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OFFICE OF SECRETARY DOCKETING & SERVICE BRANCH

Mr. Vincent S. Noonan, Project Director
PWR Project Directorate #5
U. S. Nuclear Regulatory Commission
Washington, DC 20555

South Texas Project
Units 1 and 2
Docket Nos. STN 50-498, STN 50-499
Responses to DSER/FSAR Items
On Chapter 8

Dear Mr. Noonan:

The enclosed provides STP's response to Draft Safety Evaluation Report (DSER) or Final Safety Analysis Report (FSAR) items. Additional changes to Chapter 8 are included.

The item number listed below corresponds to one of those assigned on STP's internal list of items for completion which includes open and confirmatory DSER items, STP FSAR open items and open NRC questions. This list was given to your Mr. N. Prasad Kadambi on October 8, 1985 by our Mr. M. E. Powell.

The attachment includes mark-ups of FSAR pages which will be incorporated in a future FSAR amendment unless otherwise noted below.

The items which are attached to this letter are:

Attachment	Item No.*	Subject
1	D 8.3-6	Loads on Emergency Buses Note: See Section 8.3.1.2.10.5 on page 8.3-22.

*Legend
D - DSER Open Item   C - DSER Confirmatory Item
F - FSAR Open Item   Q - FSAR Question Response Item

L1/NRC/a2

If you should have any questions on this matter, please contact Mr. M. E. Powell at (713) 993-1328.

Very truly yours,

M. R. Wisenburg
Manager, Nuclear Licensing

REP/yd

Attachments: See above

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date of commercial operation of both the connection and the terminal facili-
ties is ~~December, 1985)~~. June, 1989). 36

8.1.2 Onsite Electrical System

The Onsite Electrical System of each unit consists of the unit auxiliary
transformer, four 13.8 kV auxiliary buses, three 13.8 kV standby buses, five
13.8/4.16 kV auxiliary transformers, two balance-of-plant (BOP) 4.16 kV 36
auxiliary buses, and three Engineered Safety Feature (ESF) 4.16 kV auxiliary 12
buses. The three ESF 4.16 kV auxiliary buses feed the redundant Class 1E ac 36
power loads.

During normal operation, each unit's ac electrical power is supplied by its
unit auxiliary transformer, with the exception of 4.16 kV ESF buses E1B and 36
E1C, which are supplied by the standby transformer.

Power from the utility grid ~~and~~ (the offsite electrical system) is made availa-
ble to the onsite electrical system through the respective unit auxiliary 36
transformer, and/or the two plant standby transformers (no. 1 and no. 2) and the
138 kV emergency transformer (See Figure 8.2-1). Onsite standby power is
provided by three standby diesel generators (DGs) for each unit. These oper-
ate at 4.16 kV. (Two BOP buses per unit are served from separate 480 V and 43
4160 V DGs. One BOP bus common to both units is served from a 480 V lighting
DG). One standby DG is tied to one Class 1E ~~ac~~ bus per unit. The three
standby DGs and their associated Class 1E ~~ac~~ Power Systems make up three in-
dependent systems which provide ac power to the three independent ESF load
trains designated as Train A, Train B, and Train C. Each train of the Class
1E ~~ac~~ Power System is provided with an independent Class 1E 125 Vdc system.
Train A serves an additional Class 1E 125 Vdc distribution system which sup-
plies power to the fourth Reactor Protection System (RPS) channel. Each Class
1E 125 Vdc system is designed to carry all of its required loads during design
basis events. The non-Class 1E ~~dc~~ loads are supplied by 48 Vdc, 125 Vdc, and 12
250 Vdc systems supplied by the respective batteries. In addition, the plant
computer is served by its own 250 Vdc battery system. These non-Class 1E ~~dc~~ 12
systems are served from non-Class 1E 480 V motor control centers.

The ESF ~~ac~~ and ~~dc~~ Power Systems are designed with redundancy and independence
of onsite power sources, distribution systems, and controls in order to pro-
vide a reliable supply of electrical power to the ESF electrical loads neces-
sary to achieve safe plant shutdown, or to mitigate the consequences of postu-
lated accidents.

8.1.3 Offsite Electrical System

The Offsite Electrical System consists of ~~the respective unit auxiliary transformers, (29-13.8/13.8 kV), two standby transformers, (362.25-13.8/13.8 kV), two main generators, two pairs of main power transformers (362.25-25 kV),~~ the 36
345 kV lines connecting the main power transformers and the standby trans-
formers to the switchyard, the 345 kV switchyard, and the eight 345 kV trans- 28
mission circuits from the STP 345 kV switchyard to the STP owners' intercon-
necting grids, and the 138 kV line from CPL's Blessing Substation to the 138
kV emergency transformer. The eight 345 kV transmission circuits connect the 28
STP 345 kV switchyard to the STP owner's grids as follows:

1. STP to Hill Country (CPS)

sufficient capacity to provide power to one ESF bus of each unit. Each unit auxiliary transformer is individually connected to the 345 kV switchyard by a separate and independent overhead ~~ties~~ tie through the main ~~transformers~~ transformer. These 345 kV ties are connected at separate positions on the breaker and-a-half 345 kV switchyard. These transformers have the capacity for startup, full-load operation and safe shutdown. Each unit auxiliary transformer has the capacity for the BOP loads and safe shutdown loads of all three of its ESF buses. ~~and BOP loads.~~ 36

The switchyard station service is supplied by two 4.16 kV non-Class 1E feeders (one from each unit) via ~~its~~ a local 480 V load center and is provided with two independent 125 vdc systems. This redundancy in power supplies assures that protective devices have a power source to maintain the reliability of the offsite supply. 12

The eight 345 kV transmission circuits connecting the owners' grids to the STP switchyard and the connection from the 345 kV switchyard at the STP to the southern terminal facilities of the HVDC interconnection system are routed so that loss of any independent right-of-way or outage of any two circuits ~~does not alter the operation of the plant during either full generation output or total plant shutdown.~~ may necessitate some reduction in generation output but do not significantly reduce the capability of the offsite supply of power. 28

8.1.4.2 Onsite Power System. The Onsite Power System is designed to supply the power requirements of all auxiliary loads required for all modes of plant operation. Sufficient instrumentation and protective control devices are provided to ensure reliability and availability of the system.

A listing of safety systems and loads is given in Table 8.1-1 and Table 8.3-3 respectively. These tables indicate the redundant loads associated with Train A, Train B, and Train C safety features. Safety functions and power requirements (ac or dc) of these loads are listed for the various plant conditions. 36

Those portions of the Onsite Power System required for the distribution of power to Class 1E electrical subsystems and components which are safety-related meet the following safety design bases: 36

1. Each ~~redundant~~ safety-related electrical load group (Train A, B, or C) is provided with an onsite standby power source, electrical buses, distribution cables, controls, relays, and other electrical devices separate from the other load groups.

2. Each onsite standby power source has sufficient capacity to provide power to its associated auxiliary power system to shut down and maintain the unit in a safe condition or to mitigate the consequences of a DBA in the event of a loss of the offsite power sources. 36

3. Redundant parts of the system are physically independent to the extent that a single event, including a single electrical failure, does not cause loss of power to redundant loads ~~groups~~.

4. In the event of the loss of all offsite power, the safety-related loads are ~~system is~~ connected to the onsite standby power sources automatically and in sufficient time to safely shut down the unit or limit the consequences of a Design Basis Accident (DBA) to within applicable regulatory limits. ~~In case any standby DG fails to start, that particular ESF transformer can be connected manually to the 138 kV emergency transformer.~~ 36 36

5. The Class 1E Electrical System (4.16 kV ESF buses, associated DGs and 480 vac, 120/208 vac and 125 vdc power and control systems) is installed in Seismic Category I structures.

6. The Class 1E Electrical System is designed to withstand the effects of design basis natural phenomena, assuming ~~simultaneous~~ single active failure, without loss of onsite power to those safety-related electrical components required to shut down the plant and maintain it in a safe condition or to mitigate the consequences of postulated accidents.

7. The three offsite ac power sources (two standby ~~transformers~~ and the respective unit auxiliary transformers) are capable of supplying power to each Class 1E electrical system bus. 36

8. One standby DG set and one independent 125 vdc system are provided for each Class 1E load group. (An additional 125 vdc system for the fourth RPS channel is provided using Train A as the ~~AC~~ power supply.)

9. Physical separation and electrical isolation are provided to maintain independence of all redundant Class 1E circuits and equipment. 20

10. Manual initiation of each protective action at the system level is provided in the main control room.

11. Inoperability and bypassed status indication for the safety-related systems are provided at the ESF system level and component level in the main control room. (Refer to Section 7.5.4). 29 Q430.03 2 Q40.01 36

The applicable criteria and codes, such as Regulatory Guides and IEEE standards, concerned with power requirements of the safety-related electrical loads are met by these systems. (See Table 8.1-2).

TABLE 8.1-2

LISTING OF APPLICABLE CRITERIA

Criteria	Title	Conformance Discussed In	
1. Regulatory Guides*			36
2. Institute of Electrical and Electronics Engineers Standards Not Otherwise Incorporated by RG Reference:			2 Q40.1 49
IEEE Std. 420-1973	IEEE Trial-Use Guide for Class IE Control Switchboards for Nuclear Power Generating Stations	8.3.1.3	44
IEEE Std. 485-1978	IEEE Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations	8.3.2.1.1	49 Q430.107
3. Branch Technical Positions			36 49
BTP ICSB 8 (PSB)	Use of Diesel Generator Sets for Peaking	8.3.1.1.4	36 29 Q430.04N
BTP ICSB 11 (PSB)	Stability of Offsite Power Systems	8.2.2.1	
BTP ICSB 18 (PSB)	Application of the Single Failure Criterion to Manually-Controlled Electrically Operated Valves	6.3.1 6.3.2.2, 6.3.5.5, 7.6.3, 7.6.7 See Figures 7.6.3 and 7.6-10	49 Q430.107N
BTP ICSB 21	Guidance for Application of RG 1.47	7.1.2.6	
BTP PSB-1	Adequacy of Station Electric Distribution System Voltages	8.3.1.1.4.6	
BTP PSB-2	Criteria for Alarms and Indications Associated with Diesel Generator Unit Bypassed and Inoperable Status	8.3.1.1.4.7	

*See Table 3.12-1 for revision and STP position on the following Regulatory Guides: 1.6, 1.9 (IEEE 387-1977), 1.22, 1.29, 1.30 (IEEE 336-1971), 1.32 (IEEE 308-1974), 1.40 (IEEE 334-1971), 1.41, 1.47 (IEEE 279-1971), 1.53 (IEEE 379-1972), 1.62 (IEEE 279-1971), 1.63 (IEEE 317-1976), 1.73 (IEEE 382-1972), 1.75 (IEEE 384-1974), 1.81, 1.89 (IEEE 323-1974), 1.93, 1.100 (IEEE 344-1975), 1.106, 1.108, 1.118 (IEEE 338-1977) 1.128 (IEEE 484-1975), 1.129 (IEEE 450-1975), and 1.131 (IEEE 383-1974) 49 Q430.107N Q430.108N 49 Q430.108N

TABLE 8.1-2 (Continued)

LISTING OF APPLICABLE CRITERIA

Criteria	Title	Conformance Discussed In
4. General Design Criteria		
"A" → GDC 17	Electrical Power Systems	3.1.2.2.8.1 8.2.1.3 8.3.1.2.1 8.3.2.2.1
GDC 18	Inspection and Testing of Electric Power Systems	3.1.2.2.9.1 8.3.1.2 8.3.2.2.1
GDC 21	Protection System Reliability and Testability	3.1.2.2.12.1 8.3.1.2.1 8.3.2.2.1
GDC 50	Containment Design Basis	3.1

36

"A"

GDC 2	Design Basis for Protection Against Natural Phenomena	3.1, 7.2.1.1
GDC 4	Environmental and Missile Design Bases	3.1, 3.11
GDC 5	Sharing of Structures, Systems, and Components	3.1

8.2 OFFSITE POWER SYSTEM

8.2.1 Description

This section provides a description of the Offsite Power System and components
and a discussion of system compliance with the design criteria indicated in
Section 8.1.4.1. Compliance with applicable regulatory guides is also ad- 36
dressed in Section 8.1. The systems, circuits, and components of this section
designated as "345 kV" refer to the assigned nominal value of a given voltage
class for convenient designation.

8.2.1.1 <u>Transmission Lines</u>. Eight 345 kV transmission circuits rated
from 850 to 1,080 mVA connect the STP 345 kV switchyard to the owner's re-
spective systems, as shown on Figure 8.2-4. These eight 345 kV circuits pro-
vide the source of ac power to the 345 kV switchyard. The 345 kV transmission 12
circuits terminate at seven points in the owner's respective systems as fol- 28
lows: at Velasco 345 kV Substation (Houston Lighting & Power Company [HL&P] -
existing); at W. A. Parish 345 kV Substation (HL&P - existing); at Hill Coun-
try 345 kV Substation (City of Public Service Board of San Antonio [CPS] -
existing); at Skyline 345 kV Substation (CPS - existing); at Holman 345 kV
Substation (City of Austin [COA]-Lower Colorado River Authority - existing);
at Lon Hill 345 kV Substation (Central Power and Light Company [CPL] - exist- 28
ing); and at Blessing 345 kV Substation autotransformer (CPL - future-planned
completion prior to the fuel load date of STP Unit No. 1). (The Blessing 345 36
kV autotransformer will be connected to CPL's existing Blessing 138 kV Sub-
station). In addition to the eight 345 kV transmission circuits there will be
a connection, rated 1,080 mVA, from the 345 kV switchyard at the STP to the 28
southern terminal facilities of a high voltage direct current (HVDC) inter-
connection system described in Section 2.2.2.1 (the estimated date of com-
mercial operation of both the connection and the terminal facilities is 36
~~December, 1985~~ June, 1989).

Three rights-of-way commence from the STP property toward the termination points described above as shown on Figure 8.2-5. The eastern right-of-way is 100 ft wide and contains two 345 kV circuits to Velasco (on double-circuit structures). The western right-of-way is 100 ft wide and contains a 345 kV circuit to Blessing. The middle or northwestern right-of-way is 400 ft wide and contains the five remaining circuits. These circuits are carried on three sets of double-circuit towers. The W. A. Parish and a future line position are on the eastern structures, the Hill Country and Holman lines are on the middle structures, and the Skyline and Lon Hill lines are on the western structures. (There is adequate spacing between the middle and western towers to allow complete failure of one without jeopardizing the other. For the purpose of analysis, the right-of-way has been considered as two independent rights-of-way.) This right-of-way is approximately 20 miles long and terminates in four separate rights-of-way varying in width from 100 to 150 ft. 36

The 138 kV emergency standby supply to STP is furnished from a radial line out of CPL's Blessing Substation. The 138 kV grid of CPL is intertied with HL&P at South Lane City Substation by the existing Blessing-South Lane City transmission circuit, Bay City-South Lane City circuit, and the El Campo-South Lane City circuit.

lightning flashover ~~as derived~~ from the expected number of lightning strokes (the number of lightning strokes is assumed proportional to the number of thunderstorm days per year).

The South Texas Interconnected System grid and transmission system ensures that ac offsite power is available for shutdown of STP Units 1 and 2 and for mitigating the consequences of postulated accidents at either unit. | 36

8.2.1.2 Substation. As indicated on Figures 8.2-2 and 8.2-3, a breaker-and-a-half scheme is incorporated in the design of the 345 kV switchyard. The switchyard bus is of a 40 gva fault duty design. ~~These figures also indicate the respective breaker continuous current ratings.~~ The 345 kV circuit breakers in the switchyard are rated according to the following criteria: | 31

1. Circuit breaker continuous current ratings are chosen such that no single contingency in the switchyard (e.g., a breaker being out for maintenance) will result in a load exceeding 100 percent of the nameplate continuous current rating of the breaker.

2. Interrupting duties are specified such that no fault occurring on the system, operating in steady-state conditions, will exceed the breaker's nameplate interrupting capability.

3. Momentary ratings are specified such that no fault occurring on the system, operating in steady-state conditions, will exceed the breaker's nameplate momentary rating.

4. Voltage ratings are specified to be greater than the maximum expected operating voltage.

All 345 kV breakers have a maximum symmetrical interrupting capability of 40,000 amperes. The Onsite Electrical System is designed for a future maximum switchyard short circuit contribution of 30 GVA. | 36

The north and south buses of the 345 kV switchyard each have connected to it a 150 mVAr shunt reactor. Each shunt reactor is connected to the bus by a 2,000 ampere circuit switcher. | 36

The breaker-and-a-half switchyard arrangement offers the following operating flexibility:

1. Any transmission line into the switchyard can be cleared either under normal or fault conditions without affecting any other transmission line or bus.

2. Either bus can be cleared under normal or fault conditions without interruption of any transmission line or the other bus.

3. Any circuit breaker can be isolated for maintenance or inspection without interruption of any transmission line or bus.

4. A fault in a tie breaker or failure of the breaker to trip for a line or generator fault results only in the loss of its two adjacent circuits until it can be isolated by disconnect switches. | 36

breakers. Cables are routed from each breaker to the respective trenches in such a fashion as to maintain separation between primary and secondary circuits. 31 04-07

8.2.1.3 Standby Transformers. Each standby transformer has the capacity to supply all ESF buses in both units and two 13.8 kV auxiliary buses. These transformers ~~are~~ can be shared between Units 1 and 2 and ~~are~~ the two preferred power can supply sources (the north and south 345 kV buses). Each transformer has two low-voltage windings rated at 13.8 kV. Each of the low-voltage windings is connected to two 13.8 kV standby buses of one unit and one 13.8 kV standby bus and one auxiliary bus of the other unit. Each transformer is rated ~~at approximately~~ 46.5/62/77.5 mVA, oil to air/forced air/forced oil and air (OA/FA/FOA) cooled at 55°C ~~rise,~~ with a 12-percent supplementary rating at 65°C ~~rise.~~ Each low-voltage winding is rated ~~at approximately~~ 23.25/31/38.75 mVA, OA/FA/FOA at 55°C ~~rise,~~ with a 12 percent supplementary rating at 65°C ~~rise.~~ 36 12

Figure 8.2-1 is a schematic representation of the physical layout of the preferred power supply circuits which connect the standby transformers to the switchyard. 36

As indicated on Figure 8.2-1, both transformers are connected to 345 kV buses in the switchyard by overhead conductors on steel structures. The no. 2 standby transformer is connected to the south bus, and no. 1 to the north bus. 36

The following separation criteria apply to the standby transformers and associated leads in order to maintain their independence from each other and ensure conformance to GDC 17 and Regulatory Guide 1.32.

1. The high-voltage circuit~~s~~ of each standby transformer ~~are~~ is routed on separate steel structure~~s~~ and terminate~~d~~s on a separate bus~~es~~ in the 345 kV switchyard. The north bus is extended so the no. 1 standby transformer leads do not cross over the south bus. 36

2. The separation of the steel structure is so arranged that a complete failure of a structure serving one standby transformer could not jeopardize the integrity of a structure or its associated high-voltage leads serving the other standby transformer.

3. The no. 1 and no. 2 standby transformers are physically separated from each other to prevent a single accident ~~of~~ affecting one transformer (e.g., fire) from jeopardizing the operation of the other transformer.

4. Each transformer's low voltage windings are connected to the associated 13.8 kV switchgear of each unit by cables (15 kV insulated) routed in underground concrete-encased duct banks and manholes and in air by nonsegregated phase bus duct. These cables terminate at the 13.8 kV switchgear of each unit. 44 46

5. The 138 kV transmission line does not cross any high-voltage lead from the 345 kV switchyard to the plant.

6. The 138 kV emergency transformer is physically separated from both the no. 1 and no. 2 standby transformers by a minimum of 800 ft. This will ensure that a single accident in the 138 kV emergency transformer will not jeopardize the standby transformers. 36

The impendances of the standby transformers have been selected to ensure satisfactory startup, acceleration, and operation of all safety-related motors during the most limiting conditions considering the short circuit and voltage requirements. All ESF motors are specified to start and accelerate satisfactorily with 80 percent of the motor's rated voltage applied at their terminals. 36 36

Each of the standby transformers is protected by primary and backup relays. The primary relay is of the high speed, percentage slope, harmonic restraint, differential overcurrent type (87/ST1 or 87/ST2) to detect transformer internal faults. The backup relay is of the non-directional, inverse time overcurrent, induction unit and instantaneous overcurrent unit type (50/51/ST1H or ST2H) to provide overload protection as well as backup protection to the transformer differential and transformer lowside relays. These relays are connected in conjunction with auxiliary relays (86/ST1 or ST2) to initiate the 13.8 kV standby bus supply breakers tripping and transferred tripping to 345 kV circuit breakers located in the switchyard and lockout closing of circuit breakers. The control power for these relays is supplied from the respective unit's non-Class 1E 125 vdc battery system. 31 Q430.07N

Normal transfer of the source of power for the 13.8 kV auxiliary buses between the no. 1 and no. 2 standby transformers is initiated by the operator from the control room. 36

Normal bus transfers are "live bus" transfers, i.e., the incoming source feeder circuit breaker is momentarily paralleled with the outgoing source feeder circuit breaker. This results in transfers without power interruption. 36

auxiliary transformer;

8.2.1.4 <u>138 kV Emergency Transformer.</u> In addition to the no. 1 and no. 2 standby transformers, the 138 kV emergency transformer is a source of offsite power to the ESF Electrical System. This transformer has a rating equivalent to the requirements of one ESF bus of each unit. 36

Figure 8.2-1 is a conceptual representation of a physical layout of the circuit which connects the 138 kV emergency transformer to the 138 kV transmission line.

As indicated on Figure 8.2-1, this transformer is connected to a 138 kV transmission line which is not connected to the 345 kV switchyard transmission line or related structures.

The following separation criteria apply to the 138 kV emergency transformer and its associated leads. 36

1. The location of the 138 kV steel structures is such that a complete failure of a steel structure associated with the no. 1 or no. 2 standby transformer leads will not jeopardize the integrity of a 138 kV structure or its associated leads.

2. The 138 kV emergency transformer low voltage windings are connected to the associated motor operated switches of each unit by cables (15 kV insulated) routed in underground concrete-encased duct banks, manholes and tray, and in air by non-segregated phase bus duct. 44

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The impedance of the 138 kV emergency transformer has been selected to ensure satisfactory startup, acceleration, and operation of all safety-related motors during the most limiting conditions with preferred (offsite) power available. This is accomplished as follows:

1. The impedance of the 138 kV emergency transformer is selected to maintain at least 80 percent ~~system~~ of motor rated voltage while starting the largest ESF motor with the transformer loaded to its rating minus this motor load.

2. All ESF motors are specified to start and accelerate satisfactorily with 80 percent ~~of the motor's~~ rated voltage applied at their terminals. 36

As indicated on Figure 8.2-2 and 8.2-3, the 138 kV emergency transformer is connected to the 138 kV transmission line through a 1,200-ampere circuit switcher. The 138 kV emergency transformer is protected by primary and backup relays and a circuit switcher failure protection system. The primary relay is of the high speed, percentage slope, harmonic restraint, differential overcurrent type (87/ET) to detect transformer internal faults. The backup relay is of the non-directional, inverse time overcurrent, induction unit and instantaneous overcurrent unit type (50/51/ET) to provide overload protection as well as backup protection to the transformer differential and transformer lowside relays. In addition, rate-of-rise pressure protection (63SP/ET) is also provided. These relays are connected in conjunction with an auxiliary relay (86/ET) to initiate tripping and lockout closing of the 138 kV circuit switcher and transformer lowside breakers. 31 Q430.07N

The circuit switcher failure protection system consists of a non-directional instantaneous overcurrent relay (50/CSF) connected in conjunction with auxiliary relays (2/CSF) and (86/CSF) utilized to control the circuit switcher failure timing interval and initiate applied fault tripping (138 kV "C" phase ground switch) of the remote terminal.

Additionally, a non-directional, instantaneous overcurrent relay (50B) is provided to block opening of the circuit switcher and permit remote terminal backup tripping should the fault current exceed the circuit switcher current interrupting rating. Figure 8.2-3C is a schematic of the protection system for the 138 kV emergency transformer. The control power for the 138 kV emergency transformer protection system is provided by a branch circuit from the STP 345 kV switchyard 125 vdc system.

The 138 kV emergency transformer may be used as a source of power for one ESF bus of each unit by manual transfer from the control room. The normal balance-of-plant 4.16 kV and 13.8 kV buses are not fed from the 138 kV emergency transformer. 36

8.2.1.5 Main Generators. The main generators are rated 1,504.8 mVA, 25 kV and provide power to the system grid at various loads to a maximum of ~~1,312~~ 1,354 MWe each. ~~The main generator data is given in Table 8.2-6.~~ Each main generator is directly connected to the main transformers and unit auxiliary transformer through a 25 kV, 36,600- ampere, forced-cooled, isolated phase bus through ~~a~~ disconnect links and a main generator circuit breaker. ~~to isolate the main generator from the main and auxiliary transformer bank.~~ The main generator's voltage is stepped up to 345 kV and then tied to one bay of the 345 kV switchyard. Each main transformer bank consists of two three-phase transformers, 700 mVA each, FOA rated at 55°C temperature rise, with a 36 29 Q430.06

8.3 ONSITE POWER SYSTEMS

8.3.1 AC Power Systems

8.3.1.1 Description. The onsite AC Power Systems of Units 1 and 2 each consist of four major subsystems as follows.

1. 13.8 kV Auxiliary Power System (non-Class 1E)
2. 13.8 kV Standby Power System (non-Class 1E)
3. 138 kV Emergency Transformer Systems (non-Class 1E) 36
4. Onsite Standby Power System (Class 1E)

The arrangement of the AC Power Distribution Systems provides sufficient switching flexibility and equipment redundancy to ensure reliable power supply to the Class 1E and non-Class 1E plant loads during startup, normal operation, ~~and~~ shutdown, [and] following a design basis event.

Figure 8.3-1 illustrates the bus arrangements and interconnections of Units 1 and 2. The general arrangement of the electrical equipment is shown on Figures 1.2-4, 1.2-5, 1.2-10, 1.2-26, 1.2-28, and 1.2-29. 36

Normally, the Class 1E AC Power Distribution Systems of Units 1 and 2 operate independently of each other, each being supplied power from a separate standby transformer. However, it is possible to energize the 13.8 kV auxiliary buses of a unit from either of the standby transformers. Underground cable ties are provided for interconnecting the secondary windings of the standby transformers to the 13.8 kV buses of both Units 1 and 2. This permits the operation of the Class 1E auxiliaries from either standby transformer. 36

The 138 kV emergency transformer, which is common to Units 1 and 2, can also be utilized to supply power to one train of ESF load in each unit.

The following detailed descriptions explain how the major power distribution subsystems are employed to furnish power to the plant auxiliary loads under all expected modes of operation.

8.3.1.1.1 Main Auxiliary Power Distribution: During normal plant operation, auxiliary loads are energized from the main generator through the closed main generator breaker and the three-winding unit auxiliary transformer which is connected to the isolated phase bus of the main generator. 36 Each unit auxiliary transformer [has an automatic load tap changer and] is rated 25 kV/13.8 kV/13.8 kV, 84/112 MVA, oil-to-air (OA)/ forced oil and air (FOA), 65°C, three phase, 60 Hz. 36 Each transformer secondary winding is rated 42/56 MVA. ~~OA/forced air (FA)~~

The secondary windings of the unit auxiliary transformer are loaded approximately equally. The "X" winding energizes two of the 13.8 kV auxiliary buses, and the "Y" winding energizes the remaining pair of 13.8 kV auxiliary buses of the unit, as shown in Table 8.3-1.

During plant startup, power to 13.8 kV auxiliary buses 1F, 1G, 1H, and 1J of each unit is supplied from [offsite power sources through] the unit auxiliary transformer via the main transformers with the main generator breaker open. 36

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The 13.8 kV auxiliary buses are standard, indoor, metal-clad, 15 kV class switchgear. All circuit breakers are of the magnetic, air-interruption type with an interrupting rating of 750 mVA. The continuous current rating of the incoming supply breakers, tie breakers, and feeder breakers is 1,200 amperes. All circuit breakers are electrically operated utilizing 125 vdc control power.

Non-Class 1E Motors

Motors rated 1500 hp and above are rated 13.2 kV; motors rated 300 to 1250 hp are rated 4 kV; and motors rated 3/4 hp to 250 hp are rated 460 V. 36 43

Two feeders from the 13.8 kV auxiliary buses supply power to two auxiliary transformers serving non-Class 1E equipment. These transformers are of the oil-filled type, rated 13.8 kV/4.16 kV, 5,000/6,250/7000 kVA, ~~OA/ FA, 55°C/FA 65°C~~ OA/FA/FA, 55°C/55°C/65°C three phase, 60 Hz. Switchgear distributing power from these transformers is standard, indoor, metal-clad, 5 kV class switchgear in a double-ended arrangement. Circuit breakers are of the magnetic, air-interruption type with interrupting rating of 250 mVA. The continuous current rating of all breakers in this double-ended arrangement is 1,200 amperes. 36

Other feeders from the 13.8 kV auxiliary buses are connected to low-voltage transformers supplying power through single and double-ended 480 V switchgear sections to non-Class 1E loads. These transformers are of the dry type rated 13.8 kV/480 V, ~~1,000 kVA or 1,200 kVA, air-to-air (AA) FA or 500 kVA (OA)~~, 1000/1333 kVA, AA/FA, or 1200/1600 kVA, AA/FA, or oil filled rated 500 or 1200 kVA, three phase, 60 Hz. The switchgear sections consist of standard, indoor, metal-enclosed, 600 V class switchgear. All circuit breakers are of the magnetic, air-interruption type with interrupting ratings consistent with the short-circuit duty at the point of application. All circuit breakers are electrically operated with 125 vdc control power. Feeders from the 480 V load center buses energize non-Class 1E motors and motor control centers (MCCs) from which non-Class 1E small motors and miscellaneous loads are furnished power. 36 36 36

~~Normally open~~ Bus tie breakers between ~~the bus~~ sections of the double-ended switchgear ~~sections~~ are ~~provided to allow power to selective loads on both bus sections~~ under administrative control. ~~should one of the power sources to the switchgear be disabled.~~ These breakers can be closed during maintenance periods. 36

8.3.1.1.2 Normal ESF Power Distribution: For startup and normal operation of the plant, power to the ESF buses is distributed from the standby buses through the associated ESF bus transformers.

The standby transformer of each unit is a three-winding transformer, rated 362.25 kV/13.8 kV/13.8 kV, 46.5/62/77.5 (87.19) mVA, OA/FA/FOA, 55°C (65°C), three phase, 60 Hz. The transformer secondaries are each rated 23.25/31/38.75 mVA.

During startup and normal plant operation the 13.8 kV standby buses are supplied power from the unit auxiliary and standby transformers. Standby 13.8 kV Bus 1F is supplied power from the X-winding of the unit auxiliary transformer ~~through 13.8 kV auxiliary Bus 1E~~ with the bus tie breaker closed. Standby 13.8 kV Buses 1G and 1H are supplied power from the Y and X windings, ~~respectively~~ of the standby and unit auxiliary transformers (see Figure 8.3-1). 36

or from either of the

By means of manual transfer, the 13.8 kV standby buses can be supplied from the respective unit auxiliary transformer ~~or the~~ standby transformers. Normal connections and possible interconnection from the 13.8 kV standby buses to the unit auxiliary and standby transformers are shown on Table 8.3-1. Normally, standby transformer No. 1 and 2 supply only Unit 1 and 2, respectively. Normal connections and possible interconnection from the 13.8 kV standby buses to the standby transformers are shown in Table 8.3-2. 36

Power is supplied from 13.8 kV standby buses 1F, 1G, and 1H to 4.16 kV ESF Buses E1A, E1B, and E1C, respectively, through the associated auxiliary ESF transformers.

Switchgear constituting the standby buses is of the same type and rating as switchgear constituting the auxiliary buses. The continuous current rating of the breakers in each standby bus is 1,200 amperes. 36

Each auxiliary ESF transformer supplying the ESF buses is rated 13.8 kV/4.16 kV, 5,000/6,250/7,000 kVA, OA/FA at 55°C, FA at 65°C three phase, 60 Hz. Each transformer is connected by cable to Class 1E, 5 kV class, metal-clad switchgear. 36

8.3.1.1.3 <u>Additional Source ESF Power Distribution:</u> Another offsite power source, the 138 kV emergency transformer, is capable of supplying power concurrently to one ESF bus of each unit. The 138 kV emergency transformer is a three-winding transformer rated 138 kV/13.8 kV/13.8 kV, 12/16/20 mVA, (22.5) mVA, OA/FOA/FOA, 55°C (65°C) three-phase, 60 Hz. Each secondary winding is rated 9/12/15 (16.875) mVA, 55°C (65°C). Each of the secondary windings of this transformer is connected to a separate, outdoor-type, 13.8 kV air-circuit breaker. These air-circuit breakers make it possible to supply power to the Unit 1 or Unit 2 13.8 kV emergency buses (1L). These are interlocked with the normal supply to prevent both supplies from being tied together. 36 13 36

Switchgear constituting the 13.8 kV emergency buses of Units 1 and 2 is of the same type and rating as switchgear constituting the auxiliary buses. The switchgear breakers have a continuous current rating of 1,200 amperes. Each of these breakers can supply power to one of the ESF buses, via the associated auxiliary ESF transformer, when the standby transformers are not available and the standby Diesel-Generators (DGs) fail to start. Switching and control of this switchgear are nonautomatic and by operator action only. 36

8.3.1.1.4 <u>Onsite Standby Power Supply and ESF Power Distribution:</u> The Onsite Standby Power Supply Systems of Units 1 and 2 each consist of three independent, physically separated, standby DGs supplying power to three associated load groups designated Train A, Train B, and Train C. Each load group consists of a 4.16 kV ESF bus and the electrical loads connected to that bus. The Onsite Standby Power Supply Systems of Units 1 and 2 operate independently of each other. Each standby DG and load group of a particular unit is also physically separated and electrically independent from the other two standby DGs and their load groups. Qualification of all Class 1E electrical equipment which is a part of the Onsite Standby Power Supply and ESF Power Distribution System is discussed in Sections 3.10 and 3.11. 36 44

Each standby DG is located in a separate room of the Diesel-Generator Building, which is a seismic Category I structure (described in Section 3.8.4).

Each train (i.e., Load Group) is independent but is not totally redundant; two trains are necessary to mitigate the consequences of a design basis accident.

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Each 4.16 kV ESF bus is provided with switching that permits energization of the bus by five alternate sources: 36

1. The respective unit auxiliary transformer
2. No. 1 standby transformer
3. No.2 standby transformer
4. Standby DG
5. 138 kV emergency transformer

~~When neither standby transformer nor the respective unit auxiliary transformer is available, the standby DGs supply the power required by the ESF loads to safely shut down the reactor. The 138 kV emergency transformer provides an additional means for supplying power to these systems if for any reason the above power sources are unavailable. This power source is immediately available; however, its use is operator controlled.~~

Each standby DG is automatically started in the event of loss of offsite power or safety injection (SI) signal, as described in Section 8.3.1.1.4.4, and the required Class 1E loads connected to that ESF bus are automatically connected in a predetermined time sequence. ~~after the standby DG is ready to accept load.~~ Each standby DG is ready to accept load within 10 seconds after the start signal. 36

The standby DGs are not used for peaking and therefore the design complies with BTP ICSB-8.

Figure 8.3-1 shows the configuration of the ESF buses and the standby DGs. The assignments of loads connected to each bus are shown on single line diagrams referenced in Table 1.7-1. Emergency electrical loading requirements are addressed in Table 8.3-3. 36

8.3.1.1.4.1 ESF Buses - The three ESF buses are physically and electrically separated from each other to comply with the single-failure criterion. There are no automatic or manual interconnections between ~~redundant~~ load groups.

Switchgear constituting the ESF buses is indoor-type, metal-clad, 5 kV switchgear qualified for Class 1E service. All circuit breakers are of the magnetic, air-interruption type with an interrupting rating of 250 MVA. The continuous current rating of ~~all~~ circuit breakers in this switch gear is 1,200 amperes. All circuit breakers are electrically operated with 125 Vdc control power.

Feeders from the 4.16 kV ESF buses supply power to Class 1E motors with ratings greater than 300 hp. 36

Two feeders from each 4.16 kV ESF bus supply power to a double-ended 480 V switchgear assembly. The transformer sections of this switchgear assembly consist of dry-type transformers rated 4.16 kV/480 V, 1,000/1333 kVA, AA/FA, 36
three phase, 60 Hz with impedence of 4.0 percent ± 7.5 percent tolerance. The 44
switchgear sections consist of indoor, metal-enclosed, 600 V class switchgear.

Bus tie breakers between sections of the double-ended load centers are under administrative control and can be closed during maintenance periods.

All circuit breakers are of the magnetic, air-interruption type with interrupting ratings consistent with the short-circuit duty at the point of application. All circuit breakers are electrically operated with 125 vdc control power. ~~The bus tie breakers are normally open and are closed to allow power to selected loads on both bus sections under administrative control should one of the power sources to the switchgear be disabled.~~ 36

Feeders from this 480 V switchgear supply power to ESF motors with ratings in the range of 150 hp to 300 hp. Other 480 V feeders supply power to Class 1E MCCs from which all 460 V motors with ratings equal to or less than 100 hp are controlled.

8.3.1.1.4.1.1 Non-Class 1E Loads Connected to Class-1E Power System: The non-Class 1E loads that can be powered from the standby Diesel Generators (SBDGs) during loss of offsite power are included in Table 8.3-3 and include: 32

1. Pressurizer Heaters (Back-up Groups A and B)

2. Control Rod Drive Mechanism (CRDM) Cooling Fans

3. Reactor Cavity Vent Fans, and 38

4. Reactor Support Exhaust Fan

~~A~~ redundant sets of pressurizer heaters are connected to 480 V ESF load centers E1A (Train A) and E1C (Train C) through qualified isolation devices which are tripped upon receipt of an SI signal (see Section 8.3.1.4.4.14). As indicated in Table 8.3-3 these heaters are manually ~~loaded~~ connected under administrative control during loss-of-offsite-power (LOOP) when a SI signal is not present. 36 Q430.11N Q430.30N

The balance of the non-Class 1E loads indicated above (See detailed listing in Table 8.3-3) are connected to common MCCs. As shown in Figure 8.3-1, these non-Class 1E MCCs, one per train, are connected to Class 1E 480 V MCCs through qualified isolation devices which ~~These MCC breakers~~ are tripped upon receipt of a SI signal ~~and therefore are classified as isolation devices~~ (see Section 8.3.1.4.4.14). As indicated on Table 8.3-3, these loads are either automatically sequenced or manually loaded onto the standby DGs during a LOOP when a SI signal is not present. In the event sequencing is initiated by a SI signal, these loads may be manually loaded after resetting the SI signal under administrative control.

8.3.1.1.4.2 Equipment Capacities and Loading Basis - Each SBDG has a continuous 8,760-hour rating of 5,500 kW. The loads are listed in Table 8.3-3. The design and continuous rating selected is consistent with the requirements of Regulatory Guide (RG) 1.9 and IEEE Standard 387-1977. Capacities of individual loads are determined on the basis of motor brake horsepower ~~nameplate~~ ratings. The diesel engine, generator, and accessories are briefly described in the following: 36 36 24 Q430.13N

1. The DG set, manufactured by Cooper Energy Services, has the following ratings: 2000-hour at 5935 kW, 168-hour at 6050 kW, and 30-minute at 6050 kW. These ratings are based on a cooling water inlet temperature of 115°F. 36 49

2. Each diesel engine is a cold starting, compression-ignition, multi-cylinder type. Each engine is a Type KSV-20-T, four-stroke, turbocharged machine.

3. The generator is a synchronous-type, model HS-160 ET, 4160 V, 60 Hz, three phase alternating current machine, manufactured by Electric Product Division of Portec. The generator continuous rating at 80 percent power factor lagging is 6875 kVA. The generator and exciter are capable of operating at 110 percent of the continuous voltage and power ratings for a period of 2 hours out of any 24 hours of operation with no reduction of annual maintenance interval. The generator insulation is designed for the special environmental conditions of the nuclear power plant. The generator has non-hygroscopic sealed Class F insulation in accordance with NEMA Standard MG1-22.40. 29 Q430.13N

4. The generator excitation system manufactured by Electric Product Division of Portec, is a static-type exciter-regulator having response characteristics and sufficient capacity to provide the generator with the required excitation to allow startup of the loads listed in Table 8.3-3. The exciter voltage rating is consistent with the requirements of the generator field. Regulator sensing voltage is 120 vac, three-phase, 60 Hz, and is taken from the generator output by means of potential transformers. 36

5. Each engine has two independent air compressor skids each consisting of an air compressor, dryer, air receiver, and all piping and valves. 49

   Each engine has an auxiliary skid with standby jacket water circulating pump, lube oil circulating pump, lube oil heaters, and other equipment. The auxiliary skids are located adjacent to the engine and generator skid.

   Each engine has an engine control panel, a generator control panel, and a high voltage cubicle.

   All these accessories are furnished by Cooper Energy Service (CES) but much of the equipment is fabricated by subvendors contracted to CES. 36

The DG units are subjected to the qualification program in accordance with RG 1.9 and IEEE 387-1977. 49

ESF motors are sized equal to or greater than the maximum horsepower required by the driven load under normal running and runout condition. All motors are suitable for running at ±10 percent of the nominal voltage rating. The 4.0 kV class motors have a service factor ranging from 1.0 to 1.15, whereas 460 V motors generally have a service factor of 1.15. The 4 kV ESF motors, except those that are hermetically sealed, are provided with resistance temperature detectors (RTDs) in the stator windings and with thermocouples (TCs) in sleeve bearings. The RTDs and TCs are monitored by the plant computer. The effect of any overvoltage at the motor teminal is reviewed. 29 Q430.15N 43

Motor insulation is selected on the basis of normal and design basis event ambient temperatures and anticipated temperature rise resulting from maximum loading conditions (Section 3.11.4). Class 1E motors are seismically and environmentally qualified as described in Sections 3.10 and 3.11, respectively. Trouble alarms in the control room are provided for ESF motors. 29 Q430 15N 36

Transformer impedances and standby DG voltage regulator and exciter characteristics are selected to permit starting the largest motor connected to a particular bus, when all other loads connected to the bus are energized, without the voltage at the terminals of all ESF motors falling below 80 percent of the nominal motor voltage rating.

8.3.1.1.4.3 Identification of Class 1E Equipment and Circuits - See Section 8.3.1.3 for identification of Class 1E equipment and circuits and Section 8.3.1.4 for separation of Class 1E equipment and circuits. 36

8.3.1.1.4.4 ESF Bus Load Shedding, Automatic Loading and Standby Diesel Generator Starting -The automatic loading sequence of the Class 1E buses is shown in Table 8.3-3 and a typical logic for this sequence actuation is shown in Figure 8.3-4, (Sheet 2). 36

Automatic ~~energizing~~ energization of the Class 1E buses is ~~accomplished~~ initiated by solid state ESF Load Sequencers, ~~to start~~ which also connect the required Class 1E loads ~~in~~ at programmed time increments. 29 Q430 Q3N 3

Each ESF load sequencer, one for each ~~redundant~~ actuation train load group, has independent sensor channels, power supplies, and actuated devices. No credible sneak circuits can occur to render sensors, power supplies, or actuated devices ~~in redundant channel or load groups~~ inoperable. ~~through interconnections.~~

~~Redundant~~ channel and load groups are isolated and separated in accordance with RG 1.75 (See Section 8.3.1.4). 36

A sequencer design demonstration test is performed to verify that no credible common failure modes exist in the sequencer design. The test verifies responses to credible input perturbation and series of events. 36

Each ESF load sequencer responds to three unique modes of operation as follows:

1. Mode I (Safety Injection [SI] ~~Actuation~~) discussed in Sections ~~7.3.1.1.2 and~~ 8.3.1.1.4.4.1.

2. Mode II (Loss of Offsite Power [LOOP]) discussed in Section 8.3.1.1.4.4.2. | 36

3. Mode III (SI ~~Actuation~~ Coincident With LOOP) discussed in Section 8.3.1.1.4.4.3. 29 Q430.33N

8.3.1.1.4.4.1 Mode I (SI ~~Actuation~~) ESF Load Sequence Operation: Each sequencer detects the existence of Mode I abnormal operation by the simultaneous receipt of any four or more of six SI ~~actuation~~ signals generated by the ~~SI (ESF)~~ Engineered Safety Features Actuation System (ESFAS), discussed in Section 7.3.1. The SI signal is generated by plant conditions as shown on Figure 7.2-8.

Upon detecting a Mode I ~~existence~~ condition, the ESF load sequencer logic verifies the non-existence of a Mode II signal. The ESF load sequencer then automatically energizes the equipment required for this emergency in programmed steps as shown in Table 8.3-3 and Figure 8.3-4 (Sheet 2). | 36

The manually ~~sequences for re-connecting other~~ connected loads are also shown in Table 8.3-3. ~~and on Figure 8.3-4.~~

Additionally, the standby DGs are started automatically by the ESF Actuation System. The standby DGs run with their governors automatically set in the isochronous mode, and their voltage regulators automatically set in the automatic mode. All non-critical protection devices are bypassed as described in Section 8.3.1.1.4.6. | 36

With an SI signal present and no loss of preferred (offsite) power, ESF loads are ~~fed from the~~ offsite source and the operator can reset the SI ~~actuation~~ signal from the control room. The standby DG can then be manually shut down from the control room or locally (based upon the plant emergency operating procedures). After the SI signal has been reset, ~~Subsequently, if a LOOP occurs, load shedding and load sequencing are initiated as described in Section 8.3.1.1.4.4.3.~~ However, the SI signal is memorized by the ESF load sequencer to enable recognition of a Mode III condition, as discussed in Section 8.3.1.1.4.3.2. This memory is shown on Figure 8.3-4 (Sheet 2). Simulated testing and actuation of Mode I is discussed in Section 8.3.1.1.4.7. | 36

8.3.1.1.4.4.2 Mode II (Loss of Offsite Power) ESF Load Sequence Operation: The ESF load sequencer detects the existence of Mode II (LOOP) by the simultaneous receipt of any two out of four undervoltage or degraded voltage signals which indicate that the normal preferred source to the ~~ESF~~ 4.16 kV ESF bus has dropped below acceptable limits, or has failed completely. | 36

Upon receipt of any two out of four undervoltage or degraded voltage signals, the ESF load sequencer converts the recognition of these signals into a maintained signal. | 36

Upon detecting the existence of a Mode II condition, the ESF load sequencer ~~will~~ checks for the non-existence of Mode I.

The ESF load sequencers then automatically implement the following: | 36

(a) Shed all loads on the ~~ESF~~ 4.16 kV ESF bus. ~~(except the load center transformers)~~ However, shedding of the load center transformers distribution network is accomplished by tripping the breakers on the 480V secondary side of the transformers only. The breakers on the primary side of the transformers remain connected.

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(b) Start the standby DG with the governor in the isochronous mode and the voltage regulator in the automatic mode. Non-critical protective devices are bypassed as described in Section 8.3.1.1.4.6.

(c) Trip the 4.16 kV ESF power supply breakers to disconnect the Class 1E onsite power system from the offsite source.

(d) Energize the equipment for this emergency event in programmed steps as shown in Table 8.3-3 and on Figure 8.3-4. (Sheet 2)

Disconnecting the Class 1E onsite power system from the offsite system precludes the possibility of subsequent interaction between the onsite and the offsite power systems. As each standby DG reaches rated voltage and frequency, the breaker connecting it to the corresponding 4.16 kV ESF bus closes. This automatic breaker closure is only possible when the offsite power supply breaker is open and the designed load shedding has been accomplished. Upon closure of the DG breakers, the sequencers begin sequencing the loads that are required during this event in programmed steps. When the preferred offsite power source again becomes available, the reconnection of the 4.16 kV ESF buses to this source and the shutdown of the standby DGs is accomplished manually.

insert "E" →

Simulated testing of Mode II is discussed in Section 8.3.1.1.4.7(2b).

insert "F" → ~~8.3.1.1.4.4.3 Mode III (SI Actuation + Loss of Offsite Power) ESF Load Sequencer Operation. Mode III is the simultaneous existence of Mode I and Mode II conditions.~~

8.3.1.1.4.4.3.1 Simultaneous Existence of Mode I and Mode II.

Each ESF load sequencer automatically implements the Mode III loading sequence by the simultaneous presence of four or more SI ~~actuation~~ signals from the ESF Actuation System and the presence of two out of four under-voltage signals from the ESF 4.16 kV bus undervoltage relays. The ESF load sequencer then initiates the following:

(a) Shed all loads on the 4.16 kV ESF bus. ~~(except the load center transformers)~~ insert "G"

(b) Start the standby DG with the governor in the isochronous mode and the voltage regulator in the automatic mode. all non-critical protective devices are bypassed as described in Section 8.3.1.1.4.6.

Note - the standby DG receives a simultaneous emergency startup signal directly from the ESF Actuation System due to an SI ~~actuation~~ signal. ~~This signal starts the standby DG in the isochronous mode and the voltage regulator in the automatic mode. Under these conditions~~ all non-critical protective devices are bypassed as described in Section 8.3.1.1.4.6.

(c) Trip the 4.16 kV ESF offsite power supply breakers to disconnect the Class 1E onsite power system from the offsite source.

(d) Energize the equipment for this emergency event in programmed steps as shown in Table 8.3-3 and on Figure 8.3-4. (Sheet 2)

insert "H" →

INSERT 'E'

¶ The manually connected loads are shown in Table 8.3-3.

¶ Subsequent to a Mode II recognition and the above events, if a SI actuation occurs, load shedding and load sequencing are initiated as described in Section 8.3.1.1.4.4.3.3.

INSERT 'F'

8.3.1.1.4.4.3 <u>Mode III (SI ~~Actuation~~ Signal + Loss of Offsite Power):</u>
Mode III is the existence of both Mode I and Mode II conditions. The ESF load sequencer distinguishes three separate methods of entry into a Mode III condition, as follows:

1. The simultaneous existence of Mode I and Mode II,
2. Mode I existing followed by Mode II,
3. Mode II existing followed by Mode I.

The ESF load sequencer operation for the above Mode III variations is discussed below. Regardless of the method of entry, the manually connected loads for Mode III are shown in Table 8.3-3. Simulated testing of Mode III is discussed in Section 8.3.1.1.4.7.

Q430.33N

INSERT 'G'

However, shedding of the load center transformer distribution network is accomplished by tripping the breakers on the 480 V secondary side of the transformers only. The breakers on the primary side of the transformers remain connected.

INSERT 'H'

8.3.1.1.4.4.3.2. Mode I Existing Followed by Mode II at Some Later Time. Should an existing Mode I (SI) be followed by a Mode II (LOOP), the ESF load sequencers each automatically implement the following: Q430.33N

(a) Shed all loads on the 4.16 kV ESF bus. However, shedding of the load center transformers distribution network is accomplished by tripping the breakers on the 480 V secondary side of the transformers only. The breakers on the primary side of the transformers remain connected.

(b) Shed certain selected loads on the 480V ESF distribution system, as applicable for that train (RHR pump, RCFC fans, EAB HVAC supply air fan, 480V essential chiller, pressurizer heater, spent fuel pool cooling pump).

(c) Trip the 4.16 kV ESF power supply breakers to disconnect the Class 1E onsite power system from the offsite source.

(d) Since the standby DG has been previously started by the SI signal and is running at full speed when the Mode II occurs, the sequencer delays the permissive to close the DG breaker for five seconds to allow the breakers on the

INSERT 'H' continued

secondary side of the load center transformers sufficient time to recharge the breaker closing spring mechanism.

(e) Energize the equipment for this emergency event in programmed steps as shown in Table 8.3-3 and on Figure 8.3-4 (Sheet 2).

The load shedding of Item (b) above removes all loads which are to be sequenced on or are manually loaded large loads.

8.3.1.1.4.4.3.3. Mode II Existing Followed by Mode I at Some Later Time. Should an existing Mode II (LOOP) be followed by a Mode I (SI), the ESF load sequencers then automatically implement the following: Q430.33N

(a) Shed all loads on the 4.16 kV ESF bus (except the load center transformers and their associated 480 V distribution system).

(b) Shed certain selected loads on the 480 V ESF distribution system, as applicable for that train (RHR pump, RCFC fans, EAB HVAC supply air fan, 480 V essential chiller, pressurizer heater, spent fuel pool cooling pum

(c) Energize the equipment for this emergency event in programmed steps as shown in Table 8.3-3 and on Figure 8.3-4 (Sheet 2).

The load shedding of Item (b) above removes all loads which are to be sequenced on or are manually loaded large loads.

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~~The manual sequences for reconnecting other loads are shown in Table 8.3-3 and Figure 8.3-4.~~ 29 Q430. 33N

~~Simulated testing of Mode III in Section 8.3.1.1.4.7(3).~~

8.3.1.1.4.5 Instrumentation and Control - Automatic and manual control of each of the SBDGs and the ESF equipment requiring automatic sequencing is provided. Controls for safety-related equipment are generally provided in the control room as well as at equipment locations. Redundant control circuitry and control power sources are compatible with their associated power circuits. 36 2

Instrumentation is provided to manually synchronize each SBDG with the ESF bus and to continuously monitor the status of the safety-related systems. Control power for the SBDG systems is obtained from the associated ESF 125 vdc systems. The status of each SBDG is indicated in the control room, including the following parameters:

1. Voltage, current, power, and frequency 36
2. Breaker position of each bus supply and feeder breaker
3. Cooling water pressure and temperature, lube oil pressure and temperature, starting air pressure, fuel level, and engine rpm

The bypass or inoperability status of each SBDG is automatically indicated in the control room through the ESF Status Monitoring System described in Section 7.5.4. The conditions alarmed through this system are the following: 49 Q430. 122N

1. DG not in remote mode
2. Loss of starting air/starting air system malfunction
3. Loss of control power
4. Start circuit inoperable
5. Emergency stop push button not reset
6. Overspeed lockout not reset
7. Generator differential lockout not reset

Inoperability of the SBDGs may also be manually indicated through the Status Monitoring System. These conditions each have their own alarm windows. The SBDG monitoring complies with the guidelines of Branch Technical Position (BTP) PSB-2.

These signals to the ESF Status Monitoring System, as well as other annunciator and computer alarms for various DG conditions, are shown on Figure 8.3-4 (Sheet 1).

AC control power for vital instrumentation and controls is supplied by six solid-state inverter/rectifier systems. The inverter/rectifiers are connected as shown on Figure 8.3-3. The inverter/rectifiers supplying power to instrumentation channels I and II are normally energized by 480 vac feeders from separate MCCs connected to different bus sections of the Train A, 480 vac switchgear. The inverters/rectifiers supplying power to channels III and IV are normally energized by 480 vac feeders from MCCs connected to the 480 vac switchgear in Trains B and C, respectively. Upon loss of power from the 480 vac feeds, the inverter/rectifiers are automatically powered from the Class 1E ~~DC~~ system. The output of ~~the~~ each inverter/rectifier is 118 vac, single phase, 60 Hz. Vital ~~AC~~ power from the inverter/rectifier is distributed by the instrumentation power supply buses, which consist of Class 1E distribution panel boards. Manually operated, mechanically interlocked main circuit breakers in each distribution panel permit energization of the bus either by the corresponding inverter/rectifier or by an alternate 120 vac, single-phase, regulated, backup source, as shown on Figure 8.3-3. 36 38 36 ± 2% 38

8.3.1.1.4.6 <u>Onsite Standby Power Supply System Protection</u> - The onsite standby power system is provided with protective devices to:

- Isolate faulted equipment and circuits from unfaulted equipment and circuits
- Prevent damage to equipment
- Protect personnel
- Minimize system disturbance

To ensure safe and proper operation of the system, the following interlocks and lockout features are provided: 36

1. Both the 4.16 ESF kV bus supply breakers (normal and standby generator feeds) are tripped and locked out upon the occurrence of a bus fault for that particular bus (Train A, B, or C).

2. Each 4.16 kV ESF bus supply breaker and the generator breaker for its corresponding standby DG are interlocked in such a manner that it is not possible for the DG breaker to close automatically unless the 4.16 kV ESF bus supply breaker is open. However the bus normal supply and the DG breaker can be manually closed to provide parallel operation for periodic testing of the DG sets.

Insert 1 ↓

3. ~~The disconnect switch associated with the auxiliary ESF transformer is interlocked to prevent simultaneous closing~~, thus avoiding a parallel connection between the standby transformers and the 138 kV emergency transformer. 52

4. In the automatic mode, the standby DG breaker control has permissive interlocks to prevent closing the breaker until the standby DG attains approximately 95 percent of rated frequency and voltage. Whenever the standby DG is tripped or stopped, the DG breaker is automatically opened.

Insert 2

Insert 1

The motor operated disconnect switches on the primary side of the auxiliary ESF transformer are mechanically interlocked to prevent simultaneous closing,

Insert 2

5. In the event of a normal supply breaker overcurrent trip, a signal is provided to a lockout relay which prevents closing of the generator breaker.

The details of the protection system are as follows:

1. 4.16 kV ESF System Protection - The bus incoming breaker is tripped by the auxiliary ESF transformer differential relay. In addition, instantaneous directional overcurrent and time overcurrent relays are provided in each phase to protect against reverse current and provide back-up protection to individual load feeders. |52

   Outgoing feeders from the 4.16 kV ESF switchgear are provided with overcurrent relays in each phase which trip the circuit breakers upon sensing overload and fault.

   Each motor circuit is provided with two sets of three phase ~~overcurrent~~ c relays. One set of relays provides ~~short~~ c circuit protection; ~~whereas~~ the other set provides an overload alarm.

   Each outgoing feeder is also provided with a ground sensor relay which provides a common alarm, along with the auxiliary ESF transformer ground sensing relay.

2. Diesel Generator Protection - Each standby DG is provided with the following protection: 36

   a. Generator differential

   b. Reverse power flow

   c. Loss of field excitation

   d. Low lube oil pressure (engine and turbocharger)

   e. Excess vibration

   f. Turbocharger thrust bearing failure

   g. Engine overspeed trip

   h. High jacket water temperature

   i. High engine/generator bearing temperature

   j. Generator overcurrent

   k. Generator underfrequency

   l. Ground fault

   m. Negative sequence

The above trips for the DG remain functional during periodic testing of the DGs. However, during emergency operation of the DGs all but the following protective trips are automatically bypassed: 52

a. Generator differential
b. Low lube oil pressure (engine and turbocharger)
c. ~~b.~~ Engine overspeed 36

Note: Coincident logic is required for low lube oil pressure trip.
The bypassed protective functions are alarmed in the control room to alert the operator to take appropriate action.

In addition the normal supply breaker overcurrent trip provides input to a lockout relay, which locks out the DG supply breaker from closing. 49

3. Each 4.16 kV ESF bus is provided with two levels of undervoltage detection as indicated in Figure 8.3-4, Sheet 5 of 5. Q430.107N

The adequacy of station electric distribution system voltages is in compliance with BTP PSB-1.
→ insert 1

4. 480 V ESF System Protection: Each 480 V ESF load center connected to the 4.16 kV ESF buses is protected against bus fault by a supply circuit breaker with a direct acting, solid state trip device having short time and long time trip functions. These breakers also provide backup protection to the individual load feeders. The 480 V feeders to MCCs and static loads are each similarly protected by a circuit breaker with short time and long time trip functions.

Feeders to motors from the 480 V ESF load center breakers are provided with long time and instantaneous trips. The 480 V Class 1E system is an ungrounded system and hence a ground fault is sensed at the switchgear bus; it is then alarmed in the control room.

The 480 V ESF MCCs have the combination motor starters which are provided with magnetic, instantaneous trip circuit breakers for short circuit protection. The static loads are provided with thermal magnetic breakers which provide overcurrent and short circuit protection. Motor circuits are provided with thermal overload devices in each of the three phases. The overload elements are set to protect the motor and the feeder cable. For all safety-related motor operated valves, the thermal overload devices are used for alarm only. 36

5. Safety-related 120 vac ESF System: Each 120 vac ESF system outgoing feeder is provided with overcurrent and short circuit protection by a thermal magnetic breaker or fuse. Single pole breakers are used for 120 V single phase circuits. The 120 vac ESF distribution panels are provided with a main circuit breaker which provides backup protection to the feeder circuit breakers or fuses.

The 208/120 V system is solidly grounded through the 480-208/120 four wire distribution transformers. The circuit breakers will trip on phase to phase or phase to ground fault. The 120 vac instrument (i.e., vital) bus is ungrounded. 43 43

insert "1"

The voltage setting on the relays is determined from an analysis of the voltage requirements of the safety-related loads at all distribution levels, taking into consideration the maximum and minimum voltage range of the offsite power system, various plant loading conditions and selection of appropriate tap setting of the intervening transformers. The time delays for the relays are chosen such that:

a. The allowable time delay, including margin, does not exceed the maximum time delay that is assumed in accident analysis.

b. The selected time delay minimizes the ability of short duration disturbances to reduce the availability of the offsite power source.

c. The allowed time duration of a degraded voltage condition at all distribution system levels does not result in failure of safety systems or components.

The above described protection system for the safety-related power system is analyzed and relay settings are coordinated so that a fault at any point in the system is isolated quickly without excessively damaging the equipment or interfering with the operation of the rest of the system. The relay settings also provide selective tripping so that the protective device closest to the fault will trip before the back-up device is actuated.

During pre-requisite testing each protective device will be tested for proper operation to verify the relay settings obtained ~~by~~ from the analysis.

Extensive use of solid state protective relays and integral solid state trip devices minimizes the set point drift on the relays. Also periodic testing of the relays and verification of their settings provide reliable operation of the power system. The protective devices provide visual indication of their operation locally (e.g. target on the protective relays and trip position of the circuit breakers). 36

Limiting conditions for operation during the degraded ESF bus condition will be included in the plant Technical Specifications with sufficient details.

The details of the Containment electrical penetrations protection (RG 1.63) are described in the following. Both safety-related and nonsafety-related electrical penetrations are protected against short-circuit. The protection is provided by source and feeder breakers with coordinated short circuit protection. This protection limits the maximum I^2t at the penetration to a value far less than that resulting in thermal damage to the penetration seals. Details of the specific protection scheme are provided below:

1. The only medium voltage power circuits passing through the electrical penetrations are reactor coolant pump (RCP) motor power feeders. RCP motors are fed from 13.8 kV auxiliary buses 1F, 1G, 1H, and 1J through a feeder breaker. This switchgear is located in the Turbine Generator Building (TGB) which is a non-seismic Category I Building. Protection for the penetration conductors is provided by coordinated primary and back-up protection using feeder and supply breakers, respectively. The feeder and supply breakers are supplied with 125 vdc control power from separate 125 V battery systems. 43

2. The 480 V power circuits (Class 1E/non-Class 1E) are fed from load centers and MCCs. Protection for the penetration conductors is provided by coordinated primary and backup protection using feeder and supply breakers. ~~respectively.~~ Protection for each circuit is reviewed and when coordinated protection cannot be achieved, a redundant breaker in series is provided with identical tripping characteristics.

3. 125 V dc control circuits are protected by ~~double pole~~ fuses and the system is ungrounded. ~~Therefore an~~ Any overcurrent condition is detected by two devices in series and, if one fails, the other provides the necessary protection.

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4 120 V ac control circuits are low energy circuits and are protected by one fuse. The energy released by short circuits on control cable in general is sufficiently low that backup protective devices are not required. Control circuits will be analyzed and backup devices are provided where required. 43

5. For instrumentation circuits the possible energy release for a faulted circuit is compared to the maximum that the penetration can withstand so 36
that redundant protective devices are not generally required. Backup devices are provided where required. 43

8.3.1.1.4.7 Testing of Onsite Standby Power System Equipment - Provisions are made for periodic testing of the Onsite Standby Power System equipment in compliance with RG 1.22, IEEE 338-1977 and BTP PSB 2. 29 Q 45 Q430 430.33N

Each SBDG is subjected to standard factory tests and inspections prior to shipment to the site. In addition, prior to startup of the plant, each SBDG is subjected to the field acceptance tests of starting, load acceptance with design load, full load rejection, etc., in accordance with IEEE 387-1977 and RGs 1.9 and 1.108. 33N 29 Q 430 33N 49

The ability to restart a DG by a "fast start" signal subsequent to normal shutdown of the DG is verified by functional and starting tests prior to start-up of the plant.

The objectives and requirements of the above tests are detailed in IEEE 387-1977 and RGs 1.9 and 1.108. Periodic testing of the ~~SBDGs~~ Onsite Standby Power System is conducted to verify ~~their~~ its availability and capability to perform ~~their~~ its safety functions as follows: 49 29 Q430. 33N

1. Tests are performed to verify that each SBDG can be started manually and automatically, synchronized, and loaded to nameplate rating when connected in parallel with the normal power source. Each SBDG is operated under these conditions for a minimum of one hour which is sufficiently long to demonstrate the ability of the equipment to perform its safety function. 36

   During testing, if an SI ~~actuation~~ signal occurs while the SBDG is paralleled to the normal power source, the SI ~~actuation~~ signal takes precedence, and the SBDG feeder breaker is automatically tripped by a signal directly from the ~~SI~~ ESF Actuation System. The 4.16 kV ESF bus supply breaker remains closed, and the ESF loads are connected to the 4.16 kV ESF bus by the ESF load sequencer per the design, as described in Section 8.3.1.1.4.4. 36

   The SBDG continues to run, its governor is automatically transferred to the isochronous mode, and its voltage regulator is put in the automatic mode, thereby enabling it to respond automatically to an emergency signal without the need for any operator action. Under these conditions, all non-critical protective devices are bypassed, as described in Section 8.3.1.1.4.6. 36

   If a non-critical trip occurs during testing, the SBDG ~~trips.~~ shuts down. Upon a subsequent SI ~~actuation~~ signal, the SBDG starts up automatically and runs with its governor in the isochronous mode with the non-critical protective devices bypassed. 36

   insert "X" → ~~If the offsite power source is lost while in parallel with the SBDG during testing, the SBDG feeder breaker trips automatically on overcurrent. Upon detection of undervoltage on the 4.16 kV ESF bus, Mode I is initiated by the ESF load sequencer, as described in Section 8.3.1.1.4.2.~~ 36

   When the local control position is selected at the SBDG local control panel to perform maintenance and testing, ~~a SBDG "Local Position" alarm is annunciated~~ the SBDG bypass or inoperable status window for mode selector switch not in "remote" position is lit in the main control room. An audible alarm is also sounded. 36

Insert X

In the event the DG is operating in parallel with the offsite power source (under test conditions), and the offsite power is lost, the DG feeder breaker will automatically trip. The bus will then experience an undervoltage condition (same as loss of offsite power) and the bus feeder breaker will automatically trip.

Whether the standby DG had been operating in parallel with the offsite power source or operating but not connected to the bus, upon detection of undervoltage on the 4.16 kV ESF bus, Mode II is initiated by the ESF load sequencer, as described in Section 8.3.1.1.4.4.2. The load sequencing has been arranged such that adequate time is provided between the 480V load center breaker closure (allowing time for closing spring charging) in step 2 and the next significant load required during loss of offsite power (centrifugal charging pumps) in step 4.

To prevent any starting of the standby DGs during maintenance, the "OFF" position is selected at the local control panel, and a standby DG inoperable alarm is initiated at the Bypass and Inoperable Status annunciation panel in the main control room. 30

2. Tests are performed to demonstrate the readiness and the ability of each standby DG and ESF load sequencher to start automatically in response to a simulated Mode III, which is a simultaneous SI actuation signal (Mode I) and a LOOP signal (Mode II), and for the DG to reach rated speed and voltage within 10 seconds as follows: 30

a. Simulated SI Actuation Signal (Mode I): to the Standby DG 30

With the ESF Actuation System in test, the standby DG start-up actuation slave relay can be operated directly from the Engineered Safeguards Test Cabinet. The standby DG starts automatically in the isochronous mode. The ESF Actuation System logic is so designed that if an emergency start signal occurs during testing, the automatic actuation circuitry overrides the testing. 30 29Q 430. 33N

insert "1" on next page

b. Simulated LOOP (Mode II): to the Standby DG

With the ESF load sequencer in test position, the operators are able to actuate any one of the four undervoltage relay signals to the ESF load sequencer from the 4.16 kV ESF bus. The ESF load sequencer is so designed that the signal causes a simulated actuation of Mode II (LOOP) time delay logic and contact closures. Under these test conditions, a low current is passed through the external circuits to verify circuit continuity and integrity. (Subsequent tests external to the ESF load sequencer are made to verify the operability of the external loads in accordance with IEEE 338-1977.) 36 45

The standby DG starts up automatically in the isochronous mode with the voltage regulator in the automatic mode. The ESF load sequencer actuation logic is so designed that if an actual emergency Mode II (LOOP) signal occurred during testing, recognized by the actuation of any two out of four undervoltage relay signals, the testing is overridden, and the ESF load sequencer implements the proper mode of operation as described in Section 8.3.1.1.4.4. 36

3. Tests are performed to demonstrate the readiness and ability of each standby DG and ESF load sequencher to start automatically in response to a simulated Mode III and the DG to reach rated speed and voltage within 10 seconds as follows: 36

Simulated signals of Mode I and Mode II, described in 2a and 2b above, are initiated simultaneously coincidentally. 36

The ESF load sequencer logic is so designed that the simultaneous coincident existence of Mode I and Mode II test signals causes a simulated actuation of Mode III time delay logic and contact closure. Under these conditions, a low current is passed through the external circuits to verify circuit continuity and integrity. (Subsequent tests external to the ESF load sequencers are made to verify the operability of the external loads in accordance with IEEE 338-1977.) The testing performed ensures that the ESF load sequencer responds properly to all three entry modes into Mode III as described in Section 8.3.1.1.4.3. 36 45 Q430. 14N

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The standby DG receives start signals ~~simultaneously,~~ from both the ESF Actuation System and the ESF load sequencer, and starts automatically in the isochronous mode with the voltage regulator in the automatic mode.

The ~~ESF Actuation System logic and the~~ ESF load sequencer actuation logic is ~~are~~ so designed that if ~~a simultaneous occurrence of~~ an actual SI ~~actuation~~ emergency signal ~~and a LOOP~~ occurs during testing, the testing is overridden, and the ESF load sequencer implements the proper mode of operation, as described in Section 8.3.1.1.4.4.

4. ~~Tests are performed to demonstrate the readiness and ability of each ESF load sequencer to respond to a simulated SI actuation signal (Mode I).~~

Insert "1" to pg 8.3-16

With the ESF load sequencer and the ESF Actuation System in test, the operators are able to send any one out of six individual slave relay actuation signals from the Engineered Safeguards Test Cabinet to the ESF load sequencer.

The ESF load sequencer logic is so designed that the individual test signal from the Engineered Safeguards Test Cabinet causes a simulated actuation of Mode I (SI) time delay logic and contact closures. Under these test conditions, a low current is passed through the external circuits to verify continuity and circuit integrity. (Subsequent tests external to the ESF load sequencer are made to verify the operability of the external loads in accordance with IEEE 338-1977.)

The ESF load sequencer actuation logic is so designed that if an actual emergency ~~Mode I (SI)~~ signal occurred during testing, ~~recognized by the actuations of four or more SI actuation relay signals,~~ the testing is overridden, and the ESF load sequencer begins the proper mode of operation, as described in Section 8.3.1.1.4.4.

~~The ESF Actuation System logic is so designed that if an accident occurs during the testing, the automatic actuation circuitry overrides the testing. At this time, the DG starts automatically in the isochronous mode with voltage regulator in the automatic mode in readiness for a LOOP emergency.~~

insert "2" →

8.3.1.1.4.8 Optimum Emergency Diesel Generator Readiness - To assure optimum emergency diesel generator readiness and availability on demand, STP is developing a periodic testing program and a preventive maintenance program. The following requirements will be met:

1. Plant procedures will include provisions for loading the diesel generators (DG) to a level that will remove gum and varnish buildup accumulated during periods of no load or light load operation.

2. Periodic surveillance testing will be performed in accordance with RG 1.108 with the exceptions and interpretations in Section 8.3.1.2.10.

3. Diesel generator equipment history records will be maintained and repair records will be reviewed for repeated failures which would warrant further technical investigation.

Insert 2

For normal starting operations (test mode) a timer called a "cranking limit timer", with a range of 5-50 seconds, is provided to conserve air in the starting air tanks should the engine not start. The timer is initially set by the diesel engine manufacturer at 15 seconds. The timer is located in the "incomplete sequence" circuit of the engine control panel. When a start signal is given the starting air solenoids are energized activating the starting air valve alarm check switches, then the starting air valve relay which energizes the cranking limit timer. If the engine has not started in 15 seconds the incomplete starting sequence relay de-energizes indicating an incomplete sequence activating the unit shutdown relay and thus engine cranking stops.

The "cranking limit timer" is bypassed in the emergency mode of operation.

4. Upon completion of repairs or maintenance and prior to an actual start, run and load test in a final equipment check will be made to assure that electrical circuits are functional. In addition, testing procedures will contain instructions to have the diesel generator returned to ready automatic standby service under the control of the control room operator. 45 Q430.24N

8.3.1.1.4.9 <u>Diesel Generator Fuel Oil Storage and Transfer System</u> - Each standby DG is provided with a fuel oil storage tank having enough capacity to operate the system with maximum connected load for a duration of at least 7 days. 36

The fuel oil system design and the factors considered in sizing the fuel oil storage tanks are described in Section 9.5.4. Electrical and mechanical equipment in this system are classified seismic Category I. 36

8.3.1.1.4.10 <u>Diesel Generator Cooling and Heating System</u> - The DG jacket water cooling system is described in Section 9.5.5.

8.3.1.1.4.11 <u>Diesel Generator Lubrication System</u> - The DG Lubrication System is described in Section 9.5.7. 36

8.3.1.1.5 <u>Physical Arrangement and Location of Major Electrical Equipment</u>: The mechanical, structural, and electrical integrity of major electrical equipment is safeguarded by selecting locations for the equipment which reduce the likelihood of physical damage to redundant equipment simultaneously.

Class 1E equipment is separated as much as practicable from non-Class 1E equipment to eliminate ~~minimize~~ the potential for degradation of the Class 1E equipment by failure or malfunction of non-Class 1E equipment. Separation between redundant Class 1E electrical equipment is primarily provided by physical separation as indicated by Figures 1.2-4, 1.2-5 (sheet 1), 1.2-10, 1.2-26, 1.2-28, and 1.2-29. 36

The following is a general description of the separation provided between major electrical components:

1. The main transformers and the unit auxiliary transformer of each unit are located outdoors and are separated from each other by fire walls provided between the transformers ~~units to confine a fire in any unit~~.

   The standby transformer is located on the opposite side of the TGB from the main transformer and the unit auxiliary transformer.

   The 138 kV emergency transformer is located near the switchyard and remote from any of the other large transformers.

   Each ~~All~~ of the above transformers except the 138 kV emergency transformer ~~are~~ is protected by a water deluge fire protection system.

   The main generator breaker is located outside the TGB. 43

   A sump is provided under each oil-filled transformer to contain the transformer oil in the event of rupture of the transformer tank. These ~~This~~ sumps drain ~~s~~ to an oil separator pit for water removal. 36

Each outdoor transformer is protected against ~~lighting~~ lightning and switching surges.

2. Class 1E electrical equipment is located in ~~a~~ structures or buildings which have ~~has a~~ seismic Category I classification. These buildings or structures are so designed as to protect the Class 1E electrical systems from such postulated events as floods, hurricanes, and other natural events, as outlined in Sections 3.3, 3.4, and 3.5.

~~In general~~ major Class 1E electrical power distribution equipment located 36
in the Mechanical-Electrical Auxiliaries Building (MEAB) is arranged so that each train of the three-train ESF System is located on a different floor elevation. Separate rooms or compartments are also provided within each elevation to enhance the physical and electrical independence of 36
each redundant train.

The standby DGs are each located in a separate room of the Diesel-Generator Building (DGB). The associated Class 1E electrical equipment located within each standby DG room is so located and protected within the room as to minimize the possibility of damage due to internally generated

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missiles, pipe ruptures, fires, etc. However, occurrence of any of these events does not affect the ability of the remaining trains of the ESF system to perform their safety function, since no two trains of Class 1E equipment or cables are located in or routed through any of the other standby DG rooms. Independent air intake and discharge air ducts for each DG room are furnished. Sufficient separation and isolation of air intake and exhaust gas ducts are provided to prevent dilution of the oxygen content to the diesel engines by the Air Exhaust System, as described in Section 9.5.8.

Non-Class 1E equipment located within seismic Category I structures or buildings is arranged so that a loss of or damage to this equipment cannot prevent the Class 1E equipment from performing its safety function. This is accomplished by isolation of such equipment from the Class 1E equipment by means of physical barriers, compartments, or suitable physical separation. Separation criteria for cable and raceways are discussed in Section 8.3.1.4. 36

The closest are piping to the electrical penetrations inside the Containment Building ~~is~~ the component cooling water lines (10" CC -1117 WA3) at Elevation 32'-9" with approximately 1'-10" metal to metal separation distance ~~above~~ from the nearest electrical penetration. Other piping runs including the chilled water lines, condensate lines, instrument air lines, station air lines, and fire protection water lines are in the vicinity of the electrical penetrations separated by distances of at least 7 feet from the penetrations. 2 Q40.4 36

3. Electrical penetration assemblies are provided for cables entering the Reactor Containment Building. Separate quadrants at three different elevations are selected for locating these penetrations. Three penetration areas are utilized for separate ESF trains and the RPS channels. In areas where penetrations for both an ESF train and an RPS channel are located, the penetration assemblies are grouped separately. Centerline to centerline separation between adjacent electrical penetrations within a given train or channel is 4 ft. 36

Control and instrumentation penetrations for RPS channels I and II are located at the same elevation. However, penetrations associated with these RPS channels are adequately separated to ensure their integrity during any possible event.

There is a total of 69 electrical penetrations for each unit. 36

There are 27 electrical penetrations located between Elevations 19'-0" and 37'-3" inside the Containment ~~and between~~ (Elevations 10'-0" and 35'-0" outside the Containment). 2 Q40.4

These groups of electrical penetrations have been assigned circuits to Train A, instrumentation channels I and II, and other miscellaneous related ~~to circuits of~~ the above. ~~(For all penetration locations and assignments refer to Table 8.3-12 and Figure 8.3-14.)~~ 36

There are 18 electrical penetrations located between elevations 37'-3" and 52'-0" inside the Containment ~~and between~~ (Elevations 35'-0" and 60'-0" outside the Containment). These groups of electrical penetrations have been assigned to Train B, instrumentation channel III and all other miscellaneous circuits related to ~~circuits of~~ the above. ~~(For penetration locations and assignments refer to Table 8.3-12 and Figure 8.3-14.)~~ 36

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There are 24 electrical penetrations located above Elevation 68'-0" inside the Containment (above Elevation 60'-0" outside the Containment). These groups of electrical penetrations have been assigned to Train C, instrumentation channel IV, and miscellaneous circuits related to the above. (For penetration locations and assignments refer to Table 8.3-12 and Figure 8.3-14.) 2 Q40.4

Design and qualification testing of electrical penetrations is in accordance with IEEE Standard 317-1976 and RG 1.63. Note, however, that electrical penetrations being purchased for the Containment personnel airlock are to be qualified to IEEE 317-1976, which is endorsed by RG 1.63, Rev. 2. 36 49

Protection of the electrical penetrations is provided to preclude a single failure from causing excessive currents in the penetration conductors which would degrade the penetration seals. 29 Q430.21 51 Q430.130N

Power and control field cables to the electrical penetrations are capable of carrying the load current based on the penetrating conductor ampacity as calculated for the electrical penetration protection. 29 Q430.21

8.3.1.2 Analysis. The following summary describes how the AC Power Systems comply with the requirements of NRC General Design Criteria (GDC), NRC RGs, and IEEE Standards. 36

8.3.1.2.1 Compliance with GDC 17, 18, and 21 and RG 1.93: Sections 8.3.1.1.2, and 8.3.1.1.4 describe the normal power distribution system of each unit, with provision for connection to the respective unit auxiliary transformer and the standby transformers, and the onsite standby sources of each unit. This arrangement affords sufficient flexibility and redundancy to ensure the availability of power to the ESF loads in the event of the occurrence of a design basis event. Standby DGs reestablish power to the ESF buses within 10 seconds. The offsite power sources comply with GDC 17 and RG 1.93. 43 36 49

In compliance with GDC 18 and 21, provisions are made to permit:

1. Periodic inspection and testing, during equipment shutdown, of wiring, insulation, connections, and relays to assess the integrity of the systems and the condition of components. 36

2. Periodic testing, during normal plant operation of the operability and functional performance of onsite power supplies, circuit breakers, and associated control circuits, relays, and buses.

3. Testing, during plant shutdown, of the operability of the Class 1E system as a whole. Under conditions as close to design as practical, the full operation sequence that brings the system into operation, including operation of signals of the ESF actuation system and the transfer of power between the offsite and the onsite power system is tested.

8.3.1.2.2 Compliance with RG 1.6: Section 8.3.1.1.4 describes the onsite standby power sources and explains the degree of separation and independence that exists between the three subsystems.

The three-train arrangement of power sources and load groups is designed to meet the single-failure criterion.

8.3.1.2.3 Compliance With RG 1.9: Each SBDG is rated on the basis of the sum of the nameplate ratings of the ESF loads it energizes during an accident.
During step loading of the SBDG, possible voltage dips and frequency devi- 36
ations due to the application of large motor loads may occur. These deviations do not exceed 20 percent of the nominal voltage and 5 percent of the nominal frequency. Recovery from such variations is within the RG 1.9 posi-
tion (i.e., voltage restored to within 10 percent of nominal and frequency 36
within 2 percent of nominal within 60 percent of each load sequence time interval). The DG protective trips are tagged by the ERF computer with a time, but time resolution provided may not be sufficient to identify the first trip
as depicted by Rev. 2 of RG 1.9. 49

8.3.1.2.4 Compliance With IEEE 279-1971 and RG 1.32: Class 1E systems and equipment comply with the requirements of IEEE 279-1971 (as amended by RGs
1.47 and 1.62 and RG 1.32) by virtue of the separation, redundancy, and inde- 36
pendence provided in the various systems and the location of equipment in seismic Category I buildings and structures. Surveillance of Class 1E Systems
will be described in the Technical Specifications. 36

8.3.1.2.5 Failure Mode Analysis: Application of the single-failure cri-
terion to safety-related systems is used to analyze failures of components and 4
causes and effects of failures in systems. Tabulations of failure modes and
effects are shown in Tables 8.3-9 and 8.3-13. 12

8.3.1.2.6 Effects of Hostile Environments on Electrical Equipment: Class 49
1E electrical equipment is designed to withstand the effects of the environ- 36
ment existing at the equipment locations. All equipment located inside the
Containment and required to operate during and after a design basis event is 49
identified in Table 3.11-3.

8.3.1.2.7 Compliance with RG 1.75: The design and layout of the electric system is in accordance with ~~the intent of~~ RG 1.75, As noted in Sections
~~8.3.1.3,~~ and 8.3.1.4. ~~For NSSS scope systems the position on RG 1.75 is des-~~ 36
~~cribed in Section~~ 7.1.2.2, 7.A.II.F.2.3,

8.3.1.2.8 Compliance with RG 1.53: The design of the safety-related electrical system is in accordance with the single failure criterion as discussed in RG 1.53.

8.3.1.2.9 Conformance With Appropriate Quality Assurance Standards: Conformance to RG 1.30 is as stated in Table 3.12-1 and Chapter 17. 36

8.3.1.2.10 Compliance With RG 1.108: The requirements ~~Compliance with the intent~~ of RG 45
1.108 are met with the following interpretations and exceptions: Q430.14N

1. Starting air system: System boundary starts at air receivers (isolation 36
valve downstream of the air dryer). Air compressors and dryers are not 430.102N
included since the engine can be started five times from air stored in 100 49
percent redundant (2 full capacity) receivers for each engine. 36

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2. Fuel Oil System: Fuel oil system boundary starts from the diesel fuel oil tanks and this is not part of the DG system for test purposes.

3. Cooling Water System: The Essential Cooling Water (ECW) System cools the engine jacket water, lube oil, turbocharger discharge and intake air, and governor oil cooler. The ECW system is not part of the diesel generator unit. 36

4. Position on Paragraph C.2.e.7: Tests to verify correction will be conducted after the affected DG is declared "ready for service." The diesel and the associated systems may be operated as necessary to perform troubleshooting and verify correction of specific problems, prior to such declaration, without these operations counting as a test, for the purposes of complying with this Regulatory Guide.

5. Position on Paragraph C.2.a.(3): STP takes a partial exception to the periodic operational load testing of the standby diesel generators. STP will not perform the two hour run at the two hour rating during normal plant operation, as specified in position C.2.a.3 of this Guide. ~~This test requirement is viewed as imposing unnecessary stresses on the machine since the maximum load required for the design basis accident loading sequence operation does not exceed the rating of the diesel generator.~~ The type qualification test performed on an STP diesel generator proved that the STP diesel generator can operate for two hours at the two hour rating. ~~The two hour test at the short time rating will be performed under the preoperational program as described in Section 14.2.12.2 (81). The results of this preoperational test will further demonstrate that the diesel generator and its subsystems will not exceed their respective design ratings under similar conditions.~~ 49 Q430.130N
→ insert "A"
STP will run the diesel generator for 22 consecutive hours at the continuous rating of the diesel generator. 45 Q430.14N

6. Position on Paragraph C.2.d: In addition to the above stated exceptions, the increased frequency of diesel testing in section C.2.d is excessive and may cause premature engine degradation. It is STP's intent to base the increase in testing frequency on the last 20 valid tests instead of the last 100 valid tests. This will reduce the RG 1.108 established reliability goal of .99 by four percentage points to .95, and will significantly reduce the rate of engine wear. The reliability goal of .95 is consistent with Generic Letter 84-15.

The criterion of first out alarm for diesel generator protection is not implemented as it does not reduce the damage to the diesel generator or the down time of the diesel generator.

8.3.1.2.11 Compliance With RG 1.81: Safety-related electrical systems are not shared between Units 1 and 2. Therefore, the design is in compliance with RG 1.81. 36

8.3.1.2.12 Compliance With RG 1.106: Thermal overload units on safety-related motor-operated valves are used to provide alarm only under all 49 Q430.130N

Insert A:

STP will perform the two hour run at the 2000 hour rating in accordance with the Technical Specifications. No transient condition or anticipated future load conditions will exceed the 2000 hour rating of the DG.

conditions. Activation of these thermal overload units is alarmed only in the control room. ~~Overloads which are not used for tripping is not covered by RGE 1.106.~~ 49

8.3.1.3 Physical Identification of Safety-Related Equipment. Class 1E equipment is provided with nameplates having a colored background in accordance with the color designation indicated in Section 8.3.1.4, for easy identification of separation groups.

Safety-related cables are identified by color designation indicated in Section 8.3.1.4. Color coding is provided by colored jackets during manufacturing or in the field by using colored markers of sufficient durability on black cables prior to or during installation, at intervals not exceeding 5 feet in accordance with RG 1.75.

The safety-related tray and conduit system is identified by unique numbers and colors to designate trains, channels or separation groups. Trays and conduits outside the Containment are identified with adhesive-back stickers having a colored background and the printed raceway number. Trays and conduits inside ~~in~~ the Containment have the raceway number stenciled ~~by~~ using colored pigment of the train or channel color. Color coding of the trays and conduits is done at ~~one~~ intervals not exceeding 15 feet, prior to installation of cables. Where cables and conduits penetrate walls and floors, the color markings are applied on both sides of the wall or floor penetration. 36 Q43 19

A description of the Class 1E control boards, panels, etc., furnished by Westinghouse Electric Corporation as part of the Nuclear Steam Supply System, including such items as the Solid-State Protection System, Process ~~Instrumentation and~~ Control System, and the reactor trip switchgear, is provided in Section 7.1.2.3. Other Class 1E equipment supplied by the owner conforms to IEEE Standard 420-1973 and RG 1.75.

Class 1E cables or wire bundles within control boards or relay racks are identified by color codes and/or tags to distinguish between Class 1E redundant separation groups and between cables of Class 1E systems and non-Class 1E systems.

8.3.1.4 Separation of Redundant Systems. Separation is accomplished for redundant equipment and circuits by the following methods:

1. Physically Separate Areas 36
2. Separation by Distance Q43 19
3. Separation by Barriers Q40 4

8.3.1.4.1 Separation Groups: Separation groups are identified as groups A, B, C, D, R, S, N, or M defined as follows.

Separation Group A

A Class 1E instrumentation control or power cable, raceway or equipment related to ESF Train A, ~~DC~~ Subsystem I, vital ~~AC~~ instrumentation and control channel I or ~~PAM-I~~ Post Accident Monitoring (PAM) Channel 1.

Separation Group B

A Class 1E instrumentation, control or power cable, raceway, or equipment related to ESF Train B, DC Subsystem III, or vital AC instrumentation and control channel III.

Separation Group C 36 Q430.19N Q40.4

A Class 1E instrumentation, control or power cable, raceway, or equipment related to ESF Train C, DC Subsystem IV, vital AC instrumentation and control channel IV or PAM Channel 2.

Separation Group D

A Class 1E instrumentation, control or power cable, raceway, or equipment related to DC Subsystem II, or vital AC instrumentation and control channel II.

Separation Group R

Reactor trip and ESF actuation train "R" as identified by Westinghouse. All cables are equivalent to Separation Group A and can be installed in the Group A raceway system with the exception of (1) the interconnecting cables between logic cabinet R and the output actuation cabinets ~~. Additionally,~~ and (2) the 48 V undervoltage trip signals ~~should also be routed in separate conduits.~~ These are to be installed in dedicated steel conduits from the SSPS to the reactor trip switchgear. 49

Separation Group S

Reactor trip and ESF actuation train "S" as identified by Westinghouse. All cables are equivalent to Separation Group B and can be installed in the Group B raceway system with the exception of (1) the interconnecting cables between logic cabinet S and the output acutation cabinets ~~. Additionally,~~ and (2) the 48 V undervoltage trip signals ~~should also be routed in separate conduits.~~ These are to be installed in dedicated steel conduits from the SSPS to the reactor trip switchgear.

Separation Group N (Designated M for the reservoir makeup pump facility)

All non-Class 1E cables, raceways and equipment.

8.3.1.4.2 Separation Color Codes and Measurements: Separation groups A through D and R, S, N and M shall be color coded as follows:

(Protection channels and DC subsystems of a separation group use same color)

Group A: Red (red may be replaced by violet for cables and equipment tags)

Group B: Blue (blue may be replaced by brown for cables and equipment tags)

Group C: Yellow (yellow may be replaced by gray for cables and equipment tags)

Group D: White

Group R: Orange

Group S: Green

Group N or M: Black (black may be replaced by black/white, black/blue, black/yellow, black/violet, black/brown, black/red, or black/gray, for cables)

Horizontal separation is measured to the side rail of ~~the~~ a tray. Vertical separation is measured from the bottom of the upper tray to the top of the side rail of the lower tray. 36

Horizontal, vertical or diagonal separation for conduit is measured to the closest point on the conduit, fitting body or box. Q430 19N Q40.

8.3.1.4.3 <u>Equipment Separation</u>: Equipment separation is described in Section 8.3.1.1.5.

8.3.1.4.4 <u>Raceway and Cable Separation</u>: ~~Cable trays~~ Raceways within a given train or a separation group are separated on the basis of function and voltage class. In general, separate raceways are provided for the following services in each separation group:

1. 13.8 kV ~~classe~~ circuits

2. 4.16 kV ~~classe~~ circuits

3. 600 V power circuits

4. Control circuits

5. Instrumentation circuits

Vertical tiers of cable trays carry the highest energy-level cables in the top tier. Other tiers carry lower energy-level cables in decreasing order to the lowest energy-level in the lowest tier. Instrumentation cabling occupies the lowest tier.

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Both ac and dc circuits rated 600 V and below utilize 600 V class cables. The 600 V class ac and dc power cables are routed in common cable trays. Control cables are routed in cable trays separate from power circuits as much as possible but they may be combined in one tray due to physical restraints. Instrumentation cables and other low-level signal cables are routed in separate raceways from power and control cables.

~~Redundant~~ Class 1E circuits of redundant separation groups are routed in separate penetrations, cable trays, conduits, and ~~ducts~~ other totally enclosed raceways to assure complete separation. Separation of raceway systems is as follows.

8.3.1.4.4.1 Cable Spreading Areas Tray Separation: Cable spreading areas consist of the control room, the relay room and the cable spreading rooms on Elevations 21'-0", 60'-0", and 74'-9", ~~excepting the cable chases~~.

The separation distance in these areas is based on open cable tray of either the ladder or solid bottom type. The minimum horizontal separation distance between different separation group trays is 1 ft. The minimum vertical separation distance between different separation group trays is 3 ft.

8.3.1.4.4.2 General Plant Areas Tray Separation: The separation distance in general plant areas is based on open cable tray of either the ladder or solid bottom type. The minimum horizontal separation distance between separation groups ~~trays~~ is 3 ft. The minimum vertical separation distance between trays of different different separation group trays is 5 ft. 36 043(19N 040.

8.3.1.4.4.3 Conduit-to-Conduit Separation - All Areas: The minimum horizontal, vertical or diagonal separation between conduits of different separation groups is 1 in.

8.3.1.4.4.4 Class 1E Conduit-to-Open Tray Separation:

8.3.1.4.4.4.1 Cable Spreading Areas - The minimum horizontal separation between conduit of any one Class 1E separation group and open cable trays of any other separation group is 1 ft. The minimum vertical separation between conduit of any one Class 1E separation group and open cable trays of any other separation group is 3 ft.

8.3.1.4.4.4.2 General Plant Areas - The minimum horizontal separation between conduit of any one Class 1E separation group and open cable trays of any other separation group is 3 ft. The minimum vertical separation between conduit of any one Class 1E separation group and open cable trays of any other separation group is 5 ft.

8.3.1.4.4.4.3 Class 1E Conduit to Solid Bottom and/or Solid Top Tray Separation - The minimum separation distance between a Class 1E conduit and solid bottom and/or solid top of a tray is 1 in.

8.3.1.4.4.4.4 Non-Class 1E Conduit to Open Tray Separation - All Areas - The minimum horizontal or vertical separation between totally enclosed raceway (described in Section 8.3.1.4.4.7) of non-Class 1E separation Groups N or M and open ventilated cable trays or cables in free air of any ~~Cable~~ Class 1E separation group is 1 in.

~~8.3.1.4.4.5 Exceptions to Area Separation Requirements - Where termination arrangements or plant arrangements preclude maintaining the minimum separation distances a barrier is placed between trays, or the circuits may be analyzed.~~

8.3.1.4.4.6 Separation Within Enclosures - ~~Field~~ cables ~~entering~~ within an enclosure maintain a 6-inch minimum separation between redundant safety-related group cables and between safety-related and nonsafety-related group cables. Where a 6-inch physical separation cannot be maintained, one of the following alternatives is provided:

1. Power

a. Each Class 1E separation group is installed in a totally enclosed metallic raceway. Minimum spacing between enclosed raceways is 1-inch or equivalent in thermal insulation material. The raceway is installed over the entire length of the cables or cable conductors from/to the point where a 6-inch minimum separation distance can be established (e.g., from the point of entry into the cabinet to the point of termination of the cable conductor). 36 Q430.19N Q40.4

b. A metal barrier is erected between the cabling, terminal blocks, or components of the redundant separation groups. A minimum separation of 1-inch or equivalent in thermal insulating material is maintained between the barrier and the cable, terminal blocks, or components. The barrier is extended a sufficient distance beyond the outer edge of the separation group cable or cable bundle such as to allow a minimum of 6 inches of air space between cables of redundant separation groups.

c. In case of less than a 6-inch separation between non-Class 1E cables and Class 1E cables, non-Class 1E cables are placed in totally enclosed metallic raceway and a minimum separation of 1 inch or equivalent in thermal insulating material is maintained between totally enclosed raceways and Class 1E cables. When a 1 inch airspace cannot be provided within the enclosure, a thermal insulating material may be used. Minimum separation may also be established by analysis in accordance with IEEE 384-1974.

8.3.1.4.4.7 Totally Enclosed Raceway - The following raceways are considered totally enclosed raceways: 52 Q430.126N

Rigid steel conduit

Aluminum sheathed cable and copper sheathed cable

Flexible metal conduit ~~(seamless)~~ 52 Q430.126N

Liquidtight flexible metal conduit

Flexible metallic tubing with and without integral connectors

Ventilated steel cable trays with solid steel covers installed at top and bottom of tray

Solid bottom tray with solid steel covers

8.3.1.4.4.8 Separation Criteria for Pipe Failure Hazard Areas - Separation of conduit and cable trays from pipe failure hazards in all areas is accomplished by the use of barriers, restraints, separation distance, or the appropriate combination thereof. Where it is not possible to prevent damage

Insert "A"

2. Control and Instrumentation Cables.

   a. Each Class 1E separation group is installed in a totally enclosed metallic raceways. The raceway is installed over the entire length of the cables or cable conductors from/to the point where a 6-inch minimum separation distance can be established (e.g., from the point of entry into the cabinet to the point of termination of the cable conductor).

   b. A metal barrier is erected between the cabling, terminal blocks, or components of the redundant separation groups. The barrier is extended a sufficient distance beyond the outer edge of the separation group cable or cable bundle such as to allow a minimum of 6 inches of air space between cables of redundant separation groups.

   c. In case of less than a 6 inch separation between non-Class 1E cables and Class 1E cables, non-Class 1E cables are placed in totally enclosed metallic raceway. Minimum separation may also be established by analysis in accordance with IEEE 384-1974.

to a Class 1E raceway in the event of a pipe failure, an analysis is performed to assure that safe shutdown capability is maintained. The protective mechanisms provided for pipe failure are further discussed in Sections 3.6.1.3.2 and 3.6.2.4.

8.3.1.4.4.9 Separation potential Criteria for Missile Hazard or Flooding Areas - Separation of conduit and cable trays from missile hazards, ~~in all areas is accomplished where possible by the use of barriers, orientation, separation distance, or the appropriate combination thereof. Where this separation is not practical, the routing of Class 1E conduit and trays through the area conforms to the following requirements:~~ 49 Q430.125N 36 Q430.1 Q40.4

~~1. Where the missile source involved is not assignable to a single division, and the failure causing the missile does not require protective action, Class 1E conduit and trays routed through the area are limited to a single division.~~ 49 Q430.125N 49 Q430.125N

~~2. Where the failure of the missile source involved requires protective action, Class 1E conduit and trays are not routed through the area except for those which must terminate at devices or loads within the area.~~

or flooding is accomplished where possible by the use of barriers, orientation, separation, distance, or the appropriate combination thereof. Where it is not possible to prevent damage to a Class 1E raceway in the event of a missile hazard or flooding, an analysis is performed to assure that safe shutdown capability is maintained.

~~9. Where the safety related missile source is assignable to a single division but this failure requires no protective action, Class 1E conduit and trays routed through the area are limited to the same division as the missile source.~~

8.3.1.4.4.10 Underground Class 1E Ductbanks - Where Class 1E cables must be installed between Seismic Category I structures and ~~where~~ no physical connections exist for continuation of exposed trays or conduits, underground Class 1E duct systems are provided.

Separate ducts are provided for each redundant Class 1E separation group; however, since the ducts are enclosed in reinforced concrete, the duct enclosure for ~~all~~ several separation groups may be common. Instrumentation cable and cables of different voltage levels are routed within manholes in a manner that maintains a separation commensurate with that outlined for general plant areas.

8.3.1.4.4.11 Electric~~al~~ Penetration Area - Containment electric penetrations are physically separated ~~on~~ and located at different ~~floor~~ elevations of the Containment wall. ~~and Electrical Auxiliary Building.~~ The vertical and horizontal separation distances between redundant separation groups are not less than the minimum acceptable separation distances of 3 ft horizontally and 5 ft vertically for general plant areas.

Electric~~al~~ penetrations and piping penetrations are located in different quadrants of the Containment circumference. There are no possible missile sources inside or outside the Containment electric~~al~~ penetration areas. In addition, all nonconducting, nonmetallic materials are flame retardant. 36 0430.19N 040 04

Assignment of penetrations is tabulated in Table 8.3-12 and locations of penetrations are shown on Figure 8.3-14.

8.3.1.4.4.12 Raceway Supports - ~~Cable trays~~ Raceway supports, ~~conduit supports and cable ducts~~ for Class 1E circuits are designed to comply with Seismic Category I requirements. ~~Cable trays~~ Raceway supports for non-Class 1E ~~circuits~~ raceways which are located in areas which contain safety-related or Class 1E equipment, ~~are also designed to comply with Seismic Category I requirements.~~ insert "B"

8.3.1.4.4.13 Cable Routing and Cable - Cables going to the control room ~~and~~ belonging to ~~a~~ separation groups (A and D), ~~and~~ or (B and C) are generally routed through separate cable chases and cable spreading rooms within the Electrical Auxiliary Building. Separation group A and D cables enter the lower cable spreading room while separation groups B and C cables enter the upper cable spreading room.

Non-Class 1E cables are not routed through Class 1E raceways.

Cable trays penetrating ~~horizontally through~~ fire rated walls or vertically through floors are provided with fire stops.

The fire barriers used to achieve required separation in lieu of spatial separation are rated for 3 hours unless ~~otherwise~~ a lesser rating is demonstrated adequate.

Ampacity rating and group derating factors of cables are in accordance with manufacturers' standards which comply as a minimum, with ICEA P-46-426 for cables in conduit or ducts and with ICEA P-54-440 for cables in trays. Power

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FSAR CR * 703

INSERT B

... are designed such that they will not fail during a safe-shutdown earthquake to the degree that they will degrade, to an unacceptable level, the ability of safety related, seismic Category I structures, systems and components to perform their required safety function.

cables rated at 5 kV and 15 kV are installed with 1/4 diameter maintained spacing in the trays. For power conductors rated at 600 V and below, tray fill is generally limited to 35 percent of the usable cross section of a 5-inch deep tray. In cases where this condition is exceeded, each individual case is reviewed for adequacy of the design. For trays containing only control or instrumentation cables, a 40 percent fill of a 5 inch deep tray limitation is applied in general. 45

As a minimum, power cables are sized using 100 percent load factor and rated for 90°C conductor temperature. Correction factors for ambient temperature other than 40°C are incorporated in accordance with ICEA publication P-54-440.

As stated in Section 3.11, cables are qualified in accordance with RG 1.131.

Conduit fill is based on 53 percent fill for one conductor, 31 percent fill for two conductors and 40 percent fill for three conductors or more.

8.3.1.4.4.14 Associated Circuits and Isolation Devices - Equipment that is not qualified as Class 1E and does not perform a safety function but which is connected to the 1E system through isolation devices. These circuits which by RG 1.75 definition are classified as "associated", are identified as Class 1E from the Class 1E source up to and including the isolation device. The circuit from the isolation device to the equipment is identified as non-Class 1E unless it otherwise becomes associated by sharing an enclosure or raceway with Class 1E equipment or circuits. Circuits which share an enclosure or raceway subsequent to the isolation device but which are not connected to Class 1E circuits are identified as Class 1E. Therefore, associated circuits are not identified as such but either as Class 1E or non-Class 1E. 36 Q 430.198 Q 40.4

The following are classified as isolation devices:

1. Class 1E Isolation Transformers.

2. Class 1E Thermal Magnetic Trip Devices which are tripped on receipt of a SI signal.

3. Class 1E Digital Isolators (See Section 8.3.1.5.1).

4. Class 1E Analog Isolators (See Section 8.3.1.5.2).

5. Class 1E control switches with 6" separation or barriers between separation groups.

6. Control circuit fuses (Class 1E) which isolate the non-Class 1E circuit prior to the operation of the Class 1E circuits protective device.

7. Class 1E relays with barriers.

8. Redundant Class 1E thermal magnetic trip devices in series.

9. Class 1E current transformers.

Devices which are located in the TGB (a non-seismically designed building) but which are connected in Class 1E circuits are routed in dedicated non-Class 1E rigid steel conduit in accordance with Section 8.3.1.4. 43 Q 32.31

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8.3.1.4.4.15 Administrative Responsibilities and Controls for Assuring Separation Criteria - The cable and raceway channel identification described in Sections 8.3.1.3 and 8.3.1.4.2 facilitates and ensures the maintenance of separation in the routing of cables and the connection of equipment control boards and panels. At the time of the cable routing assignment during design, those responsible for cable and raceway scheduling check to ensure that the separation group designation in the cable number is compatible with a single-line-diagram load group designation. Extensive use of computer facilities assists in ensuring separation. Each cable and raceway is identified in the computer program, and the identification includes the applicable separation group designation. Auxiliary programs are made available specifically to ensure that cables of a particular separation group are routed through the appropriate raceways. The routing is also confirmed by quality control personnel during installation to be consistent with the design document. Color identification of equipment, raceways, and cabling assist field personnel in this effort. 36 Q430.19N Q40.4

8.3.1.5 Engineered Safety Signal Isolation System. The Engineered Safety Signal Isolation System provides Class 1E to non-Class 1E and non-Class 1E to Class 1E digital and analog signal isolation while maintaining Class 1E integrity in accordance with RG 1.75. This system uses solid state components to the maximum extent practicable, consistent with interface and reliability requirements. Interchangeability is provided for all similar modules, components, or assemblies. Dissimilar modules, components, and assemblies do not permit interchangeability. To prevent incorrect insertion or interchange, cable connectors, if required, are keyed and identified. The isolation device terminal arrangement provides physical separation in accordance with RG 1.75. When isolation barriers are required, they are in accordance with RG 1.75. 32 36

To comply with RG 1.75, additional consideration is emphasized as follows:

- Mercury wetted relays are not used.
- Printed circuit board layout provides separate input and output patterns and components. 32
- Relay sockets ensure separation of relay ~~pins~~ coils and ~~terminal~~ contact connections. 36

8.3.1.5.1 Digital Isolation: Digital isolators are optical components. Separation is maintained in the interrogation of Class 1E field contacts e.g., Class 1E train A designated field contacts are interrogated only by Class 1E train A power. 32

8.3.1.5.2 Analog Isolators: Analog isolators are ~~both~~ transformer-coupled or ~~and~~ optically-coupled types whose functions and operation are neither disturbed by nor transmit electromagnetic or noise interference. Analog isolator linearity and stability does not decrease significantly as a function of time and temperature. The isolators are accurate within 0.5 percent of the input span.

8.3.2 DC Power Systems

8.3.2.1 Description. The ~~DC~~ Power Systems of Units 1 and 2 each consist of four Class 1E 125 vdc battery systems and Balance-of-Plant (BOP) battery systems ~~composed of~~ including one 48 vdc, two 125 vdc, and one 250 vdc battery in each unit 36 43

as shown in Figure 8.3-3. There are separate batteries provided with the plant computer, and other data acquisition systems. These batteries do not interface with the rest of the plant ~~DC~~ Power System. | 36

8.3.2.1.1 <u>Class 1E Battery Systems</u>: The Class 1E 125 vdc Battery System~~s~~ of each unit consists of four independent, physically separated buses, each energized by two battery chargers and one battery. Voltage on any seperate bus varies between 105-~~140~~ 135 vdc depending on the operating mode of battery charging equipment and system loads. The batteries are sized in accordance with IEEE 485-1978. | 49 Q430.107N

Emergency power required for plant protection and control is supplied by the batteries without interruption when the power from ac sources is interrupted. Each battery system also supplies power to its associated inverter system, which converts the dc power to ac power ~~at 118 vac, 60 Hz single phase~~ for the vital instrumentation and protection system, ~~The six vital ac buses supply power to instrumentation channels I, II, III, and IV. There are two vital ac buses each for channels I and IV, and one vital ac bus each for channels II and III~~ as discussed in Section 8.3.1.1.4.6. | 29 Q280.03N | 36

The ampere-hour capacity of each battery is sufficient to provide, for a minimum of 2 hours, the power required by emergency dc controls and the vital ac instrumentation and protection system. Only small dc loads and dc controls are supplied from the 125 vdc batteries. | 43 | 49 | 29 Q2 03

~~The two battery chargers associated with each of the four 125 vdc buses are connected to separate ac buses of the same train to enhance the reliability of each dc bus. Only one charger each is required for channels II and III and both chargers for each of channels I and IV are required.~~ | 13 | 36

The four 125 vdc batteries are each located in separate rooms in a seismic Category I building which inhibits the propagation of fire and provides protection against missiles. Battery chargers and distribution panels associated with a given battery are located outside of the battery room. Each battery room is ventilated by the Heating, Ventilating, and Air Conditioning (HVAC) System (Section 9.4.1) ~~through separate intake and exhaust~~ using fans which are energized from the ESF buses. | 49

The Class 1E DC Power Systems are designed to withstand the effects of tornadoes, fires, and the Safe Shutdown Earthquake (SSE) without loss of function. Flooding of the battery rooms is precluded by the elevation and location of the battery rooms in the Mechanical-Electrical Auxiliaries Building (MEAB).

The environmental and seismic qualification programs of the Class 1E battery system are discussed in Sections 3.10 and 3.11. The Class 1E Battery System ~~are~~ is designed to comply with the requirements of NRC RGs 1.6 and 1.32. | 39

Each ~~DC~~ System is provided with an annunciator window having inputs from each of the two chargers and the switchboard. The ERF computer may be used to identify which of the three inputs is being alarmed. | 43 Q430.35N

Each battery charger is provided with the following alarm circuits which are connected in common to the control room annunciator/ERF computer to indicate battery charger trouble:

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~~1. Input undervoltage (ac)~~

1. ~~2.~~ Output under and overvoltage (dc)

2. ~~3.~~ ~~dc ground~~ STET

~~4. Output breaker position (alarm when open)~~

Each 125 vdc switchboard has the following alarm circuits which are connected in common to the control room annunciator/computer: ERF | 43

1. Input breaker position from battery charger (alarm when open)

2. Input breaker position from battery (alarm when open)

3. Output breaker positions of selected loads (alarm when open) ~~Battery overcurrent (computer only)~~

~~4. Battery charger no current/overcurrent (computer only)~~ 36

4. ~~5.~~ dc bus ground and over/under voltage (combined) Q430. 35N

→ insert "1"

The following indicating instrumentation for each ~~switchboard~~ dc system is provided in the control room:

1. Switchboard bus voltage

2. Battery current

3. Battery charger current from each charger

Each battery is protected by an air circuit breaker with long-time and short-time protection. | 36

Identification of Class 1E dc systems and equipment is discussed in Section 8.3.1.3.

8.3.2.1.2 Class 1E Batteries: Class 1E 125 vdc batteries are 59-cell lead-calcium type, assembled in shock-absorbing, clear plastic, sealed containers. Noncombustible spacers are provided between cells and cell clamps to prevent shifting during seismic events. The battery cells are mounted on seismic Category I, corrosion resistant, steel racks. | 36 | 2

The batteries are suitable for continuous float duty and are maintained in a nominally fully charged state by the battery chargers. The batteries are sized to carry their connected ESF loads for two hours without power flow from the chargers in the event of loss of ~~all~~ ac power. | 36

The ESF loads energized from each dc bus are shown in Table 8.3-6.

Upon loss of power from the ~~AC~~ System to the battery chargers, the batteries automatically assume the load without switching. In the event that all off-site ac sources are lost, ac power to the battery chargers is supplied by the standby DGs. | 36

Insert 1

In addition to these annunciator alarms, the ESF Status Monitoring System, described in Section 7.5.4, is used to indicate bypassed or inoperable status of the battery or battery chargers. Component-level windows provided for the dc system indicate the following conditions:

1. Input undervoltage, charger output breaker open position or charger input to switchboard breaker open position for each battery charger. (ERF computer is used to indicate which condition caused the window to light.)

2. Battery output breaker open position.

As indicated in Section 7.5.4, actuation of any component-level window also actuates the system-level window for that system and affected systems.

Each battery is sized to provide a minimum of 1.78 V/cell at the discharge state after 2 hours. 49

8.3.2.1.3 <u>Battery Chargers</u>: ~~Each Class 1E Battery System consists of two battery chargers associated with each 125 vdc battery~~. 2
→ insert "1" 36

~~Battery chargers are sized to recharge the battery within 12 hours from the discharged state (1.78 V/cell) to the nominally fully charged state (when the charging current has stabilized at the charging voltage 2.33 V/cell, even though specific gravities have not stabilized) while supplying loads indicated in Table 8.3-6.~~ 36 29 Q 28 49 Q3 43 39

The output voltage of each battery charger is adjustable to ±10 percent of the value required for periodic equalizing charging of the battery (i.e., ±10 percent of 141 vdc). 29 13 Q28 43 37N

AC power to the Class 1E battery chargers associated with a given battery is supplied from independent MCCs connected to double-ended sections of switchgear. The switchgear sections are energized from the ESF buses and supplied with power from the standby DGs when offsite sources are unavailable.

Independence of the four battery systems is ~~secured~~ achieved by separation of cables and equipment and by prohibiting cross-ties between load groups in different trains. 36

Each battery charger is equipped with a dc voltmeter and ammeter. Protection against power feedback from the battery to the charger and ac source, upon loss of the ac source, is provided. 43

8.3.2.1.4 <u>Testing</u>: Periodic testing of Class 1E ~~DC~~ Power System equipment is performed in accordance with RG 1.32 to verify its ability to perform its safety function.

The batteries and chargers are inspected and tested in accordance with the Technical Specifications. 36

Visual inspection, liquid level, specific gravity, and cell voltage and temperature checks are performed routinely on the batteries. 36

Additional testing in accordance with RG 1.129 is performed. 36

8.3.2.1.5 <u>Service Equipment</u>: ~~All~~ Equipment of the ~~DC~~ Power Systems is located in ~~a~~ ventilated, controlled environments outside of the Reactor Containment Building. 2

Class 1E ~~DC~~ Power System ~~cables or supporting structures~~ circuits penetrating into the RCB are designed to operate in the post-accident environment for the period of time required to maintain the plant in a safe shutdown conditions following a Design Basis Accident (DBA), as discussed in Section 3.11.

8.3.2.1.6 <u>Non-Class 1E Battery Systems</u>: The non-Class 1E Battery Systems in each unit consist of one 48 vdc distribution panel bus, two 125 vdc distribution panel buses and one 250 vdc distribution panel bus. These buses are energized by two battery chargers and a battery. 43

Insert 1

There are two battery chargers associated with each of the four 125Vdc buses. These chargers are connected to their train related ac buses. One charger is required for each of Channels II and III. Two chargers are required for each of Channels I and IV.

The battery charger configurations, as stated above, are sized to restore the battery voltage within 12 hours after being discharged for the batteries' 2 hour duty cycle. The batteries are floated at 2.20V/cell (130 Vdc) and equalized at 2.27(±1%) V/cell (135Vdc).

The plant computer ~~DC System~~ and other data acquisition ~~DC~~ Systems are supplied with separate batteries. These battery systems do not interface with the other DC Systems. | 43

These non-Class 1E battery systems are entirely independent of the Class 1E batteries and the Class 1E DC Distribution System. There are no interconnections between the two classes of systems. The 250 vdc system generally supplies the large balance-of-plant loads, such as the turbine generator emergency lube oil pump and other similar loads. The 125 vdc systems supply smaller balance-of-plant loads, such as switchgear control power. The 48 vdc system is used exclusively for the plant annunciator and has no interface with the Class 1E DC Power System. | 36

Generally, characteristics and specifications of these batteries and battery chargers are similar to those of the Class 1E Battery Systems, but it is not intended that they necessarily meet Class 1E equipment requirements.

8.3.2.2 Analysis. The following summary highlights the compliance of the design of the Class 1E DC Power Systems with the NRC GDC, and NRC RGs. | 36

Failure modes and effects analysis for the Class 1E DC System is presented in Table 8.3-8. | 36

8.3.2.2.1 Compliance with GDC 17, 18 and 21: As described in Section 8.3.2.1, the Class 1E DC Power Systems are designed with sufficient flexibility and redundancy to ensure the availability of power to the plant protection ~~and control~~ systems under all postulated design basis events. In addition, when all off-site ac sources are lost, the stored energy in the batteries is sufficient to supply the power needs of critical instrumentation and control systems for a duration sufficiently long to restore the ac power sources. Therefore, the design is in compliance with GDC 17. | 36

Provision for periodic inservice testing of Class 1E DC Power System equipment is made in compliance with GDC 18 and 21. This testing verifies the availability and capability of equipment to perform its design functions. | 13

8.3.2.2.2 Compliance with RG 1.6: Figure 8.3-3 and Section 8.3.2.1 describe the separation, redundancy, and independence which exists within the Class 1E DC Power System to meet the single-failure criterion. | 36 | 13

8.3.2.2.3 Compliance with RG 1.32: To comply with RG 1.32, a study of dc loads under normal operating conditions and under accident conditions was made to determine the largest demand on each battery. Each battery was sized on the basis of meeting dc loads determined by the load study. Each battery charger is sized as discussed in Section 8.3.2.1.3. Battery performance and service test will be in compliance with RG 1.32. | 3 | 36

8.3.2.2.4 Compliance with RG 1.75: The design and layout of the Electrical Raceway System and circuits comply with the requirements of RG 1.75, as discussed in Section 8.3.1.4.1. | 3

8.3.2.2.5 Compliance with RGs 1.128 and 1.129: The Class 1E DC System is in compliance with RG ~~1.128 and~~ 1.129, and with RG 1.128 with the exception of Section 5.2.2(12) of IEEE 484-1975 endorsed by RG 1.128. The intercell connection resistance will not be greater than 150x10^-6 ohms, in accordance with NUREG 0452 (July 27, 1981) Section 4.8.2.1. Testing is described in Section 8.3.2.1.4. | 36

8.3.2.2.6 Conformance with Appropriate Quality Assurance Standards: Quality assurance, described in Chapter 17, applies to all equipment of the Class 1E DC Power System and its installation, in accordance with IEEE Standard 336-1971 and NRC RG 1.30. Conformance with RG 1.30 is as stated in Chapter 17 and Table ~~3.12?~~ 3.12-1. 36

8.3.2.2.7 Compliance with RGs 1.22, 1.47, 1.53, 1.62, 1.81, 1.93 and 1.106: The Class 1E DC System is in compliance with RGs 1.22, 1.47, 1.53, 1.62, 1.81, 1.93, and 1.106 similar to Class 1E AC Systems as stated in Section 8.3.1.

8.3.3 Fire Protection for Cable Systems

The measures employed for prevention of and protection against fires in electrical cables are described in Section 9.5.1 and in the Fire Hazards Analysis Report.

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