328

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TABLE OF CONTENTS

8. ELECTRICAL SYSTEMS

329

[redacted]

LIST OF TABLES

LIST OF FIGURES

[redacted]

330

8. ELECTRICAL SYSTEMS

8.1 DESIGN BASIS

The plant is designed to be electrically self-sufficient with adequate auxiliary equipment and standby power to assure safe handling of all emergency situations.

To prevent the concurrent loss of all auxiliary power, the various sources of power, including emergency diesel generators, are independent of and isolated from each other. The power supply and control of equipment providing engineered safeguards are arranged to minimize the possibility of a loss of their operating functions due to physical damage.

Electrical equipment will be purchased and tested to stringent requirements for reliability and quality, including appropriate NEMA, USASI and IEEE electrical standards.

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8.2 ELECTRICAL SYSTEM DESIGN

8.2.1 ELECTRICAL SYSTEM DESIGN NETWORK INTERCONNECTIONS

8.2.1.1 Network Interconnections

The unit will generate electrical energy at 22 kv which will be transmitted to the unit main transformer where it will be stepped up to 230 kv transmission voltage. Five overhead transmission lines will transmit energy from the generating station switchyard to switchyards in the area transmission network. The transmission system and the Rancho Seco switchyard include provisions for a second generating unit. 2

8.2.1.2 System Diagrams

Figure 8.2-1 is a single line diagram of the bus arrangement for the Rancho Seco switchyard. Figure 8.2-2 gives the projected 1973 transmission system of Sacramento Municipal Utility District.

8.2.1.3 Reliability Considerations

Reliability considerations to minimize the probability of power failure due to faults in the electrical system are as follows:

a. Flexibility and capability will be designed into 230 kv network interconnections by installing five transmission circuits from the generating station switchyard to switchyards in the area transmission network. The area transmission system is capable of transmitting all area generation to load centers under adverse conditions with any one line out of service.

b. Three circuits will be installed on two double circuit towers; space for one additional circuit will be available. Two circuits will be installed on a double circuit tower following a different route. 2

c. The data for each line connected to the Rancho Seco switchyard is described as follows:

To	Length	Minimum Longtime Capability	Expected Annual Outage Rate
Tesla	60.0 mi	400 MW	1.2
Hedge	22.5 mi	275 MW	0.42
Hurley	27.5 mi	275 MW	0.52
Bellota #1	28.5 mi	605 MW	0.40
Bellota #2	28.5 mi	605 MW	0.40

2 Approximately 2.9 line outages per year are anticipated for all lines terminated at the switchyard, more than 90 percent of which are of transient nature. Outages for a period longer than one second are expected to be approximately 0.25 per year. These estimates are made on the basis of routine maintenance being performed at the time of normal plant shutdown for maintenance and refueling.

d. The bus arrangement in Figure 8.2-1 will provide two 230 kv main buses. Primary and backup relaying will be provided for each circuit along with circuit breaker failure backup protection. The switchyard provisions will permit the following:

(1) Any circuit can be switched under normal or fault conditions without affecting any other circuit.

(2) Any single circuit breaker can be isolated for maintenance without interrupting the power or protection to any other circuit.

(3) Faults on a main bus will be isolated without interrupting service to any circuit.

(4) Backup relaying will insure against primary relaying failure to trip.

2 (Deleted)

8.2.2 STATION DISTRIBUTION SYSTEM

8.2.2.1 Systems Design

The plant distribution system will consist of the various electrical systems designed to provide reliable electric power during all modes of operation and shutdown conditions; and mechanical safeguards necessary to assure adequate personnel protection, including protective relaying, grounding and prevention or limitation of equipment damage during system fault conditions. The systems will be designed with sufficient power sources, redundant buses, and the required switching to provide these functions. Engineered safeguards auxiliaries will be arranged so that loss of a single bus for any reason will still leave sufficient auxiliaries to safely perform the required function.

On complete loss of power, the emergency diesel generators will start automatically. One-line diagrams of the system are shown on Figures 8.2-1 and 8.2-3. A multiple bus system ensures the reliability of the station auxiliary power distribution system. The buses have access to:

1 a. The Rancho Seco generator when running via unit auxiliary transformers.

2 b. The 230 Kv system via start-up transformer No. 1.

[redacted]

c. The 230 kv system via start-up transformer No. 2. 2

d. The emergency diesel generators.

The station distribution system is capable of starting the largest drive with the remainder of the motor load in service. Protective relaying is arranged for selective tripping of circuit breakers, thus limiting the loss of power to the affected area.

8.2.2.2 Power Generation and Transmission

Electrical energy generated at 22 kv is fed through an isolated phase bus to the main transformer. Overhead conductors carry this power to the switchyard for transmission over outgoing lines. The 230 kv system is 2
also the source of power for the two startup transformers.

8.2.2.3 Unit Auxiliary and Start-Up Transformers

During normal operation the source of electrical power for all normal 4160-volt plant auxiliaries load will be provided by the 4160-volt unit auxiliary transformer which is connected to the generator isolated phase 3
bus. All nuclear services auxiliaries load will normally be provided by 4160-volt start-up transformer No. 2 which is connected to the 230 kv switchyard. During normal operation all of the 6900-volt auxiliaries load 1
will be provided by the 6900-volt unit auxiliary transformer which is connected to the generator isolated phase bus. The unit auxiliary transformers as well as the start-up transformers will be sized to carry full 3
plant auxiliaries load. During start-up and shutdown, and after a unit trip, all of the plant auxiliary power is provided by the two start-up 1
transformers. One secondary winding of start-up transformer No. 1 will have a 4160-volt tap in each phase. These taps will provide a second 2
source of off-site power to the 4160-volt nuclear service buses.

8.2.2.4 6900-Volt System

The 6900-volt auxiliary system will be designed for the reactor coolant pump motors. The system will be arranged into two bus sections. During normal operation, both buses will be fed from the unit auxiliary trans- 1
former. During start-up and shutdown, the two buses will be fed from 3
6900-volt start-up transformer No. 1. Normal "live-bus" transfers between the start-up transformer source and the unit auxiliary transformer source 2
during startup and shutdown are manually initiated with momentary source paralleling during transfer. On loss of the unit auxiliary transformer or unit trip, there will be an automatic transfer to start-up transformer 3
No. 1.

8.2.2.5 4160-Volt System

Six 4160-volt buses will be provided, two for the normal 4160 volt reactor/ turbine auxiliaries, two for the engineered safeguards 4160-volt auxiliaries, 2
and two for the circulating water pumps and one condensate pump.

3

On loss of the unit auxiliary transformer or unit trip, there will be an automatic transfer of the unit auxiliaries to start-up transformer No. 2.

On normal or emergency shutdown of the unit, a second or standby source of off-site power will be available for the nuclear services 4160-volt auxili-
3 aries. It will be supplied by start-up transformer No. 1 and will be applied by automatic transfer when normal supply is lost. A bus tie circuit is provided between the nuclear service buses.

2 Upon loss of normal and standby power sources, the two 4160 volt nuclear service buses will be energized from the emergency diesel generators. Bus load shedding, bus transfer to the diesel generators, and pickup of engineered safeguards loads will be automatic as required.

2 No single failure shall result in the loss of more than one nuclear service switchgear bus. The nuclear service buses at the 4160-volt level are redundant.

No single failure shall prevent the connection of a power source to a sufficient number of buses to safely shut down the reactor.

No single failure shall result in a total elapsed time, starting at initia-
1 tion by protection systems and ending at full speed of the high pressure injection and decay heat pumps, of more than 25 seconds.

All safeguards buses can be tested as follows:

2 a. Components connected to any nuclear service bus can be tested individually at any time.

b. Disconnecting normal supply breaker to the nuclear services bus 1B will initiate automatic transfer to the standby
3 supply source subject to voltage being available from start-up transformer No. 1.

c. Disconnecting bus supply breakers for either bus 1B or 1C will initiate starting sequence of the appropriate diesel generator and trip the tie breakers between the buses.

8.2.2.6 <u>480-Volt System</u>

The 480-volt system is divided into four buses, two for the normal 480-volt reactor/turbine auxiliaries and two for the engineered safeguards 480-volt auxiliaries. Power for each bus is supplied from a separate station service transformer which will be fed from the 4160-volt system and arranged so that each transformer is fed from a different 4160-volt bus. Various 480-volt motor control centers will be located throughout the plant to supply power to normal or safeguards equipment within the respective areas.

The system is arranged so that multiple pieces of equipment with a common function will be fed from different buses; thus, the loss of any one 480-volt bus will not deprive the facility of all equipment associated with that particular function. Bus tie circuits are provided between nuclear
3 service buses with two circuit breakers in series to prevent the loss of two buses when there is trouble with one of the tie circuit breakers.

8.2.2.7 <u>Control Rod Drive Power</u>

Two 480-volt, 3-phase sources are provided for the control rod drive power. Each source is fed from one 480-volt normal switchgear bus and has the capacity to supply the total rod drive requirements.

8.2.2.8 <u>125-Volt D-C System (Figure 8.2-3)</u>

The 125 volt d-c system will be designed to provide a source of reliable continuous power for d-c pump motors, control, and instrumentation.

The 125 volt d-c system will consist of six isolated bus sections. Four (4) for the reactor plant, and two (2) for the turbine plant. Each bus section will be supplied by a 60-cell battery and one battery charger. 1

One standby charger will be provided for the two turbine plant buses and 1
one for each pair of reactor plant buses. The battery charger units for each 125-volt d-c bus will be energized from the 480-volt nuclear service 2
buses which, in turn, have diesel power available. Two chargers can be operated in parallel for fast recovery or emergency conditions. Each charger will provide continuous d-c load and floating charge, with occasional equalizing charge as required. Charger failure will be annunciated in the control room, as initiated by voltage failure relays in the d-c output and 480-volt a-c supply. Each bus section will include a d-c motor control center and distribution panel.

The anticipated loads on each battery bus are as follows:

a. <u>Battery 1E - Turbine Plant</u>: One-Half Hour Emergency Load 1

(1) Turbine emergency oil pump.

(2) Boiler feed pump turbine emergency oil pumps.

(3) Emergency seal oil pump.

(4) Reactor coolant pump emergency bearing oil pumps.

b. <u>Battery 1F - Turbine Plant</u>: Two-Hour Emergency Load 1

(1) Turbine plant switchgear control.

(2) Miscellaneous turbine control.

(3) Generator and auxiliaries control.

(4) Emergency lighting.

(5) Inverter - computer.

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c. Batteries 1A, 1B, 1C and 1D - Reactor Plant: Two-Hour
1 Emergency Load

2 (1) Inverter - reactor control and protection and engineered safeguards.

(2) Nuclear service switchgear control.

1 (3) Emergency lighting.

(4) Miscellaneous reactor control.

2 (5) Nuclear service d-c buses (1A and 1D only).

(6) Control Rod clutch power d-c buses (1B and 1C only).

1 The reactor plant batteries 1A, 1B, 1C and 1D will be designed with suffi-
cient capacity to carry their respective loads for 2 hours. The normal
and standby battery chargers connected to these batteries will be fed from
2 diesel-powered nuclear service buses.

The turbine plant batteries 1E and 1F will be designed with sufficient
capacity to carry their respective loads as shown above. Battery capacities
1 will be determined on basis of discharge to 1.75 volts/cell. The normal
battery chargers connected to these batteries will be fed from turbine plant
motor control centers. The standby battery charger connected to these
2 batteries will be fed from either diesel-powered nuclear service motor con-
trol center.

All normal and standby battery chargers will be designed to fully recharge
their respective battery in 8 hours. The reactor plant battery chargers
1 will be designed to carry the connected load under all operating conditions
except for complete loss of all on site and off site a-c power. The turbine
plant battery chargers will not be designed to carry the connected motor loads.

Tests to be performed on the batteries will be as follows:

a. Individual cell specific gravity and voltage will be checked once a month, using at least 2 pilot cells per battery.

b. Water level will be visually checked at the same time.

c. Once a year all inter-cell and inter-tier connectors will be checked for corrosion and tightness.

1 d. Voltmeters and ammeters will be provided as well as battery ground indication.

e. Upon installation and periodically thereafter a discharge rate for 1/2 hour will be imposed upon the battery. A check of battery voltage before and after the test will prove whether the battery discharge characteristics remain on the predicted curve.

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8.2.2.8.1 Single Failure Analysis of the 125-Volt D-C System

As shown in Table 8.2-1, the 125-volt d-c system will be arranged such that a single fault within the system will not preclude the reactor protective system, engineered safeguards protective system and the engineered safeguards from performing their safety functions.

8.2.2.9 <u>120-Volt A-C Essential Power System (Vital Buses - Figure 8.2-3)</u>

The 120-volt a-c essential power system will be designed to provide a reliable source for essential power, instrumentation, and control loads under all operating conditions. The system will consist of four 120-volt a-c bus sections, each supplied from a static inverter. Each static inverter will be supplied from a separate 125-volt d-c system bus. System low voltage or frequency will be annunciated in the control room. Each of the four bus sections will include a distribution panel.

8.2.2.9.1 Single Failure Analysis of the 120-Volt Vital Power Buses

The system is arranged such that any type of single failure or fault will not preclude the reactor protective system, engineered safeguards protective system and engineered safeguards from performing their safety functions. This is evident in Figure 8.2-3 since there are four independent buses available to the unit, and a single failure within the system can involve only one bus.

8.2.2.10 <u>120-Volt A-C Unregulated Power System (Figure 8.2-3)</u>

A low voltage 120-volt a-c power system will be provided to supply instrumentation, control, and power loads requiring unregulated 120-volt a-c power. It will consist of distribution panels and 480-120-volt transformers fed from motor control centers.

8.2.2.11 <u>Lighting</u>

Lighting is provided to permit the safe performance of operating and maintenance duties. Adequate emergency lighting is provided in essential operating areas to permit the safe performance of emergency operating duties. The switchyard and plant perimeter lighting is supplied at 277/480 volts. Plant normal lighting is supplied at 120 volts and 277/480 volts; and emergency lighting is supplied at 120 volts, all fed from the main lighting distribution switchboard. A portion of the a-c lighting switchboard is automatically transferred to the 125-volt d-c battery system, providing emergency backup lighting to vital areas. 2

338

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TABLE 8.2-1
SINGLE FAILURE ANALYSIS FOR THE 125-VOLT D-C SYSTEM

Component	Malfunction	Comments and Consequences
1. 125-Volt D-C Power Supply - Battery Charger	Loss of power from one	The 125-volt d-c bus would continue to receive power from its respective battery without interruption. A standby charger can be manually placed in service.
2. 125-Volt D-C Batteries	Loss of power from one	The 125-volt d-c bus will be supplied from the battery charger.
3. 125-Volt D-C Bus 1A, Bus 1B, Bus 1C or Bus 1D	Loss of power from one	The four 125-volt d-c control panelboards are arranged such that loss of one bus will not preclude safe shutdown or operation of engineered safeguard systems. 2
4. 125-Volt D-C Bus 1A, Bus 1B, Bus 1C or Bus 1D	Grounding single bus or conductor	The 125-volt d-c system is an ungrounded electrical system. Ground detector equipment will be provided to monitor and alarm a ground anywhere on the 125-volt d-c system. A single ground will not cause any malfunction or prevent operation of any safety system.
5. 125-Volt D-C Bus 1A, Bus 1B, Bus 1C or Bus 1D	Gradual decay of voltage on one bus	Each 125-volt bus will be monitored to detect the voltage decay on the bus and initiate an alarm at a setting above a voltage where the battery can deliver its power for safe and orderly shutdown of the plant.

8.2.3 EMERGENCY POWER SYSTEM

8.2.3.1 System Design

When the nuclear unit is installed at Rancho Seco, there will be four
sources of power available to the unit. Each source will have various 2
degrees of redundancy and reliability as outlined below:

a. As described in 8.2.2.3, all of the normal power supply to 3
plant auxiliary loads will be provided through the 4160-volt 1
unit auxiliary transformer connected to the generator bus,
and all nuclear service auxiliary load will be provided by 3
4160-volt start-up transformer No. 2, which is connected to
the 230 kv system. During normal operation all of the 6900- 2
volt auxiliary load will be provided by the 6900-volt unit
auxiliaries transformer. However, the unit auxiliaries
transformers as well as the start-up transformers will be 3
sized to carry full plant auxiliary loads.

Upon separation of the unit from the 230 kv system with no
inplant emergency, neither the reactor nor the turbine will
be tripped. Load will be abruptly reduced to that required 2
by the plant auxiliary demand, and the unit will continue in
service. Automatic provisions for abrupt loss of load are
covered in section 7.2.3.4 The unit auxiliary transformers 2
will thus supply power except when:

(1) The nuclear generating unit is not running.

(2) There is an equipment failure which prevents continued operation of the turbine-generator.

b. If power is not available from the unit auxiliary transformers, 1
it will be obtained from the start-up transformers. Start-up
transformer No. 2 will be connected to 4160 volt nuclear 2
service buses 1B and 1C. The 4160-volt tap on 6900-volt
winding of start-up transformer No. 1 will be connected to 3
4160-volt nuclear service Bus 1B by automatic transfer on
loss of start-up transformer No. 2.

c. Power to the start-up transformers will be provided by a
separate 230 kv connection from each bus which in turn will
be supplied from any one of five 230 kv transmission circuits 2
connected to the two buses. The start-up transformers will
supply power except when:

(1) There is a 230 kv system blackout.

(2) Multiple equipment failure. 2

(3) Connections to the 230-kv switchyard fail. 2

340 1

d. Upon loss of all sources of power described in (a) through
2 (c) above, power will be supplied from two automatic, fast
start-up emergency diesel engine generators.

2 These generators will be sized so that either one can carry
the total required engineered safeguards load for DBA on
the main unit, including plant blackout shutdown requirements.
2 A preliminary estimate of the rating of each emergency generator is 2,850 kw.

1
2 Each emergency generator will feed one nuclear service
2 4160-volt bus. Each unit will be located in a separate room
in the reactor auxiliary building; separated by Class I fireproof walls. There will be no interconnecting piping, wiring,
or ventilation ducts through these walls.

Each diesel will be air started by its own independent system
which will include tanks, piping and valving. Air will be
supplied by the plant air system, check valves at each tank
1 will prevent back flow in the event the main air supply is
lost. The air tanks will be sized to be capable of two
sequential starts without recharging.

Each diesel will have its own independent lubricating system
and will be provided with a fuel tank with sufficient capacity
for approximately two hours full load operation. The level in
each tank will be maintained automatically. Two independent
emergency fuel tanks, each with a 7 day fuel supply, and
3 each with dual transfer pumps, will be located remotely from
each other on opposite sides of the plant. They will supply
fuel automatically to the individual diesel generator fuel
tanks.

2 The diesel generators will be air cooled using two indepen-
1 dent cooling systems.

2 Control signals for the two diesel generators will be in
1 separate cables, routed through separate trays and conduits.
2 This separation will also be maintained at the switchgear and
at the control boards.

1 Each diesel generator will be protected by a permanently
installed fire protection header system. A rate of temperature rise detector, which will actuate a fire alarm signal
locally and in the control room, will be provided for each
2 of these two systems.

Each diesel generator will be started upon the occurrence of
any of the following incidents:

(1) Initiation of safety injection operation.

2 (2) Loss of external power from startup transformers.

341

(3) Loss of voltage on the 4160-volt nuclear service buses with which the emergency generators are associated. 2

The sequence of operation following the diesel generator starting signal will be as follows: 3

Step 1. Automatic tripping of all breakers on the bus, including bus tie breakers.

Step 2. After the units come up to speed and voltage, the emergency generator breakers will automatically close.

Step 3. Manual starting of equipment as required for safe plant operation.

If there is a requirement for engineered safeguard systems operation coincident with the loss of voltage on the 4160-volt bus, step 2 will be automatically followed by the sequential starting of safeguards equipment. 2

The sequential loading of the diesel-engine generator with engineered safeguard auxiliaries will be accomplished by the use of a high speed excitation system and by using machine voltage and excitation recovery as initiating events for starting of the next auxiliary in the chain. Loads will be added in blocks within the diesel engine generator's capability of accepting them. Timers will be used to (1) prevent a race with the next auxiliary in the chain, and (2) initiate tripping of a component which fails to start within a reasonable time, thereby preventing the sequence from stopping. 2

When starting the diesel-engine generators from a dead start, the safety injection systems will be in operation within 25 seconds.

e. All of the power sources that supply power to the 4160-volt bus sections which serve the engineered safeguards' auxiliaries and reactor protective systems will be arranged so that a failure of any single bus section will not prevent the respective systems from fulfilling their protective functions.

f. Postulating Loss of Off-Site Power Combined With a Design Basis Accident <u>Single Failure Analysis for the Engineered Safety System</u> 1

Component	Malfunction	Comments & Consequences
(1) Nuclear Service 4160 Volt Bus 1B or 1C	Short circuit	(With the loss of external power each 4160 v bus will be isolated from the others.) The

2 1 2 1

Margin		Component	Malfunction	Comments & Consequences
1 2 1 3 1				corresponding 480 volt nuclear service switchgear and motor control center will be lost, however, there are redundant valves and auxiliaries connected to the remaining switchgear sections and motor control center for safe shutdown.
2 1 3 1	(2)	Nuclear Service 480-Volt Bus 1B or 1C	Short Circuit	(a) The faulted bus will be isolated by protective circuit breaker action so that no 480-volt auxiliaries will be lost.
2 1				(b) One 480-volt nuclear service switchgear section and motor control center will be lost. Sufficient redundant suxiliaries will be fed from the remaining switchgear and motor control center. The d-c feeds to two battery chargers will be lost, but the respective battery will carry the load.
2 1	(3)	Motor Control Center Bus	Short Circuit	The faulted motor control center will be isolated by protective circuit breaker action. The a-c feeds to two battery chargers will be lost, but the respective battery will carry the load. No protective function will be lost and sufficient redundant valves and auxiliaries will be operative for safe shutdown.

0 343

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	Component	Malfunction	Comments & Consequences	Rev.
(4)	Any Bus or Feeder	Open circuit	The consequences could, at the most, result in the loss of one 4160-volt bus and the corresponding 480-volt bus and motor control center. Sufficient redundant valves and auxiliaries would remain in service for safe shutdown.	2 1
(5)	Nuclear Service 480-Volt Bus Tie Circuit Breaker	Short circuit across and to ground	There are two circuit breakers between 480-volt nuclear service buses 1B and 1C. Any such failure would be isolated from the unfaulted switchgear by the second circuit breaker. The remainder of the analysis would be identical to 2.	2 1
(6)	Diesel Generator A or B	Failure	The consequences would be identical to those of 1 above. Sufficient redundant valves and auxiliaries would remain in service for safe shutdown, fed from the remaining diesel generator.	2 1
(7)	Any Engineered Safety Feature Device	Failure	Separate undervoltage detection, relaying and logic are provided for each diesel generator and the corresponding 4160-volt and 480-volt switchgear buses. The maximum result of a failure of any component would be that of loss of one diesel generator system. Sufficient auxiliaries would remain in service to safely shutdown the plant.	2 1

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	Component	Malfunction	Comments & Consequences
2 1 3	(8) Any Load Shedding or Connecting Circuit Breaker	Malfunction	(a) There are two circuit breakers between buses and failure of one to open or undesired closing of one will have no effect. Failure-to-trip the incoming circuit breaker will result in lockout of the corresponding diesel generator.
1 2			(b) Malfunction of a load shedding circuit breaker would result in the inclusion of that load in the first block of equipment started by the corresponding diesel generator. Each diesel generator will be capable of starting any two safeguards motors simultaneously. The other diesel generator system would not be affected.
1 2			(c) Failure-to-close of one diesel generator breaker would result in the loss of a redundant sytem, as described in 1 above.
1	(9) Battery 1A, 1B, 1C or 1D	Loss of one	If the loss of a battery occurred during the first 10 seconds after initiation of diesel engine starting, the d-c feed to one inverter, one channel of reactor protection and some instrumentation circuits would be lost during this period but would be recovered when the a-c buses reenergize on closing

345

Component	Malfunction	Comments & Consequences
		the generator breaker. Since the reactor protection system operates on a two out of four basis, the loss of one channel would not cause an inadvertent trip. The d-c feed to one 4160-volt nuclear service bus would be lost thereby preventing closure of the diesel generator breaker. The consequence would be as described in 7C above. If the loss of a battery occurred after the diesel generator breaker was closed, the battery charger would carry the above mentioned loads.

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2
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8.2.3.2 Diesel Generators

2 The capacity of each of the two diesel generators will be adequate to supply 100 percent of the 4160 and 480-volt engineered safeguards and emergency power requirements fcr safe plant shutdown independent of unit and 230 kv sources of power. The units will be sized for the maximum steady state load under DBA and/or blackout conditions including the capacity to supply motor starting inrush requirements.

The following loads will be automatically applied in the sequence shown in the event of a loss-of-coolant accident coincident with a loss of power:

2

Loading Sequence*	Description	Load
Block 1	1 - Make-up pump	700 hp
3 Energize at:	1 - Decay heat removal pump	400 hp
0 + 15 sec.	Isolation valves, emergency air compressor, air compressor, air conditioner, etc.	150 hp
	2 - Battery chargers @ 30 kva	60 kva
Block 2	2 - Reactor building emergency air cooler @ 100 hp	200 hp
Energize at: 0 + 25 sec.	1 - Reactor building spray pump	250 hp
2 Block 3	1 - Nuclear Service raw water pump	450
Energize at:	1 - Nuclear Service cooling water pump	200 hp
0 + 40 sec.		2410 hp
Block 4**	1 - Auxiliary feed pump started manually if required	1000 hp
Total		3410 hp

*Diesel started at time 0 + 1 sec.
**This motor not required on a DBA condition.

2 The above represents 2800 kw for the most heavily loaded bus and will not exceed the diesel-generator nameplate rating. When both diesel-generators are running the interlocking will be provided such that the tie breakers connecting the engineered safeguard buses cannot be closed to parallel the generators. In addition, provision will be made to prevent paralleling the diesel with the exchange system when the two are out of phase.

8.2.3.3 Station Battery

The capacity of each 60-cell station battery is adequate to supply the 125 volt d-c power and control requirements for safe plant shutdown independent of outside sources of power and to provide control power to re-energize the plant auxiliary systems upon restoration of the start-up source.

[redacted]

8.2.3.4 Post Accident Operation 1

Electrical components within the containment (reactor building) required for proper functioning of the engineered safeguard systems are as follows: 2

a. Electric motor isolation valves. 1

b. Reactor building emergency cooling fan motors.

c. Instrument cables.

d. Power and control cables. 2

e. Penetrations

f. Reactor building sump level instruments.

g. Pressure Switches.

8.2.3.4.1 Component Operation

The valves must operate long enough to isolate the reactor building. The emergency cooling fans must operate to cool the reactor building environment following the accident.

The reactor building sump level instruments must operate following the accident. Cables associated with each of the above equipment need to operate as long as the equipment is required. All of this equipment will be designed to perform its required function during the reactor building 1
design basis accident.

It is expected that the final analysis of operating requirements for engineered safeguards equipment will indicate that the reactor building emergency cooling fans, the reactor building sump level instruments and associated cabling will be the only equipment required to operate for an appreciable time in post accident ambient conditions.

8.2.3.4.2 Testing

The instruments will be of a type which have demonstrated capability to perform under the environments specified. 2

The fan motors to be furnished with the reactor building emergency cooling fans will be designed so that windings and bearing surfaces are protected against the accident ambient. Motor housings will withstand 60 psi and will be provided with an air-to-water heat exchanger to be supplied from 1
the same source as its accompanying ventilating cooling coil. The heat exchanger will be selected to maintain a low humidity internal ambient with

safe winding temperatures. By proper selection of insulation type and allowable temperature rise, plus a rating in excess of load, the motor operating temperature would be at or near the accident temperature. Bearings will be of a seal type which will withstand the pressure pulse and will be cooled along with the motor internal air.

Purchase specifications will require that tests have been performed on duplicate components of equipment and cable representative of those items required for post accident operation. Certified test data will be requested prior to purchase.

The tests performed will simulate the actual environmental conditions during the 40 years of plant life plus the added exposure of an accident. The length of accident exposure will depend on the length of time that the component is required to function after the accident. All components must survive the cumulative effects of all tests while performing at rated
2 current and potential.

Gamma radiation tests will be performed on all components consistent with total exposure determined on the basis of 40 year plant life and accident time.

Pressure-temperature transient test will be performed on all components in a test chamber having an initial condition of 120 F ambient temperature and atmospheric pressure. Steam will be admitted into the chamber at a rate simulating the temperature and pressure transient of an accident with a pressure rise to 150 percent of containment design pressure.

All components listed above will be subjected to the tests described herein.

The tests to be performed will be specified and included as a requirement of the equipment and material supply contracts. Certified test reports of equivalent equipment or material subjected to similar tests will be acceptable, subject to approval.

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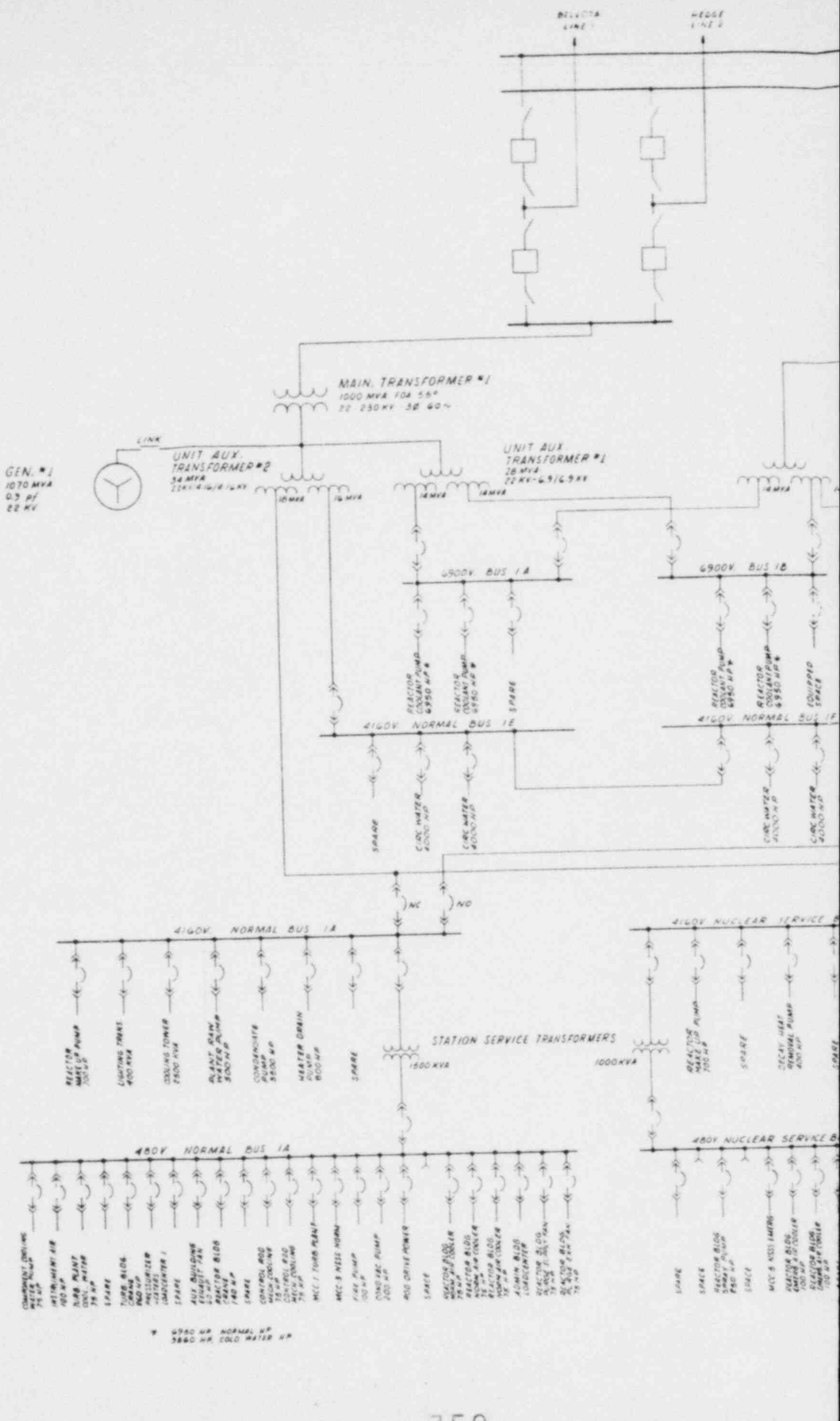
349



MAIN. TRANSFORMER #1
1000 MVA FOA 55°
22-230 KV 3Ø 60~
LINK
GEN. #1
1070 MVA
0.9 pf
22 KV
UNIT AUX. TRANSFORMER #2
34 MVA
UNIT AUX. TRANSFORMER #1
28 MVA
16 MVA
14 MVA
6900V. BUS 1A
6900V. BUS 1B
REACTOR COOLANT PUMP 6950 H.P. *
SPARE
EQUIPPED SPACE
4160V. NORMAL BUS 1E
4160V. NORMAL BUS 1F
CIRC. WATER 4000 H.P.
NC
NO
4160V. NORMAL BUS 1A
4160V. NUCLEAR SERVICE B
REACTOR MAKE UP PUMP 700 H.P.
LIGHTING TRANS 400 KVA
COOLING TOWER 2500 KVA
PLANT RAW WATER PUMP 300 H.P.
CONDENSATE PUMP 3500 H.P.
HEATER DRAIN PUMP 800 H.P.
STATION SERVICE TRANSFORMERS
1500 KVA
1000 KVA
DECAY HEAT REMOVAL PUMP
480V. NORMAL BUS 1A
480V. NUCLEAR SERVICE B
INSTRUMENT AIR 100 HP
CONTROL ROD DRIVE POWER
FIRE PUMP
SPACE
* 6950 HP. NORMAL HP
5860 HP. COLD WATER HP

[redacted]

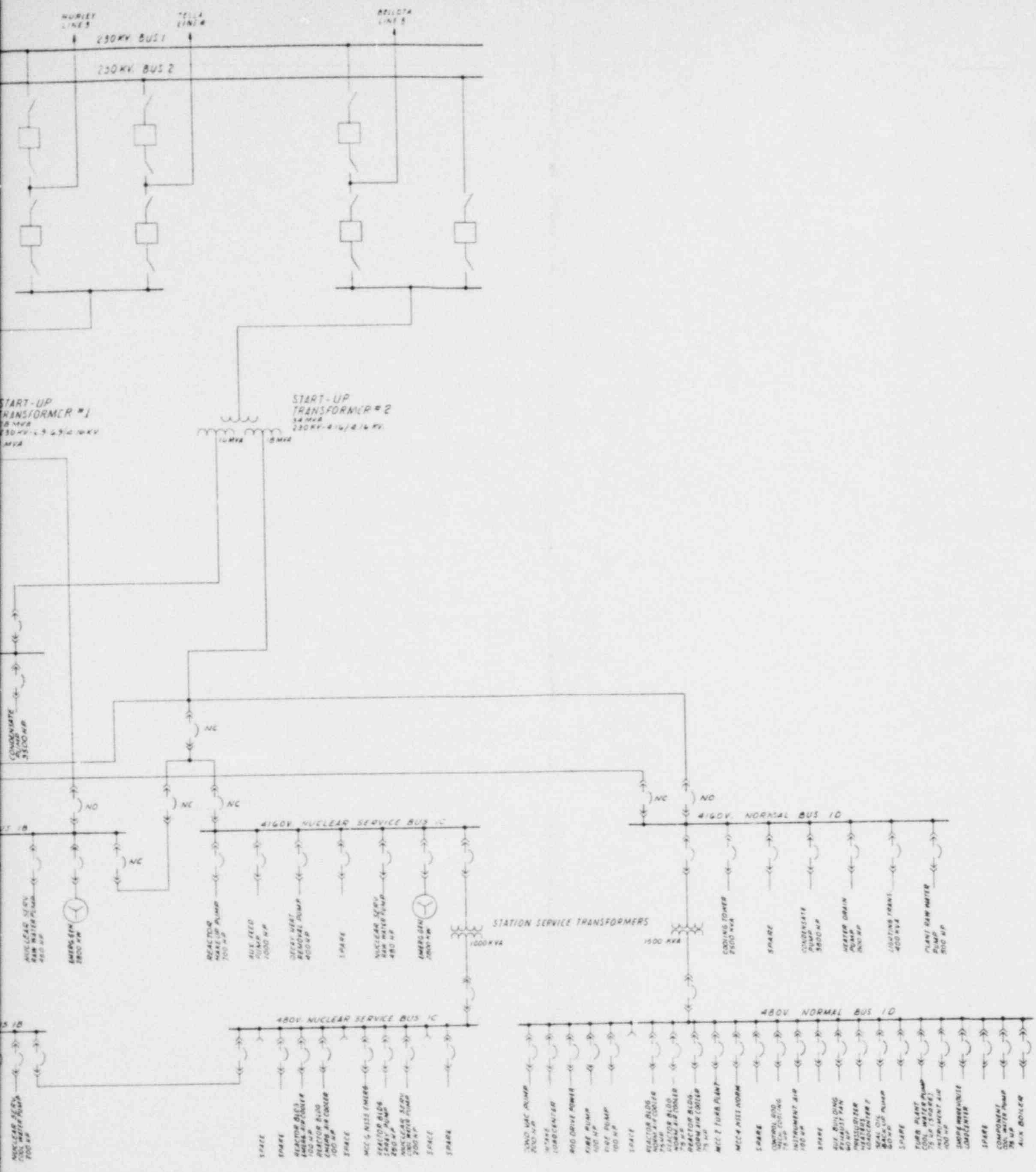
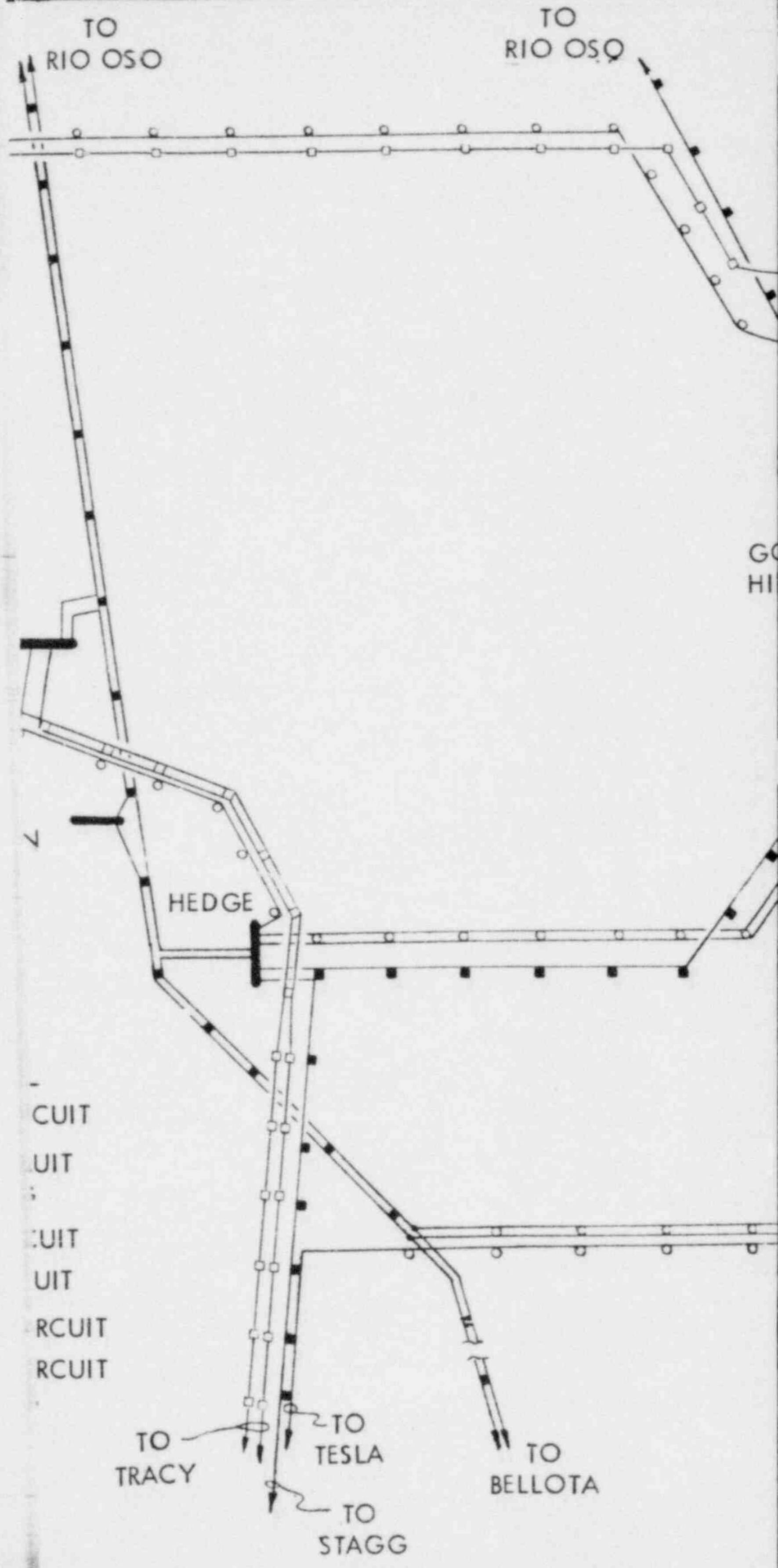


FIGURE 8.2-1
ELECTRIC POWER SYSTEMS
SINGLE LINE DIAGRAM

351

SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT

Amendment 3



352

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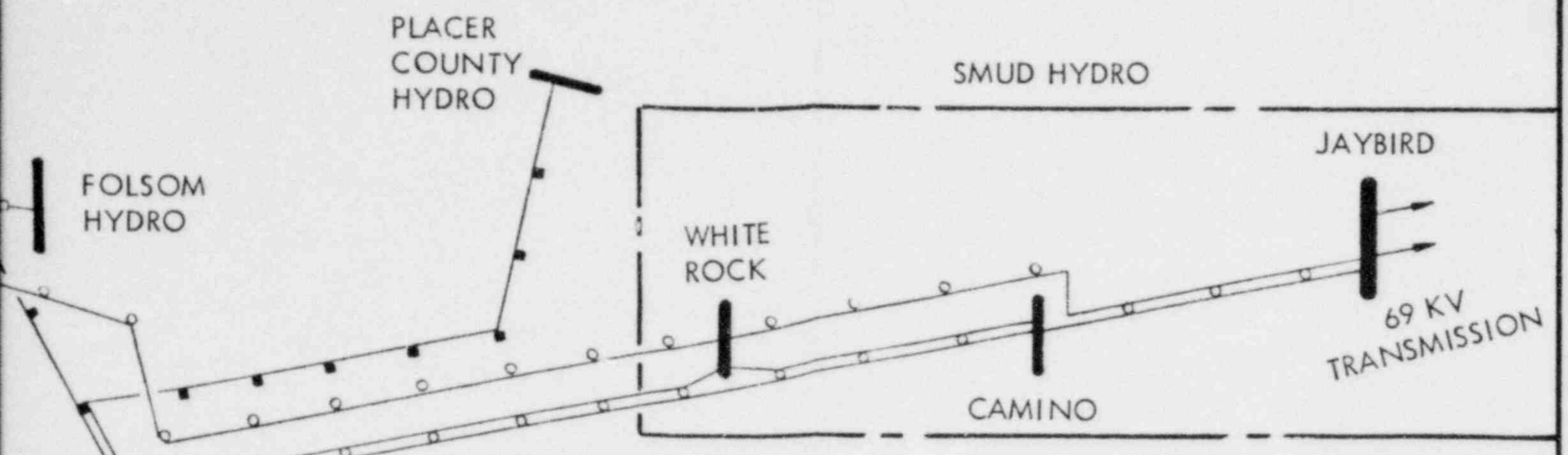

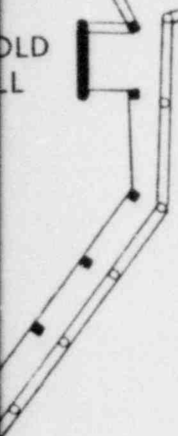

GENERATING SOURCES CONNECTED TO 230 KV SYSTEM

BUS	GENERATION	MW	(NAMEPLATE)
ELVERTA	FOLSOM HYDRO	170	
ELVERTA & HEDGE	SMUD HYDRO	630	(6 PLANTS)
RIO OSO AND TABLE MOUNTAIN	PITT RIVER AND FEATHER RIVER HYDRO	2007	(18 PLANTS)
GOLD HILL	PLACER COUNTY HYDRO	192	(4 PLANTS)
COTTONWOOD KESWICK	KESWICK, SHASTA, AND TRINITY HYDRO	833	(5 PLANTS)
BELLOTA	MOKELUMNE RIVER HYDRO	298	(6 PLANTS)
TESLA	PITTSBURG & CONTRA COSTA STEAM	2554	(2 PLANTS)

230 KV & 500 KV SYSTEMS ARE INTERCONNECTED AT TABLE MOUNTAIN & TESLA, EFFECTIVELY CONNECTING ALL MAJOR WESTERN GENERATING SOURCES INTO THE NETWORK

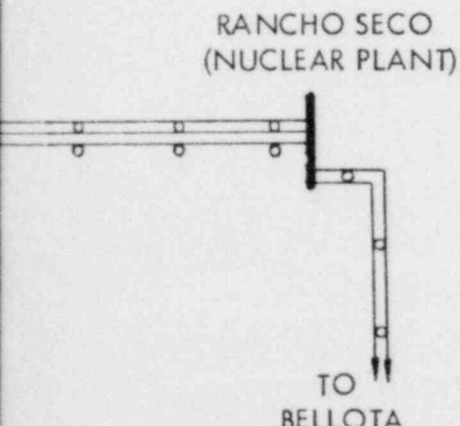

FIGURE 8.2-2
TRANSMISSION SYSTEM

[redacted]

353

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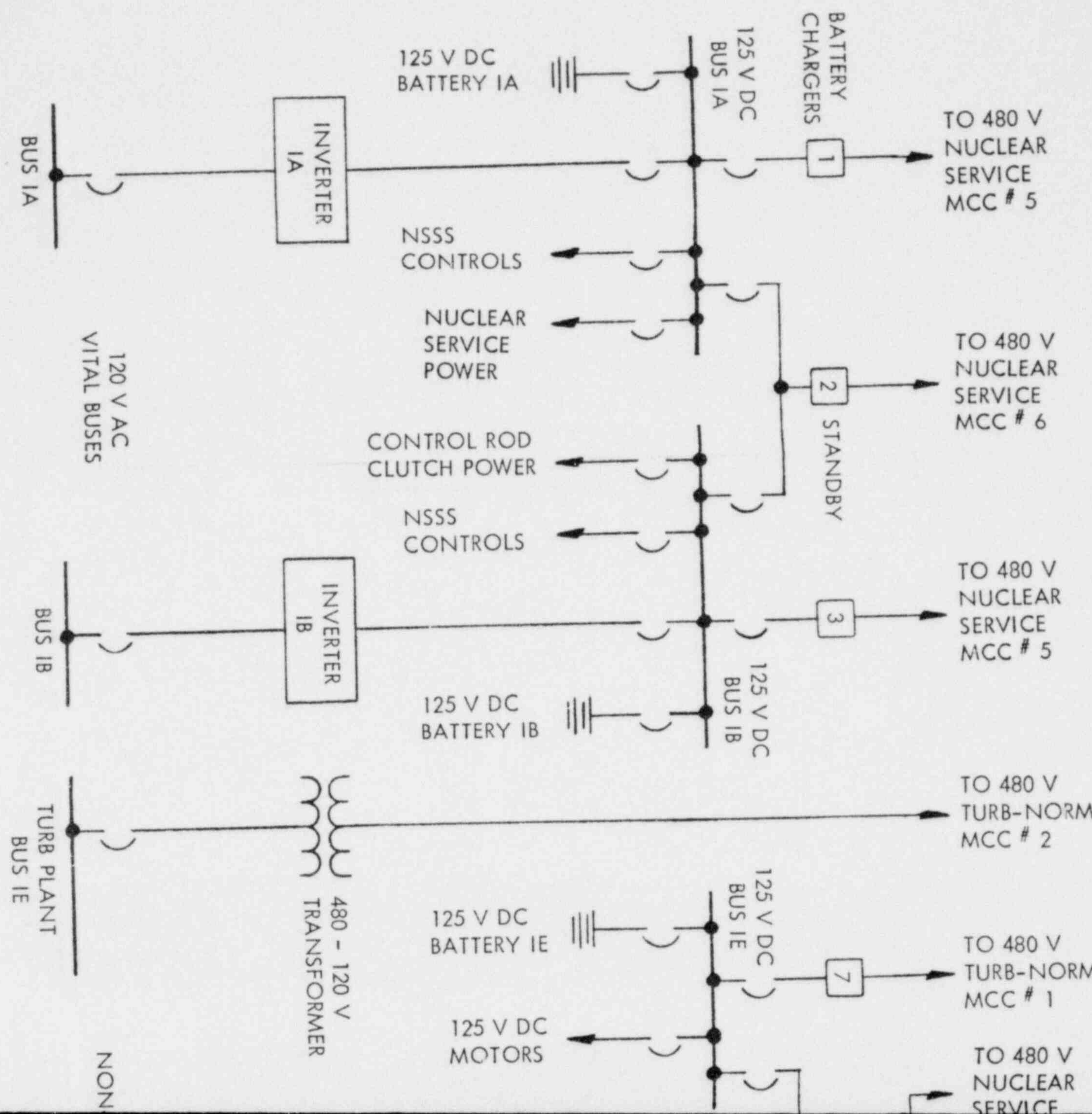
125 V DC
BATTERY IA
125 V DC
BUS IA
BATTERY
CHARGERS
BUS IA
INVERTER
IA
1
TO 480 V
NUCLEAR
SERVICE
MCC # 5
NSSS
CONTROLS
NUCLEAR
SERVICE
POWER
120 V AC
VITAL BUSES
2
STANDBY
TO 480 V
NUCLEAR
SERVICE
MCC # 6
CONTROL ROD
CLUTCH POWER
NSSS
CONTROLS
BUS IB
INVERTER
IB
3
TO 480 V
NUCLEAR
SERVICE
MCC # 5
125 V DC
BATTERY IB
125 V DC
BUS IB
TURB PLANT
BUS IE
480 - 120 V
TRANSFORMER
TO 480 V
TURB-NORM
MCC # 2
125 V DC
BATTERY IE
125 V DC
BUS IE
7
TO 480 V
TURB-NORM
MCC # 1
125 V DC
MOTORS
TO 480 V
NUCLEAR
NON

354

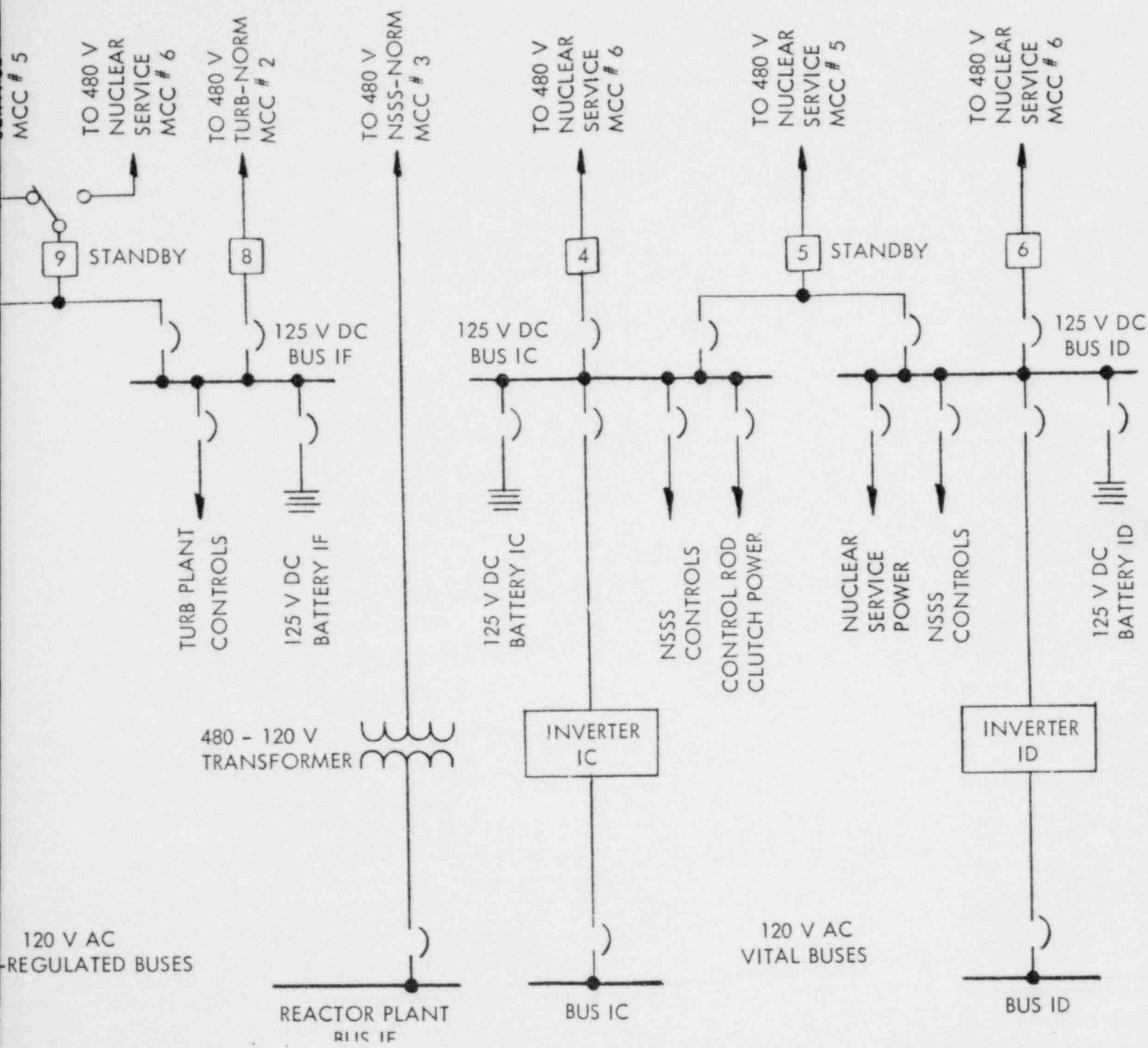

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FIGURE 8.2-3
125-VOLT DC SYSTEM AND 120-VOLT
AC ESSENTIAL POWER SYSTEM

355

SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT

8.3 DESIGN EVALUATION

The redundancy of transformers and buses in the plant and the division of load between buses yields a system that will have a high degree of reliability and integrity. The physical separation of nuclear service and 2
normal buses, system components and vital circuits will limit or localize the consequences of electrical faults or mechanical accidents occurring at any point in the system.

There are four independent nuclear service buses (two 4160-volt and two 480- 2
volt), each with its associated engineered safeguards' equipment that can be connected to the emergency diesel generators. The buses are connected such that if a fault occurs on one bus, that bus will be isolated by opening its supply or bus tie breakers, thus leaving the other buses and their required equipment available for use.

In case the normal auxiliary power sources are lost, the diesel generators are designed to start automatically and carry essential loads for an indefinite period. The diesel generators each feed a nuclear service bus 2
directly.

All of the loads connected to the 125-volt d-c system, except the motor loads can be supplied by the battery chargers. The chargers will be supplied from multiple sources of plant auxiliary power including the diesel generators. Each battery system is located in separate ventilated rooms having concrete block walls.

8.3.1 EVALUATION OF THE PHYSICAL LAYOUT

The electrical distribution system equipment will be located in such a way that the vulnerability of vital circuits to physical damage as a result of accidents will be minimized. The proposed locations are as follows:

a. The unit auxiliary and start-up transformers will be located out of doors, physically separated from each other. Lightning arrestors will be used where applicable for lightning protection. Transformers will be well spaced to minimize their exposure to fire and mechanical damage.

b. The unit normal reactor/turbine auxiliary 6900-volt switchgear, 4160-volt switchgear, and 480-volt switchgear will be located in four separate rooms to minimize exposure to mechanical, fire, 2
and water damage. This equipment will be properly coordinated electrically to permit safe operation of the equipment under normal and short circuit conditions.

c. The two sets of engineered safeguards equipment switchgear will 2
be located in separate rooms in order to minimize exposure to mechanical, fire, and water damage. This equipment will be coordinated electrically to permit safe operation under normal and short-circuit conditions.

[redacted]

d. 480-volt motor control centers and load centers will be located in the areas of electrical load concentration. Those associated with the turbine-generator auxiliary system in general will be located below the turbine-generator operating floor level. Those associated with the nuclear steam supply system will be located in the auxiliary building. Motor control centers will be located in areas which minimize their exposure to mechanical, fire, and water damage.

e. The plant batteries and associated chargers and inverters will be in separate rooms in order to minimize vulnerability to damage from any source.

f. Nonsegregated, metal-enclosed 4160- and 480-volt buses will be used for all inter-bus connections where large blocks of current are to be carried. This metal-enclosed bus will be routed in such a manner that its exposure to mechanical, fire, and water damage will be minimized.

8.3.2 ACCIDENTAL PHASE REVERSAL

Before plant operation, phase reversals due to inadvertent misconnection will be found by tests such as jogging motors.

During plant operation it is not credible that an accidental phase reversal will occur since this involves the disconnecting and connecting of two leads of a three phase system.

1 The engineered safeguards systems, makeup and purification (high pressure injection), decay heat removal system and reactor building spray system were analyzed for the consequences of an accidental phase reversal at an emergency bus under accident conditions. For this analysis it was assumed that the consequences as a result of a phase reversal would be the reverse rotation of a pump or the opposite movement of a motor operated valve from its intended direction. The analysis presented in Table 8.3-1 is based on the assumption that a major loss-of-coolant accident had occurred and that a phase reversal at an emergency bus exists.

It is not credible that the diesel can be started backwards since the starting air is injected into the cylinders when the pistons are beyond top dead center.

[redacted]

357

TABLE 8.3-1
PHASE REVERSAL FAILURE ANALYSIS 1

Component	Failure	Comments & Consequences	
a. High Pressure Injection System			
High Pressure Injection Pump	Reverse rotation of pump	Standby pump is available for operation	2
b. Decay Heat Removal System			1
Decay Heat Pump	Reverse rotation of pump	The remaining pump will deliver required flow	2
Electric Motor Operated Valve Permitting Suction from Reactor Building Sump	Valve remains closed	Two lines and valves are provided	
c. Reactor Building Spray System			
Reactor Building Spray Pump	Reverse rotation of pump	Flow and cooling capacity reduced to 50 percent of design. In combination with emergency coolers, 150 percent of total design requirements is still provided.	1
Electric Motor Operated Valve in Spray Header	Valve remains closed	Second header delivers 50 percent flow. See Comments for C-1 above.	

Motor driven emergency safeguard pumps all have redundancy. If one pump runs in reverse, it will pump at reduced head against its closed check valve, and the resultant ammeter reading will be lower than the normal pumping load. 2

Phase reversal after initial check out is in itself a remote possibility but should it ever occur, the consequences are in no case serious as indicated from the above analysis. 1

358

8.4 TESTS AND INSPECTIONS

Periodic operating tests and routine maintenance will be performed on the diesel generators, the emergency lighting system and the charger and inverter units. This will include fast starting of the diesel generators and synchronizing with the station auxiliary system to operate at full load for approximately 30 minutes.

A program of regular inspections and functional checks of equipment and protective devices common to normal central station practice will ensure the operability of auxiliary distribution system components.

The 230 kv circuit breakers will be inspected, maintained, and tested as follows:

a. Transmission line circuit breakers will be tested on a routine basis. This can be accomplished without removing the transmission line from service.

b. Generator circuit breakers can be tested with the generator in service.

Transmission line protective relaying will be tested on a routine basis. Generator protective relaying will be tested when the generator is off-line. The 6900-, 4160-, and 480-volt circuit breakers may be removed to the "test" position and tested by closing and opening the circuit breakers with the unit off-line. Circuit breakers and contactors for redundant circuits may be tested in service without interferring with the operation of the station. Contactors for motor operated isolating valves will be tested with the unit off-line.

The ungrounded d-c system will have detectors to indicate when there is a ground existing on any portion of the system. A ground on one portion of the d-c system will not cause any equipment to malfunction. D-c control circuits will be designed in such a manner that the de-energized condition will lead to the desired equipment alignment to meet accident conditions.

Grounds will be located by a logical isolation of individual circuits connected to the faulted system, while taking the necessary precautions to maintain the integrity of the vital bus supplies.

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