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8.0 INTRODUCTION TO THE ELECTRICAL DISTRIBUTION SYSTEMS

Chapter 8 of the Point Beach Nuclear Plant (PBNP) Final Safety Analysis Report (FSAR) describes the Electrical Distribution systems. This chapter has been divided into individual system divisions, based on the system designators, which comprise the electrical distribution system. The major systems sections of Chapter 8 are; 345 kV, 19 kV, 13.8 kV, 4.16 kV, 480V, 125V, 120 VAC Vital Instrument Bus Power (Y), Diesel Generator (DG), and Gas Turbine (GT).

The Chapter 8 sections of the FSAR describe each system in an appropriate level of detail based on the safety significance of the system. Each system section is divided into; Design Basis, Description and Operation, System Evaluation, and Reference section. The Design Basis section gives the functional and relevant information on the design basis of the system. The system's Description and Operation section presents the normal and emergency operations which support the functions as described in the design basis section and provides a clear understanding of the system's operation.

The purpose of the electrical distribution systems is to distribute power from the main generator to the Northeast Wisconsin 345 kV AC transmission system, to PBNP, and from offsite sources during times when adequate onsite power is not available. The integrated design of the Electrical Distribution systems provide sufficient independence and redundancy to supply those PBNP loads which are important to plant safety under all postulated conditions.

Onsite and offsite sources of electrical power and various portions of the major systems sections described in Chapter 8 are credited in the event of a fire and have been evaluated in the at-power and non-power analyses and are documented in the Fire Protection Program Design Document (FPPDD) (Reference 5).

8.0.1 PRINCIPAL DESIGN CRITERIA

Performance Standards

Criterion: Those systems and components of reactor facilities which are essential to the prevention or to the mitigation of the consequences of nuclear accidents which could cause undue risk to the health and safety of the public shall be designed, fabricated, and erected to performance standards that will enable such systems and components to withstand, without undue risk to the health and safety of the public the forces that might reasonably be imposed by the occurrence of an extraordinary natural phenomenon such as earthquake, tornado, flooding condition, high wind or heavy ice. The design bases so established shall reflect: (a) appropriate consideration of the most severe of these natural phenomena that have been officially recorded for the site and the surrounding area; and (b) an appropriate margin for withstanding forces greater than those recorded to reflect uncertainties about the historical data and their suitability as a basis for design. (GDC 2)

All electrical systems and components vital to plant safety, including the emergency diesel generators, are designed as Class I and designed so that their integrity is not impaired by the maximum potential earthquake, wind storms, floods or disturbances on the external electrical system. Power, control and instrument cabling, motors and other electrical equipment required for operation of the engineered safety features are suitably protected against the effects of either a nuclear system accident or of severe external environmental phenomena in order to assure a high degree of confidence in the operability of such components in the event that their use is required.

Emergency Power

Criterion: An emergency power source shall be provided and designed with adequate independency, redundancy, capacity, and testability to permit the functioning of the engineered safety features and protection systems required to avoid undue risk to the health and safety of the public. This power source shall provide this capacity assuming a failure of a single active component. (GDC 39)

Independent alternate power systems are provided with adequate capacity and testability to supply the required engineered safety features and protection systems.

Offsite Power

Subsequent to the issuance of the original plant license, the NRC performed an evaluation (GL79-36) of the offsite power supply relative to the requirements of 10 CFR 50, Appendix A, GDC-17, "Electrical Power Systems." The NRC evaluation determined that the offsite power supply design was in compliance with 10 CFR 50, Appendix A, GDC-17 with the exception of the winding arrangement and proximity of the 1-X04 and 2-X04 low voltage station auxiliary transformers. These exceptions to 10 CFR 50, Appendix A, GDC-17 were determined to be acceptable based on the technical specification restrictions on plant operation with an inoperable X04 transformer, the installed X04 transformer fire deluge sprinkler system, the capability to supply either units A03 and A04 4.16 kV busses from the opposite units X04 transformer via manually closed tie breakers, the development of procedures to back feed offsite power through the X01 main step up transformers, and the procurement of a spare X04 transformer (Reference 1, Reference 2). Subsequesnt to this NRC evaluation, the original 13.8 kV bus H01 has been relocated to a separate building and replaced with three busses H01, H02, and H03. A reinforced concrete fire wall has also been erected between the 1-X04 and 2-X04 transformers. These changes have further improved the physical independence of the offsite power supplies (Reference 3, Reference 4). Note that although the design is in compliance with some aspects of 10 CFR 50, Appendix A, GDC-17, PBNP was licensed prior to Appendix A being issued and never committed to GDC-17 in whole or in part.

In addition to the principal design criteria, the following general requirements are applied to the systems found in Chapter 8 where applicable. (See also Appendix D regarding general requirements associated with the installation of G03 and G04 emergency diesel generators).

1. The application and routing of control, instrumentation and power cables are such as to minimize their vulnerability to damage from any source. All cables are designed using conservative margins with respect to their current-carrying capacities, insulation properties, and mechanical construction. All engineered safeguards power cable insulation and all power cables in the reactor building have fire resistant sheathing selected to minimize the harmful effects of radiation, heat, and humidity. Appropriate instrumentation cables are shielded to minimize induced voltage interference. Wire and cables related to engineered safeguard and reactor protective systems are routed and installed to maintain the integrity of their respective redundant channels and protect them from physical damage.

2. Supports for cable trays are designed in accordance with the tray manufacturer's recommendation based upon 100% tray load. In general, cable trays are loaded such that

power and control trays are filled less than 30% and instrument trays less than 40%. The fill factor represents:

$$\frac{\text{Sum of Cross Sectional Areas of All Cables In Tray}}{\text{Cross Sectional Area of Tray}}$$

Cables in trays are derated by factors recommended by Insulated Cable Engineers Association (ICEA). Derating factors used for conduit installations are in accordance with the National Electric Code.

3. Separate wireways are provided for medium voltage power cables (4 kV and 13.8 kV). Lower voltage power cables (480 V and 125 VDC) and control cables (120 VAC and 125 VDC) may be placed in the same wireways. Separate wireways are maintained for instrumentation cables. Separation is maintained such that redundant protection channels or trains are not intermixed within the same wireway. (Note clarification on Separation of Safety Injection Reactor Trip Signals in Section 7.3.3). Cables for nonvital circuits have not been excluded from wireways carrying protection system cabling.

4. When loading the cables into the trays, the height of cable bundles is maintained equal to, or below, the height of the tray except when special evaluations prove acceptability under other conditions. (Reference SER 93-025-17) More cable tray loading criteria are located in this section.

5. All wireways are identified by a unique number. In addition, all cable trays containing engineered safeguards or protection circuits are marked by a color which designates the particular channel for which it serves.

6. Minimum separation between the two penetration areas is 20 ft. Within each area, penetrations for cables which serve engineered safeguards and reactor protection circuits are located below cabling for nonessential services. Cables which contain mutually redundant circuits do not share a common penetration. Penetrations for safeguards or protection circuit must be separated from penetrations with mutually redundant circuits by a minimum distance of 24 in. or a metal barrier.

7. Insulation for cables rated 5 kV are heat, ozone and moisture resistant. Insulation for cables rated l5 kV are also heat, ozone, and moisture-resistant. Insulation for power cables rated 600 v, which are used for engineered safeguards services, are ozone and moisture-resistant with flame retardant overall jacket.

8. Insulation for control cables which are used for safeguards and protection circuits are 600 v ozone-resistant. Individual conductors are covered with a flame retarding and moisture-resisting insulation material. Multiconductor cables are provided with overall flame retarding jacket.

9. Insulation for the various categories of cables is selected on the basis of utility practice, with special considerations given to flame retardant properties of insulation and jackets for cables which serve engineered safeguards or protection functions.

10. All cables are protected against overload in accordance with the National Electrical Code.

11. Wiring between vital elements of the system outside of equipment housing is routed and protected so as to maintain the true redundancy of the systems with respect to physical hazards.

12. No provisions are made for temperature monitoring of cables.

13. During selection of insulation materials for the various categories of cables, the environmental effects of cables have been taken into account. Specific attention was given to the effects of radiation, high ambient temperatures and moisture. In addition, provisions are made to protect against mechanical damage, where necessary.

14. Each cable is identified at both terminations by a unique number. In the case of cables containing engineered safeguards or reactor protective circuits, the cable number includes two additional characters, one identifying a cable as a safeguard or protective cable, the other identifying the actual channel with which it is associated. In addition, a color coded marking is placed on or near the cable label for additional channel identification.

15. During construction and subsequent modifications, verification of the proper routing of cables was made through independent inspections by site personnel. During original plant construction, when a safeguards circuit was randomly selected for inspection, the routing of its companion circuit was inspected to assure that separation had been accomplished.

NOTE: The following describes the original method used to seismically evaluate electrical equipment. Additional verification of the seismic adequacy of plant mechanical and electrical equipment was performed as discussed in Section A.5.6, Verification of Seismic Adequacy of Equipment per Generic Letter 87-02.

16. An evaluation of electrical equipment ability to withstand seismic events is documented in Westinghouse report WCAP-7397-L, titled “Topical Report Seismic Testing of Electrical and Control Equipment” E.L. Vogeding, dated January 1970. Refer to Section 7.2.3.4 for additional seismic qualification requirements.

    The switchgear equipment has been specified to withstand accelerations in excess of 0.15g horizontally and 0.10g vertically. This capability was a matter of procurement specification of Westinghouse and its design agents and design action of the vendors. The safeguards circuits employ Westinghouse Series W motor control centers, DB and DH circuit breakers and associated metal-enclosed or metal-clad switchgear. Review of these switchgear for proof of adequacy of the seismic resistant design determined that the Series W motor control centers and DB breakers, mounted in the metal enclosures, have been shock tested and proven to remain fully operable for shocks of at least 3g in any direction. Proof of resistance of the DH metal-clad switchgear to a seismic response spectrum established for Point Beach has been demonstrated by vibration testing of typical, equivalent metal-clad switchgear, incorporating the DHP circuit breaker. The DH circuit breakers installed in Point Beach are an earlier design than the DHP. However, the general configuration, weight distribution, and vibration resistant design approach of the DH are essentially identical to the DHP. When subjected to a spectrum equivalent to or greater than Figure B-2, there was no loss of function of the DHP metal-clad switchgear.

The power supply leaving the switchgear operates the safeguards equipment completing the actuation train. The DC power supply may be considered as a branch to this main train of actuation. The source of DC power may be either the battery chargers or the station batteries. The batteries and battery racks present a simple structural problem which was analyzed and found adequate for the forces imparted by the floor upon which they are located. The conduit and cable trays carrying the DC power to the main station train received the same study for seismic support as described above.

17. Local or remote control is provided to key safeguards breakers to prevent a casualty from disabling the safeguards power supplies. Separation is maintained in both the 4.16 kV and the 480V systems to allow the plant auxiliary equipment to be arranged electrically so that redundant items receive their power from the two different buses. [redacted] and so forth. Redundant valves are supplied from motor control centers 1-B32 and 1-B42 for Unit 1 and 2-B32 and 2-B42 for Unit 2.

18. In order to prevent propagation of cable fire in the event that such a fire occurs, fire stops are placed at the following locations: all cable trays entering the main control room, cable spreading room, vital switchgear room and other areas with high concentrations of cables. (For additional information see the Fire Protection Program Design Document (FPPDD) (Reference 5).

19. In addition, fire stops are placed in all vertical cable tray risers, and all trays which contain engineered safeguards or protection circuits, and where such trays penetrate a wall.

20. Fire stops are designed to provide an effective barrier against propagation of flames, heat, gases and smoke.

21. Fire detectors are placed in the following critical areas: cable spreading room, switchgear rooms, diesel generator rooms and electrical equipment rooms. The detectors operate on the ionization principle actuated by the presence of combustion products or gases, except for the G03 and G04 rooms which have rate-of-rise heat detectors.

8.0.2 REQUIRED PROCEDURES AND TESTS

Tests are specified to demonstrate that the diesel generators (DG) will provide power for operation of equipment. The tests also assure that the emergency generator system controls and the control systems for safeguards equipment will function automatically when required. The tests are performed in accordance with the Point Beach Nuclear Plant Technical Specifications.

8.0.3 SINGLE LINE DIAGRAMS

The basic components of the station electrical system are shown on the Electrical One Line or Single Line Diagrams, Figure 8-1 through Figure 8-8, including the main one line, the 480 volt and 120 volt AC instrument bus systems and the 125 volt DC system.

8.0.4 REFERENCES

1. NRC Safety Evaluation “Safety Evaluation of the Preferred Power Systems Conformance to General Design Criteria 17,” dated August 29, 1983.

2. NRC Safety Evaluation “Adequacy of Station Electric Distribution System Voltages,” dated August 29, 1983.

3. 10 CFR 50.59 Evaluation 87-022, “MR 87-002 (Common) 13.8 kV H01 Switchgear Replacement (Three Bus Sections),” dated April 6, 1987.

4. 10 CFR 50.59 Evaluation 87-022-02, “1-X04 and 2-X04 Transformer Fire Wall,” dated September 30, 1991.

5. NFPA 805 Fire Protection Program Design Document (FPPDD).

Figure 8-1 UNITS 1 & 2 MAIN ONE LINE DIAGRAM

[redacted]

Figure 8-2 UNIT 1 480 VOLT ONE LINE DIAGRAM

[redacted]

Figure 8-3 UNIT 2 480 VOLT ONE LINE DIAGRAM (Sheet 1)

[redacted]

Figure 8-3 UNIT 2 480 VOLT ONE LINE DIAGRAM (Sheet 2)

[redacted]

Figure 8-3 UNIT 2 480 VOLT ONE LINE DIAGRAM (Sheet 3)

[redacted]

Figure 8-4 480V ONE LINE DIAGRAM ALTERNATE SHUTDOWN SYSTEM

[redacted]

Figure 8-5 UNITS 1 & 2 125 V ONE LINE DIAGRAM

[redacted]

Figure 8-6 UNITS 1 & 2 125 VDC ONE LINE DIAGRAM

[redacted]

Figure 8-7 125V ONE LINE DIAGRAM

[redacted]

Figure 8-8 UNITS 1 & 2 INSTRUMENT BUS ONE LINE DIAGRAM

[redacted]

8.1 345 kV AC ELECTRICAL DISTRIBUTION SYSTEM (345 kV)

The main transmission lines to PBNP and other Eastern Wisconsin power companies operate at 345 kV AC. The Point Beach Nuclear Plant has two main generators that produce electrical power at 19 kV AC. The output of the main generators is stepped up to 345 kV AC by the main transformers 1/2-X01. Unit output circuit breakers F52-122 for Unit 1 and F52-142 for Unit 2, are on the 345 kV side of the main transformers and connect to the 345 kV AC Switchyard Bus Sections 2 and 4 respectively.

8.1.1 DESIGN BASIS

The 345 kV system does not perform any safety related function and is classified non-safety related. The 345 kV distribution system performs the following functions:

1. Transmits power generated at PBNP to the 345 kV grid.
2. Provides standby power to PBNP auxiliaries during unit(s) startup, shut down, and after reactor trip.
3. Provides a reliable source of normal power to PBNP engineered safeguards equipment.
4. Acts as an interconnecting terminal for the four 345 kV lines at PBNP.

The design of the system is such that sufficient independence or isolation between the various sources of electrical power is provided in order to guard against concurrent loss of all auxiliary power. Safety related auxiliary electrical loads are normally powered from offsite power supplies (through the high voltage and low voltage station auxiliary transformers) to ensure continuity of power during plant transients.

The 345 kV AC system is credited in the event of a fire and has been evaluated in the at-power and non-power analyses (Reference 3).

8.1.2 SYSTEM DESCRIPTION AND OPERATION

In each unit, electrical energy generated at 19 kV AC is transformed to 345 kV AC by the main transformer banks, (rated 756 MVA at 65°C rise) and delivered through the unit output circuit breaker (rated at least 345 kV, 15,000 MVA, 2 KA) to the 345 kV switchyard located at the plant site. The switchyard is located on the west side of PBNP adjacent to the protected area fence. The unit output circuit breakers F52-122 and F52-142 are located in the switchyard and the control power for these breakers is derived from the switchyard batteries. These breakers remain closed following a unit trip in order to provide power to the unit's auxiliary loads by back feeding through the X01 main transformer. The electrical output of both units is integrated into Northeast Wisconsin's 345 kV AC transmission system which presently has 345 kV interconnections with other Wisconsin utilities as well as Illinois and Minnesota utilities.

The 345 kV system consists of 4 lines connected to the plant switchyard. Each line is carried on a separate line structure in order to minimize the possibility of losing more than one circuit at a time. One of the four 345 kV transmission lines can supply all of the plant auxiliary power. The output of the main generator is connected to the 345 kV system through the 19 kV generator output breaker and the X-01 transformer. Control power for the 19 kV generator output breaker is obtained from the station batteries. Figure 8.1-1 depicts the 345 kV system and electrical connections.

The 345 kV system supplies the high voltage station auxiliary transformers (1/2-X03) which provide the interface to the 13.8 kV system and are the normal offsite power supply for auxiliary loads associated with plant engineered safeguards. Under some conditions, if the normal offsite supply is not available, safeguards equipment can also be supplied from offsite power by back feeding through the main transformer. Refer to FSAR 8.3 and FSAR 8.4 for further discussion on this alternate offsite power line up.

Lightning arresters are used for lightning protection. All oil filled transformers, except the high voltage station auxiliary transformers, are covered by automatic water spray systems to extinguish oil fires quickly and prevent the spread of fire. Transformers are spaced to minimize exposure to fire, water and mechanical damage. The X03 high voltage station auxiliary transformers, located in the 345 kV switchyard, are separated by the full length of the switchyard, approximately 600 ft.

The 345 kV switchyard utilizes two batteries to improve the reliability of the 125 VDC control system. All 345 kV breakers are provided with redundant trip-coils; each trip-coil of a particular breaker is deliberately supplied from a separate battery. Reliability is further enhanced by providing each battery with separate battery chargers; sufficient charger capacity exists to supply the DC loads and maintain a float charge on each battery.

8.1.3 SYSTEM EVALUATION

Analysis of the interconnected 345 kV system shows that a fault on any one of the four transmission lines or any bus section at Point Beach, or the loss of both Point Beach units will not cause a cascading failure of the 345 kV AC transmission system, provided all four transmission lines and five bus sections at Point Beach are in service.

Additional studies show that when one or more of the four transmission lines is out of service, there is the potential for cascading failure of the 345 kV AC transmission system, given the loss of one of the remaining transmission lines or the occurrence of a fault on one of the remaining transmission lines or any bus section at Point Beach. The potential for such a cascading failure of the 345 kV AC transmission system is dependent upon the level of generation at Point Beach and the transmission load at the time of the failure or fault. These studies also show that the Power System Stabilizers (PSS) installed at Point Beach would improve the response of the main generators to external 345 kV system disturbances by dampening system transients. Operating Procedures have been developed and implemented which limit operation of the Point Beach Units, such that a cascading failure of the 345 kV AC transmission system described above will be minimized. The Operating Procedures include conditions for both with and without the PSS in service at Point Beach. The off-site power supply to the plant for any of the aforementioned failures is therefore assured (Reference 2).

Comprehensive studies of the interconnected transmission network in the American Transmission Company (ATC) / Midcontinent Independent System Operator (MISO) footprint under contingency conditions have been made. These studies showed that the sudden loss of any single unit will not affect the ability of the 345 kV AC transmission system to supply power to the Point Beach Nuclear Plant auxiliary systems. A simplified one line diagram of the 345 kV system interconnections is shown on Figure 8.1-2.

The physical locations of electrical distribution system equipment is such as to minimize vulnerability of vital circuits to physical damage as a result of accidents. The main transformers and high voltage station auxiliary transformers are located outdoors and are physically separated from each other.

If either 125 VDC switchyard system battery should become open circuited, which is the most likely failure mode, the control voltage supply would be maintained by the associated battery charger. If, however, a battery becomes short circuited the associated control supply will fail. Loss of both local and remote operability is highly unlikely since simultaneous short circuits on both batteries or on the battery leads must take place. Any short circuit of an individual control feeder would clear through individual fusing provided; the remainder of the control supplies would remain intact.

Assuming that both switchyard batteries become short circuited and that a fault occurs on a 345 kV bus or line connected to the switchyard, protection is obtained by second zone protective relay schemes at the remote line end terminals which will trip the remote end breakers connected to the fault. The unit affected would be tripped by any of several protective schemes depending on the type and location of the fault. These schemes include a negative sequence relay, turbine overspeed trip device or, if an underfrequency condition exists, the main coolant pumps will be tripped. Any of these protection systems will trip the reactor, the turbine and the generator field breaker.

Reference 1 provides additional information regarding the site's response to a Station Blackout (SBO).

Open Phase Protection

Analyses were performed to evaluate the impact of open phase conditions on safeguards equipment. The open phase conditions analyzed are those on the high side of offsite power sources 1X-03 and 2X-03 (1X-01 and 2X-01 for back feed) where one or two of the three incoming phases are open circuited. The open phase conditions considered include all loading conditions. Evaluations show that safeguards equipment will be protected for applicable open phase conditions, or that the amount of unbalance is tolerable, without equipment damage, for a period of time that would allow for identification of the open phase condition. This protection is provided via the following station equipment:

- Degraded Voltage Relays for 4160V safeguards buses 1A-05, 1A-06, 2A-05, and 2A-06
- Loss of Voltage Relays for 4160V safeguards buses 1A-05, 1A-06, 2A-05, and 2A-06
- Transformer Neutral Overcurrent Relays for transformers 1X-03 and 2X-03 (1X-01 and 2X-01 for back feed)

For certain double open phase conditions without a safety injection signal present, it is possible for motors to trip on overcurrent. For this scenario, Operations will have sufficient time to restart the motors as applicable.

In addition, Open Phase Detection (OPD) monitoring systems are installed for each of the offsite power sources 1X-03 and 2X-03 (1X-01 and 2X-01 for back feed) to identify open phase conditions. When an open phase condition is detected by an OPD system, an alarm is provided in the control room.

References 4 through 6 provide additional information regarding Open Phase Protection.

8.1.4 REFERENCES

1. FSAR Appendix A.1 “STATION BLACKOUT”
2. Procedure OP 2B, “345 KV Transmission System Impacts Upon PBNP Station Operation”
3. NFPA 805 Fire Protection Program Design Document (FPPDD)
4. NEI Industry Initiative on Open Phase Condition, dated September 20, 2018
5. Calculation 0292-0056-CALC-005
6. Calculation 0292-0056-CALC-006

Figure 8.1-1 345 kV SWITCHYARD AND INTERCONNECTIONS

[redacted]

Figure 8.1-2 PBNP 345 kV INTERCONNECTIONS

[redacted]

8.2 13.8K VAC ELECTRICAL DISTRIBUTION SYSTEM (13.8kV)

The 345 kV system and the Gas Turbine (G05) are the sources of power to the 13.8 kV system. The 13.8 kV electrical distribution system is the intermediate voltage power distribution system which provides the normal offsite power supply to the 4.16 kV safeguard buses during power operations and during plant startup, shutdown and following main generator trips. The 13.8 kV system also supplies safe-shutdown buses (via X08), various plant support loads (via X27), G05 auxiliaries (via X500), 345 kV switchyard auxiliaries (via X48), Nuclear Engineering Services Building (via X65), Training Building (via X66), and Sewage Treatment Plant (via X72).

8.2.1 DESIGN BASIS

The 13.8 kV system does not perform any safety related functions. The 13.8 kV system shall distribute power from the Gas Turbine (GT) to those loads required during a station blackout, to achieve and maintain safe reactor shutdown (Reference 1). The 13.8 kV system is credited in the event of a fire and has been evaluated in the at-power and non-power analyses (Reference 3).

8.2.2 SYSTEM DESCRIPTION AND OPERATION

Figure 8.2-1 is a sketch of the 13.8 kV system showing its interconnections to the station and to the 345 kV switchyard. The 13.8 kV system boundaries include the high voltage station auxiliary transformer (1/2X03) up to the high side connection of the low voltage station auxiliary transformers (1/2X04), and various 480V transformers.

The 13.8 kV system supplies offsite power to the Point Beach Nuclear Plant via the 4.16 kV and 480V systems. The 13.8 kV system is divided into three buses which are designated H01, H02, and H03. The H02 bus supplies Unit 1 and is normally served by the high voltage station auxiliary transformer 1X03. The H02 bus supplies power to the low voltage station auxiliary transformer 1X04. In a like manner, the H03 bus supplies Unit 2 and is normally served by the high voltage station auxiliary transformer 2X03. The H03 bus supplies power to the low voltage station auxiliary transformer 2X04. The units can be interconnected to alternate supplies by arranging bus tie breakers to connect H02 to H01 and H03 to H01. The power generated by the Gas Turbine can be delivered to either unit by also arranging the13.8 kV tie breakers of the H01, H02, and H03 buses.

The normal 13.8 kV electrical arrangement is to have one of the two bus tie breakers (H52-21 or H52-31) closed supplying power to the H01 tie bus. The H01 bus supplies the gas turbine auxiliaries as well as the north service building transformer X27 and the alternate shutdown transformer X08. The gas turbine generator G05 is connected to the tie bus H01 through breaker H52-10 (see Section 8.9 for GT startup requirements).

In addition, a three phase, 15 MVAR capacitor bank has been added to 13.8 kV bus H01. Aligning bus H01 to either bus H02 (Unit 1) or H03 (Unit 2) could then align this capacitor bank to either unit’s offsite connection. Under certain conditions, the capacitor bank will permit a lower offsite 345 kV grid voltage while still maintaining adequate voltage at the 4160V safety buses (A-05 and A-06) such that the degraded grid relays will not actuate and transfer the safety buses to the onsite emergency diesel generators. Procedural controls prevent the capacitor bank from operating simultaneously with the gas turbine generator G-05 (Reference 2).

The H01, H02 and H03 bus configuration allows a high voltage station auxiliary transformer (X03) to be removed from service and its associated low voltage auxiliary transformer to be supplied through the H01 bus from the other X03 transformer or Gas Turbine. When a high voltage station transformer (X03) experiences a fault, the tie breakers between H02 and H01; and H03 and H01, receive an automatic transfer signal to restore power to the respective low voltage station transformer. Additional protective relaying exist to protect the 13.8 kV buses by preventing closure of circuit breakers to faulted buses. The closing of the tie breakers into a common fault is prevented by trip and lockout interlocks in the breaker control circuits. Auto closure of the tie breakers can be defeated by placing the remote control switches in pullout, or transferring to local control.

The local control panels for the H01, H02 and H03 buses are C221, C222 and C223 respectively. The metering and relaying for each breaker associated with the switchgear is located on the local control panels. Each breaker of the switchgear has local control switches located on their respective control panels with the main feeder and tie breakers having additional remote control switches on Control Room Panel C02. Remote control and metering circuits are separately fused so that a control or cable spreading room fire can not disable local operation.

The 13.8 kV switchgear is controlled by 125 VDC power supplied from plant station batteries D105 and D106. Each bus section has a separate DC supply panel with an associated manual transfer switch which allows for selection of one of the two independent supplies. These supplies are separated and fused so that a fire in any of the three rooms (H01, H02, or H03 switchgear sections) will not disable both supplies for the other two rooms. Each circuit within the DC panels has separate fuse monitor relays which input to a common control room annunciator.

The 13.8 kV breakers are manually synchronized by utilizing synchronizing scopes and switches. The synchronizing switch provides interlocks to prevent manual breaker closure without the synchroscope and incoming and running voltmeters being turned on.

The primary protective relaying for each 13.8 kV bus section is provided by bus differential relays (87). The secondary protective relaying for bus H02 and bus H03 is provided by inverse time overcurrent relays (51) connected to the transformer side of the feeder breakers in H05 and H06. The differential and overcurrent relays for the buses operate manually reset lockout relays (86) which trip and lockout each breaker on the bus section. The lockout relays (86) for the H02 and H03 buses also trip and lockout their associated feeder breakers located in H05 and H06 respectively. Ground fault protection is provided for H03 and H02 by a low voltage pickup overvoltage relay (59) connected across the break in a grounded wye-broken delta voltage transformer circuit. This relay activates an alarm.

Power supplied by circuit breakers H52-11 (X08), H52-16 (X27), and H52-23 (H08 and H09) is protected by inverse time overcurrent phase relays (51) connected to the bus-side current transformers of the feeder breaker.

The primary protective relaying for the High and Low Voltage Station Auxiliary Transformers is provided by transformer differential relays (87). Backup protection for the transformers is provided by sudden pressure relays (63). Further backup protection is given by overcurrent relays (51). These relays actuate the respective transformer manually reset lockout relays (86). The transformer manually reset lockout relays trip low voltage breakers of the affected voltage transformers. The lockout relays (86) also trip the high voltage breaker of the affected Low Voltage Station Auxiliary Transformer and the high voltage circuit switcher for the affected High Voltage Station Auxiliary Transformer.

Breaker failure relays (62BF) are installed in the system to avoid significant problems caused by the failure of primary protection. The additional protection is required due to the automatic bus crosstie logic of the 13.8 kV system where one fault could cause the loss of all offsite power for both Units.

8.2.3 SYSTEM EVALUATION

The normal offsite power supply for safeguards equipment is supplied from the 345 kV AC transmission system via the high voltage and low voltage station auxiliary transformers (X03) and (X04), respectively. The 13.8 kV system can also be used to provide offsite power to non-safety related electrical loads via the X03 and X04 transformers during startup and shutdown, although this is not the normal alignment. Each low voltage station auxiliary transformer can supply all the auxiliary loads for its unit. Refer to FSAR 8.3 for a description of the unit auxiliaries normally supplied by the 19 kV system via the unit auxiliary transformer (1/2-X02).

Two separate outside sources can serve either unit's low voltage station auxiliary transformer. The primary source of power to the safeguards buses for each unit, is a low voltage station auxiliary transformer aligned with its respective high voltage station auxiliary transformer. Alternate power may also be supplied by aligning the 13.8 kV buses to the opposite unit’s high voltage station auxiliary transformer or to the Gas Turbine Generator. Transfer from the normal to the alternate high voltage station auxiliary transformer is accomplished automatically if the normal high voltage station auxiliary transformer is tripped.

The system is designed to minimize, to the extent practical, the likelihood of a simultaneous loss of offsite power to Units 1 and 2 due to any single credible incident to any component or at any location. This is achieved by physical separation of the bus sections, transformers, duct runs, manholes, cables, etc. The H01, H02, and H03 switchgear sections are located in the 13.8 kV Switchgear Building. This building is divided using one hour fire walls into separate rooms for each bus which include local panels for relaying and control.

Through equipment selection and administrative controls, the 13.8 kV system has adequate protective relaying and interrupting capability to properly interrupt all possible faults, assuming any of the above described alignments. Additional, controls exist to limit the paralleling of the high voltage station auxiliary transformers (1/2X03) during transfer of the H01 tie bus.

8.2.4 REFERENCES

1. FSAR Appendix A.1 “Station Blackout”

2. PBNP 10 CFR 50.59 Evaluation EVAL 2009-013-01, PBNP EC 13600 Capacitor Bank Addition,” October 14, 2009.

3. NFPA 805 Fire Protection Program Design Document (FPPDD).

Figure 8.2-1 13.8 kV SIMPLIFIED ONE LINE DIAGRAM

[redacted]

8.3 19K VAC ELECTRICAL DISTRIBUTION SYSTEM (19 kV)

The 19 kV AC Electrical Distribution System (19 kV) distributes the energy developed by the unit's main generator (1/2-TG01) to the main transformer (1/2-X01) and the unit's auxiliary transformer (1/2-X02) via the main generator output circuit breaker (1/2-G52-TG01). This section of the FSAR presents both the 19 kV Electrical Distribution system as well as portions of the unit's main generator (1/2-TG01).

8.3.1 DESIGN BASIS

The 19 kV system does not perform any safety related function and is classified non-safety related. The 19 kV AC distribution system performs the following functions:

1. Transmit the power generated by the main generator (1/2-TG01) to the main (1/2-X01) and unit auxiliary (1/2-X02) transformers.
2. Provide power to unit auxiliaries via 1/2-X02 during normal plant operations, startup, shut-down and following a unit trip.
3. Provide a means to step up the output voltage of the main generator, from 19 kV to 345 kV, for use in the 345 kV AC transmission system.
4. Provide a means to isolate the main generator from the 345 kV AC transmission system and to phase the unit on line.
5. Provide a means to back feed power from the 345 kV AC transmission system to the 4160 VAC safeguard buses via the 1/2-X01 and 1/2-X02 transformers when the 1/2-X04 transformer is out of service.

The 19 kV system is credited in the event of a fire and has been evaluated in the at-power and non-power analyses (Reference 1).

8.3.2 SYSTEM DESCRIPTION AND OPERATION

Each unit is equipped with one Westinghouse hydrogen inner-cooled turbine generator. Each generator produces and delivers 19 kV, 3 phase, 60 Hz. electric power to the main transformer (X01) where it is stepped up to 345 kV AC. The Unit's main transformer output is connected to the 345 kV AC transmission system. Each generator output also feeds the associated unit auxiliary transformer (X02) where the voltage is stepped down to 4160 VAC for use within the station. Each generator is rated at 684 MVA at a power factor of 0.94. The rotor (field), rotating through the 4-pole per phase armature at 1800 RPM, produces a 60 Hz alternating current.

During normal operation each generator delivers power to the main and auxiliary transformers through isolated phase buses (1/2 Z-117A, B, C). The isolated phase bus is a force-cooled metal clad bus which connects the output of the main generator to the main transformer (X01) via the generator output circuit breaker (1/2-G52-TG01). The service water (SW) system provides the cooling for the isolated phase bus through an air-to-water cooler.

The unit's main transformer (X01) steps up the main generator output voltage for use in the 345 kV AC transmission system. The main transformer consists of a bank of three separate transformers, one for each phase. Each transformer is a cooling class ODAF, outdoor, shell form power transformer. The ODAF class is cooled by forced oil which in turn is cooled by forced air.

The main transformers are located outside and adjacent to their respective turbine buildings (South for Unit 1 and West for Unit 2).

The bulk of the power required for station auxiliaries during normal operation of either unit is supplied by an auxiliary transformer (1/2-X02) connected to the isolated phase bus of that unit. The 1/2-X02 transformers are also located outside, in close proximity to their respective main transformers (1/2-X01). The unit auxiliary transformers (1/2-X02) are part of the 4.16 kV system and are described in FSAR 8.4.

Protective relaying for the 1/2-X01 and 1/2-X02 transformers is provided by primary and backup transformer lockout relays (86). The lockout relays will isolate the transformers in the event of fault or failure of the 19 kV or connected 345 kV system. Protective relaying for the main generator is provided by primary and backup generator lockout relays (86). These lockout relays will open the main generator breaker and main generator field breaker to isolate the generator in the event of a generator fault or turbine trip.

Following a turbine generator trip, the 19 kV main generator breaker (1/2G52- TGO1) opens. The auxiliaries on the 4.16 kV non-safeguards buses remain fed by the unit auxiliary transformer (1/2X-02) via the main transformer (1/2X-01). With a low voltage station auxiliary transformer (1/2X-04) out of service, the 19 kV system can also be used to provide offsite power to the shutdown unit's 4.16 kV buses by back feeding from the 345 kV system through the X-01 and X-02 transformers.

8.3.3 SYSTEM EVALUATION

There are no Technical Specification requirements placed on the 19 kV system, however portions of the system may be used to satisfy the offsite power requirements of Technical Specification 3.8.1, “AC Source - Operating,” and Technical Specification 3.8.2, “AC Source - Shutdown” when a low voltage station auxiliary transformer (1/2X-04) is out of service. Periodic testing of the 19 kV system is performed per the applicable maintenance procedures.

8.3.4 REFERENCES

1. NFPA 805 Fire Protection Program Design Document (FPPDD)

8.4 4.16K VAC ELECTRICAL DISTRIBUTION SYSTEM (4.16 kV)

The majority of electrical loads, used for both safety and non-safety related applications, at PBNP are powered by the 480V AC system. The various sources, used to supply the 480V AC system, are rated at different voltages and the 4.16 kV system provides the primary means to interconnect the onsite and offsite power sources and distribute the power to the 480V AC system.

8.4.1 DESIGN BASIS

The 4.16 kV system provides a reliable source of power to the safety related loads during all normal and emergency plant operating conditions. During station blackout conditions the 4.16 kV system shall supply power to those loads required to achieve and maintain safe reactor shutdown (See Reference 1 for additional Station Blackout information). The 4.16 kV system has sufficient independence from offsite sources to be rapidly isolated to protect the safeguard buses in the event of a design basis accident. The 4.16 kV system is designed with redundant loads to ensure a single failure will not prevent a safety related component from performing its intended function.

The 4.16 kV system is credited in the event of a fire and has been evaluated in the at-power and non-power analyses (Reference 5).

8.4.2 SYSTEM DESCRIPTION AND OPERATION

Each unit’s main generator serves as the main source of electrical power for the non-safety related auxiliary loads during “on-the-line” operation of the unit. Power is supplied, to the 4.16 kV system, via a 19/4.16 kV three winding unit auxiliary transformer that is connected to the main leads from the unit’s generator. Upon a generator trip, offsite auxiliary electric power is backfed from the 345 kV AC transmission system via transformers X01 and X02.

The 4.16 kV system is comprised of six buses per unit (A01 through A06), the unit auxiliary transformer (X02), and the low voltage auxiliary transformer (X04). Figure 8-1 shows the station’s electrical interconnection, and the 4.16 kV distribution system is shown in Figure 8.4-1. Two buses per unit, A03 and A04, are connected to the 13.8 kV system via bus supply breakers to the independent windings of the low voltage station auxiliary transformer (X04). Buses A03 and A04 serve buses A05 and A06 respectively. Buses A05 and A06 are connected to buses A03 and A04 using manually closed tie breakers. A05 and A06 supply all of the safety-related loads (4.16 kV and 4.16kV/480V transformers).

During unit operation the output of the unit's main generator supplies power to the primary side of the unit auxiliary transformer (X02) which is directly connected to the 19 kV system bus between the generator output circuit breaker (G52-TG01) and the main step up transformer (X01). The 4.16 kV buses A01 and A02 are then connected to the independent windings of the secondary side of the unit auxiliary transformer (X02). All normal operating non-safety related 4.16 kV auxiliaries are split between buses A01 and A02. In addition, buses A01 and A02 each serve one 4160/480 volt station service transformer. Buses A0l and A03 or buses A02 and A04 can be tied together via bus tie breakers. The normal at-power alignment is with the tie breakers between A01 and A03 (A02 and A04) open. Following a turbine generator trip, the 19 kV main generator breaker (G52-TG01) opens. The auxiliaries on the 4.16 kV non-safeguards buses remain fed by the unit auxiliary transformer (X02) via the main transformer (X01). Control power for the 4.16 kV breakers is obtained from the station batteries.

If either low voltage station auxiliary transformer 1-X04 or 2-X04 is removed from service, tie breakers between buses 1-A03 and 2-A03 and between 1-A04 and 2-A04 can be manually closed. Offsite power can also be provided to the A03 and A04 buses from the A01 and A02 buses respectively when back fed from the 345 kV system through the X01 and X02 transformers. A spare X04 transformer is maintained in a condition which will allow expeditious repair or replacement of 1-X04 or 2-X04 (Reference 3).

Buses A05 and A06 each serve one of the two 4160/480 volt station service transformers for the unit's 480 volt safeguards equipment and one of the two safety injection pumps. Buses 1A-06 and 2A-05 each serve one motor driven auxiliary feedwater pump. No transfer is required for the safeguards equipment in the event of a turbine generator trip. In addition to being served by buses A-03 and A-04, buses A-05 and A-06 are directly served by the Train A and Train B emergency diesel generators respectively.

[redacted] The overhead bridge and associated towers are non-safety related seismic Class III structures designed to AISC Steel Specifications to withstand the design bases wind speed of 100 mph. Strategically located bollards prevent accidental impact to the tower legs from limited height moving vehicles, such as fork-lift trucks. The design and location of the overhead bridge structure is such that any postulated failure would not affect the offsite power supply from the opposite unit’s X04 transformer (Reference 2, Reference 4).

8.4.3 SYSTEM EVALUATION

The auxiliary electrical system is designed to provide a simple arrangement of buses requiring the minimum of switching to restore power to a bus in the event that the normal supply to that bus is lost.

The 4.16 kV system has a series of relays which automatically initiate features designed to provide protection to the safety related buses and loads, and to ensure that all safety-related loads are capable of starting and operating continuously to perform their safety functions. The 4.16 kV relaying scheme is designed to detect abnormal conditions of frequency and voltage, including degraded voltage and loss of voltage, and effect compensatory actions (i.e. tripping/closing tie breakers, tripping feeder breakers, starting the emergency diesel generators, etc.). The 4.16 kV relaying scheme is also designed to prevent premature or unnecessary separation from offsite power. 4.16 kV system components receive various actuation signals including; Safety Injection (SI), Containment Pressure Condensate Isolation (CPCI), Steam Generator Feedpump Trips, Heater Drain Tank low level, Motor Driven AFW pump low suction pressure, and AMSAC. Additionally, the 4.16 kV system provides input to various systems including; the Safety Injection (SI) reset logic, reactor trip logic, Diesel Generator (DG) starting logic, and AMSAC. Bus supply breakers from offsite power are tripped on loss of bus voltage and they must be manually reclosed upon restoration of offsite power. Manual alignment of alternate shutdown buses B-08 and B-09 (breaker B52-59B) to the 4.16 kV bus 2A-06 (breaker 2A52-94) via alternate power transformer (X-05) is allowed during NFPA-805 events where supply via X-08 is not available. Breakers B52-59B and 2A52-94 are administratively controlled in the

OPEN position during the normal plant operation. In an emergency condition, (i.e., loss of 4160V bus voltage), breaker 2A52-94 is tripped automatically.

The 4.16 kV buses are located in areas which minimize their exposure to mechanical, fire and water damage. This equipment is designed to permit safe operation of the equipment under normal conditions and to provide protection for short circuits. This equipment is electrically coordinated to limit the extent of equipment affected by a short circuit, sufficient to maintain plant safety.

8.4.4 REFERENCES

1. FSAR Appendix A.1 "Station Blackout"
2. 50.59 Evaluation 2008-003, Rev. 1, "Installation to Replace Portions of Power Cables from 2X-04 to 2A-03 and 2A-04," dated December 11, 2009.
3. NRC Safety Evaluation, Safety Evaluation of the Preferred Power Systems Conformance to General Design Criterion 17," dated August 29, 1983.
4. 50.59 Evaluation 2010-002, Rev. 0, "EC 13251 - Reroute of 1X04 Low Voltage Side power Cables to Facade," dated November 15, 2010.
5. NFPA 805 Fire Protection Program Design Document (FPPDD).

Figure 8.4-1 4.16 kV AC DISTRIBUTION SYSTEM

[redacted]

8.5 480 VOLT AC ELECTRICAL DISTRIBUTION SYSTEM (480V)

The majority of the electrical loads used for normal and emergency plant operations are powered by the 480 Volt AC Distribution System (480V). The 480V system is supplied primarily from the 4.16 kV system, although some non-safety related portions are supplied by the 13.8 kV system. This section describes the 480V system and components, the types of loads, system protective features, and the 480V electrical interconnections.

8.5.1 DESIGN BASIS

The 480V system provides a means to reliably distribute 480 VAC power to those loads required during normal and emergency plant conditions; including those loads required to mitigate the consequences of all postulated accidents. Circuit protection is provided to the loads supplied by the 480V system. Portions of the 480V system are required to provide power to essential safe shutdown equipment during Station Blackout (SBO) conditions (See Reference 1 for additional Station Blackout information). The 480V system is credited in the event of a fire and has been evaluated in the at-power and non-power analyses (Reference 2).

8.5.2 SYSTEM DESCRIPTION AND OPERATION

The 480V system buses and switchgear are supplied by the 4.16 kV system through the 4160/480 VAC station service transformers (1/2X-11 through X-14) and diesel generator building transformers (1/2X-06). The alternate shutdown transformer (X-08) supplies the alternate shutdown buses, B-08 and B-09, from the 13.8 kV system. Manual alignment of alternate shutdown buses B-08 and B-09 to the 4.16 kV System via alternate power transformer (X-05) is allowed during NFPA-805 events where supply via X-08 is not available.

The 480V system is shown in Figure 8-2 through Figure 8-4. The 480V system is divided into four buses per unit. The buses for Unit 1 are supplied from the 4,160 volt buses as follows: 1B-0l from 1A-01, 1B-02 from 1A-02, 1B-03 from 1A-05, and 1B-04 from 1A-06. Tie breakers are provided between 480 volt buses 1B-01 and 1B-03, buses 1B-02 and 1B-04, and buses 1B-03 and 1B-04. No synchronization ability has been provided with the 480 volt tie breakers, and they accordingly utilize a dead bus transfer scheme. The Unit 2 480 volt buses have the same arrangement as described for Unit 1.

The 480 volt safeguards equipment is connected to buses B-03 and B-04. Power for safeguards valve motors is supplied from the motor control centers B-32 and B-42 which in turn are served from buses B-03 and B-04, respectively. Since the normal source of power for these buses is the 345 kV system (via station auxiliary transformers X-03 and X-04; 4160 volt buses A-03, A-05 and A-04, A-06; and station service transformers X-13 and X-14), no transfer is required in the event of a turbine generator trip.

Auxiliary equipment (fuel oil pumps and fuel oil pump room heaters) for the Train A emergency Diesel Generators (DG) is powered from 1B-30 and 2B-30. These emergency diesel generator motor control centers are powered from the motor control centers 1B-32 and 2B-32, respectively. The auxiliary equipment for the Train B emergency diesel generators (DG) is powered from 1B-40 and 2B-40. These emergency diesel generator motor control centers are powered by transformers from the 1A-06 and 2A-06 buses, respectively. 1B-40 and 2B-40 are each divided into a safety related and a non-safety related section. The non-safety related portion of these motor control centers is isolated from the safety related section by an undervoltage signal on the associated 4.16 kV bus. (Reference 3)

The alternate shutdown buses (B-08 and B-09) are supplied from the 13.8 kV bus (H-01), via the X-08 transformer. Alternate shutdown equipment can be powered from the G-05 Gas Turbine (GT) through 480V buses B-08 and B-09 and alternate transfer switches located at remote shutdown stations throughout the plant (Reference 2). Alternate shutdown buses (B-08 and B-09) to be manually aligned to the 4.16 kV bus (2A-06) via the X-05 transformer is allowed during NFPA-805 events when supply via X-08 is not available.

The 480 volt motor control centers are located in areas of electrical load concentration. Those loads associated with the turbine-generator auxiliary system in general are located in the turbine building. Those loads associated with the nuclear steam supply system are located in the Auxiliary Building. Those loads associated with the emergency diesel generators (G-03 and G-04) are located in the Emergency Diesel Generator building.

There are various other 480 VAC transformers, buses, and power panels used throughout the site that are not directly relied on for plant operation. These 480 volt components are only mentioned in this section to describe how they are supplied from the onsite/offsite electrical distribution systems. Table 8.5-1 is a listing of the associated 480 volt loads, supply transformer, and transformer's supply bus. These 480 volt associated loads are considered non-critical and are not discussed in any further detail.

8.5.3 SYSTEM EVALUATION

The 480 V load centers are located in areas which minimize their exposure to mechanical, fire and water damage. This equipment is designed to permit safe operation of the equipment under normal conditions and to provide protection for short circuits. This equipment is electrically coordinated to limit the extent of equipment affected by a short circuit, sufficient to maintain plant safety. The electrical system equipment is arranged so that no single contingency can inactivate enough safeguards equipment to jeopardize the plant safety.

The 480 V system provides undervoltage protection of the loads on the safeguards buses B-03 and B-04. The undervoltage devices on the 480 V system controls the load shedding on the 480 V buses and determines when the load sequencing timers can begin timing after a Diesel Generator (DG) start. The 480V undervoltage devices are disabled for ‘A’ train buses when powered by the emergency diesel generator.

B-03 and B-04 bus tie breakers (1B52-16C and 1B52-19B for Unit 1 and 2B52-40C and 2B52-30A for Unit 2) are supplied to facilitate maintenance of the normal supplies to the buses. The use of these breakers is limited to certain circumstances defined in the Technical Specifications to minimize the probability of failure propagation that could disable both 480 volt safeguards buses in a unit in recognition of the need to maintain operability of shared safety features for any operating unit and operability of decay heat removal for any shutdown unit. These breakers are administratively controlled in the open position with their control power fuses removed. In an emergency condition, i.e., loss of 480 volt safeguards bus voltage or safeguards actuation in a unit, tie breaker 1B52-16C for Unit 1 or 2B52-40C for Unit 2 will be tripped automatically.

The safeguards equipment (listed in Section 8.8.3) which are automatically sequenced during an undervoltage occurrence have feeder circuit breakers which can be reclosed from the control room should they trip due to overcurrent. Overload trip elements on the reversing starters associated with the various motor-operated valves can be reset at the motor control centers.

The 480V system requirements to meet Station Blackout (SBO) are outlined in FSAR Appendix A.1 (Reference 1).

8.5.4 REFERENCES

1. FSAR Appendix A.1 "Station Blackout"
2. NFPA 805 Fire Protection Program Design Document (FPPDD).
3. SCR 2007-0223, "Design Detail for MCCs 1B-40 and 2B-40," dated January 9, 2008.

Table 8.5-1 ASSOCIATED 480 VOLT SOURCES

DESCRIPTION	SUPPLIED BY TRANSFORMER	TRANSFORMER SUPPLY
B-60	X-65	H-08
TRAINING BUILDING	X-66	H-08
MAUSOLEUM	X-24	A-08
TRAILERS	POLE TRANSFORMERS	A-08
QUONSET HUTS	X-42	A-08
MET TOWER	X-25	A-08
B-07	X-27	H-01
SOUTH GATE HOUSE	1X-704	1A-04
SWITCHYARD AUX.	X-48	H-01
WAREHOUSE 3	X-07 & X-90	2A-04 & A-09

8.6 120 VAC VITAL INSTRUMENT POWER (Y)

The 120 VAC Vital Instrument Power (Y) is supplied from the 125V DC and 480V AC systems. The 120 VAC Vital Instrument (Y) system provides power to both safety and non-safety related systems and is used throughout the plant.

8.6.1 DESIGN BASIS

During normal, abnormal, or emergency conditions the 120 VAC Vital Instrument Power system (Y) shall continuously provide power of adequate voltage and quality to connected safety related loads. During a design basis accident combined with a loss of offsite power and a single failure, the Vital 120 VAC Instrument Power system shall continuously provide power to the Engineering Safety Feature (ESF) Actuation System to ensure a spurious Safety Injection actuation does not occur in the non-accident unit. During a Station Blackout (SBO) or plant fires, the vital 120 VAC Instrument Power system shall continuously supply power to those instrument loads necessary to achieve and maintain safe reactor shutdown (See Reference 1 for additional station blackout information and Reference 2 for fire related issues).

8.6.2 SYSTEM DESCRIPTION AND OPERATION

The 120V AC vital instrument power system (Y) distributes power to safety related and non-safety related systems from diverse power sources (AC and DC).

The 120V AC vital instrument power system provides and distributes reliable 120 VAC power to plant instruments and controls. The system consists of sixteen buses, divided among four instrument channels. Each of the four channels (red, white, blue, and yellow) are allocated four buses. The distribution buses are further subdivided into two bus groups, one group serving Unit 1 and the other serving Unit 2.

Each channel is powered by three inverters (see Figure 8.6-1 and Figure 8.6-2). One inverter is dedicated to the Unit 1 bus group and a second inverter is dedicated to the Unit 2 bus group. The third inverter is an alternate, and can swing between the Unit 1 and Unit 2 buses. Shifting between normal and alternate inverters is accomplished using manual make-before-break transfer switches. Use of the alternate inverter allows either dedicated inverter to be removed from service for maintenance.

The function of the inverters is to convert 125 volt DC from station batteries to 120 volt AC. The inverters are therefore powered from the 125 volt DC system. The three inverters powering any one instrument channel share a common supply from one of the main 125 volt DC buses.

The red channel inverters (1/2DY-01 and DY-0A) are powered from bus D-01 through panels D-11, D-12, and D-26. The blue channel inverters (1/2DY-02 and DY-0B) are powered from bus D-02 through panels D-13, D-14, and D-27. The white (1/2DY-03 and DY-0C) and yellow channel (1/2DY-04 and DY-0D) inverters are powered directly from buses D-03 and D-04, respectively.

Although normally powered from an inverter supply, each instrument channel can be powered from a backup power source. The backup power source is from non-safety-related Y-15 or Y-16 buses which are supplied from 480V bus B-09 via regulating transformer XY-08. The output of each inverter is connected to a static transfer switch that will automatically transfer the associated instrument buses to the backup power source in the event of an inverter failure, with little or no power interruption. Signals causing the transfer of the static switches include low voltage, current overload, and inverter failure signal (anticipatory to loss of voltage). The backup source is designed to maintain power to affected buses only until they can be manually transferred back to an operable inverter. The backup source is designed to supply the Unit 1 and Unit 2 loads of one instrument bus channel. It will therefore maintain power to the affected instrument bus channel in the case of a main DC bus failure. Electrical interlocks are in place to prevent static switches from more than one instrument bus channel from transferring to the backup source at the same time.

The White and Yellow instrument channels supply 1/2XY-113 and 1/2XY-114 isolation transformers which supply the Radiation Monitoring (RM) Systems non-safety-related instrument panels 1/2Y-113 and 1/2Y-114. Panels 1/2Y-113 and 1/2Y-114 supply instrument panels 1/2Y-11, 1/2Y-21, 1/2Y-31 and 1/2Y-41 which supply other non-safety related loads. The isolation transformers are used to prevent remote faults from non-safety related components from feeding back to the protection buses.

In the event of an inverter or bus failure of a 120V instrument protection channel(s), multiple alarms will sound in the control room. The alarms are located on the auxiliary safety instrument panel (ASIP), panel C20 in the control room. The inverters are operated locally at the inverter panels.

In addition to the four 120 volt instrument channels there are two (per unit) non-safety related portions of the 120 VAC Instrument power system (Y). These four additional instrument buses supply power to non-protection, non-redundant instruments. Each bus is energized from a single 480/120 volt transformer with no alternate sources of power from the 480V system (see Figure 8.6-3). Transformers 1/2XY-05 supply power to distribution panels 1/2Y-05 and transformers 1/2XY-06 supply power to distribution panels 1/2Y06. These buses reduce the required load on the static inverters supplying the protection channels.

The 120V AC Vital Instrument System (Y) provides power to various instrument racks for the Reactor Protection System (RPS), the Engineered Safety Feature (ESF) Actuation System, the Nuclear Steam Supply System (NSSS) Controls, and other miscellaneous instrumentation and control systems.

8.6.3 SYSTEM EVALUATION

Instrument Buses Y-01/Y-101, Y-02/Y-102, Y-03/Y-103, and Y-04/Y-104 must each be supplied by independent, battery-backed sources to ensure that a single failure combined with a loss of offsite power will not prevent mitigation of a design basis accident. Upon a loss of an inverter, the instrument bus will automatically transfer to a non-safety-related 120 VAC bus (Y-15 or Y-16) if available. The amount of time that an instrument bus may be operated on a non-safety-related 120 VAC source is outlined by Technical Specification. Monitoring of instrument bus voltage and alarm indication each shift ensures that any loss or transfer of an instrument bus to non-safety related source is detected.

The 120 VAC Vital Instrument Power (Y) system configuration prevents any instrument bus inverter from supplying more than one instrument channel bus. Electrical separation (for DY-01 through DY-04) and administrative controls (for DY-0A through DY-0D) prevent any instrument bus inverter from supplying more than one unit's instrument channel. Electrical interlocks prevent more than one instrument channel (two units, same color) from being supplied by the non-safety-related source (Y-15 and Y-16).

8.6.4 REFERENCES

1. FSAR Appendix A.1 “Station Blackout”

2. NFPA 805 Fire Protection Program Design Document (FPPDD).

Figure 8.6-1 INSTRUMENT POWER RED AND BLUE CHANNELS

[redacted]

Figure 8.6-2 INSTRUMENT POWER WHITE AND YELLOW CHANNELS

[redacted]

Figure 8.6-3 INSTRUMENT POWER NON-PROTECTION SECTION

[redacted]

8.7 125 VDC ELECTRICAL DISTRIBUTION SYSTEM (125V)

The 125 VDC Electrical Distribution system (125V) provides a reliable source of power for safety and non-safety related loads of both PBNP units. The system includes six separate, independent DC distribution buses, each capable of being connected to a common “swing” bus. Four of the six buses and the swing buses are safety related and shared between the units. The other two buses are non-safety related and each is dedicated to a single unit.

Each DC bus is powered by at least one AC-to-DC battery charger (eight total), backed up by a station battery (seven total). The swing buses have two chargers and one battery that are sized to carry any one of the six independent buses.

8.7.1 DESIGN BASIS

During normal operation each safety-related DC bus shall supply uninterruptible DC power of adequate voltage and quality to support systems that monitor for abnormal/accident conditions and initiate protective actions. During abnormal or emergency conditions, with or without a concurrent loss of offsite power, each safety-related DC bus shall supply uninterruptible DC power of adequate voltage and quality to safety-related loads for accident mitigation. During station blackout, the system shall continuously supply power to those loads required to achieve and maintain safe reactor shutdown during the blackout period (See Reference 1 for additional Station Blackout information). During normal plant operation, the system shall continuously supply power of adequate voltage and quality to connected loads. The 125 VDC system is credited in the event of a fire and has been evaluated in the at-power and non-power analyses (Reference 2).

8.7.2 SYSTEM DESCRIPTION AND OPERATION

The safety-related 125V system consists of four main distribution buses: D-01, D-02, D-03, and D-04 (see Figure 8.7-1). The D-01 (train A) and D-02 (train B) main DC distribution buses supply power for control, emergency lighting, and the red and blue 120 VAC Vital Instrument bus (Y) inverters. The D-03 (train A) and D-04 (train B) main DC distribution buses supply power for control and the white and yellow 120 VAC Vital Instrument bus (Y) inverters.

Each of the four main distribution buses is powered by a battery charger (D-07, D-08, D-107 and D-108) and is backed up by a station battery (D-05, D-06, D-105, and D-106). The function of the battery chargers is to supply their respective DC loads, while maintaining the batteries at full charge. All of the battery chargers are powered from the 480V AC system. The battery chargers have been sized to recharge any of their respective partially discharged batteries within 24 hours while carrying normal loads.

The battery chargers are interlocked such that a loss of offsite power will disconnect the battery chargers from their 480V AC source. A coincident safety injection signal would prevent restoration of the battery chargers unless offsite power is restored to the safeguards buses or safety injection is reset. This limits the loading on the standby emergency power supply during the period immediately following a safety injection signal. During this period the 125V DC loads are supplied by their associated station battery until such time as power to the chargers is restored.

In addition to the four 125V safety related main distribution buses, there exist two safety-related swing DC distribution buses (D-301 and D-302) which permit the connection of a swing battery and/or a swing charger to one of the four main distribution buses. Two swing battery chargers are available through one of the swing DC distribution buses. Swing charger D-09 is connected to swing DC distribution bus D-301 and can provide a source of DC power to distribution buses D-01 or D-02. Likewise, swing charger D-109 is connected to swing DC distribution bus D-302 and can provide a source of DC power to distribution buses D-03 or D-04.

In addition, there exists a swing safety-related battery D-305 which is connected to swing DC distribution bus D-301. This swing battery is capable of being aligned to any one of the four main distribution buses to take the place of the normal battery. Mechanical interlocks exist on swing DC distribution buses D-301 and D-302 which prevent the paralleling of redundant DC buses.

The swing bus D-301 can be connected with two non-safety related buses designated 1/2D-201. The two D-201 buses are connected to two non-safety related batteries 1/2D-205 respectively and powered from chargers 1/2D-207.

The 480V AC supplies for chargers designated D-07, D-08 and D-09 are from motor control centers 1B-39, 2B-49, 1B-49, and 2B-39 in the control building (see Figure 8.7-1). Motor control centers 1B-39, 2B-49, 1B-49, and 2B-39 are supplied by 480 volt buses 1B-03, 2B-04, 1B-04, and 2B-03, respectively. The 480V AC supplies for chargers designated D-107, D-108 and D-109 are from motor control centers 2B-39, 1B-49, 1B-32, and 2B-42 in the control or primary auxiliary building (See Figure 8.7-1). Motor control centers 2B-39, 1B-49, 1B-32, and 2B-42 are supplied by 480 volt buses 2B-03, 1B-04, 1B-03, and 2B-04 respectively. Interlocks are provided to assure that Train and divisional separation is maintained when supplying power from the swing buses D-301 and D-302 to the safety related main distribution buses.

Emergency power supply for vital instruments, control power, and for some DC emergency lighting of both units is supplied from [redacted] which are common to both units. Additional emergency lighting, provided in "safe shutdown" areas and access routes to and from these areas, [redacted]

There are two non-safety related 125V distribution buses (1/2D-201), batteries, and battery charges installed. These buses and ancillary equipment are dedicated to a specific unit, and supply power to non-safety related loads. A connection is provided from swing bus D-301 to both non-safety related buses to allow the power of non-safety related loads while performing maintenance on the associated battery charger and/or battery. Test connections are also provided.

The PAB battery and electrical equipment room ventilation system (VNBI) maintains the station batteries (D-105 and D-106), inverters, and other safety-related components within established temperature limits. This system also prevents hydrogen buildup in the battery rooms. An annunciator in the Control Room will alert the operators of a ventilation system failure or high room temperature.

8.7.3 SYSTEM EVALUATION

Safety related station batteries D-05, D-06, D-105, and D-106 have been sized to carry their expected shutdown loads following a plant trip/LOCA and loss of offsite power or following a station blackout for a period of one hour without battery terminal voltage falling below either: (1) the design minimum battery terminal voltage (equivalent to 1.75 volts per cell for battery considerations), or (2) the minimum battery terminal voltage required to maintain the most limiting component, and therefore all fed components, operable. D-05, D-06, D-105, and D-106 are 60 cell, lead acid station batteries. The safety related swing station battery D-305 is a 60 cell, lead acid station battery sized to carry the expected loads and provide adequate voltage when aligned to any one of the four main DC buses. Load profiles for D-05, D-06, D-105, D-106, and D-305 are provided in the design basis sizing, voltage drop and short circuit calculations (Reference 3, Reference 4, Reference 5, and Reference 6). Each station battery is located in a separate room.

One battery charger is in service on each battery so that the batteries are always at full charge in anticipation of loss of AC power incident. This ensures that adequate DC power is available to initiate the starting of the emergency generators and other emergency uses. A description of the station batteries requirements for station blackout can be found in Reference 1

The swing battery chargers and the swing battery allow the normally on-line battery chargers and batteries to be removed from service for maintenance that can not be performed with the equipment on-line.

To ensure the quality of DC power on a bus powered by a station battery charger, the charger should be connected to a station battery. A connected battery will filter the output of the charger. In any configuration, the quality of the battery charger output and battery charger operability may be ascertained from control room annunciation of the following conditions on a common “Battery Charger Trouble” alarm; AC Power Failure, Low DC Volts, High DC Volts, DC Ground, Output Breaker Open.

The unit specific non-safety related DC buses and batteries are of adequate size to supply power to the currently connected loads and additional non-safety related loads which may be rewired from the safety related buses.

8.7.4 REQUIRED PROCEDURES AND TESTS

Periodic testing, including discharges that envelope the calculated service test duty cycle associated with each battery, is performed for each battery in accordance with Technical Specification surveillance requirements. Each battery’s service test duty cycle is based on the bounding load profile from its design basis battery calculation (Reference 3, Reference 4, Reference 5, and Reference 6). The service test duty cycle for swing battery D-305 is required to bound the most limiting load profile of the four battery sizing calculations.

8.7.5 REFERENCES

1. FSAR Appendix A.1 “Station Blackout”
2. NFPA 808 Fire Protection Program Design Document (FPPDD).
3. PBNP Calculation N-93-056, “Battery D05 System Sizing, Voltage Drop and Short Circuit Calculations.”
4. PBNP Calculation N-93-057, “Battery D06 System Sizing, Voltage Drop and Short Circuit Calculations.”
5. PBNP Calculation N-93-058, “Battery D105 System Sizing, Voltage Drop and Short Circuit Calculations.”
6. PBNP Calculation N-93-059, “Battery D106 System Sizing, Voltage Drop and Short Circuit Calculations.”

Figure 8.7-1 125 VDC ELECTRICAL DISTRIBUTION

[redacted]

8.8 DIESEL GENERATOR (DG) SYSTEM

The normal source of power to safety related 4.16 kV and 480V buses is from offsite through the station low voltage auxiliary transformers. If this normal source should fail, the standby source of emergency power is the diesel generating (DG) system. The DG system is composed of four diesel generators that directly supply the safety related 4.16 kV electrical distribution system. Each diesel engine is supported by its own dedicated auxiliary systems for maintaining the start readiness, starting, and continued operation. The independent design of the diesel generator engine and auxiliary systems precludes any single failure from preventing the DG system from performing its intended safety related function.

8.8.1 DESIGN BASIS

Each Emergency Diesel Generator (EDG) is capable of sequentially starting and supplying the power requirement of one complete set of safeguards equipment for one reactor unit and providing sufficient power to allow the second reactor unit to be placed in a safe shutdown condition. Each diesel generator provides the necessary power to cool the core and maintain the containment pressure within the design value for a loss of coolant accident (coincident with a loss of offsite power) in addition to supplying sufficient power to shut down the unaffected unit (no accident is assumed in the second unit). Each diesel generator will be started upon the receipt of an undervoltage condition signal on either its primary or opposite unit same train 4160 volt bus, and re-energize its 4160 volt bus. All four diesel generators will start when a safety injection (SI) signal is received from either unit. The EDGs are required to start and be ready for loading within 10 seconds after receiving a start signal. Sufficient fuel oil is maintained by each train to provide for a 6 day run of one EDG at rated design load. The DG system is credited in the event of a fire and has been evaluated in the at-power and non-power analyses (Reference 2). During a station blackout (SBO), an EDG from the non-blacked out unit can be used as an Alternate AC (ACC) source. An EDG will start, accelerate to rated frequency and voltage, and can be connected to an emergency AC (EAC) bus in either unit within ten minutes of SBO initiation. Additional detail is included in Reference 1.

8.8.2 SYSTEM DESCRIPTION AND OPERATION

The emergency diesel generator configuration consists of four shared emergency diesel generators. The diesel generators are divided into two trains, “A” and “B.” The two Train A emergency diesel-generator sets are located in separate rooms in the seismic Class I section of the turbine building and are connected to the Train A 4160 volt auxiliary system safeguards buses of both units. The two Train B emergency diesel-generator sets are located in separate rooms in the seismic Class I Emergency Diesel Generator Building (DGB) and are connected to both Train B 4160 volt auxiliary system safeguards buses of both units. All four emergency diesel generators are normally available. The target reliability for each EDG is 97.5% (Reference 1 and Reference 3).

The emergency diesel generators are General Motors Corporation, Electro-Motive Division, Model 20-645E4 diesel engine-generator units.

The two Train A emergency diesels are G-01 and G-02. The two Train A diesels are normally aligned as standby emergency power, G-01 to the Unit 1 Train A 4160 volt bus (1A-05) and G-02 to the Unit 2 Train A 4160 volt bus (2A-05). The two Train B EDGs are normally aligned as standby emergency power, G-03 to the Unit 1 Train B 4160 volt bus (1A-06) and G-04 to the Unit 2 Train B 4160 volt bus (2A-06). G-01 will automatically provide power to 1A-05 if power is lost on 1A-05, G-02 will automatically provide power to 2A-05 if power is lost on 2A-05. G-01 may be manually connected to provide power to 2A-05, and G-02 may be manually connected to provide power to 1A-05. Additionally, if G-01 is out of service, G-02 may be placed in a mode that will allow it to automatically provide power to 1A-05 or 2A-05 or both, if either or both buses lose power. When G-02 is out of service, G-01 can be aligned in the same manner as G-02, described above. Emergency diesel generators G-03 and G-04 have similar capabilities for the B Train, as the A train EDG. Unintentional paralleling of two EDGs is controlled by the use of key switches for the EDG output breakers to the opposite units' same train 4160 volt bus and with interlocks which prevent the automatic closure of two EDGs to the same 4160 volt bus (Reference 3). Offsite power is not locked out upon emergency generator operation.

The DG system has several auxiliary support systems that must function in order to perform its safety related function, including; Diesel Starting Air (DA) system, engine fuel oil system (FO), engine cooling system, engine lubricating system, and room ventilation system (VNDG).

Train A Emergency Diesel Generators

The Train A units are rated at 2,850 kw for 2000 hours, 0.8 power factor, 900 rpm, 4160 volts, 3-phase, 60 cycle AC. Additional ratings for the Train A units include 2963 kw for 200 hours, 3000 kw for 4 hours and 3050 kw for a 30-minute period.

The Train A emergency diesels are automatically started by two pairs of air motors. Each engine has its own independent starting system, including two banks of three air storage tanks and two compressor systems powered from a 480 volt safeguards bus. By manually aligning the pulley belt, one air compressor in each unit may be powered by its own independent auxiliary diesel engine. Each bank of air receivers has sufficient storage to crank the engine five times for the normal cranking duration. The starting air systems are completely redundant for each diesel generator.

Starting air for the Train A emergency diesels is admitted from the storage tanks at a nominal working pressure of 196 psi to the starting system through two-way solenoid valves. Sufficient air storage is provided to permit at least 5 starts before the tanks are exhausted. When the signal to start the diesel is initiated, a motor driven fuel pump and governor booster pump will start, and the solenoid valves for both air banks will be energized to open. When the starter motor pinions are engaged, both banks of starter motors will crank the engine.

Cranking continues until either the engine starts or until the start failure time delay has elapsed. At this time, the start failure alarm will be initiated and start attempts will be automatically repeated until either the engine starts or the start lockout time delay expires. At least 3 start attempts will be made on an initiated start signal. Upon start lockout, operator action is required prior to additional start attempts. The emergency diesel generators are capable of being started and ready to accept load within 10 seconds (i.e., fast start).

One of the two motor-driven starting air compressors associated with each diesel is fed from the emergency bus supplied from a B train diesel. Using a B train power supply for the A train diesel generator starting air compressor provides additional assurance that starting air will be available to start the diesel generator. Each of the two motor driven compressors associated with each A train diesel is stripped upon an undervoltage condition on the related motor control center and requires manual action to reset (Reference 9). The control voltage for the diesel starting system is backed up by a manually switched 125 V DC power supply from an alternate station battery.

To ensure rapid start, each diesel unit is equipped with an immersion heater which furnishes heat to the engine cooling water when the engine is shut down. Thermosyphon flow of hot water through the oil cooler heats the lube oil. The warmed oil is circulated through the engine and turbocharger by lube oil circulating pumps and is returned to the engine lube oil sump.

Low lube oil pressure, overspeed, reverse power, and loss of generator field protective interlocks are incorporated in the diesel generators control systems.

For low lube oil pressure, three pressure switches are connected such that actuation of any combination of two are required to stop the engine. Faulty action of one switch will not result in engine shutdown. The reason for the 2-out-of-3 trip function is to prevent destruction of the bearings, a condition which would rapidly occur and would quickly result in power failure while leading to further engine damage.

Overspeed will shut down the engine. Overspeed would rapidly lead to engine destruction.

Electrical protection for emergency diesel generators G-01 and G-02 include time overcurrent, reverse power, loss of field, ground fault, and overload relays. The time overcurrent, reverse power, and loss of field relays trip and lockout the affected diesel generator's output circuit breaker until the condition clears (along with triggering various alarms). The overload and ground fault relays provide alarms only.

The audible and visual alarm system is located in the main control room and will alarm off-normal conditions which include engine starting and operating parameters, loss of DC control power and control switches that are not in the auto position. Overload/overpower alarms are provided via Overload Relays 67P-1 and 67P-3 to alert operators when the diesel generator is overloaded.

A ground fault alarm is provided for G-01 and G-02 by a low voltage pickup overvoltage relay (59) connected across the break in a grounded WYE-broken delta voltage transformer circuit.

Auxiliary equipment (fuel oil pumps and fuel oil pump room heaters) for the Train A emergency diesel generators is powered from 1B-30 and 2B-30 which are powered from the motor control centers 1B-32 and 2B-32, respectively.

Train B Emergency Diesel Generators

The Train B units are rated at 2848 kw for 2000 hours, 0.8 power factor, 900 rpm, 4160 volts, 3 phase, 60 cycle AC. Additional ratings for the Train B units include 2951 kw for 200 hours, and 2987 kw for 4 hours.

The Train B emergency diesels are automatically started by two pairs of air motors. Each engine has its own independent starting system, including two banks of two air storage tanks and two compressors, one powered from the associated 480 volt emergency diesel generator MCC and the other from a fuel oil powered diesel engine. Each bank of air receivers has sufficient storage to crank the engine five times for the normal cranking duration. The starting air systems are completely redundant for each diesel generator.

Starting air for the Train B emergency diesels is admitted from the storage tanks at a nominal working pressure of 240 psi, applied to the starting system at 196 psi through a pressure regulator and two-way solenoid valve. When the signal to start the diesel is initiated, a motor driven fuel pump and governor booster pump will start, and the solenoid valves will be energized to open. When the starter motor pinions are engaged, the starter motors will crank the engine. Cranking continues until either the engine starts or until a predetermined time period of 5 seconds has elapsed. At this time, the start failure alarm will come on. Although sufficient air storage is provided to permit at least 5 starts before the tanks are exhausted, operator action is required for additional start attempts. The emergency diesel generators are capable of being started and ready to accept load within l0 seconds (i.e., fast start).

One of the two motor-driven starting air compressors associated with each diesel is driven by a fuel oil powered diesel engine. This provides additional assurance that, if a diesel fails to start, its air storage tanks can be replenished.

Train B 125 V DC distribution panels D-28 and D-40 are located in the DGB and are supplied by safety related DC buses D-04 and D-02 respectively. D-28 provides DC control and auxiliary power for G-03 and 1A-06. D-40 provides DC control and auxiliary power for G-04 and 2A-06. Each distribution panel has a manually switched alternate feed from the opposite panel and interlocks are provided to prevent the panels from being energized simultaneously from both the normal and alternate supplies.

To ensure rapid start, each diesel unit is equipped with an immersion heater which furnishes heat to the engine cooling water when the engine is shut down. Thermosyphon flow of hot water through the oil cooler heats the lube oil. The warmed oil is circulated through the engine and turbocharger by lube oil circulating pumps and is returned to the engine lube oil sump.

Local/Remote Control Switches located in the DGB are used to transfer control between the DGB (local) and the Main Control Room (remote). When the switches are in the local position, control of the G-03 and G-04 EDGs is from the DGB only and all control signals from the Main Control Room will be isolated. Controls and indication are sufficient to allow an EDG to be started, synchronized and loaded to the normal and/or alternate 4.16 kV buses manually from either the Main Control Room or locally in the DGB. The EDGs can also be manually fast started locally or from the Main Control Room.

A normal or emergency shutdown of the EDG will automatically trip the generator output breaker. A normal shutdown of an EDG can be initiated locally or from the Main Control Room if an automatic fast start signal is not present. A normal shutdown results in a cooldown run at idle speed for approximately 15 minutes before the engine is shutdown. If an automatic fast start signal is received during cooldown, the normal shutdown is defeated and the diesel will enter the fast start mode of operation.

An emergency shutdown of an EDG is initiated by the following protective trips: low lube oil pressure, high jacket water temperature, generator differential current, and overspeed. An emergency shutdown can also be initiated via an emergency stop pushbutton located on the engine control cabinet independent of the position of the Local/ Remote transfer switch.

The three low lube oil pressure switches are connected such that actuation of any combination of two are required to stop the engine. Faulty action of one switch will not result in engine shutdown. The reason for the 2-out-of-3 trip function is to prevent destruction of the bearings, a condition which would rapidly occur and would quickly result in power failure while leading to further engine damage.

The overspeed trip function provides protection against engine destruction caused by an overspeed condition. The overspeed trip results in the injectors being mechanically held in the no fuel position using mechanical components independent of those used to control the injectors during a normal or other type of emergency shutdown.

Electrical protection for diesel generators G-03 and G-04 includes differential current, time overcurrent, reverse power, loss of field, ground fault, overload, and voltage monitoring relays. The time overcurrent, reverse power, and loss of field relays trip the affected diesel generator's output circuit breaker. The overload and ground fault relays provide alarms and the voltage monitoring relay provides a permissive to allow closing the diesel generator output circuit breaker.

All protective trips other than overspeed, low lube oil pressure, and generator differential current are bypassed upon receipt of an automatic emergency start signal and will be annunciated in the Control Room.

The audible and visual alarm system is located in the main control room and will alarm off-normal conditions which include engine starting and operating parameters, loss of DC control power and control switches that are not in the auto position. Overload/overpower alarms are provided via Overload Relays 67P-1 and 67P-2 to alert the operators when the diesel generator is overloaded. A ground fault alarm is provided for G-03 and G-04 by a low voltage pickup ground detection relay (64) connected across the break in a grounded WYE-broken delta voltage transformer circuit. Abnormal operating conditions and all trip functions are also alarmed locally.

The auxiliary equipment for the Train B emergency diesel generators is powered from 1B-40 and 2B-40 which are located in the DGB and powered by transformers from the 1A-06 and 2A-06 buses, respectively. 1B-40 and 2B-40 are each divided into two sections, a safety-related section and a non-safety-related section. The non-safety-related section is fed from its associated safety-related section via a circuit breaker that is tripped on an undervoltage actuation signal from the associated 4.16 kV bus. All safety-related loads in the DGB are fed from the safety-related portion of the MCC. The cooling water immersion heaters and generator space heaters for G-03 and G-04, and the G-04 fuel oil day tank room space heaters are stripped upon an undervoltage condition on the associated motor control center and require manual action to reset (Reference 9).

See Reference 1, Reference 2, and Appendix D for additional system design and/or operational information.

8.8.3 SYSTEM EVALUATION

Loading Description

Each emergency diesel generator is automatically started on the occurrence of either of the following incidents:

1. Initiation of safety injection operation from either unit; or
2. Loss of Voltage on either of the two 4160 volt safeguards buses (1A-05 or 2A-05 for G-01 and G-02 and 1A-06 or 2A-06 for G-03 and G-04) to which the emergency generator is associated.

With the occurrence of undervoltage on a 4160 volt safeguards bus and loss of voltage on the associated 480 volt safeguards bus, the automatic sequence is as follows:

1. Trip 4160 volt safeguards bus supply breaker to isolate the bus from offsite power.
2. If running, the motor driven auxiliary feedwater pump 4160 volt breaker will trip (only applicable to Unit 1 B train and Unit 2 A train buses).
3. All feeder breakers on the associated 480 volt safeguards bus, except for the component cooling pump motor, standby steam generator (SSG) feedwater pump motor (if applicable), and feeder breakers to safeguards motor control centers and distribution panels are tripped. The tie breakers to non-safeguards buses receive a trip signal. One of the tie breakers between opposite train safeguards buses (1B52-16C in Unit 1 or 2B52-40C in Unit 2) receive a trip signal. These breakers are tripped by 480 VAC Loss of Voltage Relays. For the train A 480 VAC buses, this load shedding function is blocked after the associated 4160 volt safeguards bus emergency diesel generator output circuit breaker closes. This is necessary to prevent inadvertent load shedding during load sequencing. For the train B buses, this load shedding function is not blocked. The train B emergency diesel generator transient voltage response is sufficient to maintain bus voltage above the 480 VAC Loss of Voltage Relays' setting during load sequencing. A minimum time delay is required to ensure that proper coordination is maintained between the 4.16kV and 480V Loss of Voltage functions. Proper coordination is required to prevent the 4.16kV function from occurring faster than the 480V function. This is required to prevent the EDG from reenergizing the safeguards bus prior to the actuation of the 480V load shedding function, which will allow the ESF loads to be sequenced as analyzed.
4. Start the associated emergency diesel generator.
5. When the emergency diesel generator reaches its rated speed (as determined by the engine speed sensing switches) and voltage (as determined by the presence of generator field voltage for G-01 and G-02), the associated emergency diesel generator output breaker automatically closes to re-energize the safeguards bus.

Note: The time from receipt of start signal (i.e. following 4.16 kV Loss of Voltage relay actuation) to emergency diesel generator ready to accept load shall not exceed 10 seconds.

6. If the standby steam generator (SSG) pump or the component cooling pump had been operating prior to the loss of voltage, they would restart upon return of bus voltage. If the component cooling pump had not been running, it would be subject to its automatic starting logic.

7. Manually start any auxiliary as required for safe plant operation. If there is a requirement for engineered safety features operation coincident with undervoltage, step 5, above, is automatically followed by the sequential starting of engineered safety features equipment. This loading sequence for a single EDG providing power to both the Unit 1 and Unit 2 safeguard buses is as follows, continuing from step 5.

	Time Lapse After Step 5*
a. Start Safety Injection Pump	0 sec.
b. Start Residual Heat Removal Pump	5.5 sec.
c. Start Containment Spray Pump	>10.25 sec.
d. Start Service Water Pump	15.5 sec.
e. Start Service Water Pump	20.5 sec.
f. Start Service Water Pump	25.75 sec.
g. Start Auxiliary Feedwater Pump (U1 B train or U2 A train only)	32.5 sec.
h. Start Containment Ventilation Fan	39.4 sec.
i. Start Containment Ventilation Fan	46.75 sec.

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* Nominal time delays for initiation of the load breaker closing signal after the emergency diesel generator energizes the bus (Reference 3).

Starting of containment spray pumps is independent of the starting sequence listed above. It occurs 10.25 seconds after a containment high pressure signal with the supply bus energized. It may occur simultaneously with the start of any other load sequenced after 10.25 seconds. The emergency generator automatic loading sequence, including engine starting, will be accomplished in approximately 60 seconds.

If running, the standby steam generator (SSG) pumps will be stripped from the bus upon a motor driven AFW pump automatic start signal or either unit's safety injection signal. The SSG pumps do not receive any automatic start signals.

Component cooling water pumps will strip and will not automatically restart upon a safety injection signal coincident with a loss of voltage on the associated 480 VAC bus.

Safeguards motor control centers are energized and injection valves are opened at the same time that the safety injection pump is energized.

Automatic start of the control room recirculation and filter fans is initiated by a containment isolation signal, a control room high radiation signal, or a loss of offsite power. EDG load analysis supports the starting of these fans at anytime during the EDG loading sequence (Reference 9).

If the emergency generator is overloaded, an alarm is annunciated in the control room.

Each diesel generator set will start automatically on a safety injection signal from either unit or upon the occurrence of undervoltage on either of its corresponding 4160 volt auxiliary buses. Each diesel has adequate capacity to supply the engineered safety features for the hypothetical accident in one unit and to allow the second unit to be placed in a safe shutdown condition in the event of loss of offsite electrical power. No accident is assumed in the second unit. These loads are tabulated in Table 8.8-1.

Tests are performed to demonstrate assurance that upon the initiation of a start signal the diesel generator will start and assume the required load in the timing sequence listed above. The frequency for performing surveillances required by Technical Specifications will be in accordance with the Surveillance Frequency Control Program (Reference 10).

Dynamic loading calculations for G-01, G-02, G-03 and G-04 establish the link between the required Technical Specification refueling interval testing and the design basis accident loading. The EDG load analysis includes consideration of EDG frequency variations and worst case loading and voltage drop for large motors. The analysis addresses the effects of the EDG dynamic load response on components such as contactors, control fuses, inverters, battery chargers, solenoids, MOVs, thermal overloads, and solid state devices. The operation of critical MOVs was evaluated in detail for meeting the stroke time requirements consistent with accident analysis assumptions, including the potential for stalling and overheating during voltage transients (Reference 7).

Fuel Oil Supply

No. 2 fuel oil is used for the emergency diesel generators. (See TRM 4.12, “Diesel Fuel Oil” regarding the use of blended No. 1 and 2 fuel oil). A 12,000 gallon non-safety related fuel oil fill tank, which is common for both trains, is provided to receive and hold fuel oil from delivery trucks for testing prior to placing the fuel oil into the fuel oil storage tanks.

A 550 gallon “day tank” is located near each diesel generator. The capacity of each day tank will allow its associated EDG to run continuously at 100% rated load for at least 120 minutes without makeup. An additional 550 gallon storage tank is located in the base of each of the Train A diesels.

Two underground fuel oil storage tanks on site (one Train A, one Train B) each have a capacity of approximately 35,000 gallons. Sufficient fuel is normally maintained between the two tanks to allow one diesel to operate continuously at the required load for 7 days. At the minimum Technical Specification required level, one tank could provide enough fuel for an emergency diesel generator to operate for 6 days at rated load (Reference 6). Transfer of oil from each fuel oil storage tank to automatically maintain level in the associated day tanks is accomplished by two 100% capacity motor-driven pumps in each train. Either fuel oil transfer pump is capable of serving either emergency generator in the same train by the use of normally closed manual cross-connect valves between the associated train day tanks. Fuel oil can also be transferred from one underground fuel oil storage tank to the other via the use of a fuel oil transfer pump and normally closed manual cross connect valves. The fuel oil transfer pump controls for G-01 and G-02 are located in the Main Control Room. The fuel oil transfer pump controls for G-03 and G-04 are located in the DGB.

The tanks and piping needed for emergency diesel operation are designated as safety related and meet Class I seismic criteria.

Approximate Fuel Oil Usage Rates

Diesel Generator at rated load: 210 - 220 gal/hr.

8.8.4 REFERENCES

1. FSAR Appendix A.1 “Station Blackout”
2. NFPA 805 Fire Protection Program Design Document (FPPDD).
3. Calculation 2005-0014, “Instrument Uncertainty of Safeguards Sequence Time Delay Relays,” Rev. 1, dated August 8, 2005.
4. SE 93-025-26, “Nuclear Power Department Safety Evaluation Report, MR 91-116, Two Additional Diesel Generators, Final Configuration,” dated March 28,1996.
5. Calculation 2004-0002, “AC Electrical System Analysis,” Revision 4, dated March 26, 2011.
6. NRC Safety Evaluation, “Point Beach Nuclear Plant, Units 1 and 2 - Issuance of Amendments RE: Diesel Fuel Oil Storage Requirements (TAC Nos. ME3282 and ME 3283),” dated August 4, 2011.
7. NRC Safety Evaluation, “Point Beach Nuclear Plant (PBNP), Units 1 and 2 -Issuance of License Amendments Re: Auxiliary Feedwater System Modification (TAC Nos. ME1081 and ME1082),” dated March 25, 2011.
8. NRC Safety Evaluation, “Point Beach Nuclear Plant (PBNP), Units 1 and 2 -Issuance of License Amendments Regarding Use of Alternate Source Term (TAC Nos. ME0219 and ME0220),” dated April 14, 2011.
9. EC 262738, “Alternate Source Term Implementation and CREFS Upgrades to Support Alternate Source Term License Amendment Request.”
10. NRC Safety Evaluation, “Point Beach Nuclear Plant Units 1 and 2 - Issuance of Amendments Regarding Relocation of Surveillance Frequencies to Licensee Control (TAC NOS. MF4379 and MF4380),” dated July 28, 2015.

Table 8.8-1 EMERGENCY DIESEL GENERATOR LOADING FOLLOWING A LOSS OF COOLANT ACCIDENT

Automatic Loads

Accident Unit and Common Loads:

- Safety Injection Pump (700 HP)
- Residual Heat Removal Pump (200 HP)
- Three Service Water Pumps (300 HP each)
- Two Containment Fans (150 HP each)
- Containment Spray Pump (200 HP)
- Auxiliary Feedwater Pump (350 HP)
- Safeguards 480V MCC and EDG Auxiliary Loads
- Transformer and Conductor Losses
- Control Room Charcoal Filter Fan (7.5 HP)
- Control Room Recirculation Fan (15 HP)

Non-Accident Unit Loads (Hot or Cold Shutdown):

- Component Cooling Water Pump (250 HP)
- Transformer and Conductor Losses

Manual Loads

Accident Unit and Common Loads:

- PAB Exhaust Stack Fan (60 HP)
- PAB Filter Fan (75 HP)
- Two Battery Chargers
- Component Cooling Water Pump (250 HP) or Charging Pump (100 HP)

Non-Accident Unit Loads (Hot Shutdown):

- Charging Pump (100 HP)
- Containment Fan (150 HP)
- Instrument Air Compressor (100 HP)

Non-Accident Unit Loads (Cold Shutdown):

- Residual Heat Removal Pump (200 HP)

Notes to Table 8.8-1 (Reference 5, Reference 7 and Reference 8)

1. The worst-case EDG load results from a loss of coolant accident on one unit, with the other unit in cold shutdown with residual heat removal (RHR) required. A unit in cold shutdown on RHR results in higher EDG loading than a unit in hot shutdown because of the additional loading due to an RHR pump, which is required for shutdown cooling. For the non-accident unit in hot shutdown, sufficient time exists to restore a charging pump, containment fan, and instrument air compressor under EDG load management procedures. Worst case EDG loading is expected to occur during the initial phases of a loss of coolant accident. As conditions are stabilized, EDG loads such as a safety injection pump and an

auxiliary feedwater pump may be secured to increase EDG load margin. Under EDG load management procedures, all required loads to support the accident and non-accident units can be started within the required time.

2. EDG loading is evaluated during the injection and recirculation phases of a loss of coolant accident, as well as the transition period between injection and recirculation.
3. The worst-case EDG load results when only a single EDG is available and supplying both units A train or B train safety related buses. If more than one EDG is available, additional load margin and flexibility regarding load management exists.
4. The maximum total EDG load during the event is within the 2000 hour load rating.
5. Plant Operators may add optional loads to the emergency diesel generator(s) for mitigation of the event under EDG load management procedures.
6. The EDG steady-state loading analysis is consistent with plant emergency operating procedures and evaluates EDG loading based upon the required engineered safety features for an accident in one unit and to allow the other unit to be placed in a safe shutdown condition, coincident with a loss of offsite power.
7. Horsepower values shown in the table are nominal values. Maximum EDG loading values for all loads are evaluated throughout the event.
8. The motor driven AFW pump will automatically start on the non-accident unit upon a loss of offsite power and subsequent EDG breaker closure, however this will only effect the loading of the EDG train opposite to the train supplying the motor driven AFW pump on the accident unit.

8.9 GAS TURBINE SYSTEM (GT)

The gas turbine generator (G-05) is nominally rated at 20 MW and can be connected to 13.8 kV Bus H01. It can be paralleled with the normal source of plant startup power or as standby power. It may also be paralleled with, or serve in lieu of, (under certain conditions) standby power to provide the first source of power to plant electrical loads. G-05 can supply power to either unit through 13.8 kV/4160 V low voltage station auxiliary transformers (1X04 or 2X04), to the power grid through 13.8 kV/345 kV high voltage station auxiliary transformers (1X03 or 2X03), to the north service building through 13.8 kV/480 V transformer X27, and to provide alternate shutdown power independent of the 4160 V system through 13.8 kV/480 V transformer X08.

8.9.1 DESIGN BASIS

The gas turbine performs no safety-related functions.

G-05 performs the following augmented quality functions:

During a station blackout (SBO), G-05 is relied on as an Alternate AC power source. As such, G-05 must be capable of providing AC power to safe shutdown loads within one hour of the onset of the SBO and supply those loads for the duration of the SBO coping period (4 hours) and subsequent recovery (under certain circumstances, a non-blacked-out emergency diesel generator may be credited as an Alternate AC power source in addition to or in lieu of G-05). (Reference 1)

The Gas Turbine System is credited in the event of a fire and has been evaluated in the at-power and non-power analyses (Reference 2).

8.9.2 SYSTEM DESIGN AND OPERATION

In addition to the four rapid starting emergency generators, there is a gas turbine generator installed at the site. This unit is rated approximately 23.1 MVA and is normally used for spinning reserve, station blackout, and for peaking purposes. This gas turbine unit is connected to the auxiliary electrical system such that it can be paralleled with the normal source of plant startup or standby power. It may also be paralleled with, or serve in lieu of, (under certain conditions) standby power to provide the first source of power to plant electrical loads. The unit is capable of being started and accepting load within one hour of the onset of the SBO using the “Normal” start method. It could be considered a small power plant within itself, fully capable of operating independent of the remainder of the plant.

The gas turbine (G-05) is of the single cycle, heavy-duty type, containing only compressor, combustor, and exhaust sections. It contains a single shaft, terminating at the exhaust end in an overriding clutch, to which a starter diesel engine is attached. The turbine shaft rotates at 4910 rpm, and is coupled to a main reduction gear which drives a conventional 3-phase AC generator and exciter at 900 rpm.

Startup power for G-05 and its auxiliaries is normally supplied by 13.8 kV bus H01 through a 13.8 kV/480 V auxiliary transformer. Bus H01 is energized from one of the high voltage station auxiliary transformers (1/2 X03) when G-05 is shutdown. When G-05 is running, it supplies its own auxiliaries through the same 13.8 kV bus, transformer, and breaker. Because G-05 is designed for startup during a loss of offsite power, the auxiliary loads can also be powered from a separate auxiliary diesel generator located in the gas turbine building. An undervoltage device on the secondary of the transformer will sense a loss of normal power and will start the auxiliary diesel generator and align it to supply the G-05 auxiliaries. Once G-05 is supplying power to bus H01, its auxiliary loads can be transferred back from the auxiliary diesel to bus H01.

The auxiliary diesel generator also serves as a backup power supply to the Technical Support Center (TSC) through breaker 52T and a normal seeking automatic transfer switch. Normal power to the TSC is from buss 1B01. On loss of the normal power supply, control circuitry senses the loss, starts the diesel generator, closes breaker 52T, and operates the automatic transfer switch. The automatic control logic on breaker closure is arranged such that the need for the auxiliary diesel generator to supply gas turbine auxiliaries has priority over the need to supply the TSC loads.

G-05 can be operated from a local control panel located in the gas turbine building or remotely from control room panel C02R. For a startup during a loss of offsite power, automatic synchronization of the generator will not occur and it will be necessary to close breaker 52-G-05 manually onto the dead bus. Required shutdown loads can then be reenergized through their respective low voltage station auxiliary transformer (1/2 X04) or through alternate shutdown transformer (X08) as required.

An air inlet weather hood structure has been installed over the existing G-05 air intake structure. The air inlet weather hood is a non-safety related seismic Class III structure designed to AISC Steel Specifications to withstand the design bases wind speed of 100 mph. The design and location of the air inlet weather hood is such that any postulated failure would not affect the offsite power supply from the opposite unit’s X04 (see Section 8.4.2 for 4.16 kV System Description and Operation).

8.9.3 SYSTEM EVALUATION

Although the gas turbine system has no safety related functions, it is relied on to provide backup power during some abnormal situations. During a station blackout, G-05 is designated as an alternate AC power source to supply safe-shutdown loads through the low voltage station auxiliary transformers to each unit. G-05 is also capable of supplying safe-shutdown loads through transformer X08 to the alternate shutdown panels (Reference 2). These loading requirements are significantly less than the original G-05 design capacity.

On a loss of normal power to the Technical Support Center, the G-05 auxiliary diesel generator will start and supply this load.

A supply of diesel fuel oil is maintained on the site in two 60,000 gallon storage tanks to supply the gas turbine and indirectly the heating boilers, and diesel fire pump. An adequate supply of fuel oil is maintained in these tanks to ensure the availability of G-05 for design function performance.

When additional fuel oil is needed to fill an on-site bulk storage tank, the fuel oil may be provided by local suppliers under a purchase order. Local suppliers within 35 miles of Point Beach have bulk storage capacity of about 12.6 million gallons and the capability to provide emergency delivery at any time.

The number of days that equipment consuming fuel oil can operate is dependent upon the weather, the amount of fuel available, and the specific loads connected to the gas turbine generator.

8.9.4 REQUIRED PROCEDURES AND TESTS

Although no Technical Specification surveillance testing is required, minimum reliability requirements must be satisfied to meet SBO commitments. SBO and Alternate AC power are discussed further in Appendix A.1.

8.9.5 REFERENCES

1. PBNP FSAR Appendix A.1, Station Blackout
2. NFPA 805 Fire Protection Program Design Document (FPPDD).