VIII - ELECTRICAL POWER SYSTEMS

VIII - ELECTRICAL POWER SYSTEMS (Cont'd.)

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VIII - ELECTRICAL POWER SYSTEMS

1.0 SUMMARY DESCRIPTION

The station electrical power systems provide a diversity of dependable power sources which are physically isolated. The station electrical power systems consist of the normal and startup AC power source, the emergency AC power source, the 4160 volt and 480 volt auxiliary power distribution systems, standby AC power source, 125 and 250 volt DC power systems, 24 volt DC power system, 115/230 volt AC no break power system, and the 120/240 volt AC critical power system. (See Tables VIII-1-1, VIII-1-2, and VIII-1-3)

The normal AC power source provides AC power to all station auxiliaries and is the normal AC power source when the main generator is operating. The startup AC power source provides AC power to all station auxiliaries and is normally in use when the normal AC power source is unavailable.

The emergency AC power source provides AC power to emergency station auxiliaries. It is normally used to supply emergency station auxiliary loads when the main generator is shutdown and the startup AC power source is unavailable.

The station 4160 volt and 480 volt auxiliary power distribution systems distribute all AC power necessary for startup, operation, or shutdown of station loads. All portions of this distribution system receive AC power from the normal AC power source or the startup AC power source. The critical service portions of this distribution system also can receive AC power from the standby AC power source or the emergency AC power source.

The standby AC power source provides two independent 4160 volt DGs as the on-site sources of AC power to the critical service portions of the auxiliary power systems. Each DG provides AC power to safely shutdown the reactor, maintain the safe shutdown condition, and operate all auxiliaries necessary for station safety.

In addition, an on-site and independent 3250kW Supplemental Diesel Generator (SDG) is available as a supplemental 4160 volt AC source able to power the F or G busses through the emergency station service transformer (ESST) bus in the event that the DGs and the ESST are unavailable.

The above power sources are integrated into the following protection scheme to insure that the CNS emergency loads will be supplied at all times:[1]

The offsite power sources at CNS are a startup station service transformer which connects to the CNS 161 kV switchyard and the 345/161 kV, 300 MVA auto-transformers connected to the 345 kV switchyard, and a separate emergency station service transformer energized by a 69 kV line connected to a 161/69 kV, 56 MVA auto-transformer in the 161 kV switchyard or the 69 kV subtransmission system. The 161 kV switchyard is connected to one 161 kV line which terminates in a switchyard near Auburn, Nebraska, and two 345/161 kV, 300 MVA auto-transformers which connect to the CNS 345 kV switchyard. The 345 kV switchyard has five (5) lines which terminate in switchyards near Tarkio, Missouri; Hallam, Nebraska; St. Joseph, Missouri; Fairport, Missouri, and Nebraska City, Nebraska. The emergency station service transformer is fed either by the CNS 161/69 kV auto-transformer or by a 69 kV line which is part of a subtransmission grid of another utility (OPPD). If the normal station service transformer (powered by the main generator) is lost, the startup station service transformer, which is normally energized, will automatically energize 4160 volt buses 1A and 1B as well as their connected loads, including the critical buses. If the startup station service transformer fails to

TABLE VIII-1-1

LIST OF MAJOR ELECTRICAL EQUIPMENT
NORMAL STARTUP AND EMERGENCY AC POWER SOURCES

1.	Station Main Generator		983 MVA, 22 kV 0.85 power factor, 0.60 SCR
2.	Transformers		
	a.	Main Transformer Bank	4-287/410 MVA, ODAF1/ODAF2, 65°C, 345-20.9 kV, 3 ph, 60 Hz (3 normally in service-1 spare)
	b.	Normal Station Service Transformer	18/24/30 (33.6) MVA, OA/FA/FA, 55 (65)°C, 21-4.16/4.16 kV, 3 ph, 60 Hz
	c.	Startup Station Service Transformer	21.7/28.8/36 (40.5) MVA ONAN/ONAF/ONAF 55 (65) °C, 161-4.16/4.16 kV, 3 ph, 60 Hz
	d.	Emergency Station Service Transformer	9/10.08/12.6 MVA, OA/FA, 55/65°C, 67-4.16 kV, 3 ph, 60 Hz
3.	Isolated-Phase Bus		
	a.	Main Generator Bus	22 kV, 28,000A, 3 ph, 60 Hz
	b.	Normal Station Service Bus	22 kV, 1200A, 3 ph, 60 Hz

TABLE VIII-1-2

LIST OF MAJOR ELECTRICAL EQUIPMENT AUXILIARY POWER SYSTEM

1.	Switchgear	
a.	4160 Volt (Normal Service) Switchgear 1A and 1B	250 MVA, 2000A Main Breakers 1200A Feeder Breakers
b.	4160 Volt (Normal Service) Switchgear 1C, 1D, 1E	250 MVA, 1200A Main Breakers 1200A Feeder Breakers
c.	4160 Volt (Critical Service) Switchgear 1F and 1G	250 MVA, 1200A Main Breakers 1200A Feeder Breakers
2.	Load Centers	
a.	480 Volt (Normal Service) Load Centers 1A and 1B	Transf. 1500 KVA, 4160V - 480/277V, 3 ph, 1600A Feeder Breakers
b.	480 Volt (Normal Service) Load Center 1E	Transf. 750 KVA, 4160V - 480/277V, 3 ph, 600A Feeder Breakers
c.	480 Volt(Critical Service) Load Centers 1F and 1G	Transf. 2000 KVA, 4160V - 480/277V, 3 ph, 1600A Feeder Breakers

TABLE VIII-1-3

LIST OF MAJOR ELECTRICAL EQUIPMENT
125/250 VOLT DC POWER SYSTEMS

1.	Batteries		
	a.	125VDC: 1A and 1B	125 Volt, 58 cell, 1800 A-hr @ 8 hr rate
	b.	250VDC: 1A and 1B	250 Volt, 120 cell, 1800 A-hr @ 8 hr rate
2.	Battery Chargers		
	a.	125VDC: 1A, 1B, and 1C	125 VDC, 200A
	b.	250VDC: 1A, 1B, and 1C	250 VDC, 200A
3.	DC Buses		
	a.	125VDC: 1A and 1B	125 VDC, 1600A 25,000A Momentary
	b.	250VDC: 1A and 1B	250 VDC, 1600A 25,000A Momentary

energize the critical buses, the emergency station service transformer, which is normally energized, will automatically energize both critical buses. If the emergency station service transformer were also to fail, the DGs would automatically energize their respective buses.

In the event that the DGs also fail to start, the SDG could be connected to the ESST bus through a motor operated disconnect switch (MODS) assembly which would disconnect the ESST and connect the SDG to the ESST bus. This supplemental power source is engaged manually through procedural control. The SDG, though an available power source, is not considered part of the overall protection scheme.

The station 125 and 250 volt DC power systems each provide two independent on-site sources of DC power for startup operation, shutdown and all loads required for station safety.

The 24 volt DC system supplies the source and intermediate range neutron monitors and their trip auxiliaries, selected process radiation monitors and the process radiation monitor trip auxiliaries and the safety system status panel.

The station 115/230 volt AC no break power system provides a versatile distribution system to supply AC power to the instruments and control devices requiring uninterruptible power and other emergency instrumentation, monitoring, and communication systems. The PMIS (Plant Management and Information System) UPS (Uninterruptible Power Supply) system provides uninterruptible power to the plant Process Computer, Annunciator System, and "Y" (Data Acquisition) Side Plant Data Network. The 120/240 volt AC instrument power system provides for critical services that are necessary for the operation of the station but are not critical to station safety.

2.0 NORMAL AND STARTUP AC POWER SOURCES

This USAR section contains historical information as indicated by the italicized text. USAR Section I-3.4 provides a more detailed discussion of historical information.

2.1 Normal AC Power Source

2.1.1 Power Generation Objective

The station main generator, while supplying power to the 345 kV transmission system, shall also supply the necessary AC power to all station auxiliaries.

2.1.2 Power Generation Design Basis

The station main generator shall be capable, through the normal station service transformer, of providing power to all station auxiliaries during normal operation.

2.1.3 Description

The station main generator provides power through the isolated phase bus at 22 kV to both the main transformers and the normal station service transformer. The generator voltage is stepped up through the main transformers to 345 kV and power flows into the 345 kV switchyard which consists of a breaker-and-a-half scheme with 345 kV transmission lines to Atchison County, Nebraska City, St. Joseph, Fairport, and Mark T. Moore Substations and a 345/161 kV transformation connection to the CNS 161 kV substation. The generator voltage is reduced through the normal station service transformer to 4160 volts and power flows into the auxiliary power distribution system as described in Section VIII-4.

The main generator is rated at 983 MVA, 0.85 power factor, 0.60 short-circuit ratio, 60 psig hydrogen pressure, 1800 rpm, 22,000 volts, three-phase, 60 Hertz. The stator core and rotor conductors are hydrogen cooled. Excitation is from a self-excited, shaft-driven alternator with stationary rectifier banks to accomplish the AC to DC conversion. The generator is grounded through a grounding transformer with a secondary resistor. (See Burns and Roe Drawing 3001 for details of the excitation and protective relay systems for the generator. Use Burns and Roe Drawing 3070 for list of symbols.)

The isolated phase bus is rated at 22,000 volts, three-phase, 60 Hertz. The main bus from the generator to the main transformer is rated at 28,000 continuous amperes and 300,000 asymmetrical momentary amperes. The auxiliary bus from the main bus to the normal station service transformer is rated at 1200 continuous amperes and 430,000 asymmetrical momentary amperes. The generator feeds three 410 MVA single-phase main power transformers with one 410 MVA single-phase transformer as a spare. Bus duct is provided to the spare transformer through open links. If a single-phase main transformer fails, by opening the links to the faulted transformer and closing the links on the spare transformer together with the quick disconnect connections on the 345 kV side and the control system connections the generator can be returned to service while the faulted transformer is repaired.

The main transformer bank is rated at 1230 MVA (3-410 MVA, single-phase transformers), forced oil-forced air cooled, 65°C temperature rise, three-phase, 60 Hertz. The high voltage winding is rated at 345,000 volts, 1,175,000 BIL volts, and is connected in grounded wye. The low voltage winding is rated 20,900 volts, 150,000 BIL volts, and is connected in delta.

The normal station service transformer is rated at 18/24/30 (33.6) MVA, OA/FA/FA, 55 (65)°C temperature rise, three-phase, 60 Hertz. The high voltage winding is rated 21,000 volts, 150,000 BIL volts, and is connected in delta. The two low voltage windings, X and Y, are each rated at 4160 volts, 75,000 BIL volts, and are connected in resistance-grounded wye. The X winding feeds five 250 MVA switchgear buses and the Y winding feeds two 250 MVA switchgear buses. These buses are in the auxiliary power distribution system and are described in Section VIII-4.

2.1.4 Inspection and Testing

1. *Inspection and testing at vendor factories and initial system tests were conducted to insure that all components are operational within their design ratings.*

2. Periodic test/inspection of equipment is performed as defined in maintenance programs to determine equipment operability and functional performance.

2.2 Startup AC Power Source

2.2.1 Safety Objective

The startup AC power source shall provide a source of off-site AC power to the critical service portion of the auxiliary power distribution system adequate for the safe shutdown of the reactor.

2.2.2 Safety Design Bases

1. The startup AC power source shall be capable of supplying all loads on the critical service portions of the auxiliary power distribution system. The ECCS loads are sequenced on to the critical bus under LOCA conditions.

2. The availability of the startup AC power source shall be monitored by indication provided in the main control room.

3. The startup AC power source shall be automatically connected to the auxiliary power distribution system including the critical service portion in the event that the normal AC power source is lost.

4. The startup AC power sources shall be as independent as possible from the emergency and normal AC sources within the constraints of the transmission system development.

5. The startup AC power source shall not be synchronized with the emergency AC power source except to permit live source transfers. The startup AC power source shall not be synchronized with the standby power source except to permit live source transfers and for standby power system performance tests.

2.2.3 Power Generation Objective

The startup AC power source shall provide a source of off-site AC power to the entire auxiliary power distribution system adequate for the startup operation or shutdown of the station.

2.2.4 Power Generation Design Bases

1. The startup AC power source shall be capable of supplying all loads during normal station startup.

2. The startup AC power source shall be capable of supplying all loads during normal station shutdown.

2.2.5 Description

The station is connected to the Southwest Power Pool (SPP) through 345 kV and 161 kV buses located in independent switchyards adjacent to the station. The 345 kV breaker-and-a-half scheme, and 161 kV ring bus scheme switchyard buses are connected to the following (refer to Figure VIII-2-3).

1. Generator main transformer bank, described in Section 2.1.
2. One Atchison County 345 kV transmission line to Atchison County switchyard.
3. One St. Joseph 345 kV transmission line to St. Joseph switchyard.
4. One Mark T. Moore 345 kV transmission line.
5. One Nebraska City 345 kV transmission line.
6. One Missouri, Iowa, Nebraska 345 kV transmission (MINT) line to the Fairport, Missouri switchyard.
7. One Auburn 161 kV transmission line.
8. Startup station service transformer (startup AC power source).
9. Two 345/161 kV auto-transformers connecting CNS 345 kV and 161 kV substations and each supplying a 13.8/12.5 kV transformer.
10. One 161/69 kV auto-transformer connecting the 161 kV substation to the 69 kV supply to the ESST.

Offsite AC power for station startup and shutdown is obtained from the 345 kV switchyard through either or both 345/161kV auto-transformers to the CNS 161 kV substation and on to the plant through the startup transformer to the station auxiliary power distribution system. The five 345 kV transmission lines and one 161 kV line are individually or jointly capable of supplying power to the startup station service transformer.

The startup station service transformer supplies power to the station auxiliary power distribution system whenever the main generator is off-line. After the main generator has been synchronized to the 345 kV system and has been partially loaded, approximately 20%,[3] most of the auxiliary power distribution system is manually transferred from the startup station service transformer to the normal AC power source (normal station service transformer).

Automatic fast-transfer capability is provided in the design to transfer 4160 volt buses 1A and 1B, as well as their connected loads, to the startup AC power source (startup station service transformer) in the event that the normal AC power source is lost for any reason.

The breaker controls for the startup AC power source are arranged to prevent inadvertent interconnection with either the normal, standby or the emergency AC power source. A momentary interconnection between two AC sources may occur for live source transfers. The normal or startup AC power source may be synchronized with one standby AC power source for standby AC power system performance tests. Procedural guidance backs up the breaker interlocks and assures that interconnection of the startup AC power and normal AC power sources occur only at low loads and for a short period of time.

The startup station service transformer is rated at 21.7/28.8/36 (40.5) MVA ONAN/ONAF/ONAF/ 55 (65)°C temperature rise, three-phase, 60 Hertz. The high voltage winding is rated 161,000 volts, 750,000 BIL volts and is connected in grounded wye. The tertiary winding is connected in delta. The two low voltage windings, X and Y, are each rated 4160 volts, 110,000 BIL volts and are connected in resistance-grounded wye. The X winding feeds five 250 MVA switchgear buses through 2000 A breakers and the Y winding feeds two 250 MVA switchgear buses through 1200 A breakers. These buses are in the auxiliary power distribution system and are described in Section VIII-4.

The transmission system is protected in accordance with normal utility practice using carrier relaying with primary and secondary relays on the lines and high-speed differential protection with backup differential protection on the transformers. The 161 kV switchyard breakers are controlled by the NPPD Doniphan energy control center. The 345 kV switchyard main generator output breakers are controlled directly from the main control room. All remaining 345 kV switchyard breakers are controlled by the NPPD Doniphan energy control center. Appropriate 345 kV breaker position, appropriate 345 kV transmission line voltages, startup station service transformer voltage, and other parameters are monitored in the main control room.

Control and protection power for the 345 kV breakers is supplied at 125 volt DC from two separate DC panels fed by two independent 125 volt battery systems in the 345 kV switchyard control house. Each 345 kV breaker is equipped with two independent trip coils and breaker failure protective relaying schemes fed by separate DC power sources.[4] Control and protection power for the 161 kV breakers is supplied by a 125 volt DC battery system in the 161 kV switchyard control house. Each 161 kV breaker is equipped with two independent trip coils fed from one power source.

AC power for switchyard auxiliaries is provided from two separate 300 kVA 4160/480-277 V transformers located adjacent to the 345 kV switchyard control house, fed by independent 4160V feeders connected to station service buses 1A and 1B.

The twelve power circuit breakers are rated at 345 kV, either 2000 or 3000 ampere, three-phase, 25,000 MVA and are installed in the circuit to separate the eight connections to the 345 kV buses. Disconnect switches are provided on each side of each circuit breaker. A line disconnect switch is provided on each of the five 345 kV lines.

There are five 161 kV power circuit breakers rated 3000 ampere, three phase, and are installed to separate the five connections to the 161 kV bus. Disconnect switches are provided on each side of each circuit breaker. A line disconnect switch is provided on each of the five connections.

The transmission line design considerations are provided in Section VIII-2.3.

2.2.6 Safety Evaluation

The 345 kV transmission system and breaker-and-a-half scheme switchyard are arranged so that an electrical fault on any line will not result in the loss of the main generator, the other 345 kV lines, or the startup station service transformer. Any one transmission line is capable of carrying the full station output and of supplying the startup station service transformer. The startup station service transformer rating is large enough that the critical service loads are sequentially connected under accident conditions while the buses are supplying normal plant loads.[43]

A high degree of reliability in the transmission system is provided so that the station output is available to the Missouri Basin System power grid and a continuous power source is assured to the startup station service transformer.

Automatic fast-transfer capability is provided in the design to transfer 4160 volt buses 1A and 1B, as well as their connected loads, to the startup AC power source (startup station service transformer) in the event that the normal AC power source is lost for any reason. This satisfies Safety Design Bases 1.

Appropriate 345 kV breaker position, appropriate 345 kV transmission line voltages, startup station service transformer voltage, and other parameters are monitored in the main control room. This satisfies Safety Design Bases 2.

The generator and startup station service transformer have direct connections to the five transmission lines coming from the north, south, east, and west. The transmission lines do not run adjacent to each other.

In the event of a forced outage of one of the 345 kV transmission lines, the two adjacent power circuit breakers in the present breaker-and-a-half scheme will open to disconnect the affected line. The main generator and the startup station service transformer are unaffected and still connected to the other four transmission lines and the 345/161 kV auto-transformers and station operation are unaffected. To ensure security of the breaker and a half scheme, the remote direct transfer trip can be actuated only by a power line carrier or the NPPD Microwave System.[1]

In the event of main generator loss, both generator power circuit breakers will open, but the startup station service transformer will still receive power from the 161 kV bus from the transmission lines.

With the 161 kV ring bus scheme, it is possible to lose the startup station service transformer on a second contingency outage in either of two situations involving breaker failure: (1) loss of the T-2 345/161 kV auto-transformer combined with failure of breaker 1604 to open or (2) loss of the T-5 345/161 kV auto-transformer combined with failure of breaker 1606 to open. Either case would isolate the startup AC source and cause the emergency station service transformer automatically to energize critical buses 1F and 1G.

If the main generator were off-line prior to loss of one of the 345/161 kV auto-transformers and one of the 161 kV breakers failed, the loss of the startup AC power source (startup station service transformer) would automatically connect the emergency power source and initiate the standby AC power source, described in Section VIII-5. The startup AC power source would be restored to service, as soon as practical, by opening the two 161 kV breaker disconnects and line switch to isolate the failed breaker and the de-energized transmission line or transformer and then manually transfer the startup station service transformer back to the operating element.

The startup AC power source is in conformance with 10CFR50 Appendix A, GDC 17. The physical independence of the 161 kV offsite power source from the 69 kV emergency AC power source is described in Section VIII-2.3. This satisfies Safety Design Bases 3 and 4.

The breaker controls for the startup AC power source are arranged to prevent inadvertent interconnection with either the normal, standby or the emergency AC power source. A momentary interconnection between two AC sources may occur for live source transfers. The normal or startup AC power source may be synchronized with one standby AC power source for standby AC power system performance tests. Procedural restrictions back up the breaker interlocks and assure that interconnection of the startup AC power and normal AC power sources occur only at low loads and for a short period of time.

Based on the above, it is concluded that the safety design bases for the startup AC power source are met.

2.2.7 Inspection and Testing

1. *Inspection and testing at vendor factories and initial system tests were conducted to insure that all components are operational within their design ratings.*

2. Periodic tests of the equipment and the system are conducted to determine the operability and functional performance of the startup and emergency station service transformers, relays, switches, and buses as defined in IST and maintenance programs.

3. The startup station service transformer provides the first choice for preferred AC power. Control circuitry is arranged so that upon opening of 4160 volt switchgear breaker contacts for normal station service transformer supply, the breakers for startup station service transformer supply automatically close on fast transfer. Testability can be demonstrated by control switch operation to open the normal station service transformer breaker.

2.3 Transmission Line Design Considerations

2.3.1 General

The five 345 kV and one 161 kV transmission lines, as well as those with which they interconnect, are designed to equal or exceed the requirements for heavy loading districts, Grade B construction. These load requirements are four pounds per square foot wind on one half inch radial ice on cable, and 30 pounds per square foot wind on 1.5 faces of the towers with one half inch ice cover, with the National Electrical Safety Code overload factors. The five transmission lines are designed to equal or exceed the requirements for traverse hurricane wind of 25 pounds per square foot on bare cable at 60°F, and 40 pounds per square foot on 1.5 faces of the tower with an overload factor of 1.25. The design is such that lightning should cause less than one outage per one hundred miles per year.

2.3.2 Station Blackout Analysis

The offsite power source has been evaluated using the methodology of NUMARC 87-00, Rev. 1 as input into the required station blackout coping duration. Based on:

a) the susceptibility of grid-related loss of offsite power (LOOP) events,
b) estimated LOOP frequency due to severe and extremely severe weather, and
c) the degree of independence of the offsite power source transmission lines, the offsite Power Design Characteristic Group P1-I1/2.

2.3.3 Line Separation Analysis[6]

There are five 345 kV transmission lines emanating from the switchyard. Each line is on a separate right-of-way and each right-of-way contains only one circuit per tower line. Although all 345 kV lines are in close proximity at the switchyard location, the routings diverge immediately after leaving the switchyard area in order to minimize the possibility of loss of more than one line during any single storm or weather conditions. The routings of the five 345 kV transmission lines are shown in more detail and in relation to each other on NPPD Drawing NC29546.

Two 345/161 kV auto-transformers in the 345 kV switchyard interconnect the 161 kV substation to the 345 kV substation.

The routes of the 161 kV lines are: (1) from the East side of the 345 kV switchyard to the North side of the 161 kV switchyard, (2) from the West side of the 345 kV switchyard to the South side of the 161 kV switchyard (3) from the 161 kV switchyard to the startup station service transformer, and (4) from the 161 kV switchyard to the Auburn Substation.

The route of the 69 kV line follows roads within the plant area and only at the 161 kV switchyard and near the termination point at the plant building does the 69 kV line approach the 161 kV line. See NPPD Drawing NC29546.

To maintain the independence of the two off-site power circuits in conformance with 10CFR50, Appendix A General Design Criteria 17, separate bus supporting structures are provided for the 4160 volt buses connecting the 161 kV-4160 V and 69kV-4160 V transformers on the low voltage side to the onsite electric distribution system.

On the high voltage side of the offsite transmission circuits the 69 kV enters the 161 kV switchyard from the South approximately 70’ east of the easterly phase of 161 kV transmission line 1962 and exits the 161 kV switchyard to the East approximately 57’ South of the southerly phase of 161 kV transmission line 1961. Line 1961 diverges to the northeast, while the 69 kV line transits East and then Southeast. The 69 kV transmission line enters the site from the southwest to a point 28'6" from the southerly phase of the 161 kV line 1961 near the SSST. A steel, self-supporting turning tower is then utilized to direct the line eastward to the transformer yard. The turning tower is located between two steel, self-supporting dead-end towers.

The following discussion shows that, from a practical standpoint, the turning tower cannot fail in a manner to interact with the incoming 161 kV line. Turning tower design criteria are, in general, considerably more stringent than standard transmission towers. And specifically, the turning tower utilized on the 69 kV line was designed to be self-supporting under high (80 mph) wind conditions, heavy icing, and with the dead-end tension of the transmission lines, although the dead-end tension of the transmission lines is currently absorbed by the dead-end towers.

The following represents design data concerning the 69 kV turning tower:

A. Weight of structure - 10,000 lbs.
B. Weight of equipment on tower - 900 lbs.
C. Weight of maximum ice and snow load on tower - 5500 lbs.
D. Designed to withstand a wind velocity of 80 mph.

The following data describes the conductors (3) and shield wires (2) on one span of the 69 kV transmission line.

	Ultimate Strength	Ice and Wind Load	Normal 120°F Load
One 69 kV conductor	8420 lbs.	1932 lbs.	192 lbs.
One shield wire	6000 lbs.	1500 lbs.	250 lbs.
Total all five lines	37,260 lbs.	8796 lbs.	1076 lbs.

From the above data, it is evident that, in addition to its inherent design capabilities, the turning tower has the added support of 37,000 lbs. from either a southwesterly or easterly direction. Any one of the five wires comprising the 69 kV transmission line can be considered equivalent in strength to a guy wire.

Postulating the worst accident or environmental condition (i.e., tornado, seismic, etc.) wherein both northerly legs fail, it would be impossible for the tower to fall northward. The entire tower, even with heavy icing conditions, weighs only 16,400 lbs. while the transmission line exerts a force of 37,000 lbs. toward the southwest and 37,000 lbs. toward the east.

Therefore, the 69 kV turning tower, having been designed as self-supporting with a significant factor of safety, and having the equivalent of five guy wires to the southwest and five to the east, cannot fail in a manner to cause interaction with the 161 kV line.

2.3.4 Analysis of a Transmission Line Break[6]

CNS is provided with a 69 kV transmission line for emergency shutdown and a 161 kV line for startup. These lines run parallel over the span from the 69 kV turning tower east to the 69 kV dead end tower. The possibility of the two transmission lines coming into contact with each other in the event one breaks is discussed below.

Load on the wires due to ice would make the wires fall straight down more readily than horizontally. Therefore, this load condition was removed from further consideration. "Snapping" action of the wires would be very small at the small loads shown above. Assuming a wire broke, any snapping reaction would tend to prevent the wires from coming into contact. The worst possible case entails the breakage of a normally loaded wire, following which the wire is blown by the wind into the opposing transmission line.

The lines are protected from the wind on the north by the Reactor Building and on the east by the Turbine Generator Building and Machine Shop. This protection eliminates the possibility that the 161 kV lines could be blown southward into the 69 kV lines. A calculation has been completed for the worst possible case, which consists of the northerly 69 kV shield wire breaking where it attaches to the 69 kV turning tower and being blown northward into phase C of the 161 kV transmission line. The shield wire was chosen because it weighed less than the conductors and its point of attachment to the turning tower was at a greater elevation.

The calculation indicated that a 74 mph wind from the south was required to blow the shield wire into phase C of the 161 kV transmission line. Reference was made to the National Climate Center in Asheville, North Carolina, whose records for Lincoln, Nebraska (nearest major city to CNS), show a 73.7 mph wind in August, 1956, and a 76 mph wind in June, 1946. These records cover the period from 1878 until preparation of the calculation and indicate a near zero frequency of occurrence for winds over 70 mph. This, plus the fact that the wire must break (by some tremendous outside force, a wind could not break the wire) at the same instant the wind is blowing 74 mph from the south, forces the probability of the two transmission lines crossing to almost zero. In addition, conservative assumptions were made in the calculation which indicate that it can be safely assumed that the 69 kV and 161 kV lines are located such that they will not contact each other in the event of one's breakage.

The normal load on the shield wire is 250 lbs. At this small load the shield wire would fall almost as a thin rod. Very little "snapping" action would be exhibited. The calculation is based on the following assumptions:

1. The shield wire is assumed to break at the turning tower and pivot at the dead end tower attaching point.

2. The shield wire falls as a thin rod.

3. Wind force acts at right angles to wire at all times (a conservative assumption, since this would require less wind force to blow the shield wire into phase C of the 161 kV line).

4. The component of gravity force normal to the wire at the initial position will be used as a constant at all times. (This is a conservative assumption because this force increases as the wire falls.)

5. Forces are located at the center of percussion, which is 2/3 of the distance from the pivot point at the dead end tower to the breaking point of the 69 kV shield wire.

2.3.5 Redundant Guying System[6]

In order to provide redundancy of design against failure of the 69 kV turning tower into the adjacent 161 kV line, the District has installed an independent cable wire rope guying system. This guying system is installed such that the wire rope guy is oriented in a southerly direction from the 69 kV turning tower. The tower guy is attached as near as possible to the tower's uppermost point and from thence to an intermediate pole from which two (2) guy wires in turn connect to two (2) concrete anchors. The interpositioning of a pole between the 69 kV turning tower and the concrete anchors is necessary to insure maintenance of proper clearance above the adjoining road and railroad.

The elevation of the guy wire from the 69 kV turning tower has also considered all requirements necessary to maintain proper electrical clearance from the adjoining phase wires. Since the guying wire from the 69 kV turning tower is also oriented in a southerly direction, this system assures the prevention of any part of the tower from falling northward toward the incoming 161 kV lines. In addition, the section of the horizontal guy from the turning tower to the intermediate pole is constructed with a sag of about eight (8) feet. This large sag creates relatively low horizontal and vertical reactions on the 69 kV turning tower when considering the normal everyday cable loadings.

In the event the 69 kV turning tower fails at a point at or close to its base, the aforementioned eight (8) foot sag will permit the top of the tower to deflect northward approximately 2 to 3 feet. At this point, the guy will become taut and prevent the tower from continuing any further failure in the northerly direction. Therefore, by use of the above described guying system, prevention of a possible failure of the 69 kV turning tower in such a manner as to cut any of the adjoining incoming 161 kV line wires has been assured.

3.0 EMERGENCY AC POWER SOURCE

This USAR section contains historical information as indicated by the italicized text. USAR Section I-3.4 provides a more detailed discussion of historical information.

3.1 Safety Objective

To provide an additional source of power to the critical service portion of the auxiliary power distribution system to back up the normal and startup sources and to permit portions of the 345 kV system to be removed from service for inspection, testing, and maintenance.

3.2 Safety Design Bases

1. The emergency AC power source shall be capable of providing electric power to all equipment which is required for the safe shutdown of the reactor.

2. The emergency AC power source shall be as independent as possible from the startup AC power source within the constraints of the transmission system.

3.3 Power Generation Objective

The emergency AC power source shall provide a source of off-site AC power to the critical buses which shall distribute power to the equipment which is required for the safe shutdown of the reactor.

3.4 Power Generation Design Basis

The emergency AC power source shall distribute power to all station auxiliaries necessary for the safe shutdown of the reactor and distribute power to critical services such as emergency lighting, battery charging, turbine turning gear and other necessary power requirements during the shutdown period.

Emergency AC power is also utilized as an alternate power feed for various temporary applications when operating within an emergency operating procedure.

3.5 Description (Refer to Burns and Roe Drawings 3001 and 3002)

The emergency AC power source is connected to a 69 kV transmission system operated in the nearby geographic area by OPPD and NPPD.[7] The 69 kV network has six sources as listed.

OPPD Sub 906 (Omaha), 161-69 kV
OPPD Sub 1263 (Brock), 161-69 kV
OPPD Sub 974 (Sterling), 115-69 kV
NPPD Humboldt Substation, 161-69 kV
OPPD Sub 1214 (Ashland), 115-69 kV
NPPD CNS 161 kV Substation, 161-69 kV

The T6 source will not be connected to the other five sources as a parallel supply unless switching between the sources. The supply from the CNS 161 kV substation will be used or the other five interconnected sources will be used. A brief interconnection to switch sources is allowed. The CNS 161/69 kV auto-transformer is rated at 56 MVA. This is sufficient to supply the 12,800 KVA (10,240 KW*) maximum momentary load** which is adequate to handle the emergency load in addition to the village of Peru, Nebraska if both are not connected to the OPPD 69 kV OPPD Substation.

When supplied from the CNS 161 kV substation source, with the 161 kV ring bus scheme, it is possible to lose the emergency station service transformer on a second contingency outage in either of two situations: (1) loss of the Auburn line combined with breaker 1610 failure to open, (2) loss of the T5 345/161 kV auto-transformer with breaker 1608 failure to open. Either case would isolate the emergency station service transformer. If the ESST was supplying either critical bus, the associated EDG would start automatically to energize critical Buses 1F and 1G.

All sources, except the T6 auto-transformer, operate continuously interconnected through the transmission network. CNS is served over a 21.4 mile line segment direct from one of the sources, Brock Substation. Capacity at the Brock Substation is sufficient for the plant safety feature loads.

NPPD has a Wheeling Service Agreement for Station Power Service with OPPD. This agreement states that OPPD will maintain a continuously energized source of supply to supply a 10,000 KVA (8000 KW*) maximum sustained or 12,800 KVA (10,240 KW*) maximum momentary load** at the OPPD 69 kV connection to CNS which is adequate to handle the emergency load.

*Power Factor = .8
**The 12,800 KVA maximum momentary load is defined by contract as being supplied for at least 10 minutes.

The 10,000 KVA maximum sustained load on the OPPD 69 kV line is equal to the combined capacity of the two DGs.

Since the 69 kV power source is continuously energized, no prior communication with OPPD personnel is required in order to utilize this power source.

This agreement is good until October 16, 2004, and thereafter until terminated by four years prior written notice given by either party. During this time, OPPD agrees to maintain adequate transmission capacity in its facilities between its Omaha substation 1206 and the CNS delivery point to deliver the agreed power and energy to CNS at voltage levels of not less than 90% of the nominal voltage.

The Brock to CNS 69 kV line is continuously monitored by recording ammeters. Weekly readings taken by OPPD are used to monitor load growth and assure that the required power availability to CNS is maintained. NPPD will review OPPD's load growth data on an annual basis to verify that the required power availability to CNS is maintained. The Omaha to Brock 69 kV breakers are under OPPD direct supervisory control.

The voltage is reduced from 69 kV to 4160 volts by the emergency station service transformer which can be connected to 4160 volt critical buses 1F and 1G through 1200 A breakers.

The emergency station service transformer is rated at 9/10.08/12.6 MVA, 55°C/65°C, OA/FA cooled, 3-phase, 60 Hertz, with a 67,000 volt high voltage winding and a 4160 volt low voltage winding.

The breaker controls for the emergency AC power source are arranged to prevent inadvertent interconnection with either the normal AC power source, the startup AC power source or the standby AC power source. These controls are backed up by procedural guidance.

3.6 Safety Evaluation

In order to insure continued availability of the emergency AC power source, the cable feeders from one critical power bus are physically separated from the cable feeders of the other critical bus. All 480 volt and 4160 volt power cables connected to the critical buses are installed in rigid conduit. The cable routing and the installation of power cables in rigid conduit localizes any electrical fault, makes one system of emergency power completely independent of the second system and makes both systems free from mechanical accidents.

The emergency AC power source and the on-site distribution system are of sufficient capacity and capability to automatically start as well as operate all required safety loads within their voltage ratings in the event of: a) an anticipated transient (such as a unit trip) or b) an accident (such as a LOCA).[8]

In order to insure that the supply of emergency AC power would not be compromised by the loss of CNS, a grid stability analysis was performed.[9]

The CNS 161 kV and 345 kV switchyards are connected through transmission lines to adjacent systems in Kansas, Iowa, Missouri, and Nebraska. The 345 kV interconnections reach Minneapolis, Kansas City, Wichita, and St. Louis.

The grid stability analysis showed that if CNS instantaneously dropped off-line, the rest of the interconnecting system would not become unstable. Therefore, CNS would still be supplied with off-site 69 kV and 161 kV power[40].

The emergency AC power source is in conformation with 10CFR50 Appendix A, GDC 17. The physical independence of the 69 kV offsite power source from the 161 kV power source is described in Section VIII-2.3

It is concluded that the design satisfies the safety design basis.

3.7 Inspection and Testing

1. *Inspection and testing at vendor factories and initial system tests were conducted to insure that all components are operational within their design ratings.*

2. Periodic tests/inspections of equipment is performed as defined in maintenance programs to determine equipment operability and functional performance.

3. The emergency station service transformer provides the second choice for preferred AC power. Control circuitry is arranged so that upon opening of 4160 volt switchgear breaker contacts for incoming normal or startup supply to the 4160 volt critical bus, the breaker for emergency station service transformer supply automatically closes. Testability can be demonstrated by control switch operation to open the incoming breaker to the critical bus.

Provision is also made in the under-voltage protective scheme for the 4160 volt switchgear on critical buses 1F and 1G for automatic assumption of critical loads by the emergency station service transformer before standby AC power is used. This function can be tested during normal operation.

4.0 AUXILIARY POWER DISTRIBUTION SYSTEM

This USAR section contains historical information as indicated by the italicized text. USAR Section I-3.4 provides a more detailed discussion of historical information.

4.1 Safety Objective

The critical service portion of the auxiliary power distribution system shall under all transient and accident conditions, distribute AC power required to safely shutdown the reactor, maintain the safe shutdown condition, and operate all auxiliaries necessary for station safety.

4.2 Safety Design Bases

1. The critical service portion of the auxiliary power system shall distribute power to the station auxiliaries and all loads which are necessary for plant safety.

2. The auxiliary power system, normal and critical service portions, shall be arranged so that a single failure will not prevent or impair the operation of critical station safety functions.

3. The critical service portions of the auxiliary power system shall be supplied from both off-site and on-site AC power sources.

4. The critical service portion of the auxiliary power system shall be in accordance with the "IEEE 308 Criteria for Class 1E Electrical Systems for Nuclear Power Generating Station," issued in 1970.

4.3 Power Generation Objective

The entire auxiliary power distribution system, normal and critical service portions, shall distribute AC power to all station AC auxiliaries required for startup, operation, and shutdown of the station.

4.4 Power Generation Design Basis

The auxiliary power distribution system shall distribute power to all the station auxiliaries necessary for normal station operation.

4.5 Description (Refer to Burns and Roe Drawing 3001)

4.5.1 Arrangement of Auxiliary Buses (See list of major auxiliary equipment on Table VIII-1-2)

There are seven 4160 volt buses (1A, 1B, 1C, 1D, 1E, 1F, and 1G) in the station auxiliary power distribution system. The seven buses are divided into critical service and normal service buses. The two critical service buses, 1F and 1G, supply power to critical loads required during abnormal operational transients and accidents. The five normal service buses, 1A, 1B, 1C, 1D, and 1E, supply power to other station auxiliaries requiring AC power during planned operations.

Power is distributed to the seven 4160 volt station auxiliary buses during normal operation from either the normal station AC power or the startup AC power source. The startup AC power source is used to supply 4160 volt buses during normal startup and shutdown. After the main generator has been synchronized to the 345 kV system and a minimum stable load established (approximately 20% of full output), the 4160 volt buses may be individually transferred from the startup AC power source to the normal AC power source. This is done automatically by manually closing the normal AC power source supply breaker (after synchronization checks), to an individual 4160 volt bus while it is still energized from the startup AC power source. The startup AC power source supply breaker to this bus is then automatically opened and the transfer is complete. This results in the temporary interconnection of the startup AC power source (startup station service transformer) and the normal AC power source (normal station service transformer) through a single 4160 volt auxiliary bus.

This process is repeated until all required 4160 volt buses have been individually transferred from the startup AC power source to the normal AC power source. 4160 volt bus 1E is subfed from either bus 1A or 1B. Procedural guidance and synchronization switch interlocks assure that the 4160 volt buses are individually transferred. The startup and normal AC power sources are paralleled through one 4160 volt bus only for the short period required to verify that the normal AC power source supply breaker has closed before the startup AC power source supply breaker is automatically opened.

Automatic fast transfer is provided to restore 4160 volt buses 1A and 1B, as well as their connected loads, to the startup AC power source in the event that the normal AC power source is lost. The startup AC source supply breakers to 4160 volt buses 1A and 1B close automatically whenever the normal AC power source supply breaker to the bus opens, and there is no fault on the buses, thus maintaining power to all station auxiliaries connected to that bus. The fast transfers of individual 4160 volt buses from the normal AC power source to the startup AC power source will not interfere with normal station operation. Each bus is transferred individually and in one direction only, from the normal power source to the startup AC power source.

The 4160 volt critical service buses, 1F and 1G, receive power from 4160 volt buses 1A and 1B respectively. Buses 1F and 1G can also be supplied from the emergency AC power source or the standby AC power source. In the event that both the normal AC power source and the startup AC power source are lost, the emergency AC power source is automatically connected to buses 1F and 1G. In case the emergency AC power source is not available then the standby AC power source re-energizes buses 1F and 1G within ≤14 seconds. The emergency AC power source may also be manually connected to the 4160 volt critical service buses. The standby AC power sources are capable of being independently synchronized for parallel operation with the emergency AC power source. This synchronization will be done manually for live source transfers. The breaker controls for the emergency AC power source are arranged to prevent inadvertent interconnection with either the normal, the startup, or the standby AC power sources.

The five, 480 volt buses, 1A, 1B, 1E, 1F, and 1G, are also divided into normal service buses and critical service buses. The critical 480 volt auxiliaries required during abnormal operational transients and accidents are all supplied from the two critical service buses, 1F and 1G. The three normal service buses 1A, 1B, and 1E supply power to other 480 volt auxiliaries required during plant operations. The 480 volt critical service buses 1F and 1G receive power from the 4160 volt critical buses 1F and 1G respectively.

AC power for switchyard auxiliaries is obtained from two separate 300 KVA 4160-480 volt transformers adjacent to the switchyard control house, fed by independent 4160 volt feeders connected to station service 4160 volt buses 1A and 1B.[4]

Power from the 4160 volt switchgear buses is fed directly to 300 hp and larger motors and to load center transformers feeding the 480 volt load center buses. Power from the 480 volt load centers is fed directly to motors from 125 hp through 250 hp and to MCCs. Power from the MCCs is fed directly to motors from ½ hp through 100 hp, through motor operators. The MCCs also feed power panels. (See Burns and Roe Drawings 3003, 3004, 3005, 3006, 3007 and 3401).

The list of major loads of the auxiliary power system is shown in Table VIII-4-1.

4.5.2 System Components

All of the 4160 volt switchgear are of the metal-clad, indoor drawout type. The circuit breakers that are electrically operated three-pole breakers with stored energy closing mechanism operated from the 125 volt DC station batteries described in Section VIII-6.

All 480 volt load centers consist of low voltage switchgear and transformers. All of the switchgear are of the metal enclosed indoor drawout type. Each of the sealed dry type transformers is rated at 750 to 2000 KVA, 150°C temperature rise, three-phase, 60 Hertz. The circuit breakers are electrically or manually operated three-pole breakers.

The 460 volt MCCs used to feed all loads are NEMA Type I, or greater, manually operated fused disconnects or molded case circuit breakers. Overcurrent protection is provided on all phases.

Cables have adequate flame-resistant properties, and are designed to resist high temperature and high humidity levels in the area in which they are installed, as specified in Contract E-69-17, page G-35. Insulation and components of all 5 kV, 1000 volt, and 600 volt cable makeups are capable of withstanding 1.0×10^7 rads inside the drywell and 1.0×10^6 rads outside the drywell, integrated over a 40 year life.[29] Power and control cables to safeguard equipment within the primary containment are designed to withstand the environmental conditions caused by any accident during which the equipment they are supplying is assumed to operate, as specified in Contract E-69-17. Normal continuous operating conditions in the drywell are 150°F at 100% humidity.[29] The current carrying capacity of all power cables is conservatively calculated to preclude thermal overloads. Cables used within the containment penetration sealed canisters meet additional insulation material and current carrying capacity restrictions.

Cables and components of redundant circuits are physically separated by means of space and fire barriers to assure maximum independence of redundant channels. The 4160 volt cables are installed in conduits. The 480 volt power cables and control cables are installed in conduit and metal trays.

4.6 Safety Evaluation

Provisions to assure continued availability of AC power to the critical service portions of the auxiliary power distribution system have been made in the design. The multiplicity of off-site and on-site sources feeding these buses, the redundancy of transformers and buses within the plant, and the division of critical loads between buses yields a system that has a high degree of reliability. The physical separation of buses and service components provides independence to limit or localize the consequences of electrical faults or mechanical accidents occurring at any point in the system. Safety design bases criteria 1 and 2 are satisfied.

TABLE VIII-4-1

LIST OF MAJOR LOADS
AUXILIARY POWER SYSTEM

1. Loads on 4160 Volt Switchgear Buses (Normal Service)

a. Bus 1A

Circ. Water Pump 1A	1750 hp
Circ. Water Pump 1B	1750 hp
Condensate Booster Pump 1A	2500 hp
Condensate Pump 1A	800 hp
480 V Sta. Serv. Substa. 1A	1500 KVA
4160 V Critical Bus 1F	5000 KVA
345 kV Swyd. Service Transf. (Normal)	300 KVA
*4160 V Swgr. Bus 1E	

b. Bus 1B

Circ. Water Pump 1C	1750 hp
Circ. Water Pump 1D	1750 hp
Condensate Booster Pump 1B	2500 hp
Condensate Pump 1B	800 hp
480 V Sta. Serv. Substa. 1B	1500 KVA
4160 V Critical Bus 1G	5000 KVA
345 kV Swyd. Service Transf. (Backup)	300 KVA
*4160 V Swgr. Bus 1E	

c. Bus 1C

Reactor Recirc. M-G Set 1A Motor	7000 hp

d. Bus 1D

Reactor Recirc. M-G Set 1B Motor	7000 hp

e. Bus 1E

Condensate Booster Pump 1C	2500 hp
Condensate Pump 1C	800 hp
Intake Struct. 480 V Substa. 1E	750 KVA
Screen Wash Pump 1C	350 hp
Screen Wash Pump 1D	350 hp

2. Loads on 4160 Volt Switchgear Buses (Emergency Service)

a. Bus 1F

480 V Swgr. Critical Bus 1F	2000 KVA
Station Serv. Water Pump 1A	300 hp
Station Serv. Water Pump 1C	300 hp
RHR Serv. Water Booster Pump 1A	1000 hp
RHR Serv. Water Booster Pump 1C	1000 hp
RHR Pump 1A	1250 hp
RHR Pump 1B[11]	1250 hp
Core Spray Pump 1A	1250 hp

b. Bus 1G

Station Serv. Water Pump 1B	300 hp
Station Serv. Water Pump 1D	300 hp
RHR Serv. Water Booster Pump 1B	1000 hp
RHR Serv. Water Booster Pump 1D	1000 hp
RHR Pump 1C[11]	1250 hp
RHR Pump 1D	1250 hp
Core Spray Pump 1B	1250 hp
480 V Swgr. Critical Bus 1G	2000 KVA

*4160 V Swgr. Bus 1E is included with both 1A and 1B since it may be supplied power from either source.

The 4160 volt critical service buses, 1F and 1G, receive power from 4160 volt buses 1A and 1B respectively. Buses 1F and 1G can also be supplied from the emergency AC power source or the standby AC power source. In the event that both the normal AC power source and the startup AC power source are lost, the emergency AC power source is automatically connected to buses 1F and 1G. In case the emergency AC power source is not available then the standby AC power source re-energizes buses 1F and 1G within ≤14 seconds. The emergency AC power source may also be manually connected to the 4160 volt critical service buses. The standby AC power sources are capable of being independently synchronized for parallel operation with the emergency AC power source. This synchronization will be done manually for live source transfers. The breaker controls for the emergency AC power source are arranged to prevent inadvertent interconnection with either the normal, the startup, or the standby AC power sources. This satisfies safety design basis 3.

During normal operation the facility auxiliary loads are carried by the station generator. The generator voltage is maintained essentially constant by the automatic voltage regulator and, as a result, the auxiliary bus voltage remains constant.

In accordance with ANSI C84.1-1970, p. 9, the safety related motors and non-safety motors can operate continuously over a range from 3600 V to 4400 V. At 3000 V the following events are subject to occur.

a. Failure of motor starters to close, and the subsequent failure of the respective motors to start.

b. Blowing of control fuses in AC control circuits for motor starters.

c. Overheating of motors due to excessive current drawn by the motor operating at low voltage.

In order to preclude damage to motors on critical equipment due to undervoltage conditions, the 4160 volt critical buses 1F and 1G are provided with two levels of protection.[10] Normally these buses operate in a voltage range of approximately 3950 to 4400 volts.

The first level of undervoltage protection is a loss of voltage scheme. Voltages on 4160 volt critical bus 1F (1G) are monitored by relays 27/1F1 (27/1G1) and 27/1FA1 (27/1GB1). Upon loss of voltage, relay 27/1F1 (27/1G1) will initiate the following:

1. A start signal to DG1 (DG2)

2. Load shedding of all motors on 4160 volt critical bus 1F (1G). Relays 27X1/1F (27X1/1G) and 27X2/1F (27X2/1G) perform this function.

3. Load shedding of the non-essential Motor Control Centers (MCC), with the exception of MCC-L and MCC-T, and non-essential motors fed from critical 480V bus 1F (1G). Relay 27X2/1F (27X2/1G) and time delay relay 27X18/1F (27X18/1G) perform this function. The time delay of approximately 5.5 seconds will prevent the load shedding of these 480V loads if the bus is transferring to the emergency station service transformer which is capable of supplying these loads in addition to the ECCS loads. If the emergency station service transformer does not energize 4160 volt critical bus 1F (1G), DG1 (DG2) will be connected to the bus. The time delay of approximately 5.5 seconds will ensure that the loads will shed prior to transferring to DG1 (DG2).

The other first level undervoltage relay 27/1FA1 (27/1GB1) will trip breaker 1FA (1GB) a short time later (1/2 to 1 second).

The first level undervoltage relays are time undervoltage relays with inverse time characteristics (the lower the voltage, the faster the actuation). The relays have a tap plug setting which corresponds to about 2870 volts, which assures timely operation for a loss of voltage condition, but doesn't spuriously operate during momentary voltage dips created by motor starts. The relays operate along a time-voltage curve defined by the time dial setting of the relay. A relay is tested at various voltage levels and the time delay is checked at each level to assure the relay is operating on its defined curve.

The Technical Specification setting for the first level undervoltage (loss of voltage) relays is 2300 volts ± 5%, $0 \leq T \leq 5$ seconds, where T is the time delay. This window sectionalizes an area of the relay curves which corresponds to the median of voltage levels tested during surveillance testing. In this fashion, the relays are checked to assure they function as designed and are operating within Technical Specification limits.

The second level of undervoltage protection is a sustained undervoltage scheme. Voltages on 4160 volt critical bus 1F (1G) are monitored by relays 27/1F2 (27/1G2) and 27/1FA2 (27/1GB2). When bus 1F (1G) is energized from bus 1A (1B), low voltages on each bus will be sensed by two relays 27/1F2 (27/1G2) and 27/1FA2 (27/1GB2). When bus 1F (1G) is energized from the emergency station service transformer, low voltages on each bus will be sensed by only one relay 27/1F2 (27/1G2). Any momentary voltage dips caused by starting of large motors will not operate undervoltage relays. When bus 1F (1G) is powered from either the startup or normal station service transformer via bus 1A (1B), a low voltage on bus 1F (1G) below 3880 volts for 12.5 ± 1.3 seconds will trip the tie breaker 1FA (1GB) unless a RHR initiation seal-in is present, in which case breaker 1FA (1GB) would trip on a low voltage on bus 1F (1G) below 3880 volts for 7.5 ± 0.8 seconds. When bus 1F (1G) is powered from the emergency station service transformer, a low voltage on bus 1F (1G) for 15 ± 1.5 seconds will trip breaker 1FS (1GS). After the tie breaker 1FA (1GB) trips on low voltage, the associated DG starts and the first level undervoltage protection will trip all 4160 volt motor breakers. After the emergency station service transformer breaker 1FS (1GS) trips on low voltage, the associated DG starts and the first level undervoltage protection will trip all 4160 volt motor breakers and non-essential MCC breakers, with the exception of MCC-L and MCC-T. |

Additionally, lockout of load shedding on bus 1F (1G) (i.e., blocking the trip function of motor breakers due to undervoltage) occurs if the tie breaker 1FA (1GB) is open and bus 1F (1G) is energized from its DG. Forty-one seconds after breaker EG1 (EG2) closes, the load shedding from the first level undervoltage protection is automatically restored.

Bus 1F (1G) low voltage is alarmed in the control room at two voltage levels; relay 27/1F2 (27/1G2) alarms when the voltage drops below 3880V, and relay 27/1F1 (27/1G1) alarms when voltage drops below 2870V.

Startup station service transformer low voltage is alarmed in the control room at two voltage levels; relay 27/STX-2 alarms when the voltage drops below 3675 V, and relay 27/STX-1 alarms when the voltage drops below 2870 V.

Emergency station service transformer low voltage is alarmed in the control room when the voltage drops below 2870 volts, which is monitored by relay 27ET1.

The 27ET3 (27/ET4) relays have an alarm and a permissive function. The permissive function is via the 27X14 1F(1G) relays, which prevent automatic closure of the 1FS(1GS) breakers if the unloaded emergency station service transformer secondary voltage is below 4328 volts. An alarm function is provided to identify that breaker 1FS(1GS) automatic closure is not permitted if the emergency station service transformer secondary voltage is below 4328 volts.

The entire discussion satisfies safety design criteria 4. Therefore, it is concluded that the design satisfies the safety design basis.

4.7 Inspection and Testing

1. *Inspection and testing at vendor factories and initial system tests have been conducted to insure that all components are operational within their design ratings.*

2. Periodic tests of the equipment and the system are conducted to:

    a. Detect the deterioration of equipment in the system toward an unacceptable condition.

    b. Demonstrate the capability of normally de-energized equipment to perform properly when energized.

5.0 STANDBY AC POWER SOURCE

This USAR section contains historical information as indicated by the italicized text. USAR Section I-3.4 provides a more detailed discussion of historical information. The information being presented in this section as historical has been preserved as it was originally submitted to the NRC in the CNS FSAR.

5.1 Safety Objective

To provide a single failure proof source of on-site AC power adequate for maintaining the safe shutdown of the reactor following abnormal operational transients and postulated accidents.

5.2 Safety Design Bases

1. The standby AC power system shall consist of two independent AC power sources that are self-contained within the station site and which are independent of off-site power sources.

2. Each standby generator unit shall be capable of providing sufficient power to satisfy the load on its independent critical bus, upon failure of all off-site power.

3. Each standby generator unit and its switchgear shall be designed in accordance with Class I Seismic criteria.

4. The DG sets shall be capable of automatic start at any time and capable of continued operation at rated load, voltage and frequency until manually stopped. USAR Section XIV requires each DG set to be operable for a 30 day mission time to support its safety objective for postulated design basis accidents.

5. The generator sets shall have the ability to pick up loads as described in Table VIII-5-1 in a sequence and time period as described in Table VIII-5-2 to satisfy design basis loss-of-coolant accident acceptance criteria assuming a loss of all off-site power sources.

6. The DGs shall be capable of being independently synchronized to the normal station service transformer (NSST), the startup station service transformer (SSST) or the emergency station service transformer (ESST). This synchronization will be done manually for system performance tests or live source transfers. In the emergency mode, provisions shall be made in the design to prevent: (a) the automatic parallel electrical interconnection of both DGs and (b) the automatic electrical interconnection of either DG with the NSST, SSST or ESST.

7. Each DG unit shall have a unit fuel (day) tank. Either unit fuel (day) tank shall be supplied from the combined two main fuel storage tanks. Each unit fuel (day) tank will provide enough fuel to allow a minimum of 3.9 hours of full load operation of the DG unit.[34] Both main fuel oil tanks combined shall have sufficient fuel for seven days of operation of one DG unit at full load which bounds postulated accident conditions. The specific Emergency Diesel Generator (EDG) fuel oil volumes contained in the diesel fuel oil storage tanks necessary to ensure that EDG run-duration requirements are met, are calculated using Section 5.4 of American National Standards Institute (ANSI) N195-1976, “Fuel Oil Systems for Standby Diesel Generators,” and are based on applying the conservative assumption that the EDG is operated continuously for 7 days at its rated capacity. This fuel oil calculation methodology is one of two approved methods specified in Regulatory Guide (RG) 1.137, Revision 1, “Fuel Oil Systems for Standby Diesel Generators,” Regulatory Position C.1.c.

8. Control power required for the startup and operation of each DG unit shall be supplied from the 125 volt station DC power system. Other auxiliaries necessary to ensure continuous operation shall be supplied from the DG through the critical buses.

9. The units shall be capable of being started or stopped manually from local control stations near the diesels or remotely from the Control Room. The diesels shall be capable of being connected to the 4160 volt critical buses during loss of off-site power: (a) automatically when the Control Room has remote control or (b) manually when the local control stations have local control.[32] The diesels shall start automatically upon the loss of voltage on the 4160 volt critical buses, or low reactor water Level 1 or high drywell pressure.

10. The standby AC power system shall conform to the applicable sections of "IEEE 308 Criteria for Class 1E Electrical Systems for Nuclear Power Generating Stations", issued in 1970.

TABLE VIII-5-1

DIESEL-GENERATOR LOADING TABLE
STANDBY AC POWER SYSTEM

USAR Table VIII-5-1 is derived by the existing plant AC load study[23], and was constructed for the worst case condition described below:

> LOCA WITH LOSS OF OFF-SITE POWER (LOCA W/LOOP): This condition calculates the loading on each DG during a Loss of Offsite Power condition. The loading on each DG is calculated assuming the redundant DG is inoperative. This condition assumes a LOCA occurs at the time t = -16 seconds and the SSST and ESST are unavailable.

USAR TABLE VIII-5-1

DIESEL GENERATOR #1 SEQUENTIAL LOADING (kW)

		TIME INTERVAL										
	NOTE 1	0-5 Sec.	5-10 Sec.	10-15 Sec.	15-20 Sec.	20-30 Sec.	0.5-2 Min.	2.0-10 Min.	10-30 Min.	0.5-2 Hours	2-12 Hours	0.5-7 Days
SW-MOT-SWPA (OR C)	**NOTE 2**	0	0	275	275	275	275	275	275	275	275	275
RHR-MOT-RHRP1A	**NOTE 3**	969	969	969	969	969	969	969	969	969	969	969
RHR-MOT-RHRP1B	**NOTE 4**	0	968	968	968	968	968	968	0	0	0	0
CS-MOT-CSP1A	**NOTE 5**	0	0	1115	1115	1115	1115	1115	1004	1004	1004	1004
SW-MOT-RSWPA	**NOTE 6**	0	0	0	0	0	0	0	916	916	916	916
SS1F	**NOTE 7**	494	494	497	506	592	589	573	772	795	732	732
MCC-DG1		53	53	53	80	80	80	80	59	59	59	59
SUBTOTAL		1516	2484	3877	3913	4000	3997	3980	3995	4019	3955	3955
0.75%		11	19	29	29	30	30	30	30	30	32	30
Total	**NOTE 8**	**1527**	**2502**	**3906**	**3943**	**4030**	**4027**	**4010**	**4025**	**4049**	**3985**	**3985**

DIESEL GENERATOR #2 SEQUENTIAL LOADING (kW)

		TIME INTERVAL										
	NOTE 1	0-5 Sec.	5-10 Sec.	10-15 Sec.	15-20 Sec.	20-30 Sec.	0.5-2 Min.	2.0-10 Min.	10-30 Min.	0.5-2 Hours	2-12 Hours	0.5-7 Days
SW-MOT-SWPB (OR D)	**NOTE 2**	0	0	275	275	275	275	275	275	275	275	275
RHR-MOT-RHRP1C	**NOTE 3**	0	992	992	992	992	992	992	0	0	0	0
RHR-MOT-RHRP1D	**NOTE 4**	993	993	993	993	993	993	993	993	993	993	993
CS-MOT-CSP1B	**NOTE 5**	0	0	1115	1115	1115	1115	1115	979	979	979	979
SW-MOT-RSWPB	**NOTE 6**	0	0	0	0	0	0	0	882	882	882	882
SS1G	**NOTE 7**	316	316	326	336	430	432	458	561	599	571	571
MCC-DG2		52	52	52	79	79	79	79	58	58	58	58
SUBTOTAL		1361	2353	3753	3790	3885	3886	3912	3747	3786	3758	3758
0.77%		10	18	29	29	30	30	30	29	29	29	29
Total	**NOTE 8**	**1371**	**2371**	**3782**	**3819**	**3915**	**3916**	**3943**	**3776**	**3815**	**3787**	**3787**

NOTES FOR TABLE VIII-5-1:

1. Time steps were chosen to match the calculation and are not intended to reflect actual component start time. However, for the purpose of the calculation, the time steps used bound actual start times.
2. Service Water Pumps SW-MOT-SWPC and SW-MOT-SWPD (or SWPA and SWPB) are automatically started at 13 seconds.
3. RHR-MOT-RHRP1A(1D) is automatically started at t=0 seconds (as modeled in the calculation).
4. RHR-MOT-RHRP1B(1C) is automatically started at t=5 seconds, and manually shutdown at t=10 minutes.
5. CS-MOT-CSP1A(1B) is automatically started at t=10 seconds.
6. SW-MOT-RSWPA or C and B or D is manually started at t=10 minutes.
7. SS1F(SS1G) represents the 480 VAC loads fed from 4160-480 VAC distribution transformer SS1F(SS1G).
8. A 0.75% margin for DG1 and a 0.77% margin for DG2 has been added to bus totals to account for cable and transformer losses.

TABLE VIII-5-2

STANDBY DIESEL GENERATOR SYSTEM
TYPICAL SEQUENTIAL LOADING OF DIESEL GENERATORS

Event	Time (sec)	Comment
Design basis loss of coolant starts, normal auxiliary power assumed lost.	-16	
Signal diesel generator to start from drywell high pressure or vessel low water Level 1 or loss of voltage on buses 1F or 1G.	-14	This sequence applies to one diesel and its associated loads. The other diesel has a similar sequence and load.
Energize 480 volt critical bus.	0	
Start first RHR pump (LPCI mode).	.5	
Start second RHR pump (LPCI mode).	5	
Start core spray pump.	10	This is the relay setting. Reload Licensing Analysis is based on 11 seconds which includes relay drift.(39)
Start station service water pump.	13	
Start REC pump.	20	

5.3 Description

(Refer to Burns and Roe Drawing 3002)

5.3.1 System Operation

The NSST and two preferred off-site AC power sources are available to each 4160 volt critical bus; the preferred sources are the SSST and ESST. The NSST and SSST are connected to buses 1A and 1B; buses 1A and 1B supply the critical buses through the normal supply breakers 1FA and 1GB. The loss of the NSST source results in an automatic fast transfer to the SSST source. The loss of both the NSST and the SSST sources to either critical bus results in the automatic dead bus transfer of the critical bus to the ESST source and the automatic starting of the DG associated with that bus. If the ESST source fails or is unavailable the DG will reach rated speed and voltage prior to closing the supply breaker within 14[39] seconds, restoring power to the affected critical bus.

A DG starts automatically on a loss of coolant accident signal (i.e., low reactor water Level 1 signal or high drywell pressure signal) or on a critical bus loss of voltage signal. After the DG has started, it automatically ties to its respective bus after off-site power is tripped as a consequence of critical bus loss of voltage or degraded voltage, independent of or coincident with a LOCA signal. On a LOCA signal without a LOOP the DGs start and operate in the standby mode without tying to the critical bus. Upon loss of voltage to a critical bus all off-site supply breakers to the critical bus are tripped and all loads are shed from the critical bus except the feeder to the 480 volt critical bus. When the DG circuit breaker closes onto the critical bus, loads are then sequentially connected to its respective critical bus. The sequencing logic controls the permissive and starting signals to the motor breakers as noted in Table VIII-5-2 and to prevent overloading the DG.

The following events occur under loss of coolant accident conditions in the order indicated:

1. The DGs are automatically started (independent of availability of off-site AC power).

2. If the SSST source is available, some non-essential loads of buses 1A, 1B, and 1E are re-energized and critical loads of buses 1F and 1G required for safe shutdown are started sequentially.

3. If there has been a loss of power from the SSST source:

   a. The normal power source breakers, 1AF&1FA and 1BG&1GB, to the critical buses are tripped open.

   b. All 4160 volt feeder breakers from the critical buses are tripped open, except the feeds to the 480 volt critical buses.

   c. If the ESST source is available, the ESST source feeder breakers, 1FS and 1GS, are automatically closed, feeding the critical buses.

   d. When the voltage on any critical bus is restored, essential auxiliaries are then automatically started in a pre-determined sequence as shown on Table VIII-5-2.

4. If there has been a loss of power from the SSST and the ESST source:

a. The normal power source breakers 1AF&1FA and 1BG&1GB and the ESST source breakers 1FS and 1GS to the critical buses are tripped open.

b. All 4160 volt feeder breakers from the critical buses are tripped open, except the feeds to the 480 volt critical buses.

c. The diesel-generator supply breaker closing sequences are automatically started.

d. Within 14 seconds[39], the DG supply breakers, EG1(EG2), will close at each critical bus when its DG has reached rated voltage and speed.

e. When the voltage on any critical bus is restored, essential auxiliaries are then automatically started in a pre-determined sequence as shown on Table VIII-5-2.

DG auxiliary and support subsystems such as fuel oil and fuel oil transfer, lubricating oil, jacket water, service water, and starting air are required for operation of the DG. USAR Section X-8.1, provides a detailed discussion of the SW supply to the DG jacket water subsystem.[45]

5.3.2 Diesel Generator Protection

Each DG is connected to only one 4160 volt critical bus. Interlocks and procedural restrictions assure that the two DGs are not interconnected. Directional overpower relays are installed to monitor the generator power output to reduce the possibility of overloading the DGs in the test mode.[14] Phase overcurrent relays protect the generator from overload resulting from external fault currents.

Since critical buses 1F and 1G supply 4160 volt power to the core cooling equipment, any power interruption to these buses must be avoided. There is a possibility that the DG1(2) could carry the load of two (2) buses, 1A and 1F (1B and 1G), during surveillance testing. Under these conditions the capacity of the DG could be exceeded which would result in an overload stall of the engine. Should this occur the 4160 V bus 1F (1G) would be deenergized. To prevent exceeding the stall horsepower of the engine, an overpower relay 32/1FE (32/1GE), set at 115% of rated power, will trip breaker 1FA (1GB) and isolate bus 1A from bus 1F (bus 1B from 1G) lowering the bus load to prevent a DG stall from the overload condition. This will assure continuous operation of the DG and availability of 4160 volt critical bus 1F (1G).[14]

The DG is tripped by the following:

1. Overspeed,
2. Incomplete sequence,
3. Emergency stop push button,
4. Generator lockout,
5. Excessive vibration,
6. Low lube oil pressure,
7. High jacket water temperature,
8. Main and connecting rod bearing high temperature,
9. Turbocharger thrust bearing failure and
10. Low turbocharger oil pressure.

Trips 1, 2, 3 and 4 are active in both the test and emergency mode of DG operation. Trips 5, 6, 7, 8, 9 and 10 are active in the test mode but are bypassed in the emergency mode of DG operation.

The generator lockout is initiated by the following protective relays:

1. generator differential current,
2. generator phase overcurrent,
3. loss of field,
4. generator overvoltage and
5. reverse power.

The overcurrent relays are set so they will not trip the generator on transient overcurrents or surges in power due to starting or tripping of large loads. Protective relays and devices are provided to annunciate abnormal DG conditions. Annunciator panels are located in the Control Room and at the local control station. Annunciators at the local control station subsequently annunciate the "DIESEL GEN 1(2) TROUBLE" annunciator in the Control Room.

The design criteria for the diesel-generator set protective relaying are as follows:[15]

1. Seismic

The specification requires that the equipment and accessories shall be capable of withstanding seismic conditions listed below without any failure and without causing false operation of relays and controls. The equipment and accessories also shall be capable of operation during and following the occurrence of an earthquake having seismic forces at the equipment of magnitudes up to and including those listed as follows for a hypothetical maximum earthquake.

Horizontal = 2.4 W

Vertical = 0.14 W

Where W is the weight of the item under consideration.

2. Temperature

The protective relays are designed for operation at a maximum coil temperature of 105°C per IEEE 313-1971.

3. Overspeed

The two overspeed devices which will shutdown the engine during an emergency are the mechanical overspeed governor and electronic relay tachometer, with one exception. If the diesel experiences an emergency start, has reached a speed of 550 rpm or greater, and the MPU to the relay tachometer is lost, then only the mechanical overspeed is available. The diesel engine shall be tripped on engine overspeed in excess of a nominal 10% of rated speed. Each trip generates a concurrent overspeed alarm.

4. Vibration

During the test mode of operation, the vibration control unit mounted on the DG set will shut the engine down. However, this control function is bypassed by an emergency start and only initiates an alarm.

5. Humidity

All protective relays are mounted in enclosed cases as in switchgear on panels raised one foot above floor elevation and are installed for usual service conditions in regard to humidity.

6. Physical Arrangement

All components of the protective system are installed in separate Class I seismic rooms for complete independence and protection against design basis events enumerated in IEEE 308-1970.

Each DG unit is housed in a reinforced concrete Class I Seismic structure. Each unit is completely enclosed to provide independence from the other unit. DG1(2) is connected to the 4160 volt critical bus by cables routed in underground ducts and in rigid steel conduits, in compliance with the requirements for physical separation of Class 1E electrical equipment.[16] 4160 volt switchgear 1F(1G) is housed in a separate room within a Class I Seismic structure.

The generator, static exciter and voltage regulator are designed to accept load and accelerate the motors in the sequence and time requirements shown in Table VIII-5-2. Voltage drop on starting of large motors has been calculated to ensure proper acceleration of the pumps under the required conditions for core cooling after a design basis loss of coolant accident. Proper control and timing relays are provided so that each load is applied automatically at the proper time in the starting sequence as indicated in Table VIII-5-2. After the automatic loading sequence of the emergency loads is completed, the operator may manually add other loads within the rating of the DG. The operator will follow an emergency operating procedure when determining which loads to manually connect or disconnect following a DBA, using the ammeter and wattmeters installed in the Control Room to evaluate loads on the DGs. By these means, the operator can prevent an overload condition and yet assure that required loads will not be disconnected.[17] The operator may also manually trip redundant emergency loads if their continued operation is not necessary.

Each DG, associated auxiliaries, control system and distribution of power to the various emergency loads is segregated and separated from the corresponding systems of the other DG. Each unit is operated independently of the other unit.

All necessary information, data and annunciation of trouble at the DG is provided in the main Control Room. Table VIII-5-3 shows DG nominal ratings. The abnormal conditions delineated on Table VIII-5-4 would prevent the diesel generator from responding to an automatic emergency start signal.[18] These conditions are alarmed in the Control Room.

5.3.3 Diesel Generator Reliability Assurance

To insure increased reliability in starting each unit, air is injected into each cylinder of each unit for quick starting. One electric motor driven air compressor and one tandem diesel or electric motor driven air compressor are provided for each DG. Two air receivers are provided for each diesel engine, with each air receiver capable of providing sufficient air to perform multiple starts without immediate replenishment. Additional flexibility is provided by a cross-connect line that allows, if needed, air receivers to be filled from the other diesel generator air compressors.

CNS is required to monitor the DG to maintain a minimum 0.95 reliability.

TABLE VIII-5-3

STANDBY AC POWER SOURCE EQUIPMENT NOMINAL RATINGS

Diesel Engine

Rated Speed	600 rpm
Continuous Rated Capacity	5560 HP
Overload Capacity	6536 for 2,000 hrs. per yr.
Maximum Overload Capacity	6953 HP at generator synch. Speed 7158 HP at stall point
Fuel Consumption at Rated Capacity	.0486 gals/HP hr.
Manufacturer	Cooper - Bessemer

Generator

Continuous Rated Capacity	4000 KW
Power Factor	0.8
Frequency	60 Hz
Voltage	4,160 volts
Phase (connection)	3 (wye)
Overload Capacity	4700 KW for 2,000 hrs. per yr.
	5000 KW for 320 hrs./total
(DEMA Standard Rating)	4400 KW for 2 hrs. per day

Exciter

Size	33 KW

DG Startup

Starting time to rated speed and voltage, and ready to accept load (analytical limit)	≤ 14 seconds
Starting time to rated load	≤ 30 seconds

Fuel Oil Storage

Day Tank	2,500 gallons
Main Storage Tank	30,000 gallons

TABLE VIII-5-4

ABNORMAL DIESEL GENERATOR DISABLING CONDITIONS AND CONTROL ROOM INDICATION[18]

CONDITIONS RENDERING DG INCAPABLE OF RESPONDING TO AN AUTOMATIC EMERGENCY START SIGNAL	CONTROL ROOM INDICATION AND ANNUNCIATOR WORDING	OTHER ALARM SIGNALS THAT ALSO CAUSE THE CONTROL ROOM ANNUNCIATOR TO ALARM
1. Loss of voltage to 125V DC PNL DG1.	All indicating lights associated with DG1 go out. DG-1 DC CONTROL POWER FAILURE	None
2. Loss of voltage to 125V DC PNL DG2.	All indicating lights associated with DG2 go out. DG-2 DC CONTROL POWER FAILURE	None
3. Blown fuse in any of the 125V DC circuits for DG control.	DG-1 DC CONTROL POWER FAILURE or DG-2 DC CONTROL POWER FAILURE	None
4. DC control power to DG1 breaker 72D tripped.	DG-1 DC CONTROL POWER FAILURE	None
5. DC control power to DG2 breaker 72D tripped.	DG-2 DC CONTROL POWER FAILURE	None
6. Maintenance lockout switch in OFF for DG1 or DG2.	DIESEL GEN 1[25] MAINT LOCKOUT SW IN OFF or DIESEL GEN 2 MAINT LOCKOUT SW IN OFF	None
7. Incomplete sequence relay 48/ISEX not reset (seal in circuit) caused by engine overspeed or by excessive cranking time (more than 20 sec).	White light above the reset push button ON for each respective DG. DIESEL GEN 1 TROUBLE or DIESEL GEN 2 TROUBLE	Local alarm FAILURE TO START
8. Diesel Generator lockout relay 86/DG1 actuated.	DIESEL GEN 1 LOCKOUT	None
9. Diesel Generator lockout relay 86/DG2 actuated.	DIESEL GEN 2 LOCKOUT	None

CONDITIONS RENDERING DG INCAPABLE OF RESPONDING TO AN AUTOMATIC EMERGENCY START SIGNAL	CONTROL ROOM INDICATION AND ANNUNCIATOR WORDING	OTHER ALARM SIGNALS THAT ALSO CAUSE THE CONTROL ROOM ANNUNCIATOR TO ALARM
10. Loss of all air pressure in both air tanks for DG1 or DG2.	DIESEL GEN 1 TROUBLE or DIESEL GEN 2 TROUBLE	Local alarm STARTING AIR LOW PRESSURE
11. Failure of starting air solenoids 20SAR and 20SAL.	DIESEL GEN 1 TROUBLE or DIESEL GEN 2 TROUBLE	Local alarm STARTING AIR SOLENOID VALVE FAILURE
12. Automatic tripping of output breaker EG1 or EG2 for DG1 or DG2.	DIESEL GEN 1 BKR EG1 TRIP or DIESEL GEN 2 BKR EG2 TRIP	None
13. Automatic tripping of output breaker 1FE or 1GE for DG1 or DG2.	4160V BUS 1F BKR 1FE TRIP or 4160V BUS 1G BKR 1GE TRIP	None
14. DG1 or DG2 output breaker lockout relay 86/1FE or 1GE actuated.	4160V BUS 1F BKR 1FE LOCKOUT or 4160V BUS 1G BKR 1GE LOCKOUT	None
15. Emergency stop push button 86ESD not reset.	DIESEL GEN 1 EMERG STOP NOT RESET[26] or DIESEL GEN 2 EMERG STOP NOT RESET	None
16. Selector switch for DG1 and DG2 on BD-C not in AUTO.	DIESEL GEN 1 MODE SWITCH NOT IN AUTO[25,26] or DIESEL GEN 2 MODE SWITCH NOT IN AUTO	None
17. DG1 control power isolation switch(es) (IS-DG1 A/B) not in remote.	DIESEL GEN 1 ISOLATION SW IN LOCAL	None[32]
18. DG2 control power isolation switch(es) (IS-DG2 A/B) not in remote.	DIESEL GEN 2 ISOLATION SW IN LOCAL	None[32]

NOTE: Shared annunciators for DG disabling conditions cannot be cleared in the Control Room until all abnormal (disabling) conditions are corrected.[25]

5.4 Safety Evaluation

5.4.1 General

The DG units were selected on the basis of their proven reliability and independence as standby power sources. Redundancy is provided in the air starting system components for each unit to improve the starting reliability of the units.

Either DG is capable of starting and continuously operating under postulated accident conditions for a period of seven days using fuel stored on-site in underground storage tanks. Independent sources of 125 volt DC control power are used to supply electrical control power to the air-starting system for the DG units. The units and all necessary auxiliaries are housed in Class I seismic structures.

The emergency loads are divided between the two 4160 volt critical buses so that the failure of one DG or one 4160 volt critical bus will not prevent a safe shutdown of the reactor. Each DG and its associated system is separated so that failure of any one component will not affect the operation of the redundant system. Sections VIII-2.2.5 and VIII-3.5 discuss the interlocks which prevent the inadvertent electrical interconnection of either diesel generator with the SSST or the ESST.

The capability of the DG to start and attain rated voltage and frequency within 14 seconds, to accept the necessary emergency engineered safeguard loads and to start and accelerate the emergency core cooling system pumps in the required time meets the necessary requirements for the standby AC power system. This is shown by comparing the DG ratings on Table VIII-5-3 with the load requirements on Table VIII-5-1.

Although the DGs are designed to start and attain rated voltage and frequency within 10 seconds, analyses[33,39] have been performed which show that the maximum DG startup time that assures consistency with the loss of coolant analysis (LOCA) is 14 seconds. This conclusion is based upon the loading sequence identified in the referenced analysis.

The Station Blackout Rule, 10CFR50.63, required all licensees to assess the capability of their plants to maintain adequate core cooling and appropriate containment integrity during a station blackout event and to have procedures to cope with such an event. CNS has performed the Station Blackout assessment[38] and determined that CNS has a four hour coping duration and a .95 DG target reliability. The NRC has reviewed[35,36,37,42] the District's submittals and has accepted the District's determinations of a four hour coping duration and .95 DG target reliability.

DG2 can be isolated from the Control Room.

5.4.2 Single Failure Analysis[16]

General

Each of the two DG sets is housed in completely independent, separated rooms, together with the respective auxiliary systems which are provided independently in all respects for each unit. The rooms are connected by doors which are nonlouvered, 1 3/4" thick steel doors with an "A" fire rating.

Each DG Room is designed as a Class I Seismic building.

Engine Fuel System

Each DG set is supplied from a unit fuel oil day tank. Each day tank has sufficient capacity for a minimum of 3.9 hours of operation at full load, for its respective DG.[34]

Two diesel oil storage tanks are provided, each with its own transfer pump and piping connections to its respective fuel oil day tank. A cross-tie is provided such that either DG can be supplied from both diesel oil storage tanks. Both diesel oil storage tanks combined contain sufficient fuel for seven days operation of one DG at its rated continuous load of 4 MW.

Separation and seismic consideration are incorporated in the installation of storage tanks, transfer pumps and piping in order to comply with the single failure criteria.

Electrical Sources

Electrical feeders needed for the operation of the DG set auxiliaries are derived from independent sources associated with each DG set.

The feeders connecting the sources to the auxiliaries in the DG Rooms are routed in compliance with the requirements given for physical separation of Class 1E Electrical equipment.

Cross-Tie Lines

Review of the DG cross-tie lines indicate that there are four lines of importance. Two lines are Starting Air System cross-ties and two lines are Fuel Oil System cross-ties.

The 2" Starting Air System cross-ties provide a pair of common lines between the air receivers located in each room. Each line has a manually operated stop valve at each end. There is also a manually operated equalizing valve that ties the two cross-tie lines together. The normal valve line-up configuration maintains physical independence between the two Starting Air subsystems, such that no single failure of the cross-tie can disable both DGs.

A 2" Fuel Oil System Cross-tie line connects the discharge lines of the two fuel oil transfer pumps supplying the day tanks together. The cross-tie is downstream of the pump discharge check valves. The cross-tie has a single closed isolation valve in the DG2 Room. The normal valve line-up configuration maintains physical independence between the two Fuel Oil subsystems, such that no single failure of the cross-tie can disable both DGs.

A 4" Fuel Oil System Cross-tie line connects the two main fuel storage tanks together. The cross-tie has two open isolation valves buried between the main storage tanks in the bunker. The combined main fuel storage tanks provide sufficient fuel for seven days of operation of one DG unit under postulated accident conditions.

5.5 Inspection and Testing

Since the DGs are utilized as standby units, readiness is of prime importance. Readiness can best be demonstrated by periodic testing, which insofar as practical, simulates actual emergency conditions. The testing program is designed to test the ability to start the system as well as to run under load for a period of time long enough to bring all components of the system into equilibrium conditions to assure that cooling and lubrication are adequate for extended periods of operation. Functional tests of the automatic circuitry are conducted on a periodic basis to demonstrate proper operation.

For testing DG1(2)is manually synchronized to its 4160 volt critical bus 1F(1G) and thereby paralleled to the off-site source. During station power operation when the NSST is supplying station auxiliaries, the DG is synchronized to the NSST. When the SSST is supplying station auxiliaries, the DG is synchronized to the SSST. Synchronization to the off-site sources provides the capability to functionally test the DG at full rated power. Section VIII-5.2-6 provides additional synchronization requirements.

During a 6 year interval, each DG is inspected in accordance with instructions based on industry experience and the manufacturer's recommendations.

An initial system test was performed to demonstrate that the standby AC power system can start, accept design load within the design basis time and that the standby power source is independent of the off site power sources.

The undervoltage protective schemes for 4160 volt critical buses 1F and 1G provide for automatic start of the associated DG and assumption of load upon restoration of voltage to bus 1F or 1G. The protective scheme provides the following functions on each critical bus:

1. Clear the bus of all motor loads excepting supply to the 480 volt critical unit substation.
2. Isolate the bus by opening all incoming breakers.
3. Start the DG on emergency basis bringing it up to full speed and voltage.
4. Close the generator breaker to the critical bus when the DG is at rated speed and voltage.
5. Signal to logic for RHR and CS Systems that diesel power is available for timed starts.
6. Start the SW standby pumps after approximately 13 second delay.
7. Remain in running status until manual shutdown.

Testability of the protective scheme can be demonstrated during normal station operation by opening incoming breaker 1FE (1GE) to prevent actual standby power connection to the bus, and by using test switches at either switchgear buses 1F or 1G in proper sequence to allow all protective relays to operate as required.

Each of the two DGs has its own separate protective scheme, relays, switches, cables, buses and DC power supply. Thus a redundant source of power is available to the Standby AC Power System for safe shutdown of the reactor.

The diesel generator system is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), Buried Piping and Tank Inspection (see USAR Section K-2.1.3), Diesel Fuel Monitoring (see USAR Section K-2.1.12), External Surfaces Monitoring (see USAR Section K-2.1.14), Oil Analyses (see USAR Section K-2.1.28), Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31), Selective Leaching (see USAR Section K-2.1.34), Service Water Integrity (see USAR Section K-2.1.35), and

Water Chemistry Control - Closed Cooling Water (see USAR Section K-2.1.40). The following Time-Limited Aging Analyses are applicable: Metal Fatigue (see USAR Section K-2.2.2.2).

5.5.1 DG Vendor Inspection and Testing

The vendor has conducted seismic tests on the control and relay panels to insure compliance with the design criteria. Functional test records of the equipment are available including overspeed at 660 rpm (10% overspeed).

Since a 4000 KW diesel generator like the units selected for CNS had no prior service history as a standby power source for nuclear power plants, a rigorous qualification test program was performed to assure the suitability of the CNS units for this emergency service.[19] *This program is described below:*

A. Shop Tests

After completion at the factory and before shipment, the engine, generator, exciter and auxiliary equipment were tested in accordance with the following:

1. Diesel Engine-Generator Set

Each entire engine-generator set and all set mounted accessories and auxiliaries were assembled on the sub-base and the equipment tested as a unit. These tests demonstrated that the diesel engine generator set is capable of:

a. Operation with no load, or excitation on the generator, 110% rated speed (10% overspeed) for five minutes, without indication of harmful vibrations and/or torsional vibrations.

b. Functional operation and starting of the automatic start system by successfully starting 21 consecutive times to rated speed in ten seconds or less; followed by sequential loading at five second intervals of four 1000 KW electrical resistive loads or water rheostats, to full load of 4000 KW within 30 seconds or less.

c. Functional operation at 100% rated load using electric resistive loads for four hours, with a record of all pertinent test data including at least the following minimum data at fifteen minute intervals:

c.1 - All instrumentation on the generator control panel and the engine control panel.

c.2 - Observation and record of all temperatures, pressures, vibrations, speeds and/or other data to prove out the functional performance of the engine generator set.

c.3 - Record of all other important data in accordance with the Vendor's normal test and check-out program.

d. Functional overload test at the 2000 hour rating for two (2) hours using electric resistive loads, with a record of all pertinent data required by Section 1(c) above at the 100% rated load test.

Hydrostatic tests were performed on all tanks, in accordance with the applicable ASME Codes for Unfired Pressure Vessels. All piping provided with the engine-generator sets and accessories were hydrostatically tested at 1 1/2 times the design pressure.

The balance, eccentricity and vibration of all rotating and reciprocating elements and assemblies was determined and recorded.

All other auxiliary machinery were tested in accordance with the manufacturer's standard testing and checkout procedures, and applicable standards to demonstrate compliance with guarantees.

The generator exciter auxiliary and accessory equipment tests demonstrated adequacy and coordination with the engine requirements.

2. Generator, Exciter, and Regulator

Generator and exciter factory tests were in accordance with IEEE Test Code No. 503, for Synchronous Machines and the NEMA Test Code MG-1, Part II and include:

For the fully assembled generator:

a. *Insulation resistance of all stator and rotor windings.*

b. *Cold resistance of all stator and rotor windings.*

c. *Air gap measurement.*

d. *Dielectric tests on rotor and stator windings.*

e. *Overspeed.*

f. *Bearing and shaft current test.*

g. *Phase sequence test.*

h. *No load, short-circuit and zero power factor saturation.*

i. *Mechanical balance and inspection.*

j. *Temperature rise test.*

k. *Exciter and regulator tests.*

All control and instrument wiring together with the interconnected control and/or instrument devices were subjected to a one minute 1500 volt a-c insulation test.

B. Field Tests

Field tests were made by the Equipment Vendor and the District to determine that the material and equipment meets the specified performance.

The overspeed, lube oil and jacket water safety controls were tested to show that they are properly adjusted and functioning.

The diesel-engine generator units were field tested in accordance with the NEMA Standard Test Codes and/or the ASME Power Test Code No. 17 for Internal Combustion Engines, and conformance to IEEE-387 loading was noted.

The units and all accessories were tested on the loads to be encountered at the operating site in accordance with the load requirements listed in Table VIII-5-2, using only the larger motor loads i.e., RHR Pump, Core Spray Pumps, and RHR S.W. Booster Pumps.

Each diesel generator set and all mounted accessories when fully erected and assembled were also field tested to demonstrate capability of actually performing in accordance with specified requirements. The following tests were conducted to prove satisfactory performance and compliance with the Specification for ***each*** *unit:*

A minimum of ten consecutive successful starts (five hot, five cold) were made. Each start attained full speed and voltage in less than ten seconds followed with sequential loading per the Specification requirements of the actual equipment required for an emergency reactor shutdown. Minimum test duration was twenty minutes. During the ***series*** *of test runs, no adjustments were made to the engine and/or generators. During each test run all generator control panel and engine panel instruments were observed and data recorded. Strip chart load recorders and a sequence timer maintained permanent records of the load, voltage and time sequence of loads and events during the entire duration of each test run.*

The test results demonstrated successful operation of all standby system and auxiliaries included herein.

C. Reliability[20]

In order to demonstrate 0.99 starting reliability at 95% confidence level, 298 consecutive successful starts are required. The following consecutive successful starts have been performed on the Cooper Nuclear Station diesel-generator unit or its equivalent.

a. Forty-two (42) consecutive successful starts on the CNS units performed during factory tests. Test records show 8.8 seconds maximum starting time, approximately 4000 kW load acceptance in three equal steps within 18 seconds at each start at rated voltage and frequency.

b. Sixty-five (65) consecutive successful factory test starts on the Zion Station units for Commonwealth Edison Company performed during tests similar to those for the CNS units as described in a. above.

c. The balance of starts necessary to establish equipment reliability consisted of a combination of total successful starts as conducted by Zion Station units in combination with those conducted by NPPD.*

The units were loaded to a minimum of 50% of the continuous rating within 30 seconds with each start from design cold ambient conditions.

Prior to fuel loading, each NPPD unit was field tested a minimum of ten consecutive successful starts (five hot, five cold) to demonstrate capability of actual performance as described above.

**The Zion units are identical to NPPD's except for the following:*

1. *Static excitation vs. brushless*
2. *Electric load sensing governor vs. hydraulic speed sensing*

6.0 125/250 VOLT DC POWER SYSTEMS

This USAR section contains historical information, as indicated by italicized text. USAR section I-3.4 provides a more detailed discussion of historical information. The information being presented in this section as historical has been preserved as it was originally submitted to the NRC in the CNS FSAR.

6.1 Safety Objective

To provide an uninterruptible source of power to supply all normal and emergency 125 volt DC and 250 volt DC control and power loads under all conditions.

6.2 Safety Design Bases

1. Each 125 volt and 250 volt battery shall have adequate capacity to safeguard the station until AC power sources are restored.

2. Each battery charger shall have adequate capacity to restore its battery to full charge from a totally discharged condition while carrying the normal station steady state DC load.

3. The 125/250 volt DC power systems shall be arranged so that no single component failure will prevent the systems from providing power to a sufficient number of vital DC loads necessary for safe shutdown.

4. The 125/250 volt DC power systems shall be provided in accordance with the "IEEE 308 Criteria for Class 1E Electrical Systems for Nuclear Power Generating Stations", issued in 1970.

5. The 125/250 volt batteries and battery racks shall be Class I Seismic equipment to assure continuous operation of the equipment under maximum seismic shock conditions applicable to the area and locations of the equipment.

6. The 125/250 volt Division I and II batteries shall provide power for a 4 hour duration during a Station Blackout in accordance with 10CFR50.63, NUMARC 87-00, and Reg. Guide 1.155.

6.3 Description

The list of major equipment in the 125/250 V DC power systems is shown in Table VIII-1-3.

The DC power systems (125/250 volt for power and control) supply DC power to conventional station emergency equipment and selected safeguard system loads. The DC power systems are credited with mitigating a Station Blackout event.[35] [36] [37] [38][42] The DC power systems are shown in Burns and Roe Drawing 3058.

The 125 volt DC switchgear buses 1A and 1B each receive their power from either a 125 volt station battery or the 460 volt critical MCC-LX and MCC-TX through a 200 ampere battery charger (charger 1A, 1B or charger 1C). Chargers 1A and 1B are dedicated to their respective DC buses. Charger 1C is a spare and can supply power to either bus in place of 125 volt system charger 1A or charger 1B. Charger 1C can be powered from either MCC-LX or MCC-TX. When the 1C charger is not in operation, its feeder breakers shall be locked in the open position.

Each 125 volt distribution panel receives its power from either 125 volt DC switchgear bus 1A or 1B. Distribution panel A is normally fed from Bus 1A and distribution panel B is normally fed from Bus 1B. The 125 volt DC station batteries for Bus 1A or Bus 1B are service rated for 1800 ampere hours each at an eight hour discharge rate. The batteries are lead-calcium type with 58 cells. Each battery is located in a separate ventilated battery room.

The 250 volt DC switchgear buses 1A and 1B each receive their power from either a 250 volt station battery or the 460 volt critical MCC-LX and MCC-TX through a 200 ampere battery charger (charger 1A, 1B or charger 1C). Chargers 1A and 1B are dedicated to their respective DC buses. Charger 1C is a spare and can supply power to either bus in place of 250 volt system charger 1A or charger 1B. Charger 1C can be powered from either MCC-LX or MCC-TX. When the 1C charger is not in operation, its feeder breakers shall be locked in the open position.

The 250 volt DC station batteries for Bus 1A or 1B are service rated for 1800 ampere hours each at an eight hour discharge rate. The batteries are lead-calcium type with 120 cells. Each battery is located in a separate ventilated battery room. The 250 volt DC switchgear Bus 1A feeds through the static inverter for the 115/230 volt AC No Break Power Panel.

The 250 volt DC system contains several starter racks. The 250 volt DC Reactor Core Isolation Cooling (RCIC) starter rack receives its feed from Bus 1A. This starter rack is used for the RCIC condensate pump and vacuum pump. The 250 volt Division I Reactor Building starter rack is fed from Bus 1A. The 250 volt DC starter rack B is located in the CST room and feeds RHR shutdown cooling motor operated valves (MOVs) and the 250 volt DC High Pressure Cooling Injection (HPCI) starter rack. The HPCI starter rack is fed from Bus 1B. The 250 volt DC HPCI starter rack is used for the HPCI Auxiliary Lube Oil Pump, HPCI Gland Exhaust Blower, HPCI Gland Seal Condensate Pumps and associated motor operated valves. The 250 volt DC Turbine Building starter rack is supplied from either the 250 volt Bus 1A or 1B through a manual throw over switch. This switch is normally connected to Bus 1B. This starter rack provides DC power for the Main Turbine Emergency Oil Pump, Air Side Seal Oil Backup Pump, and the Reactor Feed Pump Turbine Emergency Oil Pumps. The 250 volt Division II Reactor Building starter rack is fed from Bus 1B. The Division I and II Reactor Building starter racks power the LPCI RHR injection valves and Reactor Recirculation Pump Discharge Valves.

Cables and components of the redundant 125 and 250 volt DC system circuits are physically separated in accordance with Section VII-1.7.3.1 to assure maximum independence of redundant channels. The 125 and 250 volt DC system cables are installed in conduits and metal trays. The current carrying capacity of all power cables is conservatively calculated in accordance with Section VII-1.7.3.2 to preclude thermal overloads. Provisions for loss of AC and DC power have been made in the design. The multiplicity of battery charger sources and the division of critical loads between buses yields a system that has a high degree of reliability. The physical separation of buses and service components will limit or localize the consequences of electrical faults or mechanical accidents occurring at any point in the system.

6.4 Safety Evaluation

Power is normally supplied to the DC systems from the critical 460 volt AC buses of the auxiliary power distribution system through the battery chargers. Loss of either AC power source to any of the four circuits causes the related battery to supply power to its DC loads. Each 125 and 250 volt battery is capable of supplying adequate power to operate its loads during emergency conditions. When AC power is returned to service after its loss, the related battery charger is then re-energized by the 460 volt service bus, and the battery charger recharges the battery while supplying power to the loads. This satisfies safety design basis 2.

Until the diesel generators are started for standby service following loss of all normal AC power to the critical service buses, the batteries are supplying all DC power. The 250 volt DC battery chargers and the 125 volt DC battery chargers will be automatically energized by the standby AC power source as soon as their respective diesel generator comes on line. Therefore, the loads receive uninterrupted DC power during AC power interruptions. The above satisfies design basis 1.

The 125 volt and 250 volt DC power systems are ungrounded with ground detectors which alarm in the main control room. The potential for multiple grounds is minimized since the first ground will be located and removed as soon as possible after alarming in the main control room.

The batteries, battery racks, and battery chargers are designed and installed to Class 1E requirements. The batteries and battery chargers are seismically qualified and are located in the Control Building which is a Class I Seismic structure per Section XII-2.1.2.1. This satisfies safety design basis 5.

Although loss of one of the four DC sources is highly improbable, loss of one source would not prevent safe shutdown of the station. The cumulative preceding discussion satisfies safety design bases 3 and 4.

Division I and II batteries have been analyzed to supply their respective loads for a minimum of 4 hours due to Station Blackout Requirements. This satisfies safety design basis 6.

It is therefore concluded that the safety design bases are met.

The 125 volt and 250 volt DC power systems are also credited for mitigation of fire events, as described in NEDC 11-019 of the CNS Fire Safety Analysis.

6.5 Inspection and Testing

Inspection and testing at vendor factories and initial system test was conducted to insure that all components are operational within their design ratings.

Periodic tests and inspections of the equipment and the system are conducted to detect the deterioration of the equipment in the system toward an unacceptable condition. The periodic tests and inspections of the 125 volt and 250 volt batteries meet the intent of the manufacturer's recommendations. The 125 and 250 volt batteries meet the requirements of "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Large Stationary Type Power Plant and Substation Lead Storage Batteries", IEEE Standard 450-1995 and "IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations", IEEE Standard 535-1979. Based on CNS engineering judgment, the safety-related batteries shall be considered at 15 years to have reached 85 percent of expected service life.[46]

The 125 and 250 volt battery chargers meet the requirements of "IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations", IEEE Standard 650-1979.

7.0 24 VOLT DC POWER SYSTEM

7.1 Power Generation

The power generation objective of the 24 volt DC power system is to provide uninterruptible DC power to neutron monitoring and process radiation monitoring instrumentation.

7.2 Power Generation Design Bases

1. The 24 volt DC batteries shall have adequate capacity to power the instrument loads for four hours upon loss of AC power supply to the battery chargers.

2. The battery chargers shall have adequate capacity to automatically recharge the batteries to full charge from a totally discharged condition while carrying the normal station steady state DC load.

3. Undervoltage relays shall be provided to alarm in the main control room on low voltage conditions.

7.3 Description

A one line diagram of the 24 volt DC power system is shown in Burns and Roe Drawing 3058. Two 24 volt DC systems are provided. Each system has two 24 volt batteries and two 24 volt battery chargers arranged in a three wire system to provide ±24 volt DC power relative to ground. Each system is insulated from ground at all points except at the main control room where the neutral wire for each instrument is grounded.

The batteries and associated chargers in each system are operated as units.

During normal operation the load requirements and system losses are supplied from the battery chargers. Upon failure of the supply of DC power from the charger, the DC loads are supplied from the batteries until power to the charger is restored or the battery capacity is exhausted. Two battery chargers, A1 and A2, are energized from the 120/240 volt AC critical distribution panel Bus 1A and the other two battery chargers, B1 and B2, are energized from the 120/240 volt AC critical distribution panel Bus 1B.

Each 24 volt subsystem is provided with an undervoltage relay that alarms in the main control room if voltage falls below normal.

Each battery has a minimum design requirement of a 60 ampere hour rating based on a constant discharge rate for four hours with a starting voltage of 2 volts per cell and a minimum voltage of 1.75 volts per cell at the end of the four hour period. General Electric Design Specification 22A1134 provides the design requirements for the 24 volt subsystems.

The 24 volt DC system supplies the source and intermediate range neutron monitors and their trip auxiliaries, selected process radiation monitors, the process radiation monitor trip auxiliaries and the safety system status panel.

Battery chargers for both divisions are fully capable of supplying their respective loads and batteries (either fully charged or depleted) during normal operation. They also have reverse current protection to prevent them from loading the batteries.

The chargers are supplied from the Critical Distribution Panels which receive their power from the normal or emergency AC systems as well as the standby AC system. The aggregate system is so arranged that the probability of system failure resulting in loss of DC power is very low.

The 24 volt batteries for each system are each located in a ventilated battery room which is separate from the other.

Loss of one of the two 24 volt DC systems will not affect plant safety since redundant instrumentation will continue to be supplied by the second system.

Total loss of power from both 24 volt DC systems will result in actuation of the intermediate range neutron monitor trips because of the fail safe behavior of the neutron monitoring system (refer to Subsection VII-5).

7.4 Inspection and Testing

The batteries and other equipment associated with the 24 volt DC system are easily accessible for inspection and testing. Service and testing is accomplished on a routine basis in accordance with recommendations of the manufacturer. The periodic tests and inspections of the equipment and the system are conducted to detect deterioration of the equipment in the system toward an unacceptable condition.

8.0 120/240 VOLT VITAL AC POWER SYSTEMS

This USAR section contains historical information, as indicated by italicized text. USAR section I-3.4 provides a more detailed discussion of historical information. The information being presented in this section as historical has been preserved as it was originally submitted to the NRC in the CNS FSAR. The vital AC power systems are comprised of the No-Break Power Panel (NBPP), Reactor Protection System (RPS), and the Critical Distribution System.

8.1 Power Generation Objectives

1. The 120/240 volt vital AC power system shall provide power to the NBPP and to the Reactor Protection System (RPS) Power Panels.

2. The 120/240 volt vital AC power system shall provide power for the Critical Distribution System. These critical services are necessary for the operation of the station but are not critical to station safety.

8.2 Power Generation Design Bases

1. The design basis of the No-Break Power System is to provide a non-interruptible power source for non-essential components that are critical for plant operation.

2. The 120/240 volt vital AC power system in conjunction with the RPS motor-generator sets provide a continuous supply of AC power required by certain controls and instruments associated with the plant operation.

3. The 120/240 volt vital AC power system provides power to the Critical Distribution System through the critical control panels (CCPs), control power panels (CPPs), and the critical distribution panels (CDPs) for distribution to components of various systems critical to plant operation.

8.3 Description (Refer to Burns and Roe Drawing 3010, Sheet 1)

The 120/240 volt vital AC power system NBPP is powered from an inverter, which is normally fed from 250 volt DC Bus 1A. An emergency AC feed to the NBPP is provided from critical MCC-R via a static switch. The NBPP is rated for 115/230 volt single phase three-wire service. The combination of the static switch and manual bypass switch also allow either the inverter or the alternate 25 KVA supply to be taken out of service for maintenance.

The 250 volt DC Bus 1A, the inverter, and the NBPP are credited with mitigating a Station Blackout event.[35] [36] [37] [38] [42]

Critical 460 volt AC MCCs L and T each feed the RPS MG sets 1A and 1B, respectively. The generator of each set feeds RPS power panels RPSPP1A and RPSPP1B. There are no electrical connections between the two RPS power panels. Each RPS bus is rated for 120 volts single phase two-wire service. A 120 volt single phase power supply from critical distribution panels CDP1A and CDP1B can be used in-lieu of each MG to allow the MG sets to be taken out of service for maintenance.

Critical 460 volt AC MCC-LX and MCC-TX each feed 75 KVA 480-120/240 volt single phase transformers which in turn feed critical distribution panels CDP1A and CDP1B. Separate feeds from CDP1A and CDP1B through fused disconnect switches, connect to a manual throw-over switch. This manual throw-over switch is directly connected to the critical instrument and control power panel (CPP), which is rated for 120/240 volts single phase three-wire service. The CPP feeds the control board instrumentation, radwaste instrumentation, radwaste monitoring system, Reactor Manual Control System and other important equipment.

8.4 Inspection and Testing

Inspection and testing at vendor factories and initial system tests were conducted to insure that all components are operational within their design ratings.

Periodic tests of the equipment and system are conducted to detect the deterioration of the equipment in the system toward an unacceptable condition.

9.0 OFF-SITE DISTRIBUTION POWER

9.1 Power Generation Objective

The 12.5 kV system shall provide a reliable supply to station support facilities with some degree of independence from those sources directly associated with, or dependent on, the main generating unit.

9.2 Power Generation Design Bases

1. The 12.5 kV system shall distribute AC power throughout the site at useable voltage levels.

2. The 12.5 kV system power sources shall be independent from site generated power such that neither the 12.5 kV power sources or the main generating unit are dependent upon the other.

3. The 12.5 kV system shall have an alternate power source.

9.3 Description (Refer to NPPD Drawing NC44587 and Burns and Roe Drawing 3009, Sheet 1)

The 12.5 kV system, which is a combined underground and overhead system that encircles the plant and its facilities, is designed to distribute power to miscellaneous plant services. These include various out buildings and utilities such as - the Craft Change Building, Condensate Storage Tank heaters, Trailers, Electric Boilers C and D, the Multi-Purpose Facility (MPF), the North Warehouse (Maintenance Training Facility), the N_2 System heaters, the Office Building, the South Warehouse heaters, the Learning Center, the West Warehouse, the Communications Building, the MET tower, the Toilet Building, the Utility Building, the North Well Pump, the LLRT Storage Site, Ionic Water Treatment Skid, the Optimum Water Chemistry (OWC) Gas Generator Building, Sewer Lagoons, the Supplemental Diesel Generator (SDG), and the Alternate Decay Heat Removal (ADHR) Subsystem of the Fuel Pool Cooling and Demineralizer System.

The 12.5 kV system receives power from the 13.8 kV/12.5 kV Transformer No. 3, which is powered from the 13.8 kV tertiary winding of the 345 kV/161-13.8 kV Auto-Transformer "T-2", both in the 345 kV Switchyard. Through an assembly of live-front feeder Switchgear, also in the Switchyard, power is distributed to strategically located pad-mounted Switchgear units and Step-Down Transformer Substations around the plant.

An alternate feed to the 12.5 kV system is from the 13.8 kV/12.5 kV Transformer No. 7, which is powered from the 13.8 kV tertiary winding of the 345 kV/161-13.8 kV Auto-Transformer "T-5", also in the 345 kV Switchyard. Through two oil circuit reclosers (OCRs), power is distributed to the 12.5 kV system.

9.4 Inspection and Testing

No inspection or testing requirements are specified for the non-essential 12.5 kV system.

10.0 REFERENCES FOR CHAPTER VIII

1. Letter J. Pilant (NPPD) to T. Ippolito (NRC) dated 12-14-79 (17525 1138).

2. Deleted.

3. Letter J. Pilant (NPPD) to D. Ziemann (NRC) dated 9-17-76 (17525 1363).

4. Q/A 8.3; Amend. 13.

5. Q/A 8.5; Amend. 14.

6. Q/A 8.2; Amend. 14, 15.

7. Q/A 8.4; Amend. 15.

8. Letter J. Pilant (NPPD) to W. Gammill (NRC) dated 12-27-79 (17525 1133).

9. Electrical Distribution Grid Stability Analysis For CNS.

10. MDC 78-25.

11. Memo J. Hackney (NPPD) to J. Pilant (NPPD); "LPCI Modification", 1977. Enclosure to letter J. Weaver (NPPD) to J. Meacham (SWEC) dated 5-28-81, LQA 8100187.

12. Deleted.

13. FSAR Markups prepared by J. Philbrick 6-23-77. Enclosure to letter J. Weaver (NPPD) to J. Meacham (SWEC) dated 5-28-81, LQA 8100187.

14. MDC 87-133.

15. Q/A 8.7; Amend. 13.

16. Q/A 8.6; Amend. 16.

17. Q/A 8.11; Amend. 11.

18. Letter J. Pilant (NPPD) to D. Davis (NRC) dated 6-2-77 (17524 1534).

19. Q/A 8.8; Amend. 14.

20. Q/A 8.13; Amend. 15.

21. MDC 74-127.

22. Q/A 8.9; Amend. 14.

23. NEDC 00-111, Revision 9, "CNS Auxiliary Power System AC Loads".

24. Deleted.

25. Letter J. Pilant (NPPD) to G. Lear (NRC) dated 5-19-78 (17524 1405).

26. MDC 78-26.

27. MDC 79-58.

28. MDC 77-24.

29. Contract E69-17, Electrical Power System.

30. Letter J. Pilant (NPPD) to D. L. Ziemann (NRC) dated 9-17-76 (17580 1965).

31. Deleted.

32. MDC 84-180.

33. Evaluation of Diesel Generator Startup Requirements for Cooper Nuclear Station (EAS-133-1187, Rev. 1, February 1988).

34. NEDC 97-012.

35. NRC Safety Evaluation Station Blackout Rule for CNS dated August 22, 1991.

36. NRC Supplemental Safety Evaluation Report (SSER) - Station Blackout Rule 10CFR50.63, for CNS dated June 30, 1992.

37. NRC Supplemental Safety Evaluation Report (SSER) - Station Blackout Rule 10CFR50.63, for CNS dated November 19, 1992.

38. Enercon Services Report NPP1-PR-01, "Station Blackout Coping Assessment for Cooper Nuclear Station," Rev. 2, June 1993.

39. DC 95-036.

40. Q/A 8.1; Amend. 9.

41. (Unused)

42. Updated Response to Station Blackout Rule 10CFR50.63, for CNS dated 12/19/94 (NLS940088).

43. DC 87-152, Rev. 1.

44. (Unused)

45. Generic Letter 89-13. (50.71e item), Service Water System Problems Affecting Safety-related Equipment.

46. License Amendment 236, dated March 18, 2010, Issuance of Amendment Re: Revise Battery Resistance in Surveillance Requirements.