sources for inverters 1 and 2 are inverters 5 and 6, respectively. Inverters 1 and 2 are synchronized to inverters 5 and 6 via static switches VS1 and VS2, respectively.

Inverters 3 and 4 are backed up by and synchronized to the normal source UPS or the backup 480/208-120 regulating transformers via VR11 and VR21 and static switches VS3 and VS4, respectively.

As internal frequency reference is used to keep the output of the inverter at 60 Hz ±0.5% if the alternate source is lost or out of tolerance. It is also used to prevent an out-of-synchronization transfer.

8.7 WIRE, CABLE AND RACEWAY FACILITIES

8.7.1 DESIGN BASES

8.7.1.1 Functional Requirements

In addition to transmitting electric power from the proper source to the designed load device, these facilities must be of a type and be properly installed and segregated to function during all postulated accident conditions.

8.7.1.2 Design Criteria

The electrical loading of conductors does not exceed, and is generally less than, the ampacities recommended by American Institute of Electrical Engineers - Insulated Power Cable Engineers Association (AIEE-IPCEA) "Power Cable Ampacities," (joint publications S-135-2 and P-46-426, 1962), and in open-top cable trays without maintained spacing in between cables the ampacities recommended by IPCEA-Institute of Electrical and Electronics Engineers (IEEE), joint publication, IPCEA Publication Number P-54-440, and National Electrical Manufacturers Association (NEMA) Publication Number. WC 51-1972.

The percent cross-section fill of wireways is governed by the allowable cable ampacities.

The physical support of wireways meet the recommendations of Chapters 2 and 3 of the National Electrical Code, 1971.

Separation of conductors and of their wireways meets the requirements of Section 4 of IEEE 279, 1971, Sections 4 and 5 of IEEE Standard 308, 1971, Criteria 1, 2, 3, 4, 17 and 18 of Appendix A of 10 CFR Part 50. Electrical penetration assemblies conform to IEEE 317, 1971.

8.7.2 SYSTEM DESCRIPTION

8.7.2.1 System

Cable types required to operate inside the containment after an accident are tested in an environment more severe than that expected in service. All cables have a sufficient degree of flame resistance to obviate the need for flame retardant coating or special fire extinguishing systems.

Fire detection is provided by a system of fire and smoke detector heads in the areas listed below. The power supply for this detector system comes from a 125 volt DC panelboard, as described in Section 8.6.2.1. In the event of smoke or flame in these areas, an annunciator in the control room displays the alarm. Additional fire protection is provided as described in Section 9.10. The areas covered by ionization type detector heads are as follows:

Computer room

Control room ventilating ducts

Main exhaust equipment room

Fuel handling area

Auxiliary building and radwaste ventilating room

Cable spreading room

Electrical penetration rooms

Cable vault

Medium-voltage switchgear rooms

Low-voltage switchgear rooms

Cable chases

8.7.2.2 Components

The raceway system is made up of cable trays, conduits and underground ducts, with the electrical cables contained therein.

Cable trays are of galvanized steel, ladder type or solid bottom, with solid covers where required. Hangers for trays carrying vital circuits are designed to withstand seismic disturbances as described in Sections 5.8.1 and 5.8.1.1.

Conduits are galvanized rigid steel where embedded in reinforced concrete in building slabs. The duct banks going to the intake structure are heavily reinforced and will withstand a seismic disturbance, as noted in Section 5.8.2.3.

All in-line splices of conductors are made only in metal enclosures such as terminal boxes and junction boxes or in designated splicing areas of the cable raceways.

Table 8.7-1 lists the physical and electrical characteristics of the cables that are used, and indicates the qualification tests. The certified results of such tests are available for inspection. Cable from vendors and of materials other than those listed in Table 8.7-1 are used when qualified in accordance with the applicable characteristics, standards, tests and the required service conditions.

The electrical penetration assemblies through the wall of the containment structure form part of the containment pressure boundary, as described in Section 5.2.6.1.1. The low voltage power and control modules are mounted in a stainless steel header plate and are designed to meet or exceed all requirements of IEEE Standard 317, 1976. The medium voltage power penetrations are designed to meet or exceed all requirements of IEEE Standard 317, 1971. A complete prototype and production test program demonstrated the suitability of the assemblies for operation under the prescribed service conditions. These tests include leak integrity, current carrying capacity (continuous, short time overload, and fault current) dielectric strength, insulation resistance, and resistance to seismic and thermal transients. The conductors contained therein meet all criteria applying to each class of service. The high-voltage conductors terminate in a stress cone and lug. Low voltage power cables larger than 4/0 AWG terminate in lugs rigidly fixed in a terminal box at each end of the penetration assembly. All other low-voltage power, control, and instrument cables except for Class 1E instrumentation and EEQ required circuits are terminated on terminal blocks enclosed in the penetration boxes at both ends of the penetrations. The Class 1E instrumentation and required EEQ circuits are terminated with EEQ qualified terminations at both ends of the penetrations. Incore detection cables, coaxial cable, and certain special multiconductor cables are terminated in connectors mounted in terminal boxes at both ends of the penetration assembly. All terminal boxes are designed for NEMA IV service.

A leak rate test is performed on each penetration assembly following its installation. This test is capable of detecting a leak rate of 1 x 10^{-2} cc/sec of dry nitrogen at ambient temperature when maximum design pressure is applied across the penetration assembly barrier. To effect this test, each assembly is fitted with a gage to monitor the pressure, and is then charged with 30 psig of nitrogen. The assembly is so designed that all seals, including conductor seals, are monitored by the gage.

8.7.2.3 Cable Ampacities

The maximum ampacities for cable installations at Millstone Unit 2 are based upon the following:

- Conductor temperature does not exceed 90°C.

- General Plant Areas are normally considered to be 50°C for ampacity analyses except specific locations (e.g., intake structure).

- Standard tray fill is 35 percent. When tray fill is above 35 percent the higher tray fill number is used.

Ampacities for cable installations in Free Air, Conduit, Maintained Space Cable Trays, and Underground Ductbanks are based upon IEEE S-135, IPCEA P-46-426, 1962. Ampacities for cable installations in Random Spaced Cable Trays are based upon ICEA P-54-440, NEMA WC-51, 1972. Cables with sizes or installations not identified in the standards above, have ampacities based on published industry papers or published vendor data.

8.7.3 AVAILABILITY AND RELIABILITY

8.7.3.1 Separation

The raceway systems are so designed that any one raceway channel may be physically sacrificed under accident conditions. The layout drawings in Figure 8.7–1 show typical examples of the separation of raceways serving different channels.

The separation of redundant cables is accomplished by spatial separation of their cable trays. This spatial separation is normally not less than four feet vertically and 18 inches horizontally to guard against damage from external fire, missile, or other accidents.

Where these spacings between trays of redundant systems cannot be maintained (physical obstructions, points of necessary convergence, crossovers, etc.), barriers are provided to preserve the physical and electrical integrity of the cables.

Vertical stacking of separate redundant trays is avoided where possible.

Where separate redundant trays must be stacked with less than 4 feet vertical separation and/or their horizontal separation is less than 18 inches, rated fire barriers must be used. In the cable vault, where an existing automatic detection and suppression system is located, separation barriers are not required.

In the case of crossover of trays carrying redundant cables, there shall be a minimum separation of 6 in. clear space between them with a barrier (equivalent to 0.5 inch of Marinite 36).

Typically, rated fire barrier material employed to enhance raceway separation is one-half inch Marinite 36, or equivalent. Installation will be as follows:

a. <u>Horizontal Separation</u>. A vertical barrier, one foot above and one foot below the trays, or to the ceiling or floor.

b. <u>Vertical Separation</u>. A horizontal barrier between trays extending one foot each side of the tray system.

c. <u>Cross-overs</u>. A horizontal barrier extending out one foot from each side of each tray, and five feet along each tray from the crossover.

In lieu of the above, conduit or a totally enclosed tray may be used and the two channels do not touch each other. For certain configurations, trays with ventilated covers, or cables in Sil-temp wrap, are considered enclosed raceways.

Generally, no more than one channel of separate redundant systems is run through a compartment containing machines with flywheels. Where this cannot be avoided, each case is evaluated for additional protection. Similarly, no more than one channel is generally routed through an area containing high pressure (275 psi and over) piping. Where necessary, the redundant raceway will be run at least ten feet from such piping. Where this spacing cannot be achieved, pipe restraints are provided and each case is evaluated for additional protection.

Where routing is unavoidable through an area subject to a possible open accumulation of quantities (gallons) of oil or other combustible liquids as a result of rupture or leakage of a fluid system, a single separation channel only is routed through this area. Furthermore, the cables are protected from dripping liquids by conduit or covered tray.

Raceways (exposed conduits, trays, penetrations, etc.) are generally stacked vertically in the following relative order:

a. 6900 volt power

b. 4160 volt power

c. 480 volt load center subfeeders

d. *480 volt power and general control

e. *Shielded control and instrumentation

(*Shielded control and instrumentation cables may be run with unshielded control and instrumentation for short distances such as risers into equipment).

Within each of these classifications, nonvital cable may be run with vital cables. However, a nonvital cable is never routed in raceways of more than one separation channel.

Vital circuits, components, and equipment are those that are safety related. That is, the safe operation and shutdown of the nuclear system is dependent on them. Vital systems meet the single failure criterion and therefore are redundant and separate.

Where indicators and other devices are not essential for the safe functioning of a vital system, current and potential transformer secondaries or other low-energy circuits feeding such devices are considered nonvital circuits.

Equipment, devices, cables and raceways have an assigned number that indicates if they are in vital service or not, and also indicates the channel. These designations are shown on one-line and three-line diagrams, schematics, circuit and raceway schedules, and the instrument index.

A "Z" prefix on a cable, conduit or tray number indicates a vital system. The absence of the Z prefix indicates nonvital service. The first figure of a cable, conduit or tray number designates the channel. Such an alpha-numeric prefix is called the Facility Code, and its use is further explained in Table 8.7-4.

Vital power and control cables fall mainly into two redundancy classifications; Channel Z1 and Channel Z2. In a few cases there is also a Channel Z5, which is a system that can be transferred from one source to another, and is run as described below. Cables such as those in reactor protection service are assigned to Channels Z1, Z2, Z3 and Z4. As shown in Table 8.7-4, nonvital Channel 1 may be routed with vital Channel Z1, and Channel 2 with Channel Z2. Low level buffered signal outputs from Z3 and Z4 channels of a four-channel instrument system may be run with nonvital channels 1 and 2 respectively. Where the system lacks a current limiting feature, Z3 and Z4 are run separately.

Channel Z5 is associated with the spare units fed from 4160-volt emergency bus A5; namely, service water pump P5B, Reactor Building Closed Cooling Water (RBCCW) pump P11B, and High Pressure Safety Injection (HPSI) pump P41B. The power circuits and the control circuits for this equipment are all transferred simultaneously to Channel Z1 or Z2 sources. Thus, their circuits are routed together as Channel Z5. The Z5 control circuit and power circuit for the spare 480 volt charging pump P18B, are transferred to Z1 or Z2 sources independent of the above circuits. Hence, the Z5 charging pump circuits are routed separately from those associated with bus A-5. Nonvital Channel 5 circuits are those associated with instrument loops or metering circuits. Channels 5 and Z5 circuits are routed together only where it can be demonstrated that their transfer to Channel 1 (Z1) or 2 (Z2) sources does not impair the separation of redundant safety related circuits.

The turbine driven AFP, the steam inlet valve, and speed adjuster motor have the capability of being transferred from their normal power supply Facility Z2 125VDC (Panel DV-20) to Facility Z1 125VDC (Panel DV-10). The transfer is accomplished by switching the position of two key-locked isolation switches on panel C-05 in the event of a loss of Facility Z2 125 or a loss of DC panel DV-20. The associated wiring from panel C-05 is routed in dedicated Z5 conduit to panel C-21, panel C-10 and ultimately to the steam inlet valve and the speed adjuster motor.

Shutdown Cooling Suction Header Containment Isolation valve 2-SI-651, auxiliary spray charging header supply valve 2-CH-517 and Loop 1A charging header supply valve 2-CH-519 have the capability of being supplied power from either Facility Z1 or Z2. However, these valves are not Facility Z5 components (Sections 8.4 and 8.5). The load side of the disconnect switches for 2-SI-651 are routed Z1 and the load side of the transfer switches for 2-CH-517 and 2-CH-519 are routed Z2. The transfer from the normal 480 volt for 2-SI-651, is accomplished through manual operation of local Kirk-keyed transfer switches which prevent tying the two motor control center buses together. Upon transfer to Facility Z2, the control for valve 2-SI-651 will be transferred from the control room to the local control panel. The transfer from the normal 125VDC for 2-CH-517 and 2-CH-519 is accomplished through manual operation of key-locked selector switches, located on panel C02, which prevent tying the two 125 VDC power sources together. These manual transfer schemes are consistent with the requirements of Safety Guide 6.

Computer and annunciator circuits are considered nonvital. Their inputs are from nonvital Channels 1 and 2 that may be routed with vital circuits as shown in Table 8.7-4. The Channel 1 and 2 segregation for the nonvital circuits is lost when they enter the final raceways at the computer or the annunciator terminal cabinets. The 480 volt power supply to the computer is reduced to 120 volts by an uninterruptible power supply (preferred) or a regulating transformer (alternate). The internal power supply provides 36 volts (fused one-half amp) to the digital inputs, and the analog inputs are 10-50 mA. The power supply to the annunciator is from two separate redundant AC to DC power supply systems which isolate the annunciator DC voltage from the AC power sources and isolate the two AC power sources from each other.

The control element drive system (CEDS), including the CEDS logic cabinets, are also considered nonvital. Two separate feeders, one from each of the two nonvital 120 VAC instrument buses, supply control power to the logic cabinets. The feeder cables are routed in separate raceway from the distribution panels to the cabinets, but are ultimately bundled together within a common logic cabinet. Separation of the nonvital 120 VAC instrument buses is maintained, however, because separate double pole circuit breakers installed in each of the nonvital distribution panels provide isolation between the two buses. No redundancy is intended, or required, for the CEDS logic cabinet power supplies.

All power supply equipment is identified with respect to its source. Odd first digits are assigned to Channel 1; i.e., B1, B12, etc. Even first digits are assigned to Channel 2; i.e., B2, B21, etc.

To assist in verifying proper separation, the jackets of all cables are color coded. Table 8.7-4 indicates the physical separation applied to cables and raceways, and the cable jacket color for each case.

Apertures for entrance of redundant vital cables into control boards, panels and relay racks are separated by at least twelve inches of air space. Where this cannot be accomplished, the entrance is made with conduit or enclosed tray.

Redundant vital cables terminate on terminal blocks at least six inches apart. Internal wiring of redundant vital circuits, and any associated devices, is separated by a minimum of six inches. Where the minimum spatial separation of six inches is not feasible, nonflammable heat shrinkable tubing, noncombustible barriers or conduit are used to provide separation. Exceptions to these criteria may be permitted on an individual basis with analysis and documentation of acceptability in the Electrical Separation specification. Acceptability of lesser separation should be based on degree of hazard and mitigative measures which demonstrate that the effects of lesser separation do not degrade Class 1E safe shutdown circuits and equipment below an acceptable level. Exceptions cannot be taken between redundant vital wires/devices inside control panels. Nonvital channels may be wired to the same device, but their conductors are bundled separately.

Whenever practicable, shipping splits and structural stiffeners are utilized as natural barriers. The barriers are comprised of two sheets of steel plates with a minimum of one inch air space or insulating fire-resistant material in between, if devices and/or wiring are mounted on both faces of the barrier. If devices and/or wiring are mounted on the barrier on only one face, a single sheet of steel plate for isolation is satisfactory provided devices and/or wiring on the other side are installed at least one inch away from the barrier. The barriers are properly supported for structural strength, and extend from top to bottom and front to back to a depth which provides a minimum of six inches separation between channels.

Typical layouts illustrating the separation of redundant wireways are shown in Figure 8.7–1.

8.7.3.2 Tests and Inspections

The various documents indicating the separate routing of redundant cables are carefully cross-checked during the design of the system. The color coded jackets of the cables permit a visual inspection to verify that the separation criteria are observed.

Insulation resistance of all power cables is measured initially and spot checks are made at refueling periods. Such tests indicate significant trends in the unlikely event there has been deterioration of the insulation.

The pressure gages on the electrical penetration assemblies are located in the auxiliary building penetration rooms and are readily accessible. These assemblies remain charged with nitrogen throughout their life, and a pressure reading will be taken and recorded periodically.

TABLE 8.7-1 CABLE CHARACTERISTICS

<table>
<tr><th rowspan="2">TYPE</th><th rowspan="2">VOLTAGE RATING</th><th rowspan="2">SER-VICE</th><th colspan="3">CONDUCTORS</th><th rowspan="2">INSULA-TION</th><th rowspan="2">JACK ET</th><th colspan="5">PROTOTYPE TESTS (CERTIFIED)</th><th colspan="3">FACTORY TESTS (CERTI-FIED)</th><th rowspan="2">APPLICA-BLE STAN-DARDS</th><th rowspan="2">VENDOR</th><th rowspan="2">COMMENTS</th></tr>
<tr><th>TYPE</th><th>STRAND</th><th>TEMP</th><th>RADIATION RESIS-TANCE</th><th>PHYSI-CAL</th><th>ELECTRICAL</th><th>FLAME</th><th>POST-ACCI-DENT ENVIRON-MENT</th><th>FLAME</th><th>ELECTRI-CAL</th><th>OTHER</th></tr>
<tr><td rowspan="2">MEDIUM VOLTAGE POWER</td><td>8 KV</td><td>6.9 KV</td><td>CU
AL</td><td>Class B</td><td>90C</td><td>EPR/
CSPE</td><td>-</td><td rowspan="2">A.O. Aged 7 days 121 C $5x10^7$ Rad Phys. Test Elec Test Flame Test</td><td rowspan="2">Per IPCEA S-68-516 Sect 6.0 Tensile, Elongation, Aging, Ozone, Moisture Absorption</td><td rowspan="2">Per IPCEA S-19-81 Sect 6.0 AC, DC, IR, PF, SIC, Corona, Level per AEIC No. 5</td><td rowspan="2">Passes Horiz. & Vert. Tests per SPEC, Passes IPCEA S-19-81 Sect 6.19</td><td>N/A</td><td>Passes IPCEA S-19-81 Sect 6.0</td><td>Per IPCEA S-19-81</td><td>Corona Level & Corona Factor</td><td>IPCEA S-68-516 S-19-81</td><td>General Cable</td><td>Each Conductor Shielded</td></tr>
<tr><td>5 KV</td><td>4.16 KV</td><td>CU
AL</td><td>Class B</td><td>90C</td><td>EPR/
CSPE</td><td>-</td><td>N/A</td><td>Passes IPCEA S-19-81 Sect 6.0</td><td>Per IPCEA S-19-81</td><td>Corona Level & Corona Factor</td><td>IPCEA S-68-516 S-19-81</td><td>General Cable</td><td>Each Conductor Shielded</td></tr>
<tr><td>LOW VOLTAGE POWER</td><td>1 KV Note (1)</td><td>480 VAC
125 VC</td><td>CU</td><td>Class B</td><td>90C</td><td>EPR/
CSPE</td><td>CSPE</td><td>Preaged 7 days, 121 C $5x10^7$RAD</td><td>Per IPCEA S-68-516 Sect 6.0</td><td>Per IPCEA S-19-81 Sect 6.0</td><td>Passes Horiz. & Vert. Tests per SPEC, passes IPCEA Sect 6</td><td>$4.9x 10^8$ R 52 psig 292°F 100% RH 11/2 1/2% boric acid by wt</td><td>Passes IPCEA S-19-81 Sect 6.0</td><td>Per IPCEA S-19-81</td><td>-</td><td>IPCEA S-68-516 S-19-81</td><td>Anaconda</td><td></td></tr>
<tr><td>CONTROL</td><td>1 KV Note 1</td><td>125 VDC
120 VAC</td><td>CU</td><td>Class B</td><td>70C</td><td>Kerite FR</td><td>Kerite FR</td><td>Results Available</td><td>Stated minimum tensile & elongation</td><td>HI POT & IR Tests on previous cable</td><td>Passes Horiz. & Vertical Tests</td><td>Results available</td><td>Passes IPCEA S-19-81 Sect 6.0</td><td>HI POT & IR Test on each Length</td><td>-</td><td>-</td><td>Kerite</td><td>Test Results Are Proprietary</td></tr>
</table>

TABLE 8.7-1 CABLE CHARACTERISTICS

TYPE	VOLTAGE RATING	SER-VICE	CONDUCTORS TYPE	CONDUCTORS STRAND	CONDUCTORS TEMP	INSULA-TION	JACKET	PROTOTYPE TESTS (CERTIFIED) RADIATION RESIS-TANCE	PROTOTYPE TESTS (CERTIFIED) PHYSI-CAL	PROTOTYPE TESTS (CERTIFIED) ELECTRICAL	PROTOTYPE TESTS (CERTIFIED) FLAME	PROTOTYPE TESTS (CERTIFIED) POST-ACCI-DENT ENVIRON-MENT	FACTORY TESTS (CERTI-FIED) FLAME	FACTORY TESTS (CERTI-FIED) ELECTRI-CAL	FACTORY TESTS (CERTI-FIED) OTHER	APPLICA-BLE STAN-DARDS	VENDOR	COMMENTS
INSTRUMENT	600 V	-	CU	Class B	-	Flame Retardant XLPE	Neoprene	$2x10^8$ Rad	See Note (2)	Passed AC hi-pot and IR tests as specified	2/C number 16 passed per Spec para 8.4.3.2	See Note (3)	Passes IPCEA S-19-81 Sect 6.0	HI POT, IR & Cdr Res on each reel	-	IPCEA S-66-524 S-19-81	Cerro	
SPECIAL INCORE CABLES	600 V	-	CU and TC Type K	Class B and Solid	-	Flame Retardant XLPE	Neoprene								-	IPCEA S-66-524 S-19-81	Cerro	
COAX	-	-	-	-	-	XLPE	CSPE	Results of previous tests on similar cable; $1x10^8$ rad min.; physical, elect. & flame test data			Available 9/73	N/A	Passed IPCEA S-19-81, Sect 6.0	Per MIL-C-17 D HI POT Imped, IR Cap	Physicals per IPCEA S-66-524, S-19-81	MIL-C-17D IPCEA S-66-524 S-19-81	BIW	
COMMUNC	600	-	CU	16	-	Flame Resistant 105C PVC	Flame Resistant 105C PVC	-	-	-	-	-	-	-	-	-	Gai-Tronics	
THERMO-COUPLE	300	-	Type E	Solid	-	Flame Retardant XLPE	CSPE	N/A	N/A	N/A	2/C number16 passed per Spec para 8.3.2.2	N/A	Passed IPCEA S-19-81, Sect 6.0	Per IPCEA S-66-524	Conduct or DC resistant	IPCEA S-66-524 ANSI C96.1-1964	BIW	

(1) In addition to the 1 kV voltage to be used for Low Voltage Power and Control Cables, it has been justified, September/October 1981 memos GEE-81-776/GEE-81-845, that 600V Insulation can also be used for new and replacement cables.

(2) Tested for tensile, elongation, aging, heat distortion, ozone and moisture absorption.

(3) Pre-aged 7 days at 121C, $2x10^8$ Rad, 104 psig, 340°F, 2% BA, Hipot, IR, Flame Tests, also Note 2.

TABLE 8.7-2 OMITTED

TABLE 8.7-3 OMITTED

TABLE 8.7-4 FACILITY IDENTIFICATION

Function		Facility Code				
		Channel 1	Channel 3	Channel 2	Channel 4	Channel 5
Power	Vital	Z1	Z3	Z2	Z4	Z5
	Nonvital	1	--	2	--	5
Control	Vital	Z1	Z3	Z2	Z4	Z5
	Nonvital	1	--	2	--	5
2-Channel Instrument	Vital	Z1	--	Z2	--	--
	Nonvital	1	--	2	--	--
4-Channel Instrument	Vital	Z1	Z3	Z2	Z4	--
	Nonvital	--	--	--	--	--
C-E Designation	Vital	A	C	B	D	--
	Nonvital	X	--	Y	--	--
Color Code	Vital	Red	Green	Yellow	Blue	Orange
	Nonvital	Black	--	White	--	Gray

MPS2 UFSAR

FIGURE 8.7–1 RACEWAY PLANS (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the <hot spots>List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.7–1 RACEWAY PLAN CABLE VAULT AREA -6, ELEVATION 25 FEET 6 INCHES (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the <hot spots>List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.7–1 RACEWAY PLAN CABLE VAULT AREA -7, ELEVATION 25 FEET 6 INCHES (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the <hot spots>List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 8.7–1 RACEWAY PLAN CONTAINMENT AREA ELEVATION 14 FEET 6 INCHES (SHEETS 4)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the <hot spots>List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.