8.1 INTRODUCTION

8.1.1 DESIGN BASIS

The Plant electrical system and the 345 kV switchyard are designed to reliably function and supply power during normal, abnormal and emergency conditions. This electrical power system is required to meet 10 CFR 50, Appendix A, General Design Criterion 17, for onsite and offsite power source requirements. The system will supply and distribute the electrical power necessary to operate the systems which preserve the Plant's three fission product barriers under all conditions of start-up, power generation and shutdown. The electrical system is divided into buses and subsystems to minimize the effects of any electrical fault and maximize the availability of onsite and offsite power sources.

The portion of the Plant electrical system which supplies the Plant engineered safeguards will be referred to as the engineered safeguards electrical system. The engineered safeguards electrical system is housed in CP Co Design Class 1 structures in accordance with Subsection 5.9.1.1 and provides a Class 1E service as defined in IEEE 308-1978. Class 1E designation applies to electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing significant release of radioactive material to the environment.

Because the plant was designed and constructed prior to IEEE 308 requirements, some components/systems that are designated as Class 1E will not have all the necessary attributes to be certified as meeting Class 1E qualifications. Although original plant components/systems were designed and qualified (by analysis) to provide safety related functions, they may not meet all of the design criteria and testing requirements of IEEE 308 and other standards incorporated by reference therein.

The designation of these components/systems as 1E will assure that proper safety and quality reviews of function are performed prior to maintenance or replacement. When modifications are performed requiring equipment upgrades, change of function, etc, the new design is evaluated to determine whether upgrading to later standards including IEEE 308 would be practical and warranted. Systems and components originally designed and installed in conformance with 1E requirements will be maintained at least to those standards unless future changes in system/component function make classification as 1E no longer necessary.

Evaluation of safety-related electrical equipment (whether or not part of the Plant electrical system) for environmental and seismic service qualifications is discussed in Subsections 8.1.3 and 8.1.4.

Safety-related electrical equipment not part of the Plant electrical system is covered by Chapter 7.

The engineered safeguards electrical system consists of the necessary power sources, power distribution equipment, electrical and control subsystems, including cabling and raceway, to furnish power and controls to the required load groups upon a safety injection signal or containment isolation signal, to reliably shut down the reactor, and to remove reactor decay heat for long periods of time.

The system is designed to the two channel concept, defined as two independent electrical control and power systems supplying redundant engineered safeguards load groups. The engineered safeguards electrical system meets the single failure criteria, by which any single failure of a component within the system will not prevent the proper system action when required, and is intended to meet all other requirements identified in IEEE 279-1971 and IEEE 308-1978. Other standards such as IEEE 323-1974, IEEE 344-1975, IEEE 384-1977 and IEEE 383-1974 are intended to be met within the limits of practicability and consistent with original design features. With the implementation of National Fire Protection Association (NFPA) 805, new cables must meet IEEE 383, or equivalent, flame test requirements.

During the Systematic Evaluation Program, NRC and CPCo staff reviewed as built electrical design against licensing criteria current at the time. The purpose of the review was to determine if the designs in older plants provided a measure of safety comparable to that provided by design in newer plants; or as a minimum, were acceptable based on plant specific challenge and response capability. The adequacy of as built characteristics designed to promote safety related availability such as channel separation, isolation and independence was evaluated. In many cases, these reviews concluded that although the existing as built design did not feature the specific configuration required by current criteria, the design was considered acceptable. Summaries of these reviews are found in NUREG 0820, the NUREG 0820 Supplement, and individually docketed SEP submittals and related NRC Safety Evaluation Reports.

Separation, isolation and independence are discussed in Sections 7.4, 8.5, and 8.7.

Water spray fire protection is provided for raceways in areas described in the Fire Safety Analyses (Section 9.6.3).

8.1.2 DESCRIPTION AND OPERATION

The Plant electrical system is shown on Figure 8-1, Plant Single Line Diagrams. The 345 kV switchyard is shown on Figure 8-2, Substation Single Line Diagram.

Six transmission circuits connect the site switchyard to the power system grid with two circuits on each of three sets of towers. A fourth tower with one circuit connects the switchyard to a nearby natural gas fired generating station. The site switchyard is connected to the Plant electrical system using three circuits; one underground and two overhead. The Plant turbine generator is connected to the switchyard through Main Transformer 1 using one of the overhead circuits. The underground and other overhead circuit supply offsite power to the Plant electrical system.

The normal power source for the Plant 4,160-volt auxiliaries is the site turbine generator which supplies the reactor plant primary coolant pumps and condensate pumps via 21 - 4.16 kV Station Power Transformer 1-1. Also, the cooling towers and associated equipment loads are supplied via the 345 - 4.16 kV Station Power Transformer 1-3. When the turbine generator is out of service, offsite power is supplied to the primary coolant pumps and condensate pumps via 345 - 4.16 kV Start-Up Transformers 1-1 and 1-3. If the turbine generator is out of service for an extended period, the generator isophase bus motor-operated disconnect switch may be opened and Main Transformer 1 can be used to backfeed 4,160-volt auxiliary power through the station power transformers.

2,400-volt reactor and turbine plant loads, including the engineered safeguards electric system, are normally supplied from either the offsite power source 345 - 2.4 kV Safeguard Transformer 1-1 or the offsite power source 345 - 2.4 kV Start-Up Transformer 1-2. Capability is also provided to power the 2,400-volt electrical system from the main turbine generator via 21 - 2.4 kV Station Power Transformer 1-2. If the turbine generator is out of service for an extended time, the generator isophase bus motor operated disconnect switch may be opened and Main Transformer 1 can be used to backfeed 2,400 volt auxiliary power through Station Power Transformer 1-2.

The Plant auxiliary electrical system includes four 4,160 volt buses, four 2,400 volt buses, and several 480 volt load centers and 480 volt motor control centers. Certain 480 volt load center buses receive power from load center transformers energized from the 2,400 volt buses. Other 480 volt load center buses receive power from load center transformers energized from 4,160 volt Buses 1A, 1F and 1G. The 480 volt motor control centers are connected to the 480 volt load center buses.

Four preferred ac systems are energized from the station battery systems through inverters to power vital instrument and control loads. Two station batteries and four chargers supply the Plant 125 volt dc systems.

The nonvital instrumentation and controls are supplied from a 120 volt ac instrument bus. The instrument bus is normally supplied from one of two 480-120 volt transformers, each transformer being connected to a separate 480 volt motor control center. The transfer to the alternate source is automatic.

The engineered safeguards system includes two 2,400 volt buses (1C and 1D), four 480 volt load centers (11, 12, 19 and 20), eight motor control centers (1, 2, 21, 22, 23, 24, 25 and 26), two dc distribution centers, four battery chargers, two batteries, four preferred ac buses, four inverters and two diesel generators. The engineered safeguards electrical system is designed on a two-independent-channel basis. Each channel is capable of furnishing power to equipment load groups which meet the minimum requirements to safely shut down the reactor and is capable of providing sufficient electrical power for functions necessary to operate the systems associated with the Plant's capability to cope with abnormal events. The system is provided with the necessary redundant circuitry and physical isolation so that a single failure within the system will not prevent the proper system action when required. The system is provided with test facilities and has alarms to alert the operator when certain components trip or malfunction or are not available or operable. Automatic controls and interlocks provide the proper sequence of operation of the engineered safeguards components with or without normal or offsite power.

Each channel of the engineered safeguards electrical system has access to the following power sources:

1. The offsite power source (Safeguard Transformer 1-1)

2. The offsite power source (Start-Up Transformer 1-2)

3. The onsite power source (Main Turbine Generator)

4. The emergency power source (one of two onsite emergency generators)

Each emergency generator may energize only its respective channel buses.

8.1.3 ENVIRONMENTAL QUALIFICATION OF ELECTRICAL EQUIPMENT

An order modifying the Palisades Plant Operating License, requiring submittal of environmental qualification information for safety-related electrical equipment, was issued by the NRC on August 29, 1980 (Reference 1). The order was revised and reissued on September 19, 1980 (Reference 2). In response to the Commission's orders, Consumers Power Company submitted a report entitled, "Environmental Qualification of Safety-Related Electrical Equipment - Palisades Plant, September 1980" (Reference 3).

The report described the Electrical Equipment Qualification (EEQ) program and identified electrical equipment needed to mitigate the effects of an LOCA or main steam line break (MSLB) inside of containment or an MSLB outside of containment, and which are in areas that will experience the direct effects (high humidity, high temperature, high radiation, etc) of these accidents. The report lists the equipment and describes the expected post-accident conditions, describes the expected duration of the hostile environment, describes the expected effects on the affected equipment, and describes the method of qualification for each piece of equipment. Subsequent to the initial report, revisions to the report and additional information on the EEQ program were submitted to the NRC (References 4, 5 and 6).

On April 25, 1983, the NRC issued its Safety Evaluation Report (SER) for the Palisades EEQ program (Reference 7). The SER also contained a Technical Evaluation Report (TER) prepared by the Franklin Research Institute for the NRC. Consumers Power Company responded to the open items of the SER on May 20, 1983 (Reference 8).

On February 14, 1984 (Reference 9), Consumers Power Company submitted additional information in response to the Safety Evaluation Report (SER). The additional information responded to environmental qualification documentation deficiencies for safety-related equipment at Palisades noted in the TER and, in addition, the letter documented discussions held on January 10, 1984 with the NRC Staff regarding the methodology to be used by CP Co in complying with 10 CFR 50.49 which had become effective February 22, 1983.

On January 31, 1985, the NRC issued a Safety Evaluation Report that concluded that Consumers Power Company's EEQ program was in compliance with the requirements of 10 CFR 50.49 (Reference 16).

On February 28, 1986, the NRC issued its Safety Evaluation Report for the Single Failure issue for the main steam isolation valves and feedwater isolation valves. The SER covers the concern that a main steam line break (MSLB) along with the single failure of one main steam isolation valve would allow both steam generators to blow down. In this review the NRC concluded that the Plant emergency operating procedures and training on the issue provide sufficient protection. They also concluded that the qualification of components inside containment for the temperature/pressure conditions resulting from a postulated double steam generator blowdown is not required. See Chapter 5 for additional information.

The present EEQ program involves the generation and maintenance of evidence that electrical equipment can perform its intended function throughout its installed life when exposed to harsh environmental conditions.

An EEQ Engineer ensures that new equipment is properly qualified, existing equipment qualification is properly maintained, and qualification files are accurate and auditable.

EEQ file reports are developed by an EEQ Engineer using information provided by others. Changes to EEQ files are justified by engineering analyses. All changes to EEQ Files are prepared by an EEQ engineer. New EEQ Files are prepared and reviewed by EEQ engineers.

8.1.4 SEISMIC QUALIFICATION OF ELECTRICAL EQUIPMENT

The seismic design criteria for safety-related electrical equipment, instrumentation and raceways are provided in Section 5.7. Seismic Category I (Regulatory Guide 1.29) and Class 1E electrical equipment and raceways are listed in Table 5.2-4. Electrical equipment anchorage and raceway supports for the components listed in that table have been redesigned in the period 1979 to 1981 as Seismic Category I as defined in Regulatory Guide 1.29. Seismic adequacy of safety-related electrical components is determined by resolution of NRC Generic Letter 87-02 “Verification of Seismic Adequacy of Mechanical and Electrical Equipment in Operating Reactors, Unresolved Safety Issue A-46.”

8.1.5 STATION BLACKOUT

In 10 CFR 50.63 the NRC defined the loss of all onsite and offsite ac power sources (station blackout) as an event with which all plants are required to cope. Such factors as redundancy of offsite power sources, severe weather potential of the site and diesel generator reliability were evaluated in accordance with NUMARC 87-00 guidance to define minimum battery capacity and instrumentation requirements. On May 20, 1991 the NRC found that the Palisades plant conformed with the SBO (Station Blackout) rule, Regulatory Guide 1.155, NUMARC 87-00, and NUMARC 87-00 Supplemental Questions/Answers and Major Assumptions.

Per NRC recommendations, the battery analysis does not consider load stripping of the station batteries until 30 minutes after SBO. Actions necessary to isolate containment were identified, and an EDG reliability program (RG 1.155 Section 1.2) was developed. Evaluations and commitments to evaluate HVAC and heat tracing were approved by the NRC per the G.B.Slade, CPCo, letter of August 1, 1991. The addition of backup nitrogen to the atmospheric dump valves provides a minimum coping duration of four hours for SBO. These actions resolved recommendations made in the May 20, 1991 SER. This resolution was documented in a SER of June 25, 1992.

8.2 NETWORK INTERCONNECTION

8.2.1 DESIGN BASIS

The 345 kV switchyard is designed to be the interconnection point between the power plant, the nearby natural gas Covert Generating Plant and the power grid system. It is designed to function reliably under all conditions of power plant operation. It will furnish start-up power to the power plant, and reliably function and isolate trouble in the power system grid under power system normal and abnormal conditions.

High-speed clearing of faults and selective reclosing assure maximum availability of power and system grid stability. A transient stability study has been made on the Palisades Plant. The results of this study indicate that no system instability will result from the loss of the Palisades Plant. The sudden drop of a large load will not adversely affect the Palisades plant or the connected electrical system. Analyses demonstrate that the electric system can sustain contingencies equivalent to, or more severe than, an abrupt 1,000 MW loss of load without adverse effects to the system or connected units.

8.2.2 DESCRIPTION AND OPERATION

Description - Switchyard - The switchyard system is shown on Figures 8-2 and 8-9.

The switchyard operates at 345 kV and is arranged to give maximum availability of the power system grid. The equipment is selected to have the capability of isolating system and substation faults with a minimum effect on stability of the power system grid.

The switchyard is designed in a breaker-and-one-half arrangement with two main buses and connections for the generator main power transformer, the Plant safeguard transformer, the Plant start-up transformers, the incoming line from the Covert Generating Plant and seven outgoing lines. Each line has sufficient capacity to carry the entire output of the main turbine generator.

The switchyard 345 kV power circuit breakers, the circuit from the switchyard to the generator main power transformer, the circuit for the safeguard transformer, and the circuit from the switchyard to the start-up transformers are provided with disconnect switches to permit isolating any power circuit breaker or any circuit from the switchyard buses. See Table 8-1 for ratings and construction of the switchyard components.

High-speed relaying is provided for the circuit from the switchyard to the generator main power transformer and for the two switchyard main buses ("F" bus and "R" bus). The "R" bus relaying includes the circuit from the switchyard to the start-up transformers. The "F" bus relaying includes the circuit to the safeguard transformer. The seven outgoing lines and the incoming line from the Covert Generating Plant are each provided with high-speed relays. In addition, all 345 kV power circuit breakers are provided with relays to trip all adjacent breakers for a failed breaker condition.

Trip of both main 345 kV Plant output circuit breakers in the switchyard activates a main turbine generator trip which indirectly trips the reactor via the Reactor Protective System loss-of-load reactor trip channels when the Plant is above 15% power (Subsection 7.2.3.6). The turbine trip output also feeds transfer schemes for fast transfer of Plant distribution busses to standby power sources. This output is blocked for each standby power source if it is unavailable as sensed by transformer undervoltage (see Section 8.6).

Description - Switchyard Control System - The 240 volt and 120 volt, 60 hertz and 125 volt dc switchyard power supplies are shown on Substation Single Line Diagram, Figure 8-9. 2,400 volt Buses 1C and 1E supply the switchyard control power through two 2,400-240/120 volt, 60 hertz switchyard power transformers. Each of the transformers supplies half the 240/120 volt, 60 hertz power requirements for the switchyard; however, either transformer can be connected to carry the total load via a bus tie breaker. The ac load is divided among four power panels; the loss of one power panel will not affect operation of the other three and hence will not jeopardize the total 240/120 volt, 60 hertz auxiliary power in the switchyard. The 345 kV power circuit breakers have enough air stored in their receivers to permit five breaker operations.

The 125 volt dc auxiliary power is supplied from a 60-cell battery which is located in the switchyard and can supply the switchyard dc power requirements for eight hours without recharging.

Two battery chargers are supplied to keep the battery fully charged and, under normal conditions, to supply the 125 volt dc power requirement. The battery circuit breaker can be used to isolate the battery from the dc power panels in event of a battery fault. The power panels can then be energized by either or both battery chargers. Each battery charger is fed from a separate 240 volt, 60 hertz power panel. The dc load is divided between two power panels; the loss of one power panel will not disrupt all the 125 volt dc auxiliary power in the switchyard.

Normal Operation - The switchyard normally operates energized with all breakers closed. The transmission line breakers are normally controlled remotely by the transmission system owner, and can be controlled locally from the switchyard relay house. The main generator breakers are normally controlled remotely from the Plant main control room; in an emergency, they can be controlled from the switchyard relay house. A supervisory panel in the Plant main control room monitors circuit breaker status.

Shutdown Operation - The switchyard furnishes power to the Plant whenever the turbine generator is not available.

Testing - The power circuit breakers may be removed from service and tested. Individual components and partial circuit tests may be carried out while the circuit breakers are carrying load.

The relays are supplied with test switches that will permit the removal of one relay or one set of relays from service for maintenance at any time. Because of the redundancy in the relay circuits, the power circuit will still be relay protected.

8.2.3 DESIGN ANALYSIS

The ratings of the 345 kV switchyard have been selected to ensure that the maximum expected fault duty is less than the rating of the equipment.

Reliability is assured by the arrangement of the switchyard which utilizes the breaker-and-one-half scheme. With this scheme, any breaker may be removed from service without affecting the operation of the switchyard.

The switchyard is arranged so that parallel outgoing overhead line circuits are connected to different bays and staggered with respect to buses. If a bay or bus has to be removed from service, only a partial loss of capacity occurs.

The seven transmission lines connecting the grid network to the switchyard and the incoming line from the Covert Generating Plant are routed on four double-line tower poles. Each of the four double-line poles is routed on separate rights of way so that no single event such as pole falling or line breaking can simultaneously affect all lines in such a way that none of the lines can be returned to service in time to prevent fuel design limits or design conditions of the reactor coolant pressure boundary from being exceeded. See Figure 2-2 for layout of the transmission lines in the vicinity of the Plant.

All circuits or portions of the buses and overhead lines have primary and backup relaying. The outgoing lines have three sets of high-speed relays. The circuit breakers have dual trip coils on separate dc control circuits, and breaker failure relays to trip the adjacent breakers. The two redundant control circuits will operate even with one set of relays out of service.

At power levels below 15%, a loss of load without generator trip, can be tolerated without subsequent reactor trip. Bypass of the turbine generator trip signal below 15% power allows for initial synchronization to the transmission grid. Also, since station electrical loads are not being fed from the main generator, Plant auxiliaries are not affected if the generator is separated from the switchyard.

Reliability of the control circuit supply is assured by two full-size transformers, each capable of carrying the total load, and one capable of being fed from a diesel generator.

In the terminology of 10 CFR 50, Appendix A, GDC 17, the three circuits connecting the switchyard to the onsite Class 1E power system consists of two immediate and one delayed access circuit. One immediate access circuit consists of a 345 kV to 2,400 volt safeguard transformer, 2,400 volt underground cable and 2,400 volt bus, and cable. The other immediate access circuit consists of an overhead 345 kV transmission line, 345 kV to 2,400 volt start-up transformer and 2,400 volt bus and cable. The delayed access circuit consists of one overhead 345 kV transmission line, 345 kV to 23 kV main transformer, 22 kV isophase bus duct, 24 kV to 2,400 volt station power transformer and 2,400 volt bus, bus duct and cable. Each of the immediate access circuits is connected directly to one of the main switchyard buses whereas the delayed access circuit is capable of being powered from either bus or directly by one of the six incoming lines from the grid.

The 2,400 volt cables associated with each immediate access circuit are routed in physically separated locations to the Class 1E onsite power system. The physical separation between these two routes is such that no single event can simultaneously affect both circuits in such a way that neither can be returned to service in time to prevent fuel design limits or design conditions of the reactor coolant pressure boundary from being exceeded.

The delayed access circuit is established by opening the motor-operated disconnect switch in the isophase bus at the main generator (to establish the main transformer backfeed mode of operation). In accordance with 10 CFR 50, Appendix A, General Design Criterion 17, this delayed circuit must be designed to be available in sufficient time, following a loss of all onsite ac power supplies and the other offsite immediate access circuit, to assure that specified acceptable fuel design limits and design conditions of the primary coolant pressure boundary are not exceeded. Without onsite ac power to operate its motor, the time required to open the isophase bus disconnect switch with a hand crank is less than 30 minutes. The dc battery system is designed to supply the required shutdown loads, with total loss of ac power, for at least 4 hours (see Subsection 8.4.2.3).

8.2.4 TRANSMISSION SYSTEM OWNERSHIP

In March 2002, Consumers Energy Company sold its wholly owned subsidiary, the Michigan Electric Transmission Company, Inc., to an independent owner. The new company, Michigan Electric Transmission Company, LLC, (METC) assumed ownership of the transmission system to which Palisades is connected, including the lines passing over the Palisades site and certain equipment in the Palisades Substation. Contractual agreements have been executed to assure that transmission system operation, maintenance, and modification activities are appropriately controlled, and that adequacy, availability and reliability of offsite power will continue to satisfy Palisades design and licensing basis.

8.3 STATION DISTRIBUTION

8.3.1 4,160 VOLT SYSTEM

8.3.1.1 Design Basis

The 4,160 volt system is designed to reliably function and supply power during normal, abnormal and accident conditions to the 4,160 volt station auxiliaries. The system will supply and distribute the 4,160 volt power for the primary coolant and the condensate pumps from either the station power or start-up transformers. Cooling tower 4,160 volt power is supplied normally from 1-3 station power transformer with backup power from the Start-Up Transformers 1-1 and 1-3.

8.3.1.2 Description and Operation

Description - The Plant's 4,160 volt system is shown on Figures 8-1 and 8-3.

The 4,160 volt system consists of Station Power Transformers 1-1 and 1-3, Start-Up (Standby) Transformers 1-1 and 1-3, four 4,160 volt Buses 1A, 1B, 1F, 1G and the incoming and motor feeder circuits.

The 4,160 volt system is divided into four sections. Buses 1A and 1B each supply two of the four primary coolant pumps and one of the two condensate pumps. Buses 1F and 1G each supply electrical load to one cooling tower.

The 4,160 volt buses consist of metal-clad switchgear with drawout circuit breakers. Wiring in the switchgear and system interconnecting cables pass the vertical flame resistance test in accordance with ASTM D470-59T. With the implementation of National Fire Protection Association (NFPA) 805, new cables must meet IEEE 383, or equivalent, flame test requirements. See Table 8-2 for ratings and construction of the 4,160 volt system components.

The 4,160 volt switchgear is provided with relay protection, grounding and the mechanical safeguards necessary to assure adequate personnel protection and to prevent or limit equipment damage during system fault conditions.

The 4,160 volt system has sufficient capacity to start and accelerate the largest motor when all other required motors are energized and carrying load.

Normal and Shutdown Operation - Power to Buses 1A, 1B, 1F and 1G during normal operation is furnished from the main generator via Station Power Transformers 1-1 and 1-3. During start-up or shutdown, power is furnished from the power system grid via the switchyard and Start-Up Transformers 1-1 and 1-3.

If the standby power source is not available, power may be furnished by the main transformer backfeeding the Plant auxiliary buses. This mode of operation is allowed during Plant shutdown.

After the main turbine generator is started, and when reactor power is approximately 20%, Buses 1A, 1B, 1F and 1G are manually transferred from the start-up transformers to the station power transformer. During normal operation, all 4,160 volt buses are energized.

Following a turbine trip, the 4,160 volt Buses 1A, 1B, 1F and 1G will automatically transfer to the standby source and auxiliaries will continue to run. If the trip is accompanied by a failure in the standby source, the turbine generator will supply power to the primary coolant pumps for 10 seconds which is controlled by a fixed timer (362/CD). Refer to Section 8.6 for 4,160 volt bus automatic fast transfer features.

When the main turbine generator is to be shut down, 4,160 volt Buses 1A, 1B, 1F and 1G are manually transferred to the start-up source. When the buses are transferred, loads continue to operate as required.

Operation of 4,160 volt equipment is effected and monitored in the control room. Breaker status is indicated by red and green indicating lights. Electrical parameters, such as bus voltage, supply voltage, incoming amperes and motor amperes, are displayed in the control room. Important functions, such as incoming breaker trip, motor breaker trip, bus undervoltage, and failure of bus transfer, are annunciated in the control room.

Provisions are included for testing relays. A faulty relay may be bypassed to permit operation of equipment.

Testing - Components may be tested when the system is de-energized. Testing of parts of the system can be performed when the system is in operation and carrying load. When individual equipment is shut down, breakers may be put into the test position and the control circuit may be functionally tested and the breaker exercised. Protective relays may be removed and tested. Standby equipment may be placed into service and running equipment shut down and, in this manner, components of the system may be tested.

8.3.1.3 Design Analysis

The ratings of the 4,160 volt system have been selected to ensure that the maximum expected fault duty is less than the rating of the switchgear.

The four Buses 1A, 1B, 1F, 1G load split permits part load operation on loss of one bus and also prevents a single fault from causing a loss of more than two primary coolant pumps. The 4,160 volt Buses 1A, 1B, 1F and 1G loads are normally supplied by the turbine generator but can be supplied by standby power. Additionally, Buses 1A and 1B can be supplied during initial turbine generator coastdown. During shutdown, after disconnecting the turbine generator, the Buses 1A, 1B, 1F and 1G loads can be supplied by the switchyard through the main transformer. The 4,160 volt loads are not required after a DBA.

8.3.2 2,400 VOLT SYSTEM

8.3.2.1 Design Basis

The 2,400 volt system is designed to reliably function and supply power during normal, abnormal and accident conditions. During start-up, normal operation and shutdown conditions, the system will supply power to the 2,400 volt auxiliary loads from either the offsite source through Safeguard Transformer 1-1, from offsite source through Start-Up Transformer 1-2, from the main generator through Station Power Transformer 1-2 or from the emergency diesel generators. Another source is available from the delayed access circuit through the main transformer and Station Power Transformer 1-2 when the unit is in a shutdown condition. Two of the four 2,400 volt buses are an integral part of the Plant engineered safeguards electrical system and are identified as Class 1E components. The engineered safeguard electrical system is designed to the two-channel concept wherein independent electrical controls and power systems supply redundant 2,400 volt engineered safeguard load groups. The 2,400 volt engineered safeguards electrical system meets the single failure criteria.

8.3.2.2 Description and Operation

Description - The Plant's 2,400 volt system is shown on Figures 8-1, 8-3 and 8-4.

The 2,400 volt system consists of Safeguard Transformer 1-1, Station Power Transformer 1-2, Start-Up Transformer 1-2, four ungrounded, delta connected 2,400 volt buses (1C, 1D, 1E and safeguard) and the feeder circuits to motors and 480 volt load centers.

2,400 volt Buses 1C, 1D and 1E have access to the following power sources:

1. Two immediate access circuits connected to independent offsite power sources.

2. One onsite power source (main generator).

3. One delayed access circuit.

The engineered safeguard electrical system also has access to the emergency diesel generator and the supplemental diesel generator (see Section 8.4).

The first immediate access circuit consists of a 345 kV to 2,400 volt transformer (Safeguards Transformer 1-1) located in the switchyard. The high side of this transformer is connected to the "F" switchyard bus through a motor-operated disconnect switch. The low side of the transformer is connected to the Safeguard Bus located within a Non-Class 1E switchgear house located within the Plant protected area. Connections between the transformer and switchgear house are provided via direct buried cable along the route between the switchyard and protected area. This cable is buried beneath the towers carrying the other immediate and delayed access circuits to provide for physical separation. The Safeguard Bus is provided to allow for selection of this immediate access circuit or Station Power Transformer 1-2 as the source of power to the 2,400 volt buses.

The second immediate access circuit consists of a 345 kV transmission line between the switchyard and plant site and a 345 kV to 2,400 volt transformer (Start-Up Transformer 1-2) located within the Plant protected area. The high side of this transformer is connected to the "R" switchyard bus through a motor-operated disconnect switch. The low side of the transformer is connected directly to the 2,400 volt bus incoming breakers.

The onsite power source consists of the main turbine generator, the 22 kV isophase bus and the 21 kV to 2,400 volt Station Power Transformer 1-2. The low side of the 2,400 volt transformer is connected to the Safeguard Bus via an enclosed bus duct. The Safeguard Bus also provides for connections to the first immediate access circuit and allows for selection of the first immediate access circuit or the onsite power source as the source of power to the 2,400 volt buses.

The delayed access circuit consists of one 345 kV transmission line, the 345 kV to 23 kV Main Transformer, the 22 kV isophase bus and the 21 kV to 2,400 volt Station Power Transformer 1-2. The low side of the 2,400 volt transformer is connected to the Safeguard Bus via an enclosed bus.

The Safeguard Bus also provides for connection to the first immediate access circuit and allows for selection of the first immediate access circuit or the delayed access circuit as the source of power to the 2,400 volt buses. Switchyard power via the delayed access circuit can be provided from either of the two switchyard buses. Power can also be provided directly from the grid via the transmission system interconnection with the American Electric Power Co (Segreto Line 1). The delayed access circuit is established by opening the motor-operated disconnect switch in the isophase bus. This switch can be opened within 30 minutes. Opening the switch allows for backfeeding via the main and station power transformers following the operation of other switchyard and in-plant breakers.

The capabilities of the 2,400 volt buses are sufficient to permit Plant operation under reduced load with any 2,400 volt bus out of service. See Table 8-3 for ratings and construction of the 2,400 volt system components.

The 2,400 volt buses consist of metal-clad switchgear with drawout circuit breakers. Wiring in the switchgear and system interconnecting cables pass the vertical flame resistance test in accordance with ASTM D470-59T. With the implementation of NFPA 805, new cables must meet IEEE 383, or equivalent, flame test requirements.

The 2,400 volt switchgear is provided with relay protection, grounding alarm and the mechanical safeguards necessary to assure adequate personnel protection and to prevent or limit equipment failure during system fault conditions. Single grounds will not impede operation of the system.

The 2,400 volt system has sufficient capacity to start and accelerate the largest motor when all other required motors are energized and carrying load.

Two of the 2,400 volt buses, 1C and 1D, supply power to engineered safeguards loads in addition to normal Plant loads and are part of the engineered safeguards electrical system. These engineered safeguards system 2,400 volt buses are designed to withstand Consumers Design Class 1 seismic acceleration forces per Section 5.7 without malfunction.

The engineered safeguards electrical system is divided into two channels so that multiple pieces of equipment with a common function are fed from opposite channels.

A separate emergency diesel generator supplies each of the emergency 2,400 volt buses (1C and 1D) and each bus supplies redundant equipment or loads consistent with the two-channel power concept.

The emergency buses are physically separated by being located in separate rooms within the Consumers Design Class 1 portions of the auxiliary building. Separation is maintained between the circuits of the two buses.

Electrical feeder cables from the emergency generators to the emergency buses and safeguards equipment motors are installed within the Consumers Design Class 1 portion of the auxiliary building or in underground ducts.

Normal and Shutdown Operation - Power to 2,400 volt Buses 1C, 1D and 1E during start-up, normal and shutdown operation is normally provided via the first immediate access circuit (Safeguard Transformer 1-1) powered from the switchyard "F" bus. Upon loss of this circuit, a fast transfer is provided to the second immediate access circuit (Start-Up Transformer 1-2) powered by the switchyard "R" bus. Refer to Section 8.6 for 2,400 volt bus automatic fast transfer features. Upon loss of both immediate access offsite power sources, the 2,400 volt Buses 1C and 1D are energized from the diesel generators. Bus load shedding, transfer to the diesel generator and energization of critical loads are performed automatically. Refer to Section 8.6 for 2,400 volt bus load shedding control.

With Safeguard Transformer 1-1 out of service, capability is provided to connect the 2,400 volt buses to the main generator via Station Power Transformer 1-2. When connected to Station Power Transformer 1-2, a reactor and/or generator trip will initiate a fast transfer to the second immediate access circuit (Start-Up Transformer 1-2).

In the event that both immediate access circuits are out of service, power may be provided by the main transformer backfeeding the Plant 2,400 volt buses. This mode of operation is allowed during plant shutdown.

Operation of 2,400 volt equipment is normally effected and monitored in the control room. Breaker status is indicated by red and green indicating lights. 2,400 volt breakers on Buses 1C and 1D are also capable of being controlled from the switchgear. Breaker 152-311, feeder to the Service Building Expansion, is not controlled or monitored in the Control Room.

Breakers 152-103, 107, 108 and 110 have special remote/local isolation switches to allow control in the event of fire in certain areas of the Plant. These switches are provided to ensure operability of safe and stable conditions equipment per 10 CFR 50.48 and NFPA 805. Post-fire safe and stable capability is further enhanced by a remote/local switch provided for Breaker 152-106 which facilitates control of startup power (where available) to Bus 1C.

Important control circuits, such as bus transfer and load shedding, have white indicating lights to show circuit availability. Undervoltage relays initiate an alarm upon loss of potential. Electrical parameters, such as bus voltage, supply voltage, bus amperes and motor amperes, are displayed in the control room. Important functions, such as incoming breaker trip, motor breaker trip, bus undervoltage, bus ground, loss of incoming breaker 125 volt dc control voltage, and failure of bus transfer, are annunciated in the control room.

Provisions are included for testing relays. A faulty relay may be bypassed to permit operation of equipment.

Testing - Components may be tested when the system is de-energized. Testing of parts of the system can be performed when the system is in operation. When individual equipment is shut down, breakers may be put into the test position and the control circuit may be functionally tested and the breaker exercised. Protective relays may be removed and tested. Standby equipment may be placed in service after which the running equipment may be shut down and the breaker tested as above. In this manner, components of the system may be tested.

8.3.2.3 Design Analysis

The ratings of the 2,400 volt system have been selected to ensure that the maximum expected fault duty is less than the rating of the switchgear.

Three buses (1C, 1D and 1E) permit part load operation on loss of one bus. The engineered safeguards loads can be supplied by the offsite power source, emergency diesel power, supplemental diesel power or from the switchyard through the main transformer after disconnecting the turbine generator.

To assure reliability, vital 2,400 volt Buses 1C and 1D obtain control power from separate dc sources. Incoming and feeder breakers on the 1C bus receive control power from Station Battery D01 via breakers in Panel D-11A. Station Battery D02 via Panel D-21A supplies control power for incoming and feeder breakers on Bus 1D. These dc sources are physically isolated to preclude any event affecting the integrity of both sources. The breakers on the Safeguard Bus receive control power from dc Panel D-21. D-21 can be powered from Station Battery D02 and/or the associated battery chargers.

8.3.3 480 VOLT SYSTEM

8.3.3.1 Design Basis

The in-plant 480 volt system is designed to reliably function and supply power during normal, abnormal and accident conditions. Four load centers and eight motor control centers are an integral part of the Plant engineered safeguards electrical system and are identified as Class 1E components. The system is designed to the two-channel concept wherein independent electrical controls and power systems supply redundant 480 volt engineered safeguards load groups. The 480 volt engineered safeguards auxiliary power system meets the single failure criterion.

The cooling tower 480 volt system is designed such that equipment for each tower is normally fed from separate 4,160 volt sources. Partial or complete failure of 480 volt supply to either cooling tower will not affect the other.

8.3.3.2 Description and Operation

Description - The Plant 480 volt system is shown on Figures 8-5 and 8-6, Single Line Meter and Relay Diagrams, 480 Volt Load Centers and Motor Control Centers.

The in-plant 480 volt system is divided into load center buses and motor control centers. Power for each (except one) load center bus is supplied from a separate 2,400-480 volt station service transformer. The transformers fed from the 2,400 volt system are arranged so that each transformer of a double-ended load center unit is fed from a different 2,400 volt bus. Load center Bus 17 is fed from 4,160 volt Bus 1A through a 4,160-480 volt station service transformer.

The cooling tower 480 volt system shown on Figure 8-5 is divided into load center buses. Power for each load center bus is supplied from a separate 4,160-480 volt station service transformer.

Power for the motor control centers is supplied from the load center buses.

Station Power Transformers 11, 12, 19 and 20, corresponding Load Centers and Motor Control Centers 1, 2, 21, 22, 23, 24, 25 and 26 are an integral part of the engineered safeguards electrical system. This equipment is arranged into two channels so that multiple pieces of equipment with a common function are fed from opposite channels. The capacities of the station power transformers and the 480 volt bus tie breakers for Load Centers 11 and 12 are sufficient to permit Plant operation with one transformer out of service for the length of time specified by Technical Specifications. During a bus tie between LC11 and LC12 the total combined load on LC11 and LC12 must be controlled such that it does not exceed the rating of the transformer remaining in service.

The 480 volt buses consist of metal-enclosed drip proof switchgear with drawout circuit breakers. The motor control centers are NEMA 1 enclosures with drip hoods installed on the majority of the equipment. Drip hoods/shields were not installed on Motor Control Centers 1 and 2 because of space limitation. As an alternative, the metal seams at the top of these motor control centers were sealed with RTV sealant to make them waterproof from the fire sprinklers. Wiring in the switchgear and motor control centers and system interconnecting cables pass the vertical flame resistance test in accordance with ASTM D470-59T or IPCEA S-61-402, Section 6.5. With the implementation of NFPA 805, new cables must meet IEEE 383, or equivalent, flame test requirements. See Table 8-4 for ratings and construction of the 480 volt system components.

The 480 volt switchgear and the motor control centers supplying engineered safeguards loads are designed to withstand Consumers Design Class 1 seismic acceleration forces per Section 5.7 without malfunction.

The 480 volt load centers and motor control centers are solidly grounded Y connected and are provided with the mechanical safeguards necessary to assure personnel protection and to prevent or limit equipment damage during system fault or overload conditions.

The 480 volt load center breakers are equipped with thermal magnetic or solid state trip devices. Motor control centers are equipped with thermal magnetic breakers for nonmotor loads, and magnetic breakers and starters with thermal protection for the motor circuits.

The 480 volt system has sufficient capacity to start and accelerate the largest motor when all other required motors on the system are energized and carrying load.

Starters in the 480 volt motor control centers assigned to engineered safeguards loads may be controlled from the control room, from local panels, or both. Status of these starters may be indicated by lights in the control room, at the local panels, or both. Other starters may be controlled at the motor control centers or at local panels. Motor overload condition for selected critical loads is annunciated in the control room.

The 480 volt engineered safeguards electrical system is installed in Consumers Design Class 1 portions of the auxiliary building.

Normal Operation - During normal operation, in-plant 480 volt power is supplied from the 2,400 and 4,160 volt systems. Following a turbine trip, 480 volt loads will continue to run from the 2,400 volt system, and from the 4,160 volt system following transfer to the Start-Up Transformers.

Operation of some of the 480 volt equipment is monitored in the control room. Status of some of the breakers is indicated by lights in the control room.

During normal operation, incoming bus breakers and motor control center feeder breakers are closed and bus tie breakers are open. The status of these breakers will be changed only for emergency or maintenance.

Loss of Offsite Power - If the offsite sources fail, cooling tower and nonessential loads will be shed. Load Centers 11, 12, 19 and 20 and Motor Control Centers 1, 2, 21, 22, 23, 24, 25 and 26, supplying engineered safeguards loads, are not shed and the essential loads will be supplied by the emergency generators through the 2,400 volt buses as described in Subsection 8.3.2.

After load shedding, the remaining in-plant load centers and motor control centers, which are not included in the engineered safeguards system, may be energized manually to serve loads which are not critical.

Shutdown Operation - No change in status of the incoming bus breakers and tie breakers is required during shutdown. Other breakers and the motor starters are operated manually or automatically as required by the shutdown sequence.

Operation After Loss of Coolant Accident - A Loss of Coolant Accident affects the 480 volt in-plant system only if accompanied by loss of offsite power in which case all loads except the engineered safeguards load centers and motor control centers are shed automatically. Upon return of power to 2,400 volt Buses 1C and 1D, additional 480 volt loads may be energized manually by the operator. Fuses are provided for containment electrical penetration overcurrent backup protection for circuit breakers in the MCC starters feeding submerged equipment not de-energized following a Loss of Coolant Accident (LOCA) and also to ensure that the operation of upstream protection does not lead to interruption of the power supply to other safety-related equipment. Fuses are provided for electrical penetration backup protection in motor starters and 120 V ac control circuits to protect electrical penetrations against damage by overcurrent. Since MCC 9 is located within the containment, a backup circuit breaker has been provided in the feeder to this motor control center.

Testing - The individual components of the 480 volt system may be functionally tested at any time. Idle loads may be energized, then de-energized, to exercise starters and breakers and to functionally test the control circuits. Those loads which may not be stopped momentarily must be replaced by standby equipment during testing. The 480 volt load center circuit breakers may be placed in the test position if energization of equipment is not desired.

8.3.3.3 <u>Design Analysis</u>

The ratings of the 480 volt system have been selected to ensure that the maximum expected fault duty is less than the rating of the switchgear.

The 480 volt buses which are part of the engineered safeguards system are installed in Consumers Design Class 1 portions of the auxiliary building.

8.3.4 CONTROL ROD DRIVE POWER

8.3.4.1 <u>Design Basis</u>

The control rod drive power system is designed as a stable, reliable supply for the control rod drive motors.

8.3.4.2 Description and Operation

Two 480-120 volt, single phase, 60 hertz transformers furnish power for the Control Rod Drive System. Selection of the transformer is made through a transfer switch on the 120 volt side. The rod drive motors are supplied through individual contactors located in the contactor panel and are controlled from the control room.

Each transformer is supplied from a manually controlled circuit breaker in a different motor control center. The motor control centers are supplied with power from 480 volt load centers and arranged so that the power for each is fed from a different 2,400 volt bus.

Loss of control rod drive power does not affect the rod position. Loss of power is annunciated in the control room.

8.3.4.3 Design Analysis

Each transformer is conservatively rated. To assure reliability, the transformers are supplied from separate buses, each of which can be supplied by a separate emergency generator. Upon loss of one transformer, the other transformer may be manually placed in service to supply power to the rod drives. A loss of both transformers will not prevent a safe shutdown since the rods may be inserted by de-energizing the clutches which release the rods.

8.3.5 DC AND PREFERRED AC SYSTEMS

8.3.5.1 Design Basis

The dc and preferred ac systems are designed to furnish continuous power to the Plant instrumentation and control systems. The power supply is continuous even during disturbances in the auxiliary electrical system. The reliability of the system is assured by duplication of vital equipment and circuits; ie, dual circuits for identical purposes are supplied from alternate buses and either circuit can initiate the safety function required.

8.3.5.2 Description and Operation

Description - General - The 125 volt dc and 120 volt preferred ac systems are shown on Single Line Meter and Relay Diagram, Figure 8-7. Equipment is designed to withstand Consumers Design Class 1 seismic acceleration forces as described in Section 5.7 without malfunction. Equipment is provided with fuse protection, grounding and the mechanical safeguards necessary to assure adequate personnel protection and to prevent or limit equipment failure during system fault conditions. See Table 8-5 for ratings and construction of the dc and preferred ac system components.

125 volt dc and 120 volt ac circuits going inside the containment to equipment susceptible to be submerged during a Loss of Coolant Accident have been provided with backup overcurrent protection, when required, to ensure the integrity of the containment electrical penetrations.

The systems are located in Consumers Design Class 1 portions of the auxiliary building.

DC System - The 125 volt dc system is divided into two independent and isolated systems.

Each system consists of a battery, switchgear, distribution panel, two chargers and instrumentation as shown on Figure 8-7. The switchgear bus consists of two sections, each of which can be fed by a battery charger. Power to switchgear and the distribution panels is supplied by the station batteries and/or the battery chargers. Protection of the dc cabling in the case of a fire emergency is provided by separate dc distribution panels located in areas allowing emergency shutdown. The following design features assure the availability of 125 volt dc power for the operation of Diesel Generators 1-1 and 1-2, 2,400 volt Buses 1C and 1D, nonsafeguards Buses 13 and 14 and the Auxiliary Shutdown Control Panel C150 in the event a fire damages 125 volt dc distribution equipment in the cable spreading room (see Figure 8-8).

1. Fuses between each battery and its bus are located in their respective battery rooms.

2. In each battery room, a nonautomatic circuit breaker with a shunt trip is provided in the circuit between the battery fuse and its bus. The shunt trip device of these circuit breakers is a trip coil that is energized by battery voltage via the 125 volt dc distribution panel. The nonautomatic circuit breakers were specified for use in 125 volt dc systems and for a steady-state load of 400 amperes. They are qualified per IEEE 323-1974 and IEEE 344-1975. They do not contain fault detectors and are not intended to interrupt fault currents although they have that capability. They are manually operated open or close with the capability of being opened remotely via the shunt trip device.

   If the shunt trip push button is closed inadvertently, the battery will be separated from the principal 125 volt dc bus. An undervoltage relay has been installed on the battery and will detect the separation of the battery from its charging source. Operation of the relay is annunciated in the control room (see later "System Monitoring" description).

3. Distribution panels are provided in Switchgear Room 1-C and Diesel Generator 1-2 room connected to their respective batteries with a fuse located in the applicable battery room. Each distribution panel contains a push button for energizing the shunt trip of the above-mentioned circuit breaker.

4. From each of the distribution panels, circuits for operating and control power are provided for the corresponding diesel generator and 2,400 volt bus with routing avoiding the cable spreading room and the diesel generator and switchgear rooms of the other channel. In addition, the distribution panel serving 2,400 volt Switchgear Bus 1-C supplies the Auxiliary Hot Shutdown Control Panel C-150 and nonsafeguards 480 volt Buses 13 and 14.

The chargers are of the solid-state type. They have provision for two charge rates, one for floating and one for equalizing the battery. The chargers are provided with filters and surge protection to enable either charger to supply the dc loads including the operation of 2,400 volt circuit breakers with the battery disconnected. The two chargers on each 125 volt dc bus are fed from separate 480 volt motor control centers. The motor control centers are supplied with power from 480 volt load centers and arranged so that the power for each is fed from a different 2,400 volt emergency bus. Administrative controls limit the operation such that only one charger per battery is in service. This removes the possibility of a common mode failure affecting both emergency buses. The battery charger cabinets were specified to operate at a design ambient temperature of 104°F.

Both dc systems are ungrounded and are equipped with ground detectors for continuous monitoring. Monitoring is also provided on other important system parameters, such as bus voltage and current. Abnormal conditions are annunciated in the control room.

Preferred AC System - The 120 volt preferred ac system has four separate buses to provide power for the four separate Reactor Protective System channels. Each bus is supplied by an inverter which is, connected to a dc bus section. Each dc bus section also has one battery charger connected. Each inverter, one at a time, can be manually bypassed and its preferred ac bus supplied from the instrument ac panel via a bypass regulator. The preferred ac buses operate ungrounded and are equipped with ground detectors. Specific safety systems, such as the RPS neutron flux monitoring power supplies (Chapter 7), have separate floating grounds.

The preferred AC inverter cabinets were specified to operate at a design ambient temperature of 104°F.

In order to comply with the electrical isolation requirements of IEEE 384, Regulatory Guide 1.75 and Regulatory Guide 1.6, the bypass regulator output breakers are interlocked to preclude supplying more than one preferred ac bus at a time. The interlock scheme has a key lock on each output breaker. The four breaker locks utilize a single key which is maintained by the shift supervisor. The key must be inserted in the desired breaker locking device before that breaker can be closed, and with a breaker closed the key cannot be removed. Therefore, only one breaker can be closed at a time.

The bypass regulator is not fed from an uninterruptible supply. On a loss of offsite power, it will not power the connected AC bus. The AC bus will be dead for the ten seconds required for diesel generator starting (when the power is restored to the bypass regulator). This delay has been analyzed in the appropriate Chapter 14 events. What hasn't been analyzed is the additional delay that the sequencers take through an initialization routine. Because of this and other functions that are lost with loss of preferred AC power, the Technical Specifications limit the time that the bypass regulator may supply power to a preferred AC bus. A Technical Specification action statement applies if a preferred AC inverter is inoperable.

Normal Operation - During normal operation, both sections of each dc bus are interconnected by a nonautomatic breaker. This ties together two inverters, one charger and one battery to the same bus, the second battery charger being left in standby. The battery on each bus is kept fully charged, floating at approximately 131 volts. The connected battery charger supplies the dc loads including the two inverters which, in turn, feed one preferred ac bus each.

Periodically, the charger voltage is raised to approximately 138 volts for battery equalizing.

Operation of circuit breakers in the dc and the preferred ac systems is manual with automatic trip for fault isolation. Tie breakers between the left and right sections of each dc switchgear bus and the battery isolation shunt trip breakers do not have an automatic trip for fault isolation.

Emergency Operation - On loss of normal and standby ac power, dc loads will be supplied from the station battery. The normal dc loads will increase since there will be additional annunciators and additional loads, such as emergency lighting and oil lift pumps, required for primary coolant pump coastdown added to the battery load as a result of ac power failure. Aside from these steady loads, some intermittent dc power for breaker operation will be required. As soon as one of the diesel generators has started and is ready for loading, a battery charger will automatically resume operation and support the battery.

Testing - A test push button is provided at the dc control center to check the operation of the dc emergency lights. Testing of the batteries is described in Subsection 8.4.2.2.

System Monitoring - The dc and preferred ac power systems (ie, chargers, inverters, batteries and breakers) are controlled locally. In accordance with IEEE 308-1978, Paragraph 7.1.2, the operational status information is displayed locally (see Figure 8-7). The dc bus monitoring devices consist of:

1. Battery voltage (voltmeter); one per battery,

2. Battery current (ammeter - charge/discharge); one per battery,

3. Battery charger output current (ammeter); one per charger,

4. Battery charger output voltage (voltmeter); one per charger,

5. DC bus voltage (voltmeter); one per bus,

6. DC bus ground current detector (milliammeter); one per bus, and

7. DC bus average ground current (recorder); one per bus.

The above indications are centrally located. Items 3 and 4 are located on the charger's front cabinet door. The remaining items are located on metering panels which are installed within approximately ten feet of the charger.

In accordance with IEEE 308-1978, Paragraph 7.1.3, IEEE 279-1971, Paragraph 4.13 and Part C of Regulatory Guide 1.47, administrative procedures and automatic control room displays are also available. These procedures and displays provide the operator a complete and timely indication of system protective actions and system unavailability (such as deliberate actions to render inoperable a component of the dc power system).

Three control room annunciations are provided to alert the operator of dc power system unavailability. The first annunciation is for dc bus undervoltage or trouble. "125 Volt DC Bus Undervoltage/Trouble" alarm annunciates upon the following inputs:

1. 125 volt dc bus tie breaker open (either bus),

2. PA system inverter undervoltage (Bus D10 only),

3. Battery undervoltage (either battery), and

4. 125 volt dc bus undervoltage (either bus).

Alarm Input 1 results from a tie breaker position switch installed on both Bus D10 and D20 tie breakers. Should either (or both) tie breakers be opened, the position switch "a" contacts will energize an auxiliary relay to effect both a control room and a local annunciation.

Alarm Input 2 results from an undervoltage relay installed to monitor the input of the public address system inverter. Should this relay sense an undervoltage condition, both a control room and a local alarm will occur.

Alarm Input 3 results from an undervoltage relay installed between the battery and the battery's downstream fused disconnect. Two relays are installed, one for each battery (see Figure 8-7). The undervoltage relays inform the control room operator whenever the batteries are disconnected from the chargers (eg, the charger feeder breakers or the battery disconnects are open). The undervoltage alarm set point was chosen below the battery's normal "float" voltage on the charger and above the battery's voltage when disconnected from its charger. By providing a control room and local alarm at this set point, the operator is alerted to a system unavailability condition in a timely manner.

Alarm Input 4 is the bus undervoltage function indicating low voltage with regard to the dc loads.

Inputs to the control room alarm also provide a local alarm. Upon control room annunciation, an operator can be dispatched locally to determine which of the four inputs for dc bus undervoltage/trouble provided the alarm and on which dc system the problem has occurred; ie, Bus System D10 or Bus System D20. A local annunciation relay is provided for each system. Each relay indicates locally which alarm input caused the control room annunciation.

The second annunciation is for battery charger trouble. This control room alarm will occur if a local alarm for low DC voltage, high DC voltage, charger failure or over temperature actuates on any one of the four chargers. Upon receiving the alarm, an operator can be dispatched to the battery chargers to determine which charger is affected.

The third control room annunciation is for dc bus ground. Should the bus-to-ground current (milliamperes) on either bus exceed a predetermined set point, a control room alarm will be energized. At this point, an operator can be dispatched to the local metering panels to determine which bus is grounded by utilizing the local milliammeters.

The following alarms and indicators are associated with the 120 volt ac preferred power panels:

1. Preferred AC bus trouble - common control room alarm (one per bus) from various inputs which each have a local alarm:

   -DC Input Overvoltage
   -DC Input Undervoltage
   -Inverter Failure
   -Over Temperature
   -Line to Ground

2. Local indication on each inverter for DC input and AC output current, voltage and frequency.

8.3.5.3 <u>Design Analysis</u>

Normal Operation - During normal operating conditions, the loading of both the dc and the preferred ac systems is much lower than the capacity of the system. Each of the two battery chargers provided on the dc bus is capable of supplying the normal dc loads on the bus and simultaneously recharging the battery in a reasonable time. A fully discharged battery can be recharged in less than 13 hours by using two chargers.

Emergency Operation - Complete loss of all ac power analysis is given in Subsection 8.4.2.3.

In order to meet IEEE 308-1978, Paragraph 7.1.3 requirements, the control room features an assortment of dc power system alarms (ie, "Battery Chargers Trouble," "125 Volt DC Bus Ground," "125 Volt DC Bus Undervoltage/ Trouble" and "Preferred AC Bus Trouble"). The proper combination of these alarms will alert the operator of most conceivable malfunctions, misalignments or maladjustments which might occur to render any part of the system inoperable. Upon being alerted, the control room can dispatch an operator locally to specifically determine what the problem is and what system components may be affected.

8.3.6 INSTRUMENT AC SYSTEM

8.3.6.1 Design Basis

The 120 volt instrument ac system is designed to furnish reliable power to the Plant instruments other than those supplied from the dc and the preferred ac systems.

8.3.6.2 Description and Operation

Description - The instrument ac system is supplied by two three-phase transformers from Motor Control Centers 1 and 2 as shown on Figure 8-7. Both Motor Control Centers are automatically supplied by emergency generators upon loss of offsite power. An automatic transfer switch is provided to transfer supply to the instrument ac panel between the two power sources.

Panel breakers are equipped with thermal magnetic trip elements. The neutral of the instrument ac system is grounded. This system can only furnish power to one of the preferred ac buses at a time through a bypass regulator.

Operation - During normal operation, power is supplied to the instrument ac bus from Motor Control Center 1. Should the power fail from that source, the panel supply will automatically be transferred to Motor Control Center 2. When power to Motor Control Center 1 is restored, the panel supply will automatically transfer back. Transfer in either direction may be made manually.

8.3.6.3 Design Analysis

Each of the two instrument ac transformers is sized to supply the panel load and one preferred ac panel bus via the bypass regulator.

Testing - The operation of the transfer switch may be checked at any time without affecting Plant operation.

8.4 EMERGENCY POWER SOURCES

The emergency power sources are designed to furnish onsite power to reliably shut down the Plant and maintain it in a safe shutdown condition under all conditions, including DBA, upon loss of normal and standby power. The emergency power sources are part of the engineered safeguards electrical system and are identified as Class 1E systems. Reliability is assured by the two-channel concept wherein independent electrical controls and sources supply redundant ac and dc engineered safeguards loads.

8.4.1 EMERGENCY GENERATORS

8.4.1.1 Design Basis

The emergency generators are designed to provide a dependable onsite power source capable of starting and supplying the essential loads to safely shut down the Plant and maintain it in a safe shutdown condition under all conditions. The reliability of this onsite power is provided by its duplication wherein each emergency generator supplies redundant loads and each is capable of providing power to the minimum necessary safeguards equipment.

8.4.1.2 Description and Operation

Description - There are two emergency diesel engine-driven generators of equal size. The generators have static-type excitation and are provided with field flashing for quick voltage buildup. Each generator is connected via a generator breaker to a separate 2,400 volt bus. The generator breaker control is shown on Logic Diagram Figure 7-14. Synchronizing equipment is provided to permit connecting the generator to the 2,400 volt bus for parallel operation with the onsite or offsite power sources during testing of the emergency generators. The synchronizing equipment is automatically bypassed by breaker position interlocks to permit manual and automatic closing of the emergency generator breaker on a dead bus. The four 2,400 volt bus safeguard/station power and start-up transformer incoming breakers are interlocked to prevent automatic closing when the associated emergency generator breaker is closed. The incoming breakers can be closed manually only by using synchronizing equipment when the associated emergency generator breaker is closed.

Support systems associated with each diesel generator include a fuel oil system, air starting system, lube oil system, jacket water system, crankcase exhauster, two starting circuits and a load sequencer (see Figure 8-11). Supply of electric power for these systems is obtained from the generator they are supporting. Each system is located in a separate room from its redundant counterpart, except for the load sequencers which are located separate from one another in the main control room.

The diesel engines are designed for air start and a separate compressor and receiver are provided for each engine. There are two receivers and two air-start motors per engine. Sufficient air is available in the air receiver tanks for nominally 24.3 seconds of engine cranking time. A separate fuel oil day tank is also provided for each engine. The diesel engines, fuel oil systems and air start systems are equipped with instrumentation to monitor important parameters and annunciate abnormal conditions. Water and oil heaters are provided to maintain the engines in "start" readiness.

The emergency generators are equipped with the mechanical and electrical safeguards necessary to assure personnel protection and to prevent or limit equipment damage during operation or fault and overload conditions. The generators and their 2,400 volt breakers have overcurrent and differential protection. Wiring passes the vertical flame resistance test in accordance with IPCEA S-28-357, Paragraph 3.4. With the implementation of National Fire Protection Association (NFPA) 805, new cables must meet IEEE 383, or equivalent, flame test requirements.

The emergency diesel generators and their auxiliaries are designed to withstand CP Co Design Class 1 seismic acceleration forces per Section 5.7 without malfunction. The emergency diesel generators and their auxiliaries, except for the fuel oil transfer system, are installed in a CP Co Design Class 1 portion of the auxiliary building and the units are separated by a wall.

Each emergency generator supplies a separate 2,400 volt bus and a redundant group of engineered safeguards consistent with the two-channel power concept.

Diesel generator reliability is targeted at 0.95. This level is to be maintained by a Diesel Generator Reliability Program in response to commitments made by CP Co March 27, 1990 in regard to Station Blackout Rule 10 CFR 50.63 (Reference 10).

Diesel Generator Control Circuits - Physical separation and electrical isolation are maintained between the control circuits for the two diesel generators. The automatic start circuits are initiated by bus undervoltage. The control circuits, in addition to the "automatic" functions, are arranged for manual start-stop at the diesel and in the control room. The controls for the governor, voltage regulator, synchronizing and for the generator breaker are located in the control room. The governor and voltage regulator also have local controls in the diesel generator room.

Normal Operation - As shown on Figure 7-14, Diesel Generator 1-1 will start when an undervoltage is sensed on 2400 Volt Bus 1C and Diesel Generator 1-2 will start when an undervoltage is sensed on 2400 Volt Bus 1D. Section 8.6 provides additional details on undervoltage starting.

When the Plant is operating normally, the diesels may be started, synchronized with the 2,400 volt buses and loaded.

The status of the emergency generators is monitored in the control room. Important functions are annunciated in the control room.

The diesel generators may be started and shut down locally or from the control room.

Shutdown Operation - During shutdown operation, the emergency diesel generators will supply power only if the offsite power source fails. At this time, the automatic features will govern and normal shutdown sequencers will sequentially load the generators.

If the emergency generators fail to start, the Plant auxiliaries can be fed via the main transformer in a backfeed mode. Refer to Subsection 8.2.3 for discussion of backfeed.

Operation After Loss of Coolant Accident - The emergency generators are required to supply power only if the offsite power source fails. At this time, the automatic features will govern and DBA sequencers will sequentially load the diesels.

Operations During or After Fire - The 1-1 emergency diesel generator has three remote/local isolation switches (one for the output breaker and two for the diesel generator) to allow control in the event of fire in some plant fire areas . These switches are intended to ensure operability of safe and stable conditions equipment per 10 CFR 50.48 and NFPA 805. The 1-2 emergency diesel generator does not have remote/local isolation switches, but operability after a fire in some areas could be restored by operation of slide links in the control circuitry. Operation of these slide links is not required by the NFPA 805 Nuclear Safety Capability Assessment. However, the Appendix R, Safe Shutdown Analysis does credit operation of the 1-2 emergency diesel generator for fires in other areas that would not require operation of the slide links. Operation of the switches or slide links is governed by Abnormal Operating Procedures (AOPs).

Testing - Automatic start and load sequencing of the emergency generators are tested as part of the safety injection testing. For details see Subsection 7.3.5. The emergency generators' start-up may be manually tested at any time to verify that the generator is ready for loading within 10 seconds and that it achieves acceptable steady state voltage and frequency. Acceptable voltage is within the rating of the generator, and acceptable frequency is such that flowrate through the safeguards pumps is within the margins of the accident analyses. To verify load acceptance by the generator, the emergency generator breaker is closed manually and the engine loaded onto the 2,400 volt bus for parallel operation with the onsite or offsite power source. Testing of load rejection and peak accident loading is also performed. Refer to Technical Specifications for further details.

8.4.1.3 Design Analysis

The emergency generators have been selected to have sufficient capacity to supply the minimum necessary engineered safeguards loads with only one generator operating. In addition, each generator has enough reserve capacity (margin) to start and carry the two largest engineered safeguards loads simultaneously.

To assure reliability, each emergency generator has two starting/control circuits, one for each of the two separate air starting motors. Although each starting circuit will initiate generator field flashing, the power for field flashing is provided from only the “B” circuit. Each engine's two starting/control circuits are powered from that engine's respective 125 VDC battery-backed channel, and are independent from the opposite diesel engine's two starting/control circuits. Each diesel engine's two starting/control circuits are actuated by redundant automatic start command signals. Physical separation is maintained between the two emergency generator units and their associated controls.

Each emergency generator and diesel engine is provided with several alarms, interlocks and trips. Each engine may be started and placed in service locally or from the control room. The generators may be synchronized from the control room so that they can be paralleled with the system for loading tests. Each diesel is located in a separate room as is shown on Figure 1-3. Each room has separate access doors.

Local alarms at each diesel are:

- Prelube Oil Pump Failure
- Low Lube Oil Pressure
- High Lube Oil Temperature
- Low Lube Oil Temperature
- High Lube Oil Filter Differential Pressure
- High/Low Jacket Water Temperature
- Low Jacket Water Level
- Low Raw Water Pressure
- Overspeed
- Low Air Pressure
- Overcrank
- Low Lube Oil Level
- Engine Trouble
- High/Low Fuel Level
- Low Jacket Water Pressure
- Bus 1C (1D) Overcurrent Lockout
- Crankcase Exhauster Failure

Any local alarm also results in annunciation of a Diesel Generator Trouble alarm in the control room.

Other diesel generator control room alarms include:

Diesel Generator Fail to Start
Diesel Generator Start Signal Blocked

The Diesel Generator Start Signal Blocked alarm is actuated by the following inputs:

Loss of DC control power
Overspeed trip
Low lube oil pressure trip
Low jacket water pressure
Overcurrent or differential current

In addition, a trip of the diesel generator breakers by anything other than a manual trip is annunciated separately in the control room as is low level in the main fuel oil storage tank, day tank hi-lo level, generator overload, and Bus 1C or 1D overcurrent lockout. The diesel generator breakers will be opened should there be an overload, or generator differential relay operation, or should the diesel shut down. Additionally, a short duration trip signal is provided to the diesel generator breakers whenever a signal is initiated to automatically fast transfer the normal source of power to the start-up transformer. This trip signal ensures that the diesel generator will not be placed in parallel with the offsite source while not in phase.

The diesel will be automatically tripped on generator differential or overcurrent relay action, engine overspeed, low lube oil pressure, or low jacket water pressure, and can be manually tripped at any time from the local station or from the control room.

There are no trips on either the generator or the engine which are bypassed while engineered safeguards systems are functioning. Since there are two emergency diesels provided, each with full capacity rating, the single failure criterion is met regardless of which diesel auxiliary component is assumed to fail. Even more pertinent is the fact that the trips are minimum in number but important in function for equipment protection. Emergency power availability is thereby enhanced by tripping the unit off for these faults which enables repair and return to service rather than burning out the generator or engine.

The diesel generator is designed to start and be ready for loading in ten seconds, and be capable of loading and carrying required safety-related loads within the times established for sequential loading. The worst case automatic loading sequence (with their associated nameplate HP) for each diesel is shown in Tables 8-6 and 8-7, with zero second being diesel start time.

The engines are nominally rated at 3,500 brake horsepower (bhp), with a predicted overload capacity of 3,840 bhp for two hours.

The generator is rated at 2,500 kW at 0.8 power factor with a two-hour overload rating of 2,750 kW. The recovery time for voltage to return to 90% of rated voltage after application of each load step is less than three seconds.

When any plant modification affects the diesel generator loading, the revised loading will be verified to not exceed either the engine or generator ratings.

Each diesel generator's fuel oil system is supplied fuel oil by a common transfer system. The transfer system consists of an underground fuel oil storage tank, a single supply line and two transfer pumps. The transfer system mechanical design is safety related; there is a single fuel oil supply line for both diesels, and the two transfer pumps are not physically separated. However, each diesel has its own day tank and belly tank, and the day tank can be refilled from a tank truck. The fuel oil stored in the day tank is sufficient to support diesel generator operation for 13.5 hours at full load (Reference 18).

IEEE 308-1978 requires sufficient fuel be onsite for the operation of one diesel for seven days assuming accident loads. Fuel oil storage tank T-10A and the day tank together have sufficient capacity to contain the required seven day supply of fuel oil for emergency diesel generator use. Additionally, plant operating procedures alert operations personnel to evaluate the fuel on hand, the probability of restoring offsite power, and the probability of getting additional fuel. Fuel conservation practices will be implemented if it is likely that seven days will elapse before offsite power is restored and additional fuel is received. The capability also exists to transfer fuel oil from another onsite storage tank, T-926, to storage tank T-10A.

Either of two fuel oil transfer pumps are used for transferring fuel oil from the storage tank to the day tanks should additional fuel oil be required. In addition, a connection is available outside the diesel rooms to pump oil directly into the day tanks from an oil tanker truck.

Each emergency generator's fuel oil day tank has its own makeup control system which is redundant to and independent from that of the other. The emergency generator tank makeup control systems interface with the fuel oil transfer pump control systems. Each day tank makeup control system has its own separate control station and is powered from its respective channel. Each day tank makeup control system can independently demand makeup from a fuel oil transfer pump.

The fuel oil transfer pump motors and their control circuits are non-Class 1E. These circuits are supplied from redundant channels but are not separate and independent. Neither transfer pump's control logic gives the emergency generator day tank makeup systems preference over or isolates those non-essential makeup systems which are also served. The arrangement of the fuel oil transfer pump power and control circuits requires operator action to establish fuel transfer via either pump during loss of off-site power conditions. This arrangement minimizes the potential for inadvertent fuel oil transfer to system ruptures caused by natural phenomena.

Transfer pump P-18A can be controlled either manually, or automatically via level controls. It is powered from non-Class 1E MCC-8, which is capable of being manually loaded onto EDG 1-2. Those portions of the P-18A control circuit which carry the demand signals from the two independent emergency generator day tank makeup control systems are not electrically isolated or separated from each other; nor are they isolated or separated from circuits for non-essential makeup systems. Transfer pump P-18B can only be controlled manually. It is powered from Class 1E MCC-1, which is automatically loaded onto EDG 1-1. Those portions of the P-18B control circuit which carry the demand signals from the two independent emergency generator day tank makeup control systems are not electrically isolated or separated from each other; nor are they isolated or separated from circuits for non-essential makeup systems.

Each diesel engine has its own self-contained jacket cooling and heating system. A jacket water pump is engine driven with a temperature controlled three-way valve which diverts part of the water through a jacket water heat exchanger which is cooled by the plant service water system. As is shown on Figure 9-1, each heat exchanger is fed from a separate critical service water header. The jacket water pump on each diesel is connected to a surge line running to a 30 gallon expansion and makeup tank located approximately 10 feet above the crankshaft centerline. Makeup water is from the primary system makeup water system. When the engines are not running, the jacket water is heated by two thermostatically controlled heating elements mounted in the engine jackets.

8.4.2 STATION BATTERIES

8.4.2.1 Design Basis

The batteries are designed to furnish continuous power to certain normal Plant control and instrumentation circuits, and to control and instrumentation circuits associated with the engineered safeguards systems. They are also used to supply emergency Plant lighting. Two identical batteries feeding separate dc control centers are provided to assure reliability.

8.4.2.2 Description and Operation

Description - The batteries are of the lead calcium type; the most reliable type presently known. Special reinforced seismically qualified battery racks with high impact cell spacers are provided to meet the seismic criteria of CP Co Design Class 1 and to prevent damage from shifting of the battery cells.

Each battery is housed in its own ventilated room in the CP Co Design Class 1 portion of the auxiliary building. A sail switch is mounted in the ventilation duct to warn the operator in the control room of a loss of battery room ventilation which could lead to accumulation of hydrogen.

Normal Operation - The batteries are kept fully charged at approximately 131 volts by the battery chargers. Periodically, the voltage is raised to approximately 138 volts for equalization of the charge on the individual battery cells. Since the batteries are normally connected to the dc switchgear, they will automatically absorb any sudden load changes that may occur on the system.

Emergency Operation - On loss of normal and standby ac power, the batteries will supply power to required preferred ac and dc loads until one of the diesel generators has started and can supply power for the chargers.

System Monitoring - In order to ensure the availability of the batteries, several annunciations are provided in the control room to warn the operator of battery conditions (see Subsection 8.3.5.2). An operator is dispatched to the battery chargers and metering panels on a shiftly basis for a general inspection of the dc power system status. Proper trickle charging of the batteries by the chargers is monitored by the dc bus undervoltage alarm in the control room and by verification of circuit breakers position. In addition, the batteries are monitored on a monthly basis as required by Technical Specifications.

Testing - The batteries are tested in accordance with IEEE 450-1995, IEEE 308-1974, NRC BTP EICSB 6 and the Technical Specifications. The major tests are as follows:

1. At least once per 18 months, during shutdown, a battery service test is performed to verify that the battery capacity is adequate to supply and maintain in operable status the actual emergency loads for four hours. A modified battery performance discharge test may be performed in lieu of the battery service test.

2. At least once every 60 months, during shutdown, a battery performance discharge test or modified battery performance discharge test is performed to verify that the battery capacity is at least 80% of the manufacturer's rating.

Technical Specifications describe additional surveillance requirements for monthly and quarterly testing.

8.4.2.3 Design Analysis

The batteries have ample capacity to supply required dc loads and preferred ac loads during a complete loss of ac power for at least four hours, assuming neither diesel emergency generator is available. The batteries are designed to furnish their maximum load down to an operating temperature of 70°F without dropping below 105 volts, and the equipment supplied by the batteries is capable of operating satisfactorily at this voltage rating. The sediment space in the individual battery cells is sized such that the battery cannot develop an internal short circuit during its normal life.

The worst battery loading case per EA-ELEC-LDTAB-009 (Reference 11) assumes that neither of the two battery chargers, which are available for each battery, is operating. This loading is based upon the required opening and closing sequences of the 4,160, 2,400 and 480 volt circuit breakers, and upon solenoid, inverter, emergency lighting, annunciator and dc motor operations.

The four-hour minimum used in the battery sizing design is conservative and allows ample time to place either of two chargers in service before adversely affecting the battery performance.

Battery calculations in accordance with the guidelines provided in NUMARC 87-00 verified that the Class 1E batteries have capacity to meet station blackout (SBO) loads for four hours. This assumes that loads not needed to cope with the station blackout are stripped. The loads and the stripping procedure are identified in Emergency Operating Procedures (EOPs). The EOPs require monitoring battery discharge current and stripping loads during a SBO. The battery analysis shows manual load shedding at 30 minutes and plant procedures are consistent with this. NRC final approval was received in a SER (June 25, 1992).

In the event of a Loss of Coolant Accident and coincident loss of offsite power with emergency generators available, one charger for each battery will be energized automatically from an emergency generator to supply dc loads. Hence, the station battery will carry full load for approximately 10 seconds during a DBA and then will be supported by the battery charger.

8.4.2.4 Dedicated Battery Supply to Address Fire Scenarios

To support safe and stable conditions in accordance with the requirements of National Fire Protection Association (NFPA) 805, a nonsafety-related, dedicated 125 VDC battery supply is installed to power alternate 125 VDC controls in the event that a fire renders the normal control capabilities unavailable (see Figure 8-12). The battery supplies power to the alternate controls for the letdown orifice stop valves, the primary coolant pump trips, and the charging pump trips. Operator actions within the control room are required to disconnect the normal power supply and align the alternate dedicated battery supply.

8.4.3 TURBINE GENERATOR COASTDOWN

8.4.3.1 Design Basis

The coastdown circuits are designed to utilize the kinetic energy of the turbine generator to maintain primary coolant flow for approximately 10 seconds after a turbine generator trip when the trip occurs simultaneously with a power system grid failure.

8.4.3.2 Description and Operation

Description - The turbine generator voltage regulator temporarily maintains excitation during coastdown. A 362CD time delay relay that has been set at 10 ± 1 second is initiated by the 386C turbine coastdown relay. The coastdown control circuits, as shown on Figure 7-14, consist of the necessary relays and components to maintain generator excitation and delay the tripping of Station Power Transformer 1-1 4,160 volt incoming breakers for the first 10 seconds of coastdown.

Operation - The coastdown circuits operate only when the turbine generator trips and there is no start-up transformer power. These circuit components act to delay tripping the 4,160 volt station power incoming breakers until after a 10 second time delay. The circuit components also act to remove the voltage regulator and exciter from service when the 4,160 volt station power breakers are tripped. Utilization of the turbine generator inertia is blocked whenever a fault occurs within the electrical system of the main generator.

8.4.4 EMERGENCY POWER SUPPLY FOR PRESSURIZER HEATERS

8.4.4.1 Design Basis

The pressurizer heaters' power supply is designed to supply one half of the heaters from an offsite power source and the other half from an emergency power source. The heaters connected to the offsite power source may be manually switched to an emergency power source to provide redundant emergency power to the heaters as required by NUREG-0737.

8.4.4.2 Description and Operation

Description - The pressurizer heater 2,400 volt power connections are shown on Figures 8-4 and 8-5. The pressurizer heater power supply is such that one half of the heater capacity (750 kW nominally) can be supplied from an offsite power source (via 2,400 volt Bus 1E); the other half of the pressurizer heaters can be supplied from the emergency power source (via 2,400 volt Bus 1D).

During 1980, modifications were made to the Pressurizer Heater Transformer 15 feeder breaker on 2,400 volt Bus 1E and the Dilution Water Pump A feeder breaker on 2,400 volt Bus 1C. This modification allows Pressurizer

Heater Transformer 15 feeder to be manually switched from Bus 1E to Bus 1C, providing flexibility to operate half the heater banks from Bus 1C or 1D.

Operation - Switching the heaters from Bus 1E to Bus 1C requires that the Pressurizer Heaters Transformer breaker on Bus 1E be racked out, the Dilution Water Pump breaker on Bus 1C be opened, the dilution water pump leads be removed from the load side of the breaker, and the "jumper cable" be connected between Bus 1C and the load side of the Pressurizer Heaters Transformer breaker on Bus 1E. The control room then closes the Dilution Water Pump breaker on Bus 1C and the pressurizer heaters can be energized.

See Subsection 4.3.7 for additional operating details for the pressurizer heaters.

8.4.5 SUPPLEMENTAL 2400 VOLT POWER SUPPLY

8.4.5.1 Design Basis

A supplemental diesel generator is provided for use during beyond design basis events. Supplemental Diesel Generator 1-3 provides a standby power source for equipment powered from plant 2400 volt buses. The supplemental diesel generator is sized to provide an alternate source of power for operation of the battery chargers and the control room heating, ventilation and air conditioning system. Additionally, the diesel is sized to provide for core heat removal via either the steam generators utilizing an auxiliary feedwater pump, or via once through cooling utilizing a high pressure safety injection pump. Other loads within the diesel generator rating may also be powered. This power supply is non-safety related and is physically separated from the Class 1E safety related power supplies. However, during events that are beyond the design basis, emergency procedures are provided to connect Diesel Generator 1-3 to Class 1E loads.

8.4.5.2 Description and Operation

Supplemental Diesel Generator 1-3 is a portable Caterpillar 3516B engine with an SR 4 Generator. Output is rated at 1825 kW at 0.8 power factor, 480 VAC 60 Hz. The generator has a standby rating of 2000 kW at 0.8 power factor for 200 hours per year. A 480/2400 step-up transformer is provided on the output diesel generator to obtain the 2400 volts required for the safety related buses.

The diesel generator is manually started and connected to the 2400 volts buses locally at the diesel and at nearby switchgear. Connection to the 2400 volts buses can only be made to a dead bus. No provisions are provided for automatically starting the diesel or synchronizing the diesel generator onto an energized ac bus.

Auxiliary power to the diesel generator is provided to power battery chargers, controls and jacket water heaters. This power, provided from a non-safety related source, is required to maintain the diesel generator in a ready-to-start condition (batteries charged and engine coolant warm). The diesel generator is provided with a local fuel oil tank. The capacity of the tank is sufficient to supply the diesel generator at rated load for a minimum of six hours.

8.5 RACEWAY AND CABLING SYSTEM

8.5.1 DESIGN BASIS

8.5.1.1 Fire Protection Features

The design features of the raceway and cabling system for fire protection of safety-related cabling are described in this section. For additional fire protection-related features, refer to Section 9.6.

8.5.1.2 Electrical Penetrations of Reactor Containment

10 CFR 50, General Design Criterion 50, as implemented by Regulatory Guide 1.63 and IEEE Standard 317-1972, requires that electrical penetrations be designed so that the containment structure can accommodate, without exceeding the design leakage rate, the calculated pressure, temperature and other environmental conditions resulting from any Loss of Coolant Accident (LOCA). Electrical penetrations of reactor containment were evaluated and accepted under the Systematic Evaluation Program (SEP) Topic VIII-4 (References 19, 20 and 21).

8.5.2 DESIGN DESCRIPTION

As noted in Subsections 8.1.1 and 8.1.2, the engineered safeguards electrical power and control system buses are divided into two channels and the loads into two groups. Each channel consists of the following buses and power sources: one 2,400 volt bus, two 480 volt load centers, four 480 volt motor control centers, one dc distribution center, one battery, two battery chargers, two preferred ac buses, two inverters and one diesel generator. The power source for driven equipment and the control power for that system are supplied from the sources in one channel. (One battery charger for each channel dc distribution center is supplied from a 480 volt motor control center in the opposite channel.) Where redundant equipment is utilized in one load group, as in the case of the safety injection valves, the redundant equipment is supplied from the opposite channel.

The raceways and containment penetrations for these systems are also divided into two groups according to the separation criteria given in Subsection 8.5.3.2. Physical separation is maintained between the two raceway systems and between the two penetration areas. The interconnecting cables for any one channel are run in their respective raceway system.

The Reactor Protective System (Section 7.2) is divided into four channels supplied from the four preferred ac buses. The raceways for these systems are divided into two physically separated raceway systems and the two channels within one raceway system are further separated by a metal barrier within the raceway according to the separation criteria given in

Subsection 8.5.3.2. Separate containment penetrations are used for like circuits.

The schematic diagrams provide the information necessary for making circuit schedule and connection diagrams. The connection block diagram shown on each schematic diagram shows the interconnecting wire, where separation is required between redundant circuits and how separation is to be effected. Scheme numbers and relay numbers are coded with odd numbers indicating Channel 1 and even numbers for Channel 2. The allocation for the power source is shown for each scheme.

The circuitry of functions which might be designated as nonsafety related are contained in the same safety-related cables serving the safety-related equipment. (Examples: remote indicating lights for valves, breakers, etc.) This circuitry has then been treated as "associated" circuitry within IEEE 384 definition and requirements.

The cable and wire connected to devices and instrumentation which are required to operate during a design basis accident (DBA) have been qualified to assure satisfactory operation through and following the accident. Essential cabling has been shown to have a 40 year qualified life. In-tray splices are not recommended but when required, use a qualified and tested design that is hermetically sealed to the expected environment (see subsection 8.1.3).

Cables installed in ventilated trays, conduit or underground ducts are thermally sized in accordance with NEC or IPCEA/ICEA ampacity values (depending on cable physical size) of concentric stranded insulated cable for the conductor operating temperature of the insulation. Insulation type may be of thermosetting, rubber or plastic. Ampacities are adjusted based on actual field conditions when possible. These adjustments may include, but not be limited to, conductor operating temperature, ambient temperature, cable overall diameter, tray depth of fill, conduit percent fill, and fire-stops. Analyses performed for densely filled cable trays, conduits and underground ducts determined that the cables were within their temperature ratings. These analyses are described in References 12 through 14. The ampacity methodology has been reviewed by the NRC and found to be acceptable (Reference 15).

High-voltage cables are run in separate raceways from low-voltage power and control cables. Low-level signal cables are kept in separate raceways. Cables installed in stacked trays are arranged to have the highest voltage located in highest level tray and low-level signal cable in the lowest tray.

No documentation of the original design basis for the sizing of cables for short circuit has been found. Station power short-circuit levels and discussions with the original AE, however, indicate that the three-phase ac cable short-circuit protection design considered the fault current due to a fault at the load and used high speed fault clearing to prevent cable damage. This design sizes the protective device for a fault at the load to prevent the conductor temperature from exceeding 250°C for thermosetting insulated cable, 200°C for rubber insulated cable, and 150°C for plastic insulated cable. If a fault occurs on the cable, the entire cable upstream of the fault would be inspected and, depending on the fault location and resulting short-circuit current, the appropriate sections would be replaced. This is the present design criteria being used. The 125 volt dc protection design considers the fault current available at the source side of the feeder protective device.

8.5.3 DESIGN EVALUATION

The design of the Plant electrical penetrations is similar to those of other plants, the probability of electrical failure of the penetrations is low, and any resultant leakage path would be small. Analysis shows that electrical penetration failure contribution to containment failure by leakage is very small; i.e., the size of a potential leakage path is small and the probability of penetration electrical failure resulting in leakage is low. See Section 8.5.1.2.

The following subsections describe how the raceway and cabling system meets NRC BTP CMEB 9.5-1, Regulatory Guide 1.75 and National Fire Protection Association (NFPA) 805.

8.5.3.1 <u>Compliance With Regulatory Guide 1.75</u>

The safety-related cabling system does not fully meet the requirements of Regulatory Guide 1.75 since the Plant was designed and constructed before the Guide was established. As a result, fixed automatic water fire suppression systems have been provided in areas of dense safety-related cables. Manual hose stations and portable extinguishers are provided as backup.

Although IEEE 383 was not in existence at the time the Palisades electrical cabling was purchased and installed, the cable was specified to meet the vertical flame tests in accordance with IPCEA S-19-81 and ASTM D470-59T. While such tests, as well as the IEEE 383 tests, provide a measure of comparability of fire retardance between various types of cables, they cannot be considered as indicative of their behavior when found in the configurations in the Plant. Cable insulation has thus been considered as combustible material for fire protection design considerations (See Section 8.7).

Starting in 1979, new cable installations utilize to the extent practical, cable construction that does not give off corrosive gases while burning. With the implementation of NFPA 805, new cables must meet IEEE 383, or equivalent, flame test requirements.

8.5.3.2 Raceway and Cabling Separation Criteria

Circuits designated as belonging to a safety-related power distribution, Reactor Protective System, engineered safeguards or other safety-related system channel are run in separate raceway systems. The raceway system includes conduit, trays, wall and floor penetrations, containment penetration, panel wire troughs, etc. In general, the circuit isolation and separation requirements are met by the use of physically separate raceways which can afford fire and missile protection. The raceway systems are so arranged that a single failure cannot affect both channels of a power or control circuit. In designing the raceway system for "channeled" circuits and in the routing of these circuits, consideration has been given to the type of hazards that could be present in regard to potential fire, as well as size and type of missiles that may be generated by the equipment in the area. Physical separation (distance) has been considered as the most reliable method of providing the circuit separation and isolation. When raceways are run near one another, a fire barrier and/or a missile shield is provided between the raceway systems.

According to FSAR Amendment 15 of August 26, 1968, original Plant construction did not require rigorous separation of vital and nonvital cables. Amendment 15 states, "Nonvital cables, except for those required to operate during a DBA, are the same as the cables used in the engineered safeguards circuits. They are sized, rated, protected and, except for separation, use identical type raceways sharing, where convenient, the same trays as engineered safeguards cables." IEEE 384 would require that these "nonvital" cables be classified as "associated circuits" and designed and installed accordingly. Separation as required by IEEE 384 was not an original design requirement and the Plant is not in total conformance with this standard.

The following designations have been utilized for the Palisades Plant circuits:

Left	Right
Channel 1	Channel 2
Channel 3	Channel 4
System 1	System 2
System 3	System 4

Following is a description of the intended separation requirements by channel designation. A few circuits have been discovered that are not separated as described below. When deviations from separation requirements are identified they are evaluated for acceptability as-is or rerouted.

Left Circuits

Circuits designated as "Left" must be routed in trays and conduits separate from circuits designated as "Right," "Channel 2" or "Channel 4."

"Left" channel circuits may be run in Nonclass 1 building above ground if there exists a redundant "Right" circuit. Typical of a Nonclass 1 structure is the turbine building. The "Left" circuits may be routed with nonredundant circuits or circuits designated as a "System" circuit or with "Channel 1 or 3" circuits.

Right Circuits

Circuits designated as a "Right" must be routed in trays and conduits separate from circuits designated as "Left," "Channel 1" or "Channel 3." The circuits may not be routed in a Nonclass 1 structure. The circuits may be run with nonredundant circuits or with "Channel 2 or 4" circuits or with any "System" circuits.

Channel 1 Circuits

Circuits designated as "Channel 1" must be routed in raceways separate from "Channels 2 and 4" circuits and separate from "Right" circuits.

They can be routed in same raceways as "Channel 3" circuits but circuits must be separated by a barrier between them. "Channel 1" circuits may be run in Consumers Design Nonclass 1 structures if there are redundant Channels 2 and 4 circuits in a protected routing. A Channel 1 circuit may be run with nonredundant circuits, "Left" circuits or "System" circuits.

Channel 3 Circuits

Similar requirements as a "Channel 1" circuits.

Channel 2 Circuits

Circuits designated as "Channel 2" must be routed in raceways separate from "Channels 1 and 3" circuits and separate from "Left" circuits. They can be routed in the same tray, penetration, etc, as "Channel 4" if a barrier is provided between them. "Channel 2" circuits must not be run in Consumers Design Nonclass 1 structures. "Channel 2" may be routed with "Right" and nonredundant circuits or any "System" designated circuits.

Channel 4 Circuits

Similar requirements as "Channel 2" circuits.

System 1 Circuits

Circuits designated as "System 1" must be routed separately from "System 2" circuits.

A System 1 circuit may be run with any other like-type circuits; i.e., power, control or instrumentation circuits.
System 2 Circuits

Similar requirements as "System 1" circuits.

System 3 Circuits

Any circuits designated as "System 3" must be routed in separate raceways from "System 4" circuits.

A "System 3" circuit may be routed with any other like-type circuit.

System 4 Circuits

Similar requirements as "System 3" circuits.

Compliance With NFPA 805

In order to ensure operability of both Emergency Generators 1-1 and 1-2 in the event a fire damages control circuitry of the equipment in the control room or the cable spreading room, support systems' power and control cabling for the diesel generators, including the power source for the engine crankcase exhausters are not routed through these areas. Furthermore, the terminations of control room and cable spreading room routed circuitry for Emergency Generator 1-2 and 2,400 volt Bus 1C and 1D switchgear positions are identified readily so that the sliding links of the terminal blocks can be opened to isolate the damaged circuitry. Isolating transfer switches are provided for Emergency Generator 1-1 and selected breakers on Bus 1C which are required for achieving safe and stable conditions. No slide link operations are credited for achieving or maintaining safe and stable conditions per NFPA 805.

In order to ensure operability of one emergency generator in the event of a fire in the emergency generator or switchgear room belonging to the other channel, the generator power cables, and control and instrument cables from the emergency generator are not routed in the opposite generator or switchgear room.

Other specific routing criteria have been established to ensure safe and stable conditions per NFPA 805.

8.5.3.3 Raceway and Cabling Fire Barriers

Fire barriers have been provided to separate the turbine building from the auxiliary building and to isolate one safe shutdown train from the associated redundant train or alternative safe shutdown equipment. Based on the type and quantity of combustibles present, the basic fire resistance of the barriers would prevent the spread of fire between fire areas.

Cable and cable tray penetration of fire barriers (vertical and horizontal) in safety-related areas of the Plant have been sealed to give protection at least equivalent to that of the fire barrier. The design of fire barriers for horizontal and vertical cable trays meets the requirements of ASTM E119, "Fire Test of Building Construction and Materials," including the hose stream test. Where fire barrier penetration seals require fire resistance characteristics, these seals in safety-related areas have been sealed to a rating equivalent to that required of the barrier. Piping penetrations of fire barriers are sealed in a similar fashion. The adequacy of seals has been demonstrated by testing [Factory Mutual Research Test Reports for Wall Penetrations (4/26/78) and Floor Penetrations (5/10/78)] and/or analysis.

The few cable tray sections in the containment building which communicate between the left and right cable tray systems are fitted with fire stops. These stops are intended to prevent a fire originating in one tray system from traveling along an interconnecting tray and affecting the other tray system.

8.5.3.4 Cable Spreading Room Protection Design

This area contains 480 volt dry-type transformers, 480 volt switchgear, cables for power, instrumentation and control for safety-related and nonsafety-related systems, and other equipment related to safety-related ac and dc power supplies. The significant combustible in this area consists of a large quantity of cable in open cable trays stacked three or four levels deep.

In order to meet the intent of Regulatory Guide 1.75 and NRC BTP CMEB 9.5-1, the following design features are provided for protection against a fire in the cable spreading room:

1. Fire detection provided by flow alarms in the sprinkler system.

2. Fire extinguishment provided by an automatic sprinkler system backed up by water hose stations and portable extinguishers.

3. Switchgear protected against flooding by mounting on curbs.

4. Physical separation and barriers used to separate redundant divisions of safe shutdown cables.

5. Capability independent of this area for achieving safe shutdown using centralized control and instrumentation (Panel C-150).

6. Smoke detectors to detect incipient fires.

7. Ladder to enhance manual fire-fighting capability.

8. Fire retardant coatings to close gaps in barriers.

9. Seal for cable penetrations on both sides.

10. Manual suppression capability to suppress fires in lower trays that may be shielded from sprinkler system water.

11. The wall to the turbine building is at least a 3-hour wall and to the adjacent switchgear room is at least a 2-hour wall. The floors and ceilings have a 3-hour fire resistance.

12. The ventilation ducts leading to the turbine building and into the battery rooms have fusible link fire dampers installed.

13. To ensure fire-fighting ability, there are two remote and separate entrances into the cable spreading room, one from the adjacent switchgear room; the cable trays are installed above the floor-mounted switchgear cabinets starting about seven feet high and extending to the ceiling except for the vertical cable runs at the south side of the room; there are four-foot aisles between floor-mounted equipment for ladders or fire-fighting equipment.

8.5.3.5 Cable Penetration Rooms Protection Design

There are two cable penetration areas into containment totally separated from each other by distance and fire barriers, one area being at the north side and the other at the southwest side of the containment. When cables penetrate fire barriers, fire rated cable penetration seals are provided. Each area contains cables for safe shutdown equipment redundant to the other area.

The significant combustible in each of these areas is a moderate amount of electrical cable insulation stacked in open cable trays.

An unsuppressed fire in either of the penetration areas could cause damage to cables affecting one division of safe shutdown systems but would not cause loss of shutdown capability.

Fire detection is provided by smoke detection and water flow alarms which are actuated by flow to the sprinkler system. Fire extinguishment is provided by an automatic sprinkler system in each area backed up by portable extinguishers and hose stations located in adjacent areas.

8.5.3.6 Raceway Runs Protection Design

Cable trays, raceways, conduit, trenches or culverts are used only for cables; no miscellaneous storage is present. No piping for flammable or combustible liquids or gases is installed in these areas.

The tunnel from the north penetration area to the Switchgear Room 1D and the cable spreading room can be vented with the HVAC system or manually vented with the door to the switchgear room from the outside. Also the tunnel can be vented with the door from the outside leading into the north penetration room.

Cables entering the control room pass through penetration seals and terminate in the control room cabinets. There are no floor trenches or culverts in the control room.

8.5.3.7 Safety-Related Cabling Routing Via Nonsafety-Related Areas

Routing of electrical cables via nonsafety-related areas to the following safety-related equipment and areas: (1) auxiliary feedwater pumps and associated valves; (2) intake structure; and (3) electrical penetration area, does not allow a fire to cause loss of redundant equipment because of the following routing features:

1. The motor feeder for motor-driven Auxiliary Feedwater Pump A is in underground conduit from Bus 1C to the motor.

2. Steam Supply Valve A to the Auxiliary Feedwater Pump B turbine and associated circuitry is located in the reactor auxiliary building.

3. Steam Supply Valve B to the Auxiliary Feedwater Pump B turbine is located above the floor of the turbine room. The associated circuits route through cable trays and conduit in the area.

4. The Auxiliary Feedwater Pump B turbine driver speed control is mechanical and no electrical cable routing is involved.

5. Auxiliary feedwater flow control valves and circuits are located in the west safeguards room and the component cooling pump room.

6. Circuit routing for service water pumps is in conduit through the turbine room, or in underground duct.

7. Circuit routing to the southwest penetration area is via a combination of underground conduit and trays in the turbine building.

8. The turbine lube oil storage area is adequately separated in an interior structure inside the turbine building. The room has fire suppression and is adequately enclosed by fire walls. The room has a recessed floor to contain the single largest lube oil storage tank inventory without leakage.

8.5.3.8 Containment Building Routing Protection

The containment building can be isolated to contain any fire source and the containment boundary will prevent any outside fire from entering the containment.

The small amount of oil associated with each primary coolant pump motor does not justify a suppression system. It is not expected that a postulated lube oil fire would cause loss of cables located in the vicinity of a primary coolant pump since an oil collection system is provided to collect and contain leakage or spills.

Cable trays, cables and penetration areas are separated into two divisions with fire stops in trays communicating between the two divisions (see Subsection 8.5.3.3).

An unmitigated fire in either cable penetration area could involve all the cables in one penetration area, but would not affect safe shutdown because only cables of one division are located in each penetration area.

As a result of this potential for fire, fire detection devices are provided in the reactor containment instrument room and cable penetration area; primary coolant pump bearing temperature and motor winding temperature readout are also available to give indication of a fire in the primary coolant pump area; portable carbon dioxide and water extinguishers are provided. Also, due to the difficulty of reaching some locations with a hand extinguisher, water hose stations are provided in containment with adequate hose to suppress fires in cables in cable trays.

8.5.3.9 Other Areas Routing Protection

For routing protection in switchgear rooms, emergency generator rooms and battery rooms, see Section 8.7. For routing protection in control station areas, see Sections 7.4 and 7.7.

Areas containing safe shutdown cabling have been designed to protect against a fire damaging both channels of safety cables and raceways, or an alternate method for the function is provided in a separate fire area.

8.6 AUTOMATIC TRANSFER, VOLTAGE PROTECTION AND LOAD SHEDDING CONTROLS

8.6.1 DESIGN BASIS

The automatic transfer control system is designed to monitor and select available offsite power sources and permit transfer of the 4,160 volt and 2,400 volt loads to the available offsite source upon loss of the normal power source. Redundant control circuits are provided for transfer of source power for the redundant 2,400 volt emergency buses (1C and 1D).

Voltage protection and load shedding features for safety-related buses at the 2,400 volt and lower voltage levels are designed in accordance with 10 CFR 50, Appendix A, General Design Criterion 17 and the following features:

1. Two levels of automatic voltage protection from loss or degradation of offsite power sources are provided. The first level provides normal loss of voltage protection. The second level of protection has voltage and time delay set points selected for automatic trip of the offsite sources to protect safety-related equipment from sustained degraded voltage conditions at all voltage levels in accordance with ANSI C8.4.1-1977, with coincidence logic to preclude spurious trips. Maximum time delays for second level trip do not exceed the maximum time delay assumed in Chapter 14 analysis for engineered safeguards actuation while allowing short duration bus voltage disturbances without trip and short enough to prevent damage or failure of safeguards systems and components. This second level of protection meets IEEE 279-1971, IEEE 308-1978, IEEE 501-1978 and its components are located in a controlled atmosphere not requiring environmental qualifications.

2. The voltage protection system automatically prevents load shedding of the safety-related buses when the emergency generators are supplying power to the safeguards loads. Automatic bypass and reinstatement is verified by periodic testing.

3. Control circuits for shedding of Class 1E and Nonclass 1E loads during a Loss of Coolant Accident themselves are Class 1E or are separated electrically from the Class 1E portions.

8.6.2 DESCRIPTION AND OPERATION

General Description - The automatic transfer, voltage protection and load shedding controls are shown on Figures 8-10 and 7-14. The controls for the safety-related 2,400 volt Buses 1C and 1D consist of redundant transfer, voltage protection and load shedding circuits connected to separate Plant batteries, circuit breaker controls for Bus 1C being fed from one battery and controls for Bus 1D being fed from the other battery. Separate voltage sensing units on each bus are utilized for each of the circuits.

During emergency conditions, a turbine or generator trip will trip circuit breakers for the nonvital 4,160 volt Station Power Transformers 1-1 and 1-3, initiating transfer to the 4,160 volt Start-Up Transformers 1-1 and 1-3. During normal shutdown conditions, the 4,160 volt auxiliary power system is manually transferred to the start-up source.

The 2,400 volt system, which includes the emergency buses, is normally powered directly from offsite power via Safeguards Transformer 1-1. In this configuration, a turbine or generator trip will not result in a fast transfer of the 2,400 volt buses to the alternate source. Capability is provided in the design to allow powering the 2,400 volt buses from Station Power Transformer 1-2. When operating in this configuration, a turbine or generator trip will initiate a fast transfer to Start-Up Power Transformer 1-2.

The 2,400 volt auxiliary power system normally remains on the Safeguard Transformer source but can be manually transferred to the start-up source or, after transferring to the start-up source, can be manually transferred to the station power source.

In order to permit the main transformer backfeed mode of operation (Subsection 8.2.3), the fast transfer on turbine trip is blocked by opening the generator isophase bus disconnect switch. No automatic transfer is provided for a transfer from the start-up transformers to the station or safeguard transformers. This operation must be done manually.

4,160 Volt System - Automatic transfer of the 4,160 volt buses from the normal power source (Station Power Transformers 1-1 and 1-3) to the start-up power source (Start-Up Transformers 1-1 and 1-3) is initiated by turbine trip or generator trip.

Automatic transfer is blocked if the start-up transformer voltage is low. Low voltage is sensed by either 4,160 volt Undervoltage Relays 227-5 and 227-6, which actuate Lockout Relays 227-X5 and 227-X6. Blocking of transfer to each start-up transformer is independent, thereby permitting transfer of one half of the 4,160 volt buses if one transformer is inoperable.

Automatic transfer of a faulted bus will also be blocked if a station power transformer incoming breaker is tripped on overcurrent. The lockout relay must be manually reset to close the faulted bus breaker after the overcurrent condition. When a turbine generator or reactor trip occurs with offsite power unavailable, turbine generator inertia is utilized to temporarily supply 4,160 volt Buses 1A and 1B. The generator excitation will temporarily be maintained. The generator excitation and primary coolant pumps will remain energized and primary coolant flow will be maintained for approximately 10 seconds. After the 10-second time delay, the generator excitation and the 4,160 volt station power bus incoming breakers will be automatically tripped (see Subsection 8.4.3 for details).

2,400 Volt System - The 2,400 volt system is normally powered directly from offsite power via Safeguards Transformer 1-1. Automatic transfer from this source to the standby source (Start-Up Transformer 1-2) is initiated by any fault which results in clearing of the Switchyard "F" bus, or by differential zone relaying which detects a fault between the Safeguards Bus and the 2,400 volt buses. If the 2,400 volt buses are connected to Station Power Transformer 1-2, an automatic transfer to the standby source (Start-Up Transformer 1-2) is initiated by a turbine trip or generator trip. The automatic transfer scheme in effect is determined by monitoring the status of the safeguard bus feeder breakers to indicate if Safeguards Transformer 1-1 or Station Power Transformer 1-2 is the source of power to the 2,400 volt buses.

Automatic transfer is blocked if the start-up transformer voltage is low. Low voltage is sensed by either 2,400 volt Relay 127-5 or 127-6, which actuate Lockout Relays 127-X5 and 127-X6. Blocking the transfer to the start-up transformer is independent for each 2,400 volt Bus 1C and 1D.

The automatic transfer will initiate a trip of the emergency generator breaker to prevent the generator from being paralleled automatically and the bus from being loaded onto the emergency generator if the transfer fails.

Automatic transfer of a faulted bus is blocked if a safeguard/ station power transformer incoming breaker is tripped on overcurrent. The lockout relay must be manually reset to close the faulted bus breaker after the over-current condition.

Automatic transfer is also blocked if a diesel generator is being tested and is paralleled with an offsite source of power to a bus.

Each 2,400 volt Bus 1C and 1D is equipped with two levels of voltage protection relays, with their functional logic as shown in Figure 7-14, Sheet 3. The first level undervoltage Relays 127-1 and 127-2 are set at approximately 77% of rated voltage with an inverse time relay. These relays protect against a sudden loss of voltage as sensed on the corresponding bus using a three-out-of-three coincidence logic. The actuation of these relays will trip their respective incoming bus circuit breakers, start their respective emergency generators, initiate bus load shed, and activate annunciators in the control room. The emergency generator circuit breaker is closed automatically upon establishment of satisfactory voltage by the use of voltage protection Relays 127D-1 and/or 127D-2 (see Figures 7-14 and 7-18).

The second level of voltage protection undervoltage Relays 127-7 and 127-8 are set at approximately 92% of rated voltage. These relays protect against sustained degraded voltage conditions on the corresponding bus using a three-out-of-three coincidence logic. These relays have a built-in 0.65 second time delay, after which their respective emergency generators will receive a start signal and activate annunciators in the control room. If a bus undervoltage exists after an additional six seconds, then the respective incoming bus circuit breaker will be tripped and a bus load shed will be initiated.

In addition to initiating the bus load shed feature, the undervoltage devices also initiate reset of the service water and component cooling water pump standby auto start feature. This feature, if enabled, would normally start the pump on detecting low system discharge pressure. Resetting this feature on bus undervoltage prevents closing the pump breaker onto a dead bus and assures that the breaker is ready to be closed by the appropriate sequencer after the diesel generator is connected to the bus.

2,400 volt Buses 1C and 1D load shedding is blocked via auxiliary contacts of the emergency generator circuit breaker when the generator is connected to the bus.

In order not to overload Safeguard Transformer 1-1 or Start-Up Transformer 1-2 during a Loss of Coolant Accident, 2,400 volt Bus 1E and selected Nonclass 1E 2,400 and 480 volt loads fed from Buses 1C and 1D are shed upon receipt of the safety injection signal. The start-up power load shed circuits are not considered Class 1E. Load shedding of selected non-Class 1E loads upon receipt of a safety injection signal provides reserve capacity and improves voltage transients on the running supply transformer. Safeguard Transformer 1-1 (10.5 MV A rated) has approximately 1.8 MVA (Reference 17) steady state reserve capacity following load shed, SIS block loading and manual re-energization of certain non-Class 1E loads. Start-Up Transformer 1-2 (10.5 MVA rated) has approximately 1.8 MVA (Reference 17) steady state reserve capacity following load shed, SIS block loading and manual re-energization of certain non-Class 1E loads.

System Monitoring - Safeguards load centers have trip and undervoltage alarms in the control room as well as voltage monitors for supervision of system status and voltage adequacy.

Testing - Verification of the voltage protection system relays and load shedding overall operation is performed during Plant shutdown with the emergency generators testing in accordance with Technical Specifications requirements.

8.6.3 DESIGN ANALYSIS

8.6.3.1 Automatic Transfer System

The reliability of the automatic transfer control system is assured by two independent and separate circuits controlling their respective auxiliary system breakers. The circuit is designed so that a loss of control power will not cause a false transfer; loss of control power will be annunciated. This circuit is also designed to prevent both offsite power and emergency power from being paralleled automatically. During 2400 volt system automatic transfer, if the standby (alternate) power source is not available, the standby power source incoming breaker is prevented from closing and the emergency generator is used to energize the engineered safeguards bus. When offsite power returns, the start-up or safeguard/station power transformer incoming breakers may be closed manually through the synchronizing circuit.

8.6.3.2 Voltage Protection and Load Shedding Systems

The voltage protection and load shedding systems meet the criteria outlined in Subsection 8.6.1 as evaluated below:

The voltage trip set point has been set low enough such that spurious trips of the offsite source due to operation of the undervoltage relays are not expected for any combination of unit loads and normal grid voltages.

This set point at the 2,400 volt bus and reflected down to the 480 volt buses has been verified through an analysis to be greater than the minimum allowable motor voltage (90% of nominal voltage). Motors are the most limiting equipment in the system. MCC contactor pickup and drop-out voltage is also adequate at the set-point values. The analysis ensured that the distribution system is capable of starting and operating safety-related equipment within the equipment voltage rating at the allowed source voltages. The power distribution system model used in the analysis has been verified by actual testing.

The time delays involved will not cause any thermal damage as the set points are within voltage ranges recommended by ANSI C8.4.1-1971 for sustained operation. They are long enough to preclude trip of the offsite source caused by the starting of large motors and yet do not exceed the time limits of safeguards actuation assumed in Chapter 14.

Once the emergency generator is connected to its bus, load shed is blocked and is reinstated upon a trip of the emergency generator.

Load shedding of 2,400 volt Bus 1E and other nonessential loads provide a more than adequate margin on Start-Up Transformer 1-2 and Safeguard Transformer 1-1 to ensure reliable power is available for engineered safeguards loads.

Load shedding on offsite power trip and load sequencing once the diesel generator is supplying the safety buses are tested periodically. The load shed bypass circuit and a simulated loss of the diesel generator with subsequent load shedding are also tested. Calibration of the undervoltage relays verify that the time delay is sufficient to avoid spurious trips.

8.7 PHYSICAL SEPARATION, ELECTRICAL ISOLATION AND SUPPORT SYSTEMS

The physical and electrical separation of the two safety-related power distribution channels and their support systems is the subject of this section. Protection against fire is included also in this subsection. Protections against physical phenomena (flooding, tornado, missiles, etc) are described in Chapter 5.

8.7.1 ELECTRICAL ISOLATION (SEE FIGURE 8-1)

Electrical interconnections between safety-related Channels 1 and 2, between Channel 1 or 2 nonsafety buses and between Channel 1 or 2 and nonsafety loads are evaluated below according to Regulatory Guide 1.6 requirements. The objective of the evaluation is to identify single failures that could cause simultaneous failure of both channels.

The 2,400 volt Buses 1C and 1D (and, therefore, Diesel Generators 1-1 and 1-2) can be tied together only if either offsite Feeder Breakers 152-105 and 152-203 (normally closed) or Breakers 152-106 and 152-202 (normally open) are closed. On loss of the offsite source, these breakers each receive an automatic open signal from independent low voltage sensing devices located on Bus 1C for Breakers 152-105 and 152-106 and on Bus 1D for Breakers 152-202 and 152-203. Thus, there is no single failure that can cause the interconnection of Buses 1C and 1D, and the paralleling of the standby onsite power sources after loss of offsite power.

The 480 volt Buses 11 and 12 may be tied together by closing Breakers 52-1118 and 52-1217 (normally open). An interlock prevents the closure of these tie breakers if both breakers connecting the redundant sources to Buses 11 and 12 (Breakers 52-1102 and 52-1202, respectively) are closed; one of these two supply breakers must be open in order to close the tie breakers.

A tie breaker auto trip will occur whenever an undervoltage condition exists on 2,400 volt Bus 1C or 1D and the associated diesel generator output breaker is open. An undervoltage condition on Bus 1C opens Tie Breaker 52-1118 and an undervoltage condition on Bus 1D opens Tie Breaker 52-1217.

Load centers and motor control centers belonging to safety-related redundant channels are not intertied except as indicated above. Interties via nonsafety-related buses are described below:

Associated nonsafety-related 480 volt Bus 77 is interconnected with nonsafety-related Bus 78 by a single tie breaker. The supply breakers to Buses 77 and 78 are interlocked with the tie breaker such that one of the two supply breakers must be open to close the tie breaker. Thus, safety-related Bus 1C cannot be paralleled with nonsafety-related Bus 1E through Buses 77 and 78. Also, the load breaker on Bus 1C opens on loss of offsite power to prevent Diesel Generator 1-1 overload. Similar arrangements are provided for the interconnection between nonsafety-related 480 volt Bus 13 and 480 volt Bus 14 and for the interconnection between nonsafety-related 480 volt buses for switchyard loads.

Safety-related MCC 1 and MCC 2 both provide power to the instrument ac bus through an automatic transfer switch. Power to the instrument ac bus is normally supplied by MCC 1. With loss of MCC 1, the power source is automatically transferred from MCC 1 to MCC 2. The “break-before-make” design of the transfer switch prevents interconnection of the two motor control centers.

8.7.2 PHYSICAL SEPARATION

8.7.2.1 General

The physical separation of redundant equipment and cabling associated with the two safety-related power distribution channels meets 10 CFR 50, Appendix A, General Design Criterion 3. Review of electrical equipment fire-related design based upon the acceptance criteria of Appendix A to NRC BTP CMEB 9.5-1 has been performed and a summary included in this subsection. See Section 8.5 for generic raceway and cabling design, Sections 7.4 and 7.7 for control stations fire-related design, and Section 9.6 for fire protection equipment. These criteria were established to prevent a single fire in any area from disabling both redundant channels. In addition, 10 CFR 50.48, effective date February 17, 1981, required a reevaluation of all areas of the Plant to the separation criteria specified in Paragraph G of Section III of Appendix R to 10 CFR 50. These last criteria are met via alternate dedicated shutdown means (auxiliary shutdown systems) and associated circuits independent of cables, systems or components in the area, room or zone utilized by the normal shutdown. Compliance with Appendix R has been replaced by compliance with National Fire Protection Association (NFPA) 805.

The Palisades Plant has been designed with physical separation to prevent the spread of a fire in safety-related equipment areas such that the function of redundant engineered safeguards is not impaired. This separation is maintained by compartment isolation of Plant safety systems and by employing redundant equipment, controls and power supplies. In the event any single system is disabled, the redundant system and the protection afforded by compartment structural boundaries will ensure that the system safety function is not jeopardized.

8.7.2.2 Transformers

All high-voltage power transformers located within the Plant safety-related areas are dry type.

The main transformer, station power transformers and start-up transformers are located south of the containment vessel and east of the turbine building. While the transformers are within 50 feet of the containment building, there are no openings in the exterior walls of containment within 50 feet of the transformers and the fire resistance of these walls is in excess of 3 hours. All the transformers are provided with an automatic water deluge system.

8.7.2.3 Protection Against Water Damage

In order to protect electrical equipment against damage from fire suppression systems, floor drains for water removal are provided in sprinkler areas containing electrical equipment. Many areas have alternate drainage via equipment sumps, door accessways or stairwells-to-sump areas. Transformers and 480 volt vital load centers are mounted on pedestals. Switchgear are floor mounted and floor drains are provided since these areas have sprinklers. In addition, valves are available to isolate sections of the firewater piping inside buildings to preclude the buildup of water and thus prevent equipment from being incapacitated due to flooding or inadvertent operation of the fire suppression equipment.

All safety-related diesel day tanks have high curbs around the tanks or the tanks are enclosed in separate fuel oil rooms with door elevated well above floor level.

Cable trays are of the open-top ladder type made of galvanized steel with galvanized steel, painted channel or unistrut-type supports.

The safety-related cabinets housing electrical equipment in the vicinity of automatic sprinklers have been designed as drip proof, and all have had the top cable entry points in the cabinets sealed to prevent water ingress. The rooms in which this equipment is mounted are provided with floor drains to prevent flooding during sprinkler operation. Refer to Section 5.4 for a discussion on flooding.

The switchgear enclosures are louvered to limit water sprays from entering the enclosures.

8.7.2.4 Smoke Control

The power supply and controls for the ventilation systems used for smoke control are run outside the fire area served by the system with the exception of the cable spreading room and the two safety-related switchgear rooms.

The normal exhaust fan for the cable spreading room and the two switchgear rooms is mounted in the cable spreading room. The emergency exhaust fan that serves the three above-mentioned rooms is mounted in Switchgear Room 1-D. All these rooms can also be readily vented with portable blowers.

All intakes are remote from locations where smoke could be exhausted.

The cable spreading room and the two switchgear rooms have both normal and emergency exhaust systems which exceed NFPA requirements. The emergency generator rooms have ample natural ventilation. Diesel day tank rooms are enclosed so that there would not be enough air to support combustion. All other locations have exhaust ventilation which exceeds the NFPA criteria.

8.7.2.5 Switchgear Rooms Protection

There are two redundant 2.4 kV switchgear rooms and an auxiliary electrical equipment room. Each switchgear room contains the switchgear to one of the redundant channels of safeguards equipment and the associated cables. A tunnel which contains cabling of one safety channel leads from Switchgear Room 1-D to the associated penetration area.

The combustibles in the switchgear rooms consist of a moderate amount of cable in open cable trays. Switchgear Room 1-C also contains piping of propane, hydrogen and acetylene. However, this piping only passes through Switchgear Room 1-C and does not service any equipment in this area. Additionally, damage to the piping is unlikely since the piping is routed near the ceiling and there is no rotating machinery in the area to present a missile hazard.

An unmitigated fire in one of the switchgear rooms could cause damage to and loss of equipment related to one channel of redundant systems but would not affect the redundant systems due to the barriers separating the rooms.

Both switchgear rooms are used as cable right of ways. Both rooms have closed head sprinkler systems to protect the cables.

The switchgear room for Bus 1C has a 3-hour fire barrier to the diesel generator room and to the turbine building.

The switchgear room for Bus 1D has a 3-hour barrier to the cable spreading room. Floors and ceilings have a 3-hour fire barrier.

Fire detection is provided by smoke detectors and flow alarms actuated by water flow in the sprinkler system. Fire extinguishment capability is provided by an automatic sprinkler system in the switchgear rooms and the cable tunnel, backed up by water hose stations and portable extinguishers.

Additional protection features are provided as follows:

- Smoke detectors for detection of incipient fires (both rooms);

- Cable penetration seals with flame retardant materials (both rooms);

- Redundant safeguards cabling is routed in each switchgear room according to the channel of power source. Local 125 volt dc distribution panels are provided such that the dc control power would not be affected in the case of switchgear room fire (see Subsection 8.3.5.2); and

- Dampers in ventilation duct penetrations of fire barriers.

8.7.2.6 Emergency Generators Rooms Protection

The redundant diesel generators are each housed in separate rooms, separated from each other by 3-hour fire-rated walls and doors, with a curb at each of the doors to prevent oil from seeping under the door. Where less than 3-hour fire rated separation has been provided between the diesel generators, engineering evaluations have been prepared to technically justify the fire resistance of the subject fire barriers.

The significant combustibles in each room are lube oil, diesel fuel and a small amount of electrical cable insulation. The day tank for each diesel is separated from the diesel generator room by a 3-hour rated fire barrier with diking provided to contain the complete inventory of the day tank.

An unmitigated fire in one of the rooms could cause loss of one diesel generator.

Fire detection is provided by flow alarms activated by water flow in the automatic sprinkler system. Fire extinguishment is provided by a fusible link-type automatic sprinkler system in each room backed up by water hose stations and portable extinguishers.

Floor drains are provided in both emergency generators rooms. Manual venting of smoke is provided by exhaust dampers mounted in the ceiling to the outside and by a door to the outside from the vestibule.

The day tanks are mounted in separate cubicles and are vented to the outside. The day tank cubicles are not provided with sprinkler systems. Portable fire extinguishers and hose stations serving the diesel generator rooms are available in case of a fire in the day tank cubicles. The day tank rooms do not have sufficient air to support combustion.

The transfer of diesel oil from the underground storage tank to the diesel generator day tanks can be stopped by manually tripping the power supply to the transfer pumps, isolating the supply either in the Diesel Generator 1-2 room or at the transfer pump discharge in the intake structure.

The diesel fuel oil storage tank is located outside and underground away from the auxiliary building and safety-related equipment.

8.7.2.7 Battery Rooms Protection

There are two separate battery rooms. They have a 2-hour fire barrier from the cable spreading room and from each other.

The significant combustibles in the battery room are the plastic battery cases and a small amount of electrical cable insulation. Hydrogen buildup from battery charging is precluded by a continuously operating ventilation system.

An unsuppressed fire in one of the battery rooms could cause the loss of one, but not both, of the batteries due to the low fire hazard and the fire barriers between the rooms. Hydrogen buildup on loss of ventilation flow is prevented by checking the batteries once a day and by maintaining the hydrogen concentration well below 2% volume through the ventilation exhaust system. A sail switch in the ventilation duct warns the control room of a loss of battery room ventilation.

Each room is maintained under negative air pressure with air intake from the cable spreading room through fusible link fire dampers. The battery rooms' ventilation exhausts to the outside.

Smoke detection is provided for these rooms. Fire extinguishment is provided by water hose stations located in adjacent areas and by portable extinguishers.

Considering the limited quantity of combustibles, manual fire protection is adequate to extinguish fires in these rooms.

8.7.3 SUPPORT SYSTEMS

8.7.3.1 Ventilation

Severe weather phenomena do not present a significant hazard to Plant electrical equipment (designed for 10° to 40°C) while the Plant is operating because simple air exchange will maintain adequate temperature control. It may be necessary to operate the diesel generators during the winter if the normal Plant heating systems fail.

Ventilation for each diesel generator room is supplied by two fans. The two fans are safety related and receive power from associated safety-related distribution systems. In addition to the normal safety related power source, vent fans V-24A and V-24B also may receive power from an alternate, non-safety related power source. The safety related power source for each fan is separated from the non-safety related power source by a manual transfer switch.

Ventilation for the remaining electrical distribution system rooms - the cable spreading room, the two 2,400 volt bus (switchgear) 1C and 1D rooms and the two battery rooms - is supplied from a single duct system. The duct system has one supply fan, one exhaust fan and one recirculation fan. The one recirculation fan is redundant to the supply and exhaust fans.

The cable spreading room can withstand a loss of ventilation for up to six hours before exceeding the upper design temperature limit. High temperature in the room is annunciated in the control room. One of the redundant fans can be connected to emergency power sources.

The 1C and 1D switchgear rooms are not affected by a loss of ventilation since no appreciable heat sources are contained in these rooms. The battery room redundant fans are powered from separate channels of safety-related sources and therefore are not vulnerable to a loss of offsite power.

Tests have demonstrated that the equipment serviced in these rooms would not be adversely affected by lack of ventilation during loss of offsite power and/or a safe shutdown earthquake as defined in Section 5.7.

8.8 MOTOR OPERATED VALVES

The Palisades Motor Operated Valve (MOV) Program satisfies the requirements of NRC Generic Letter 89-10 "Safety-Related Motor Operated Valve Testing and Surveillance" and its supplements. Generic Letter 89-10 was issued in June 1989 and superseded IEB 85-03 "Motor Operated Valve Common Mode Failures During Plant Transients Due to Improper Switch Settings." The purpose of Palisades MOV Program is to ensure safety-related MOVs are designed and maintained such that they will perform their design basis function for the life of the plant. Plant procedures identify those MOVs at Palisades subject to the requirements of GL 89-10 and describe the Palisades GL 89-10 Program as it applies to those valves.

Initial compliance to GL 89-10 consisted of a design basis review for each MOV in the Palisades GL 89-10 program to determine the worst case operating condition for each MOV. An evaluation was then performed to determine the ability to each motor operator to operate the valve under the worst case operating condition including operation at degraded voltage during worst case temperatures. Motor operator control switch settings were then calculated to ensure proper operation at the worst case operating condition.

MOV Diagnostic Testing under static system conditions was performed on each MOV to set control switches to the specified control switch setting. MOV diagnostic testing was also performed, where possible, under dynamic system conditions which duplicated, as much as possible, actual worst case operating conditions. Field data obtained from those MOVs tested under dynamic conditions were used to validate control switch settings in the initial design calculations. For MOVs where testing under dynamic system conditions was not possible, this validation was performed using other sources of test data (ie. best available industry test data, etc.).

The Palisades plan for long term compliance with GL 89-10 consists of periodic testing, both static and dynamic, of GL 89-10 MOVs to verify control switch settings, and monitoring MOV performance through use of a tracking and trending program.

8.9 LIGHTING SYSTEMS

In addition to the normal ac lighting, there are separate dc and ac emergency lighting systems provided in certain areas of the Plant.

Feeders to lighting panels from power source are carried in the cable tray system. Branch circuits from the lighting panels are carried in conduits. The emergency dc light circuits from the panel to the lights are in conduits dedicated to these circuits only. The lighting panels serving safety equipment areas are at various locations in the auxiliary and turbine buildings.

The feed to the emergency dc Panels D41 and D42 is from the D20 main dc distribution panel in the cable spreading area. The feeds to the emergency dc panels are in separate diverging trays, except at the location of emerging from the Source Panel D20 and are separated from the trays carrying the ac lighting panel feeders. The latter feeders are generally in trays separate from each other.

Fixed battery pack lights are provided for access/egress and at the location of all manual actions required to achieve safe and stable conditions per National Fire Protection Association (NFPA) 805. This lighting is in addition to plant normal and emergency ac and dc lighting. The lighting is also available to support fire fighting activities when applicable. Where fixed battery pack lighting is not available, hand held lighting is relied upon to support operator manual actions necessary to achieve safe and stable conditions.

The fixed battery pack lighting has been designed to provide 8 hour operation.

Emergency lighting inside containment is provided for personnel safety and to assist in safe handling of fuel during refueling outages. Their operability testing is specified in the Operating Requirements Manual.

8.10 QUALITY CONTROL

For a discussion of the Quality Assurance Program, see Chapter 15. For field quality control, see Subsection 7.8.7.