UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
LONG ISLAND LIGHTING COMPANY	)	Docket No. 50-322 (OL)
	)	
(Shoreham Nuclear Power Station, Unit 1)	)	

TESTIMONY OF GREGORY KENT PRICE FOR THE LONG ISLAND LIGHTING COMPANY ON SUFFOLK COUNTY CONTENTION 5 -- LOOSE PARTS MONITORING SYSTEM

Purpose

This testimony establishes that LILCO has dealt adequately with the possibility of spurious alarms in the Shoreham Loose Parts Monitoring System, and has chosen a system with the sensitivity to detect loose parts while screening out the plant background noise and normal plant movements of devises such as control rods and valves that can result in spurious alarms. Operational experience at Shoreham will enable LILCO to calibrate the Shoreham Loose Parts Monitoring System to further eliminate the potential for spurious alarms.

8.0 ELECTRIC POWER

8.1 INTRODUCTION

8.1.1 Utility Grid and Interconnections

The Tennessee Valley Authority (TVA) is a corporation of the United States Government serving the State of Tennessee and parts of six other states in the southeast on the boundaries of Tennessee. TVA is interconnected with electric power companies to the north, west, south, and east of its service area. As shown in Figure 8.1-1, the TVA grid consists of interconnected hydro plants, fossil-fueled plants, combustion turbine plants, and nuclear plants supplying electric energy over a transmission system consisting of various voltages up to 500 kv.

The Watts Bar Nuclear Plant is located 48 miles northeast of Chattanooga, Tennessee, on the west bank of the Tennessee River. The plant is connected into a strong existing transmission grid applying large load centers. Both nuclear units are connected into TVA's 500-kv transmission system. One unit is connected with three and the other with two 500-kv transmission lines which are integral parts of the 500-kv transmission grid. Normal power for the operation of a nuclear unit is supplied from unit station service transformers when the unit is connected to the transmission system through its main transformer bank. Preferred power is supplied from the existing Watts Bar Hydro 161-kV Switchyard over two radial lines located entirely on TVA property. The Watts Bar Hydro 161-kV Switchyard is interconnected with the TVA power system through ~~seven~~ six 161-kV transmission lines, five hydro generators, and four steam generators.

8.1.2 Plant Electrical Power System

The plant electric power system consists of the main generators, the unit station service transformers, the common station service transformers, the diesel generators, the batteries, and the electric distribution system as shown on Figures 8.1-2 and 8.1-3. Under normal operating conditions the main generators supply electrical power through isolated-phase buses to the main step-up transformers and the unit station service transformers located adjacent to the Turbine Building. The primaries of the unit station service transformers are connected to the isolated-phase bus at a point between the generator terminals and the low-voltage connection of the main transformers. During normal operation, station auxiliary power is taken from the main generator through these transformers. During startup and shutdown auxiliary power is supplied from the 161-kv system through the common station service transformers. The standby (onsite) power is supplied by four diesel generators.

16. NEMA TR1, Transformers, Regulators, and Reactors

17. NEMA MG1, Motors and Generators

18. NEMA WC5, Thermoplastic-Insulated Wire and Cable

19. IPCEA S-61-402, Thermoplastic -Insulated Thermoplastic-Jacketed Cables

20. IPCEA S-56-434, Polethylene-Insulated Thermoplastic-Jacketed Cables

21. IPCEA S-66-524, Interim Standard No. 2, XLPE Insulation

22. NFPA No. 78-1971, Lightning Protection Code

23. IPCEA S-19-81, NEMA WC3-1969 IPCEA-NEMA Standards Publication, Rubber-Insulated Wire and Cable. Specific references herein are from the fifth edition dated July 1969.

24. IPCEA S-28-357, NEMA WC1-1963, American National Standards Institute Requirements for Asbestos, Asbestos-Varnished Cloth, and Asbestos-Thermoplastic Insulated Wires and Cable (C8.36-1962).

8.1.5.3 Compliance to Regulatory Guides and IEEE Standards

The extent to which the recommendations of the applicable NRC regulatory guides the IEEE standards are followed is shown below. The symbol (F) indicates full compliance. Those which are not fully implemented are discussed in the footnotes as indicated.

require further clarification or

Regulatory Guide 1.6 (Safety Guide 6), "Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems." (F)

Regulatory Guide 1.9 (Safety Guide 9), "Selection of Diesel Generator Set Capacity for Standby Power Supplies." (F)

Regulatory Guide 1.22 (Safety Guide 22), "Periodic Testing of Protection System Actuation Functions." (F)

Regulatory Guide 1.29, "Seismic Design Classification." (F)

37

IEEE Trial-Use Std 338-1971, "Criteria for the Periodic Testing of Nuclear Power Generating Station Protection Systems." (F)

IEEE Std 344-1971, "Guide for Seismic Qualification of Class I Electrical Equipment for Nuclear Power Generating Stations." (F)

IEEE Std 387-1972, "Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Stations." (F)

1. The electric penetration assemblies at Watts Bar Nuclear Plant are designed in accordance with IEEE 317-1972. REPLACE WITH INSERT K-

2. Regulatory Guide 1.75 was issued after the Watts Bar design was complete. Separations criteria for WBNP are given in Paragraph 8.3.1.4.2.

3. Watts Bar Nuclear Plant shares the vital 125V d.c. power supply between units. REPLACE WITH INSERT D

4. Watts Bar Nuclear Plant Class IE equipment was qualified in accordance with IEEE 323-1971.

5. Watts Bar Nuclear Plant Class 1E equipment was seismically qualified to IEEE 344-1971. Regulatory Guide 1.100 addresses IEEE 344-1975. 35

6. The Watts Bar design complies with all of the positions of Regulatory Guide 1.108, Rev. 1, except as follows: 40.67

   a. Position C.1(5) - This guide was issued too late to incorporate first out annunciation. However, on all diesel generator protective trips such as differential overcurrent, targets have been provided. In addition, the status of protective devices installed to shut down the diesel generator unit for generator or engine trouble are alarmed in the main control room.

   b. Position C.2.a(2) - This requirement to be demonstrated at preoperational testing for both full flow and minimum flow conditions. Thereafter, testing will be performed at the minimum flow conditions.

   c. Position C.2.a.(7) - This position is not applicable to the Watts Bar design since no switching of fuel supplies is required.

~~REPLACE WITH INSERT J~~

Delete this insert and add Insert 8.1-0

7. (Add Insert 8.1-1)

380

INSERT K

PAGE 8.1-8 (Replaces revisions sent in Package 312 and 327)

A discussion of the degree of conformance of the Watts Bar design with the requirements of RG 1.63 follows:

C.1 The electric penetrations have been designed to withstand the maximum fault current for the time duration of the backup protective device. A redundant overcurrent protection system is provided (redundant breakers or a breaker and a fuse) for all penetrations except instrumentation circuits where fault current is not a problem.

The only 6.9-kV circuit feeding loads inside containment (thus requiring electrical penetrations) are for the reactor coolant pumps (RCP). The breakers associated with the RCPs are backed up by a second breaker to provide the redundant overcurrent protection systems required by RG-1.63. The breakers are provided in the normal course of auxiliary power system design and are non-Class 1E. The primary and backup circuit breakers are each provided with independent dc control power from two different batteries so that the failure of either battery will not violate the single failure criteria. Provision for testing is described below.

The 480-volt load center circuits have a low voltage power circuit breaker backed up by a current limiting fuse. The penetration withstands the available fault current vs. time duation for the load center breaker and fuse. The breakers have direct acting trips and are independent of control power. The fuse is located in the cable termination compartment of the load center bolted to the breaker cable terminal.

The 480-volt motor control center (MCC) circuits have a molded case circuit breaker backed up by a fuse. The penetration withstands the available fault current vs. time duration for the breaker and fuse. Molded case breakers have direct acting trips. The breaker and fuse were furnished in the standard design of the MCC and are located in the same compartment with approximately two inches of air space separation. This is considered adequate because of the diverse principle of operation of the fuse and breaker.

Low-voltage control circuits which have sufficient fault currents available to damage a penetration have a molded case breaker backed up by a fuse. The penetration withstands the available fault current vs. time duration for the breaker and fuse. The molded case breakers have direct acting trips.

The energy levels in the instrument systems are sufficiently low so that no damage can occur to the containment penetration.

380

K continued

Table 8.1-2 lists the parameters that show the capability of each typical penetration to withstand without loss of mechanical integrity, the maximum fault current vs. time condition that could occur as a result of a single random failure of the primary overload protection. Thus the single failure criterion of IEEE 279 is met. Figures 8.1-4 through 8.1-10 show typical time-current curves.

In addition to the single failure criterion of IEEE 279, the following requirements of IEEE 279 are met as follows:

1. Testability: The overcurrent protection system provided for 6900-volt penetration circuits include drawn out-type relays which are field testable using manufacturer provided test sets or TVA test sets to simulate fault currents following established procedures. Low voltage power circuit breakers and molded case circuit breakers are field tested using test sets built by Multiamp Corporation or equal. Testing is done by simulating fault current following established procedures.

   The only method recommended by fuse manufacturers for periodic testing of fuses is the measurement of their resistance. Resistance measurement is one of the final checks made at the factory to assure fuses have been manufactured correctly and are properly labled as to size. The validity of duplicating a factory test that measures milliohms in the field is questionable. In lieu of field testing by resistance, we will establish a fuse inspection and maintenance program that will ensure: (1) that the proper size fuse is installed, (2) that the fuse shows no sign of deterioration, and (3) that the fuse connections are tight and clean. (See IEEE Std 242 1975 Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems).

Penetration protective devices in 480V circuits energized during plant operation are mounted in either motor control centers or Class 1E low voltage switchgear. Both Class 1E and non-Class 1E motor control centers are ITE Imperial Corporation series 5600 supplied under the same contract. All 480V non-Class 1E distribution equipment that houses penetration protective devices are located in the same seismic structure as Class 1E distribution equipment. Equipment bought to Class 1E standards is qualified to operate both during and after an operating basis earthquake (OBE) or a safe shutdown earthquake (SSE). The non-Class 1E motor control centers supplied under the same contract as Class 1E are manufactured using the same materials and components which results in the same high degree of operational reliability during an OBE.

K continued

C.2 X/R ratios in excess of 15 were used in the qualification tests.

C.3 The duration times used in the qualification tests exceeded those required by IEEE 317-1976 and RG-1.63.

C.4 The basic impulse test voltage used in the qualification test for the medium voltage penetration was a 2X50 micro-second phase. The test consisted of a full wave test series of three positive and three negative waves.

C.5 Aging tests in excess of 5000 hours have been run on all non-metalic materials to establish arrhenius curves.

C.6 N/A

C.7 NA

061254.06

A discussion of the degree of conformance of the Watts Bar design with the requirements of RG 1.81 follows:

X

Position C.1

~~Does Not Fully Comply~~

~~Justification:~~

The design of the WBNP 125-volt vital dc system and the construction permit application was made before June 1, 1973. The design, as a minimum, meets the requirements of position 3 of the subject regulatory guide and branch technical position EICSB 7 as follows: The system is capable of supplying minimum ESF loads and the loads required for attaining a safe and orderly shutdown of the unit assuming a single failure and loss of offsite power. The ESF output relays and their trained loads that require power to operate, are assigned as follows:

1. Unit 1 "A" train - 125V dc Vital Battery I, 120V ac Vital UPS 1-I
2. Unit 1 "B" train - 125V dc Vital Battery II, 120V ac Vital UPS 1-II
3. Unit 2 "A" train - 125V dc Vital Battery III, 120V ac Vital UPS 2-III
4. Unit 2 "B" train - 125V dc Vital Battery IV, 120V ac Vital UPS 2-IV

Thus the ESF loads are not shared.

The 120-volt ac vital instrument power is supplied by four UPS units per unit. They furnish power for the four-channel reactor protection system (RPS) input relays. The relays fail safe, actuate reactor protection system (RPS) signal, on a loss of power, thus a single failure and/or a loss of offsite power does not prevent the safe and orderly shutdown of either unit.

Plant common loads such as emergency gas treatment are supplied from unit 1, channels I and II.

In no case does the sharing inhibit the safe shutdown of one unit while the other unit is experiencing an accident. All shared systems are sized to carry all credible combinations of normal and accident loads.

Position X C2

a. Watts Bar is a two-unit plant.

b. With a single failure (Loss of a battery or loss of a diesel generator) in the plant sufficient ESF loads are still automatically available to the accident unit and to safely shut down the remaining unit.

c. The most severe DBE is an accident in one unit and a trip of the other unit. Sufficient diesel generator (DG) power is available to attain a safe and orderly shutdown of both units with the loss of one DG unit.

d. The DG units and the standby distribution system are arranged in two redundant trains per unit. Due to the shared ESF system (example: ERCW) only one DG unit per plant can be taken out for maintenance or tested at the same time. With only one DG unit unavailable, this position is met assuming loss of offsite power.

e. No interface of the unit operators is required to meet position 2.b. and 2.c.

f. Control and status indication for the DG units is provided on a central control board (Panel 0-M-26) available to both unit operators. DC system status (volts, current, etc.) is provided on a unit basis.

g. The recommendation of RG-1.6, 1.9, and 1.47 are met. — except as discussed in Note 7

~~h. The construction permit for WBNP was issued before June 1, 1973.~~ STET

Position C.3

3/7?

Insert 8.1-0 (page 8.1-8)

d. Position C.2.a(2)

We understand this requirement to mean that the emergency loads be sequenced on to the diesel generator unit (DGU) with each load operating at its full load rating (that is a pump would be operating at full flow). This will be done as part of the preoperational testing program. For subsequent periodic testing done after preops, the loads will be sequenced on as designed except the pumps will be operated with their miniflow connection open and not at full flow.

The most severe disturbance of voltage and frequency for a diesel generator unit (DGU) occurs when starting a motor. Whether a motor is operating at full flow or miniflow, this disturbance is the same. Therefore, the capacity of a DGU to maintain frequency and voltage can be proved with the pumps operating at miniflow. The voltage and frequency will be monitored by control board meters during periodic testing to assure that the frequency and voltage are maintained within design limits.

INSERT 8.1-1

7. Since RG 1.9 has been revised, the following information defines the degree of conformance with RG 1.9 R2.

C.0 WBN meets the intent of IEEE 387-1977

C. 1 Full compliance

C. 2 Full compliance

C. 3 Full compliance

C. 4 Full compliance

C. 5 Environmental qualification of the WBNP diesel generator units will be detailed in TVA's ~~response to Nureg 0588, Category II for Class IE equipment in a~~ mild environment. equipment qualification report to be retained in TVA files per NRC requirements.

C. 6 Full compliance

C. 7 (a) Full compliance

(b) Full compliance

C.8 Does not comply - Although a first-out serveillance system is not installed at Watts Bar, all diesel generator protective trips such as differential overcurrentr have been provided with targets to indicate which protective device operated. In addition, the status of protective devices installed to shut down the diesel generator unit for generator or engine trouble are alarmed in the main control room. Where more than one protective device target is operated, an analysis of the problem will be done to determine which device operated first.

C.9 It is TVA's position that the intent of this position has been fully met. Please refer to ~~attachment 21 which is~~ TVA's response to NRC question 112.22 relating to seismic qualifications of Watts Bar safety- related equipment. In addition, please refer to FSAR Table 3.10.1, sheet 2, for a summary of the seismic qualification of electrical equipment, including the diesel generators. Further Table 3.10.3 "Watts Bar Seismic Qualifications," sheets 11 through 20 for tests, results, and references of the seismic qualification of various components of the diesel generator unit.

C.10 Full compliance

C.11 Full compliance

C.12 N/A

C.13 N/A

C.14 Does not fully comply. The load qualification test was not done as part of the type qualification test. This test has been run as part of the preoperational test program, but the requirements of IEEE 387-1977 were followed. It is TVA's position that running the short-time load test at the end is a more severe test and this sequence is justifiable. However, in order to meet this position, subsequent periodic testing of these DGUs will be done per this regulatory guide.

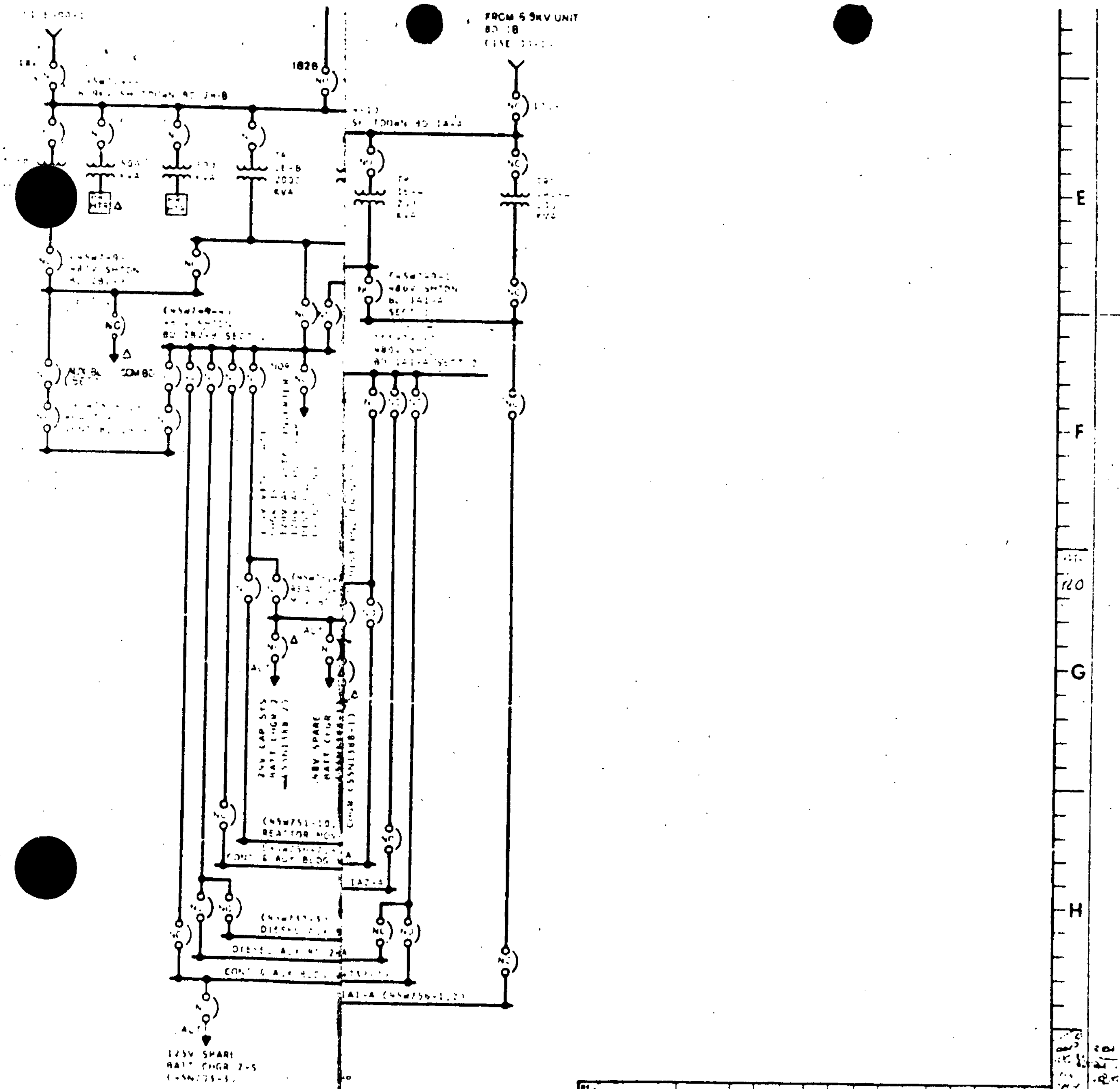
TABLE 8.1-2
ELECTRICAL PENETRATION ASSEMBLY SHORT-CIRCUIT CAPABILITY

Rated Volts	Serv Volts	Wire Size	Rated Short Ckt Sym Amp	Rated I^2t ($x 10^6$)	Tested Short Ckt Sym Amp	Calculated Short Ckt Sym Amp	Primary Device Opening Time Sec	Backup Device Opening Time Sec	Backup Device I^2t ($x10^6$)
8,000	6,900	750 MCM	36,000	2,910	50,000*	27,000	0.0165	2.7 0.0165	1,968 12.03
600	480	350 MCM	30,000	634	35,000**	10,869	0.024	0.05	5.9
600	480	250 MCM	28,000	324	33,900**	5,076	0.014	0.06	1.55
600	480	2/0	22,000	91.7	28,300**	1,917	0.043	0.05	0.18
600	480	4 AWG	12,500	9.01	15,000**	992	0.019	0.018	0.17
600	120 480	8 AWG	6,000	1.41	5,960**	646 576	.054 0.013	0.150 0.07	0.06[illegible] 0.02[illegible]
600	125VDC	10 AWG	3,600	0.558	3,900**	31	.1	.1	0.00[illegible]
600	125VDC	12 AWG	2,300	0.221	2,410**	32.5	0.2	0.2	0.00[illegible]

*Test current

**These test currents are from the vendor's test report, which been reviewed by TVA and returned to the vendor with the status "Approved With Corrections as Noted." These corrections are minor in nature and do not affect the valididty of this table.

Replace revised Figure 8.1-2 shown in Amendment 44 with the same figure of the previous amendment since the revised figure shows the new fifth diesel generator which has not been formally presented to the NRC. This revised figure will be submitted with the appropriate SAR text at a later date.



THIS DRAWING AND COMPANION DRAWING 15E500-1 SUPERSEDES DRAWING 15N500 PER ECN 2786 AND

NUCLEAR SAFETY RELATED
FSAR FIG. 8.1.2A

INSPECTED AND APPROVED FOR ISSUE
R.W. Pantell

SCALE: NTS EXCEPT AS NOTED

GENERAL

KEY DIAGRAM
STATION AUX POWER SYSTEM

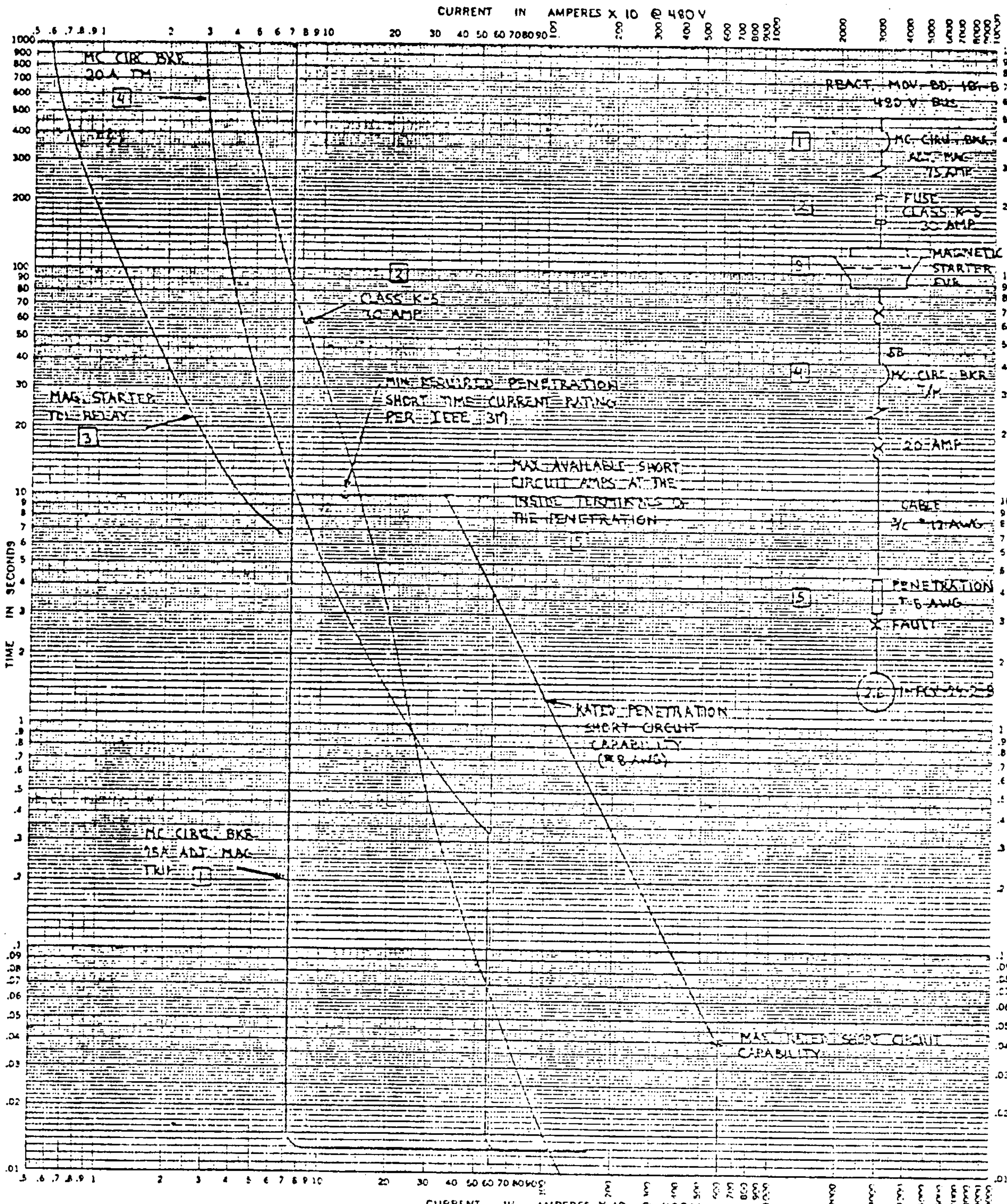
WATTS BAR NUCLEAR PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

Q

SUBMITTED	RECOMMENDED	APPROVED
[signature]	[signature]	[signature]

KNOXVILLE

327



For #8 AWG PENETRATION WBNP — TIME-CURRENT CHARACTERISTIC CURVES

Fuse Links ______ in ______

BASIS FOR DATA Standards ______ Dated ______

1. Tests made at ______ Volts a-c at ______ p.f., starting at 25C with no initial load

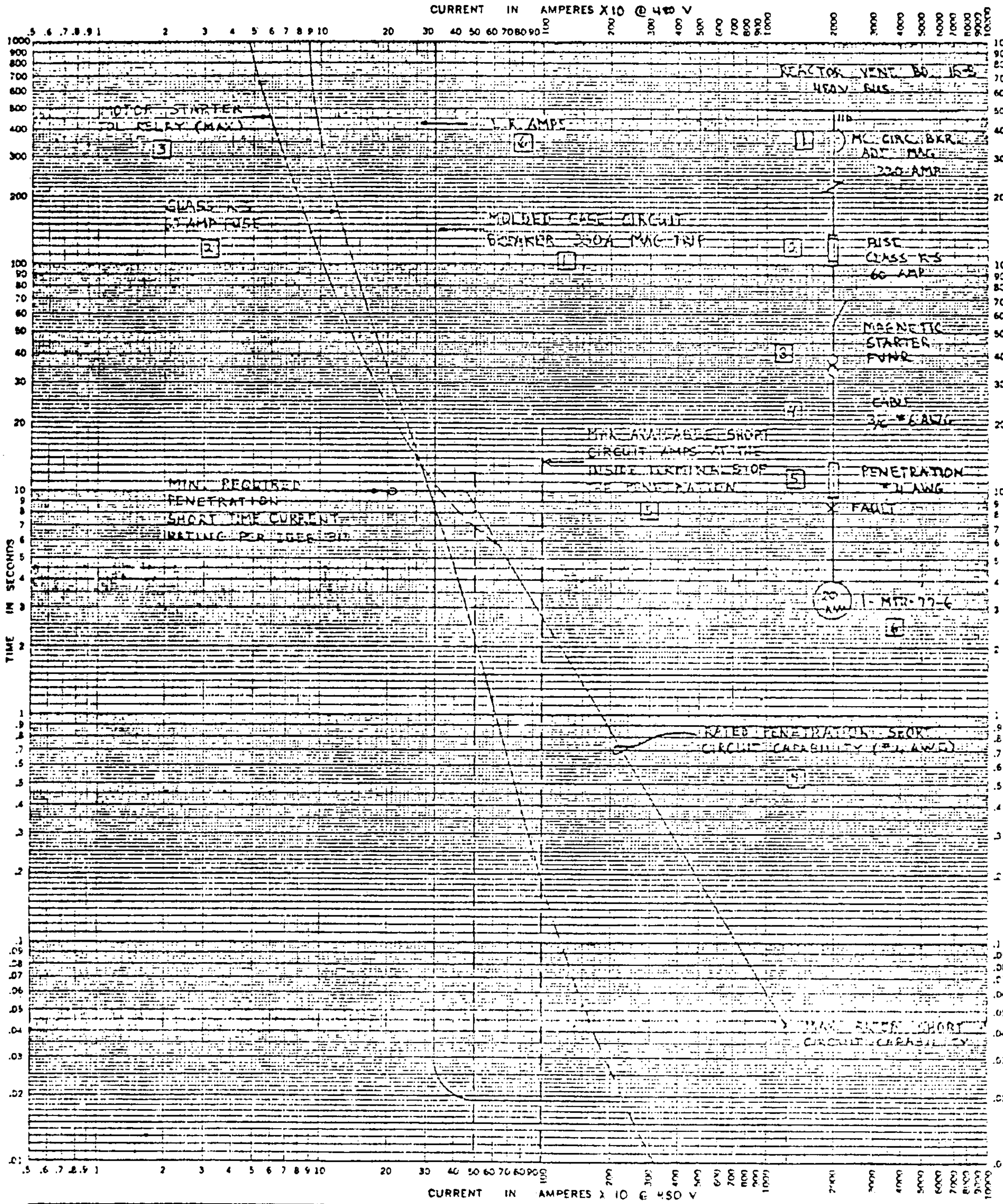
2. Curves are plotted to ______ Test points so variations should be ______

No. ______

Date ______

K-E TIME-CURRENT CHARACTERISTIC 46 5258
KEUFFEL & ESSER CO.

Fig. 8.1-4



For #4 AWG PENETRATION WBNP — TIME-CURRENT CHARACTERISTIC CURVES

Fuse Links. In ______

BASIS FOR DATA Standards ______ Date ______

1. Tests made at ______ Volts a-c at ______ p-f., starting at 25C with no initial load ______ No. ______

2. Curves are plotted to ______ Test points so variations should be ______ Date ______

K-E TIME-CURRENT CHARACTERISTIC 4F 5258
KEUFFEL & ESSER CO.

Fig. 8.1-5

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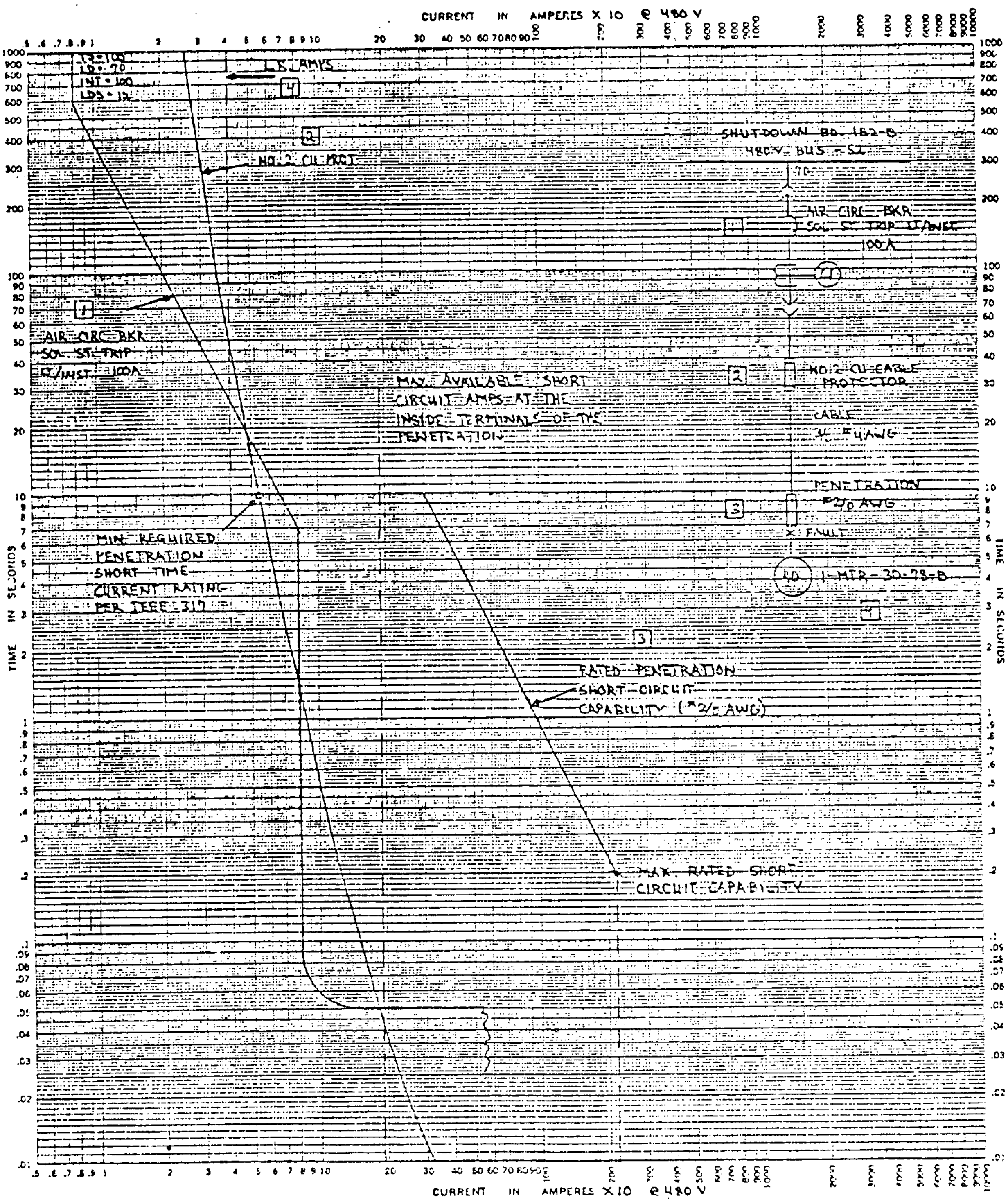


TIME-CURRENT CHARACTERISTIC CURVES

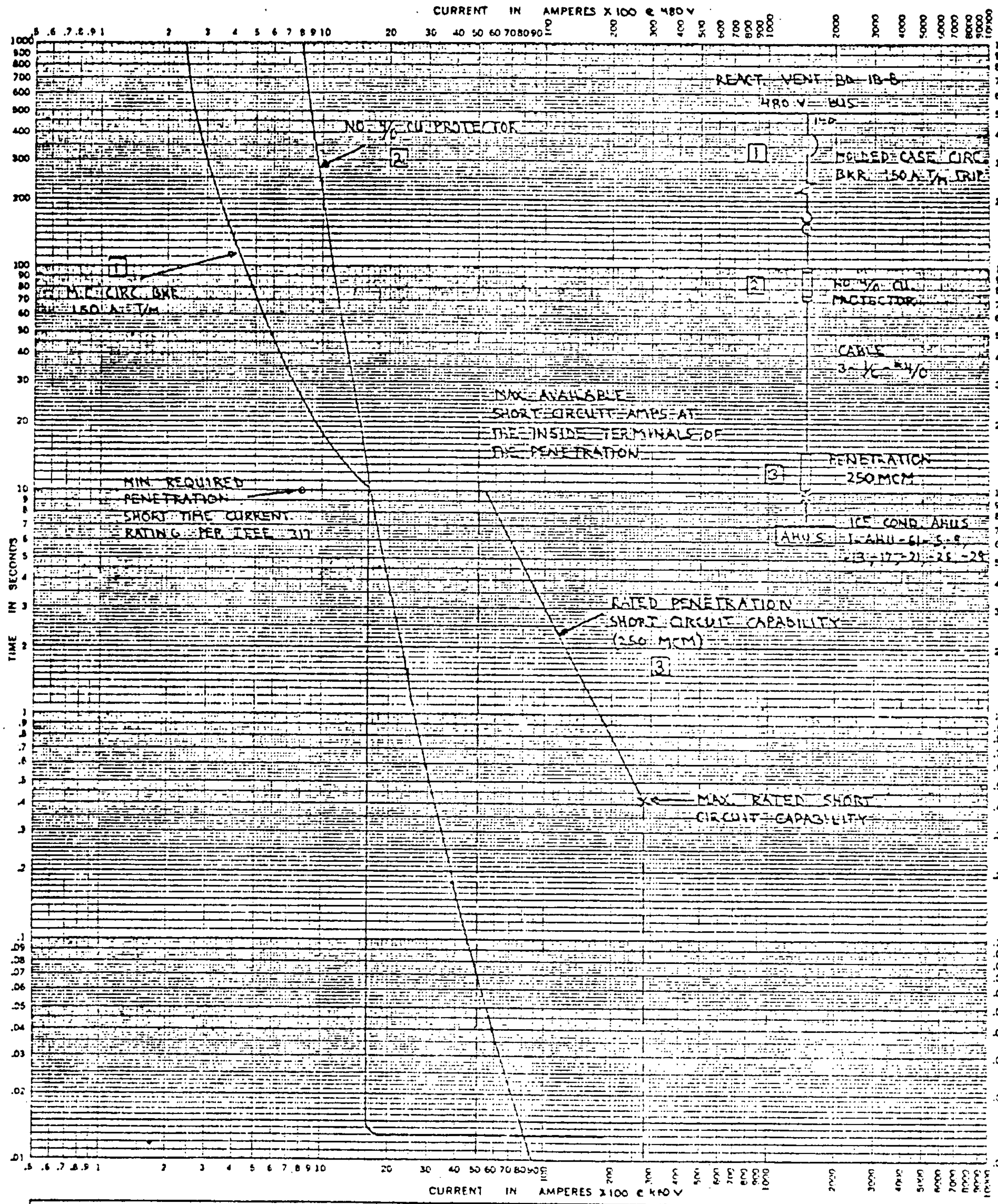
For *2/0 AWG PENETRATION WBNP Fuse Links. In

BASIS FOR DATA Standards ____ Dated ____

1. Tests made at ____ Volts a-c at ____ p.f., starting at 25C with no initial load ____ No. ____
2. Curves are plotted to ____ Test points so variations should be ____ Date ____

K+E TIME-CURRENT CHARACTERISTIC 46 5258
KEUFFEL & ESSER CO.

Fig 8.1-6



For 250 MCM PENETRATION WBNP — TIME-CURRENT CHARACTERISTIC CURVES

Fuse Links. In ______

BASIS FOR DATA Standards ______ Dated ______

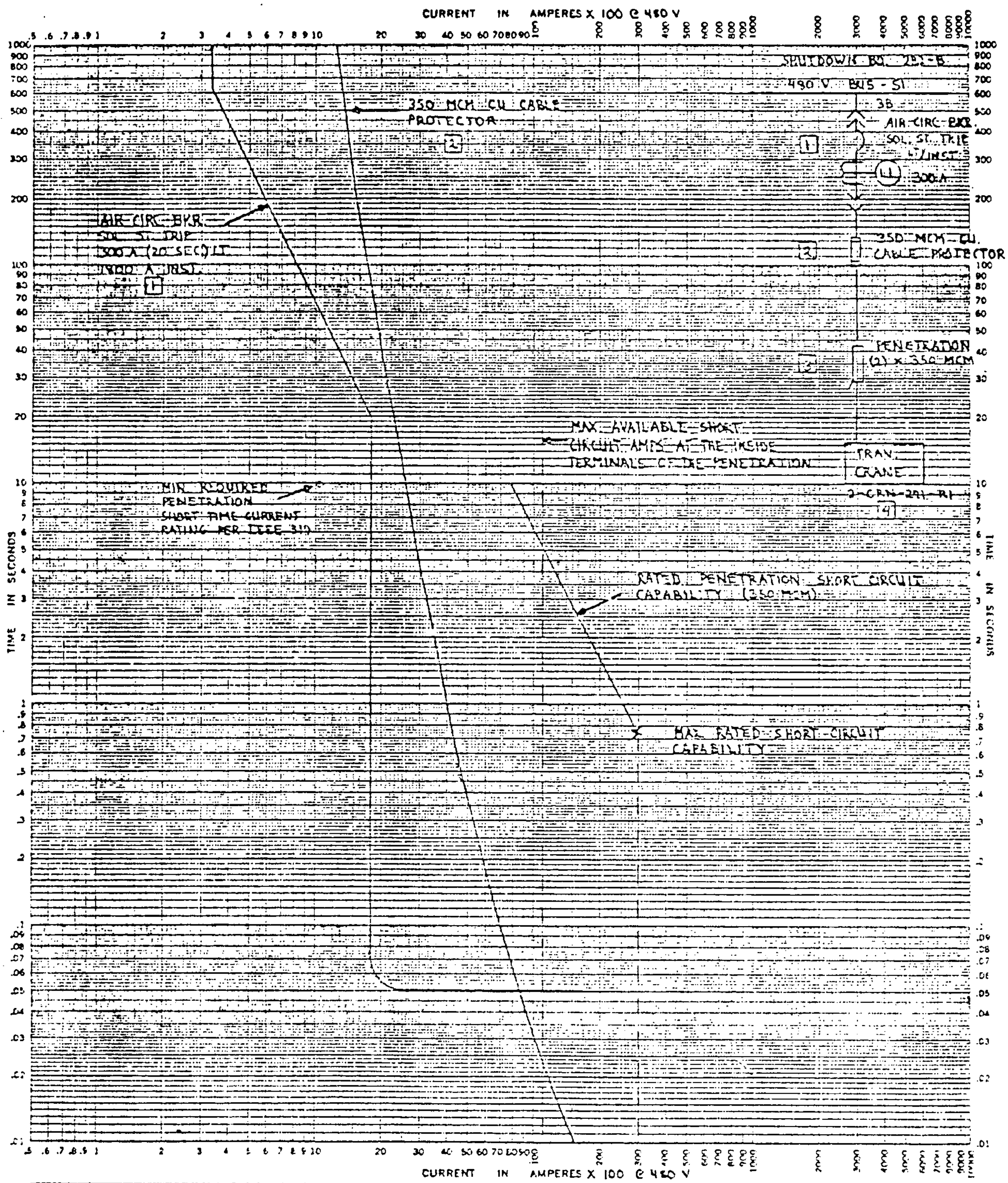
1. Tests made at ______ Volts a-c at ______ p.f., starting at 25C with no initial load ______
2. Curves are plotted to ______ Test points so variations should be ______

No. ______

Date ______

K+E TIME-CURRENT CHARACTERISTIC 48 5258
KEUFFEL & ESSER CO.

Fig. 8.1-7



For 350 MCM PENETRATION WBNP TIME-CURRENT CHARACTERISTIC CURVES Fuse Links, In ____

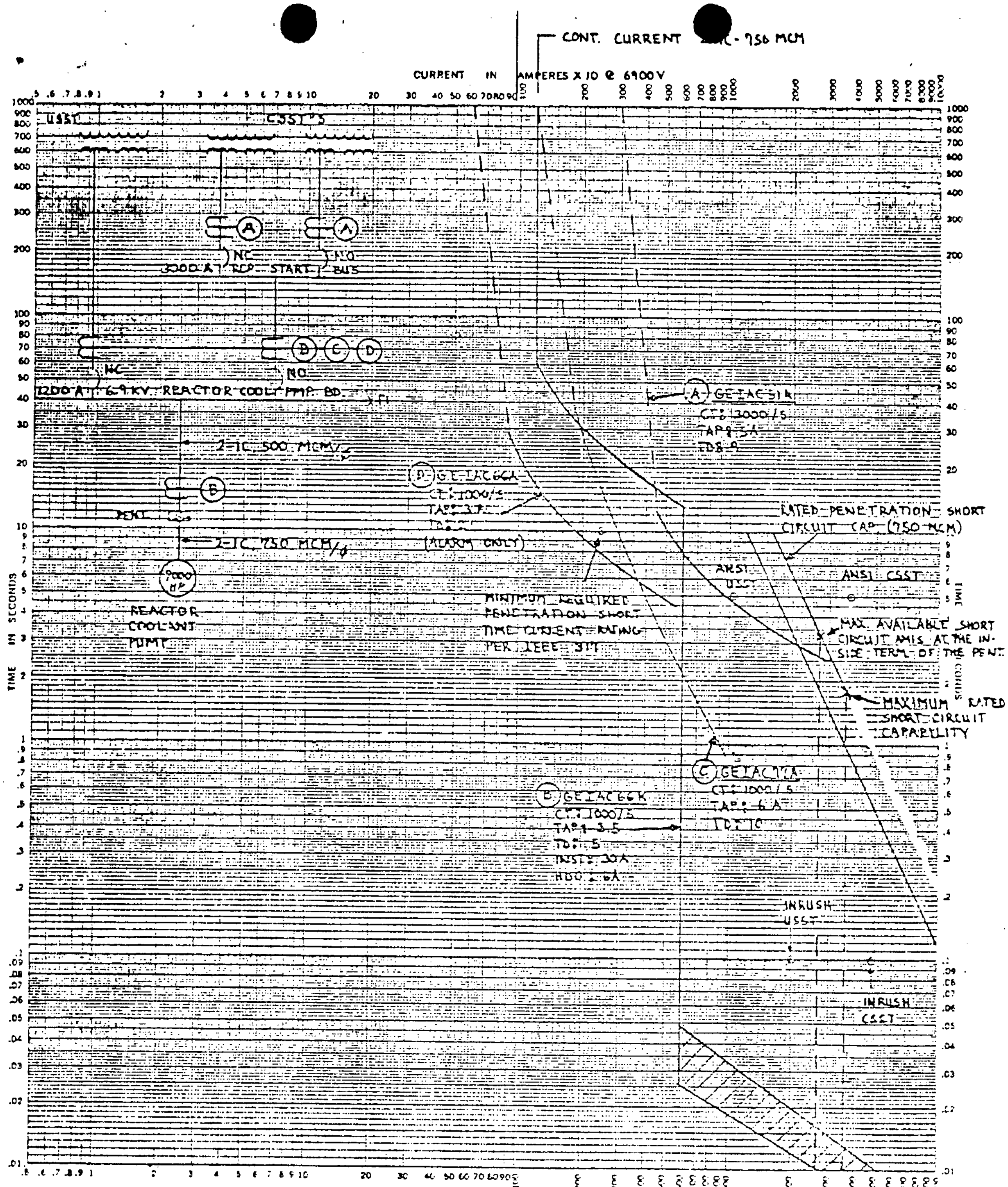
BASIS FOR DATA Standards ____ Dated ____

1. Tests made at ____ Volts a-c at ____ p-f., starting at 25C with no initial load ____
2. Curves are plotted to ____ Test points so variations should be ____

No. ____
Date ____

K·E TIME-CURRENT CHARACTERISTIC 48 5258
KEUFFEL & ESSER CO.

Fig 8.1-8



750 MCM PENETRATION

OVERCURRENT TIME-CURRENT CHARACTERISTIC CURVES

For WBNP RCP START BUSES Fuse Links, In ____

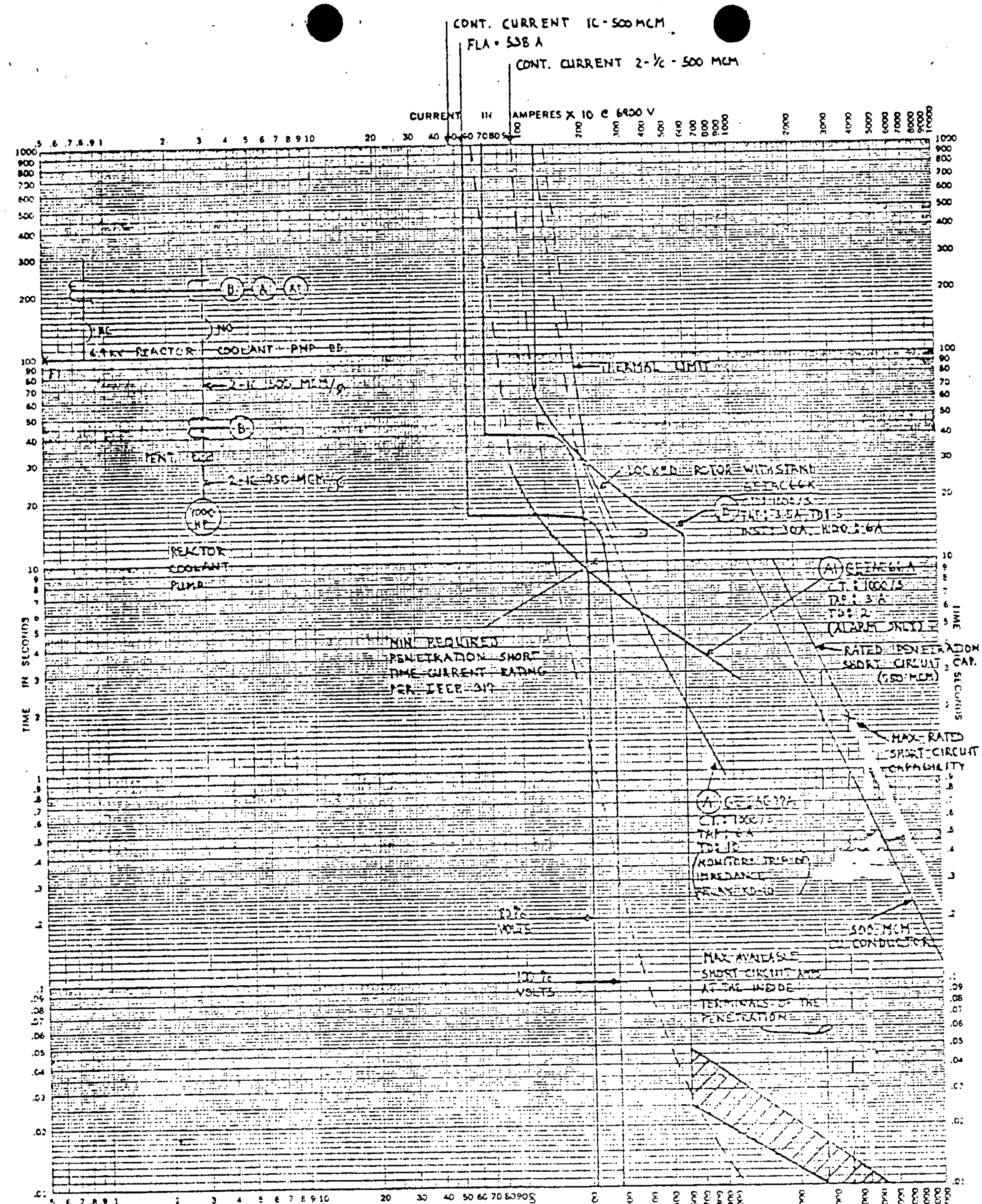
BASIS FOR DATA Standards ____ Dated ____

1. Tests made at ____ Volts a-c at ____ p-f., starting at 25C with no initial load ____ No. ____

2. Curves are plotted to ____ Test points so variations should be ____ Date ____

K-E TIME-CURRENT CHARACTERISTIC KEUFFEL & ESSER CO. 48 5258

Fig. 8.1-9



750 MCM PENETRATION

OVERCURRENT TIME-CURRENT CHARACTERISTIC CURVES

For WENP REACTOR COOLANT PUMP Fuse Links. In

BASIS FOR DATA Standards Dated

1. Tests made at Volts a-c at p.f., starting at 25C with no initial load No.

2. Curves are plotted to Test points so variations should be Date

K-E TIME-CURRENT CHARACTERISTIC KEUFFEL & ESSER CO. 46 5258

Fig. 8.1-10

8.2 OFFSITE (PREFERRED) POWER SYSTEM

8.2.1 Description

8.2.1.1 Preferred Power Supply

The features of the offsite power system are shown in Figure 8.2-1, Development Single Line Diagram.

Preferred power is supplied from the existing Watts Bar Hydro 161-kV Switchyard over two 161-kV overhead lines approximately 1.5 miles long, located entirely on TVA property. These two transmission lines will be supported on separate towers, and the separation of the two lines will be sufficient to ensure that the failure of any tower in one line will not endanger the other line.

six both

The Watts Bar Hydro 161-kV Switchyard bus arrangement is designed so that the loss of any one of the four main bus sections will not cause loss of power to ~~either~~ of the two preferred power source lines to the nuclear plant. The Watts Bar Hydro Plant Switchyard is interconnected with the TVA power system through ~~seven~~ 161-kV transmission lines and the five Watts Bar hydro generators, as shown on the ~~proposed~~ transmission arrangement, Figure 8.2-2. This switchyard also connects the four steam-driven generators in the Watts Bar Steam Plant which are not generated continuously.

The Watts Bar-Sequoyah and the Watts Bar-Athens 161-kV lines both terminate on the hydro plant switchyard bus 1, section 1. These two lines are on separate rights of way and do not cross each other. The Athens line is approximately 21.78 miles long and terminates in the Athens 161-kV Substation along with 161-kV lines from Fort Loudoun Hydro Plant and Sequoyah Nuclear Plant via Charleston 161-kV Substation. The Sequoyah line is approximately 37.37 miles long and terminates in the 161-kV switchyard at Sequoyah Nuclear Plant. The Sequoyah 161-kV Switchyard is connected to the 500-kV system through an intertie transformer bank, to one of the generating units at Sequoyah Nuclear Plant, to Chickamauga Hydro Plant, and to other substations which are integral parts of the transmission system with either direct or indirect connections to other TVA steam electric or hydro generating plants.

The Watts Bar-Great Falls 161-kV Transmission Line is approximately 53.12 miles long. This line is terminated on bus 2, section 2 in the Watts Bar Hydro Plant Switchyard. At Great Falls Hydro Plant this line is terminated in the 161-kV switchyard along with a second circuit from Watts Bar Hydro which is routed by way of Spring City 161-kV Substation and a 161-kV

The Watts Bar-Great Falls 161-kV Transmission line is approximately 53.12 miles long. This transmission line is tapped to supply the Pikeville 161-kV Substation at a point approximately 30.5 miles from the Watts Bar Hydro Plant.

transmission line that interconnects with the power system network through the Murfreesboro 161-kV Substation, McMinnville 161-kV Substation, and the Center Hill Hydro Plant. The Great Falls and the Winchester 161-kV Transmission Lines cross near the Watts Bar Hydro Switchyard.

The Watts Bar-Spring City 161-kV Transmission Line is approximately 7.38 miles long. It is terminated on bus 1, section 3 in the Watts Bar Hydro Plant Switchyard. At Spring City this line is terminated on the 161-kV bus along with a 161-kV line that extends to Great Falls Hydro Plant. The Spring City and Winchester lines that extend from Watts Bar Hydro Plant cross near the switchyard.

The Watts Bar-Rockwood and the Watts Bar-Winchester 161-kV Transmission Lines are terminated on bus 2, section 4 in the Watts Bar Hydro Plant Switchyard. The Rockwood line is approximately 23.67 miles long and is terminated on the Rockwood 161-kV bus along with 161-kV lines from ~~Kingston Steam Plant and Crossville 161-kV Substation.~~ The Crossville 161-kV Substation and the 161-kV switchyard of the [illegible] Substation. The 161-kV transmission from Roane is looped into the Harriman 161-kV Substation. Two MOD's at Harriman provide for automatic sectionalizing of the Rockwood-Harriman-Roane 161-kV Transmission Line in the event of a permanent fault on the line. The Crossville 161-kV Substation and Kingston Steam Plant are further connected to the TVA 161-kV transmission system network. The Watts Bar- Rockwood line is on a separate right of way and does not cross other lines that terminate at Watts Bar Hydro Switchyard. The Winchester 161-kV Transmission Line is approximately 76.2 miles long and terminates at Winchester 161-kV Substation by way of the Dayton and Coalmont 161-kV Substation Taps. The Winchester, Spring City, and Great Falls 161-kV Transmission Lines have crossings near the Watts Bar Hydro Plant Switchyard.

Two 161-kV transmission lines extend approximately 1.5 miles from Watts Bar Hydro Plant Switchyard to the Watts Bar Nuclear Plant site to furnish preferred power to the nuclear plant. One of these lines is terminated on bus 1, section 1 and bus 2, Section 2. This line does not cross other 161-kV lines. The other preferred power 161-kV transmission line is terminated on bus 2, section 4 and bus 1, section 3 in the hydro plant switchyard. This line crosses over the Spring City and the Great Falls 161-kV Transmission Lines near the hydro plant switchyard (Figure 8.2-2).

The transmission line structures for all 161-kV lines described are designed to exceed load requirements specified in the National Bureau of Standards Handbook No. 81 (National Electric Safety Code Part 2). Designing to these requirements ensures the adequacy of lines for wind and heavy icing conditions in excess of those that would be expected to occur in this area. The phase conductor and shield wire design tensions are selected to avoid vibration and galloping conductor problems. Long experience with area transmission lines verifies that TVA design practices have been successful in avoiding vibration problems. No galloping conductor conditions have been observed in the eastern portion of the TVA transmission system.

Transmission lines in the 161-kV voltage class have two overhead ground wires provided for lightning protection. This shielding has been effective for an area isokeraunic level of 55 and is reflected in the average operating record of only 3.86 flashover interruptions annually per 100 miles of line. The use of circuit breakers with high speed reclosing relays results in the majority of these interruptions being momentary.

8.2.1.2 Transmission Lines, Switchyard, and Transformers

The two 161-kV and the five 500-kV lines connecting the plant with the TVA transmission network are indictated functionally on Figure 8.2-1. The onsite transmission line arrangement is shown on Figure 8.2-3 and the offsite transmission line routing in the vicinity of the switchyard is shown on Figure 8.2-2. Preferred power will be supplied from the existing Watts Bar hydro 161kV switchyard (Figure 8.2-4) over two radial 161-kV overhead lines approximately 1.5 miles long. These lines are routed to minimize the likelihood of their simultaneous failure.

Location of the Common Station Service Transformers is shown on Figure 8.2-5. Physical separation is 61 feet, centerline to centerline and 35 feet between closest parts. Fire protection has been provided for each, with a water sprinkler system which can be automatically activated by thermostats or the transformer electrical protection devices. Each transformer has a single primary and two secondary windings. The primary voltage is 161-kV, rated 57/76/95, OA/FA/FOA. The secondary voltage is 6.9 kV and each is rated 36/48/60, OA/FA/FOA.

REPLACE WITH INSERT 8.2-1

8.2.1.3 Arrangement of the Start Boards, Unit Boards, Common Boards, and Reactor Coolant Pump (RCP) Boards

From the lowvoltage side of each common station service transformer, 6.9-kV station service buses supply the 6.9-kV common, unit, and RCP boards via the 6.9-kV start boards. These station service buses are outdoor, nonsegregated, partially ventilated, metal-clad structures and are shown on Figure 8.2-5. At the 6.9-kV start board these buses enter the outdoor metal-clad switchgear and connect to supply breakers. The design of the 6.9-kV start boards and RCP boards conforms to ANSI, C 37.20 (Standard for Switchgear Assemblies Including Metal-Enclosed Bus) and is classified as outdoor metal-clad switchgear. Section 20 6.2.2 of this standard defines the requirements for barriers. The circuit breakers at the 6.9-kV start boards are electrically operated, vertical lift drawout type, with stored energy mechanisms. These circuit breakers have a continuous rating of 3750 a, an insulation system for 13.8kV, interrupting rating of 1000 mva, and a momentary rating of 80,000 a amperes.

REPLACE w/ INSERT 8.2-2

INSERT 8.2-1

8.2.1.2 Transmission Lines, Switchyard, and Transformers

The two 161-kV and the five 500-kV lines connecting the plant with the TVA transmission network are indicated functionally on Figure 8.2-1. The onsite transmission line arrangement is shown on Figure 8.2-3 and the offsite transmission line routing in the vicinity of the switchyard is shown on Figure 8.2-2. Preferred power is supplied from the existing Watts Bar hydro 161-kV switchyard (Figure 8.2-4) over two radial 161-kV overhead lines approximately 1.5 miles long. These lines are routed to minimize the likelihood of their simultaneous failure.

The location of Common Station Service Transformers A and B is shown on Figure 8.2-5. Physical separation is 61 feet, centerline to centerline and 35 feet between closest parts. Each transformer has a single primary and two secondary windings. The primary voltage is 161-kV, rated 57/76/95, OA/FA/FOA. The secondary voltage is 6.9 kV and each is rated 36/48/60, OA/FA/FOA. The location of Common Station Service Transformers C and D is also shown on Figure 8.2-5. Physical separation is 70 feet, centerline to centerline and 49 feet between closest parts. Each transformer has a single primary and two secondary windings. The primary voltage is 161-kV, rated 27/36/45, OA/FA/FOA. The secondary voltage is 6.9 kV and each is rated 15/20/25, OA/FA/FOA. Fire protection has been provided for each, with a water sprinkler system which can be automatically activated by thermostats or the transformer electrical protection devices.

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INSERT 8.2-2

From the low-voltage side of each common station service transformer (CSST) A and B, 6.9-kV station service buses supply the 6.9-kV common, unit, and RCP boards via the 6.9-kV start boards. CSST's C and D are connected to their respective 6.9-kV switchgear via bus identical to CSST's A and B bus. CSST's C and D switchgear is then connected to the 6.9-kV shutdown boards via cables. The cables are routed through conduit banks and cable trays to the 6.9-kV shutdown boards.

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The circuit breakers are utilized at 6.9-kV. Therefore, there is sufficient margin between the application and the rating of these circuit breakers.

From the 6.9-kV start board the two 6.9-kV start buses A and B and the two 6.9-kV RCP start buses A and B run on separate support structures as outdoor, nonsegregated, partially ventilated metal-clad assemblies.

The bus bars are fully insulated with flame-retardant material, bus supports are flame-retardant, and the metal enclosures are such that arcing faults in one bus will not endanger the other. The 6.9-kV start buses enter the Turbine Building spaced 8' 6" centerline-to-centerline and continue on this spacing across the building. The 6.9-kV RCP start buses enter the RCP outdoor metal-clad switchgear and connect to supply breakers.

The 6.9-kV unit and common boards are indoor, metal-clad switchgear with electrically operated, vertical lift drawout breakers with stored energy mechanisms.

The four unit station service transformers are located in the transformer yard, south of the Turbine Building and directly under the delta section of the isolated-phase main generator bus. Location of the Unit Station Service Transformers is shown on Figures 8.2-5 and 8.2-6. From each of the unit station service transformer low-voltage sides two 6.9-kV buses originate, one running in the switchyard parallel to the south wall of the Turbine Building and connecting to the RCP switchgear, and the other entering the south Turbine Building wall for routing to the unit and common boards. The unit station service buses are outdoor, nonsegregated partially ventilated metal-clad construction until they enter the Turbine Building, where the construction changes to indoor type. After entering the Turbine Building, the unit station service buses are routed to the appropriate supply breakers in the 6.9-kV unit and 6.9-kV common boards, entering through the tops of the 6.9-kV unit boards and the bottoms of the 6.9-kV common boards.

All of the indoor station service buses are nonventilated, nonsegregated, metal-clad dripproof construction. In addition, the outdoor portions are weatherproof and equipped with 120V 1-phase heaters to maintain the temperature inside the housing at least 5°C above outside temperature. All buses are provided with gas-resistant seals at entry to a piece of switchgear. At the penetration of an outside building wall, the buses are provided with a fire-resistant and moisture-resistant barrier.

8.2.1.4 Arrangement of Electrical Control Area (Nuclear Plant)

Figure 8.2-7 shows the electrical control area where the relay, control, and 250V d.c. control power distribution panels are located.

Control power for power circuit breakers and associated protective relays is distributed from the 250V d.c. supply via circuit breakers on the control room d.c. distribution board. 29

Physical isolation of control power supplies for control of the two preferred power circuits is achieved by metal barriers between adjacent panels.

Two separate 250V d.c. buses are provided in these panels. Each bus can be fed from one of the two 250V battery boards through manual, mechanically interlocked, nonautomatic circuit interrupters. The power circuit breaker and associated relay control circuits are allocated to these two d.c. buses on the basis of switchyard connections. This allocation of control circuits ensures that the control and relay circuits of the two common station service transformers are fed from two independent d.c. distribution buses. Each such circuit is protected by a 30-ampere circuit breaker and supervised by an amber indicating light located on the recording and instrument board. These indicating lights are grouped on the panel on the basis of the d.c. buses they are connected to, and their wiring is physically separated on the panel on the same basis.

Each common station service transformer is protected by a percentage differential relay with harmonic restraint, a sudden pressure relay, and a neutral overcurrent relay in the 6.9-kV winding neutral.

The operation of the transformer protection relays will trip and lock out the power circuit breakers connecting it to the switchyard, trip and lock out associated 6.9-kV circuit breakers, and start a high-pressure sprinkler system to prevent or extinguish any possible fire.

8.2.1.5 Switchyard Control and Relaying

The design of the offsite power system with its provision of two immediate access circuits from the transmission network, complies with the NRC regulatory position expressed in the Regulatory Guide No. 1.32 for the preferred design of such a system.

The transmission line relay protection circuits continuously monitor the conditions of the offsite power system and are designed to detect and isolate the faults with maximum speed and minimum ~~of~~ disturbance to the system.

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The principal features of these schemes are described below. The 161-kV lines are protected by three-zone (reversed third zone) step distance phase relays augmented with directional comparison carrier blocking and have directional overcurrent carrier ground and backup ground relays. The relay potential circuits are fed from a set of potential transformers connected to each main bus section.

The 161-kV transmission line protective relays system is designed to maximize the reliability of the incoming power to the plant. The protective relaying provides for fast detection of faults and should the transmission line protective relays fail to clear the fault, adequate backup protection is available in the form of bus breakup relays. The bus breakup relays consist of impedance and ground relays. ~~that initiates a timer.~~ If the fault is not cleared within the time setting of the timer, all breakers connected to the bus section of the faulted line will be tripped and locked out.

INSERT 8.2-3

INSERT A

The Watts Bar Hydro 161-kV switchyard is protected by a bus differential relay scheme. The bus differential relays continuously monitor the current inflow and outflow from the bus section under their supervision. Whenever the current inflow does not equal the current outflow, the relays operate instantaneously to trip and lock out all breakers in their protected bus section. The bus breakup relays back up the differential relays should they fail to operate. In addition to the line and bus protection schemes, the 161-kV switchyard power circuit breakers are protected by breaker failure relays with current supervision from separate current transformers on the breaker. The breaker failure relays operate through a timing relay and should a breaker fail to trip within the time setting of its timing relay, the associated breaker failure trip relay will trip and lock out both breakers in that particular switchyard bay and also trip and lock out all breakers connected to the bus associated with the failed breaker.

The supply to the common station service transformers A and B and C and D possesses a high degree of reliability even under electrical fault conditions. The following discussion describes the sequence of events following postulated faults:

1. Transmission line fault.

   If the instantaneous element of the line protective relays is actuated the line breaker is tripped and a high speed reclosure occurs. If after the high speed reclosure the fault has not cleared, the breaker will trip again and a standard speed (synchronism check-voltage check) reclosure occurs. In the majority of the cases these reclosures restore the line back to service. However, a trip after

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INSERT O.4[illegible]

For high magnitude faults, the switchyard is instantaneously divided by circuit breaker operation so that offsite power circuits to Watts Bar Nuclear Plant are served from separate buses of the switchyard.

this will lock out the breaker isolating the fa
There is no appreciable disturbance on the two
the common station service transformers.

2. Transmission line fault and failure of the line
breaker to clear the fault.

The corresponding main bus breakup relay and bre
ure relay is automatically initiated, starting a
If the fault is not cleared within the time sett
timer, all circuit breakers connected to that bu
tripped and locked out. With normal position of
breakers described previously, both ~~common static~~
~~transformers~~ continue to receive power without in

3. Main bus fault.

This type of fault is detected by the bus differe
protection. When initiated, it trips and locks o
circuit breakers connected to the faulted bus. T
of this action are similar to those described und

4. Transformer or transformer feeder faults.

These faults cause tripping of all the transformer
breakers on the high and low voltage side of the t
former. In addition, the trip relay initiates the
former fire protection sprinkler and starts the fi

5. Common transformer or transformer feeder fault and
of one HV [(161 KV)] circuit breaker to operate properly.

These events cause the operation of protection desc
under 4 above, followed by the operation of the bre
failure relay which trips all breakers connected t
bus at the time of failure. The event results in t
of one transformer; the other transformer continues
receive power from its main bus [in the hydro switchy]

The allocation of the 250V d.c. control power circuits f
lays and circuit breakers (the description of which is i
in the preceding section) is coordinated with the switchi
requirements of the zig zag main and transfer bus arrange
and the requirement for the optimum availability of the c
station service transformers A and B.

8.2.1.6 6.9-kV Start Boards Control and Relaying

The secondaries of the common station service transformers
(CSST) [A and B] feed into two start boards containing four circuit

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breakers each. Two of the circuit breakers, 1512 and 1614, are the normal and alternate feeders for start bus A while the two breakers 1612 and 1514 are the normal and alternate feeders for start bus B. Two other breakers, 2512 and 2614, are the normal and alternate feeders for RCP start bus A, while breakers 2612 and 2514 are the normal and alternate feeders for RCP start bus B. The two circuit breakers feeding each start bus from a different CSST are interlocked and the control circuits arranged in such a manner that manually-initiated high speed (5 cycles or less) transfers can be made from either breaker to the other breaker. Automatic transfers can only be made from the normal breaker to the alternate breaker and are delayed until the bus residual voltage reduces to 30 percent of normal. All automatic transfers are initiated by undervoltage on the bus. The 250V d.c. normal control power for the pair of breakers feeding start bus A is supplied from a separate battery and d.c. distribution board from that of the normal control power for the two breakers feeding start bus B. Alternate control power feeders are similarly segregated.

Manual control of the circuit breakers is provided on the electrical control board in the Main Control Room where the operator has instrumentation showing the voltage on each of the two buses and current flowing in each of the four feeder breakers. The following annunciation is provided:

1. Start Bus Fan Failure

2. Start Bus Transfer

3. Start Bus Failure or Undervoltage

Annunciation No. 3 is composed of bus differential relay operation, bus a.c. voltage failure, and control bus d.c. voltage failure. Start Bus A is the normal feeder to 6.9-kV common board A and the alternate feeder to 6.9-kV unit boards 1A, 1C, 2A, and 2C. Start bus B is the normal feeder to 6.9-kV common board B and the alternate feeder to 6.9-kV unit boards 1B, 1D, 2B, and 2D.

INSERT 8.2-4

8.2.1.7 <u>6.9-kV Unit and RCP Board Control and Relaying</u>

The alternate feeder to each 6.9-kV unit and RCP board is from one of the start buses with the normal feeder being from a unit station service transformer.

Each 6.9-kV unit and RCP board can be selected for automatic or manual transfer between the normal and alternate supply breakers. Manual transfers are high speed (5 cycles or less) and can be made from the normal to the alternate supply or from the alternate to the normal supply. Automatic transfers can only be

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INSERT 8.[illegible]4

The secondaries of common station service transformers C and D (CSST) feed into two start boards containing two circuit breakers each. One of these circuit breakers, 1712 provides power directly to 6.9-kV shutdown boards 1A-A and 2A-A while circuit breaker 1812 provides another source of power to the same 6.9-kV shutdown boards. One other breaker, 2714, provides power directly to 6.9-kV shutdown boards 1B-B and 2B-B while circuit breaker 2814 provides another source of power to the same 6.9-kV shutdown boards. All four of the above circuit breakers are normally closed with no provision for automatic or manual transfers between circuit breakers. The 125-V dc normal control power for circuit breakers 1712 and 2714 is supplied from a separate battery and dc distribution board from that of the normal control power for circuit breaker 1812 and 2814. The alternate control power feeders for these circuit breakers are similarly segregated.

Manual control of the circuit breakers is provided on the electrical control board in the main control room where the operator has instrumentation showing the voltage on each of the two buses and the current flowing in each of the four feeder breakers.

The following annunciation is provided:

1. Loss of Control Power
2. Bus Failure or Undervoltage.

made from the normal to the alternate supply. Automatic transfers initiated by loss of voltage on the unit board are delayed unitl the bus residual voltage decreases to 30 percent of normal. Those transfers initiated by reactor trip or turbine trip signals on the unit or RCP boards are high speed transfers. Control power is from the 250V d.c. distribution system.

The unit and RCP boards are protected by overcurrent, ground overcurrent, and differential current protective relays. Manual control of the two feeder breakers of each board is provided in the Main Control Room. The operator has instrumentation that gives the voltage of each board and the current flowing in either of the two feeder breakers. The following annunciation is provided:

1. Unit and RCP Board Transfer

2. Unit and RCP Board Failure or Undervoltage

Annunciation No. 2 is composed of board differential relay operation, board a.c. voltage failure, and control bus d.c. voltage failure.

The final link to the onsite (standby) power system (the 6.9-kV shutdown boards) is feeders from the unit boards. Unit boards 1B, 1C, 2B, and 2C are the normal supplies to 6.9-kV shutdown boards 1A-A, 1B-B, 2A-A, and 2B-B, respectively, while unit boards 1A, 1D, 2A, and 2D are the alternate supplies respectively. These feeders are protected by overcurrent and ground overcurrent relays. All of these feeder breakers are normally closed with all transfers between the normal alternate feeders occurring at the 6.9-kV shutdown board.

REPLACE w/ INSERT 8.2-5

8.2.1.8 Conformance with Standards

This section discusses provisions included in the design of the offsite power system to achieve a system design in conformance with requirements of GDC 17 and NRC Regulatory Guides 1.6 and 1.32.

GDC 18

The following requirements of Regulatory Guides 1.6 and 1.32 and GDC 17 are applicable: these documents apply to offsite power.

Regulatory Guide 1.6

Regulatory Guide 1.6 requires that "Each a.c. load group should have a connection to the preferred (offsite) power source. A preferred power source may serve redundant load groups."

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INSERT 8.2-5

The final connections to the onsite (standby) power system (the 6.9-kV shutdown boards) are feeders from the unit boards and common station service transformers C and D. Unit boards 1B, 1C, 2B, and 2C are the normal supplies to 6.9-kV shutdown boards 1A-A, 1B-B, 2A-A, and 2B-B, respectively. Common station service transformers C and D provide the alternate power sources directly to the 6.9-kV shutdown boards. Common station service transformer C provides alternate No. 1 power to 6.9-kV shutdown boards 1A-A and 2A-A through circuit breaker 1712 and alternate No. 2 power to 6.9-kV shutdown boards 1B-B and 2B-B through circuit breaker 2714. Common station service transformer D provides alternate No. 1 power to 6.9-kV shutdown boards 1B-B and 2B-B through circuit breaker 2814 and alternate No. 2 power to 6.9-kV shutdown boards 1A-A and 2A-A through circuit breaker 1812. These feeders are protected by overcurrent and ground overcurrent relays. All of these feeder breakers are normally closed with all transfers between the normal, alternate No. 1 and alternate No. 2 feeders occurring at the 6.9-kV shutdown boards.

seconds following a loss-of-coolant accident to assure that core cooling, containment integrity, and other vital safety functions are maintained."

5. "Provisions shall be included to minimize the probability of losing electrical power from any of the remaining sources as a result of, or coincident with, the loss of power from the transmission network, or the loss of power from the onsite electrical power sources."

INSERT 8.2-6

Each of the above requirements and the provisions included in the design to meet them is addressed in the discussion which follows.

The discussion is arranged in two parts:

1) Physical measures for achieving independence and physical measures taken to minimize the likelihood of failures of portions of the offsite power system inducing failure of the other power sources and 2) functional provisions for achieving adequate capacity, capability, and availability; functional measures taken to minimize the likelihood of failure of portions of the offsite power system inducing failure of other power sources.

<u>Physical Measures</u>

~~The two common station service transformers and buses are connected and arranged to provide two physically independent offsite power circuits to the onsite distribution system. Either of these can be used as the preferred power supply. The outdoor portions of the buses are weatherproof and equipped with 120V, 1 phase heaters to maintain the temperature inside the housing at least 5°C above outside temperature. The conductors are fully insulated with flame-retardant material, bus supports are flame retardant, and the metal enclosures will prevent any arcing fault in one bus from damaging the other bus.~~

REPLACE w/ INSERT 8.2-7

The common station service buses A and B maintain 61 feet centerline-to-centerline separation, until they converge at the unit start board. The buses run on separate support structures and run approximately 15 feet before entering the unit start board. At the unit start board these buses enter the outdoor, metal-clad switchgear and connect to the board supply breakers. The buses are provided with gas resistant seals at the entry to the switchgear. The supply and feeder breakers at the 6.9-kV unit start board are electrically operated, vertical lift drawout type, with stored energy mechanisms. The unit start board consists of a normal feeder breaker and an alternate feeder breaker for each of the 6.9-kV start buses A and B and the RCP

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INSERT 8.2-6

General Design Criterion 18 requires that the offsite power circuits be designed to permit periodic inspection and testing to show:

a. "The operability and functional performance of the components" of the circuits,

b. The operability of the circuits as whole systems, and

c. "Under conditions as close to design as practical, the full operation sequence that brings the system into operation."

INSERT 8.2-7

The common station service transformers and buses are connected and arranged to provide two physically independent offsite power circuits to the onsite distribution system. One preferred power supply is made up by common station service transformers A and D while the other preferred power supply is made up by common station service transformers B and C.

The two common station service transformers A and B and buses are connected and arranged to provide two physically independent offsite power circuits to the onsite distribution system. Either of these can be used as the preferred power supply. The outdoor portions of the buses are weatherproof and equipped with 120V, 1 phase heaters to maintain the temperature. The conductors are fully insulated with flame-retardant material, bus supports are flame retardant, and the metal enclosures will prevent any arcing fault in one bus from damaging the other bus.

start buses A and B. The normal feeder breaker and the alternate feeder breaker obtain their supply from separate buses and separate common station service transformers, thereby giving each start bus two possible and independent sources of power.

From the feeder breakers of the 6.9-kV unit start board the two 6.9-kV unit start buses A and B and RCP start buses A and B run on separate support structures. These buses are outdoor, nonsegregated, and the conductors are fully insulated with flame-retardant material. At the penetration of the outside building wall, the unit buses are provided with fire- and moisture-resistant barriers. The RCP start buses enter the outdoor metal-clad switchgear and connect to the RCP board supply breakers. These breakers are electrically operated, vertical lift drawout type, with stored energy mechanisms.

INSERT 8.2-8

The 6.9-kV start buses enter the Turbine Building spaced 8'-6" centerline-to-centerline and maintain this spacing through the building. The start buses are tapped at appropriate places and routed to the appropriate supply breakers in the 6.9-kV unit and 6.9-kV common boards. The start buses enter the unit board supply breakers through the top of the boards. The normal supply breaker and alternate supply breaker for each board are separated along the length of the board by several feeder breakers, thereby preventing a fault in one breaker from damaging the alternate supply breaker. All buses are provided with gas-resistant seals at entry to the switchgear.

The power from the unit boards is supplied to the shutdown boards by means of cables routed via separate cable trays and conduits to their respective boards. The minimum distance between trays carrying cables to the redundant shutdown boards is approximately 30 feet, while the trays carrying normal and alternate supplies to the same shutdown board are at a minimum separation of 1 foot. A cable fault relay trips circuit breakers provided at each end of these cables so that even a simultaneous fault of the normal and alternate supply cables to one shutdown board will not effect the offsite power supply to the redundant board.

The normal distribution system to the unit boards and shutdown boards is supplied by the unit station service transformers during plant operation. The common station service transformers are used to supply the power to the unit boards or offsite distribution system during generator startup or shutdown. In case of an emergency or fault of the unit station service transformers, the common station service transformers are immediately available for use as the offsite power system and provides two separate, independent, and redundant circuits to the onsite distribution system.

INSERT 8.2-8

The two common station service transformers C and D are connected by cables and arranged to provide two physically independent offsite circuits (alternates 1 and 2) to the 6900V shutdown boards. The cables for the alternate 1 circuits are routed through separate conduits and cable trays through the turbine building and control building to the shutdown boards. The cables for the alternate 2 circuits are routed through separate conduits and cable trays alongside the exterior of the turbine building, across the top of the control building, and then enter the top of the auxiliary building and drop down to the shutdown boards.

Functional Measures

Regulatory Guide 1.6 has been implemented by providing each a.c. load group with a connection to each of the preferred source circuits. Figure 8.1-2 indicates that redundant ~~load~~ power ~~groups~~ trains in each unit are fed from different preferred source circuits. The two preferred source circuits are, however, shared between the two nuclear units.

Regulatory Guide 1.32 has been implemented by providing two immediate access circuits to the transmission network. Figures 8.1-2 and 8.2-1 indicate the functional arrangement of these continuously-energized circuits.

The rest of the discussion deals mainly with the manner in which GDC 17 has been implemented.

Between the transmission system and the incoming breakers on the 6900-volt shutdown boards are: ~~two~~ common station service transformers (CSST), A ~~and~~ B, C and D; two 6900-volt start buses, A and B; two 6900-volt RCP start buses, A, ~~and~~ B; four 6900-volt unit boards, ~~1A,~~ 1B, 1C, ~~1D, 2A,~~ 2B, ~~2C,~~ and ~~2D~~; ~~Reactor Coolant Pump boards 1A, 1B, 1C, 1D, 2A, 2B, 2C, 2D; incoming supply breakers, main buses supplying nonsafety loads, and feeder breakers for the 6900-volt shutdown boards;~~ and 6900-volt shutdown board feeder cables. Analysis to show that GDC 17 is satisfied consists of two parts: 1) a qualitative analysis to show that the loss of any one of the links listed will not cause loss of availability of offsite power to the 6900-volt shutdown boards, and 2) a quantitative analysis to show that the capacity of each of the links is such that it will carry its required load in the event of a simultaneous LOCA of one unit and full load rejection by the other with any of the links out of service.

~~Power is fed into the plant from the 161-kV Watts Bar Hydro switchyard via two common station service transformers (CSSTR's) rated 161-kV to 6.9-kV and via two 6900-volt start buses. Each CSSTR has two 6.9-kV secondary windings, one of which is the normal source for one start bus and the alternate source for the other start bus while the other winding is the normal source for one RCP start bus and the alternate source for the other RCP start bus. Each start bus serves as the startup source and the reserve running source to two of the four 6900-volt unit boards for each unit. Each of the two 6900-volt shutdown boards for each unit has a normal feed from one unit board and the alternate feed from another unit board; these two unit boards have alternate, or reserve, feeds from different start buses with automatic transfer from normal to reserve source. Thus each 6900-volt shutdown board has automatic access~~

REPLACE w/ INSERT 8.2-9

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INSERT 8.2-9

Power is fed into the plant from the 161-kV Watts Bar Hydro switchyard via four common station service transformers (CSST's) rated 161-kV to 6.9 KV and via two 6900-volt start buses. Each CSST has two 6.9-kV secondary windings, one secondary winding of CSST A and B is the normal source for one start bus and the alternate source for the other start bus while the other winding is the normal source for one RCP start bus and the alternate source for the other RCP start bus. Each start bus serves as the startup source and the reserve running source to two of the four 6900-volt unit boards for each unit.

Each of the two 6900-volt shutdown boards for each unit has a normal feed from one unit board; the unit boards have alternate, or reserve, feeds from different start buses with automatic transfer from normal to reserve source. Also, each 6900-volt shutdown board has two alternate sources directly from CSST C and D. Thus each 6900-volt shutdown board has access to any one of four common station service transformers, and both 6900-volt shutdown boards for each unit will be energized from offsite power in case of a loss of any one CSST,, start bus, unit board, supply cable from unit to shutdown board, or supply cable from CSST C or D to the shutdown boards.

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to either common station service transformer, and both 6900-volt shutdown boards for each unit will be energized from offsite power in case of a loss of any one CSSTR, start bus, unit board, or supply cable from unit board to shutdown board.

The two start buses are physically independent in that each bus has its own housing. Thus each bus is protected against migration of a fault from the other start bus by two barriers. This circuit independence extends through the start board (the outdoor switchgear assembly which houses the breakers feeding the start buses from the CSSTR's) on to the common station service transformer terminals. Sufficient heaters to prevent condensation in the bus conductor insulation or supporting insulators are provided and will be energized continuously.

INSERT 8.2-10

The overcurrent protective relays for the 6900-volt breakers are coordinated to provide a selective system for line faults and for ground faults. Thus a fault on a non-safety-related load circuit supplied from a 6900-volt unit board, will be isolated so that the continuity of power to that unit board and to the shutdown board fed from that unit board will not be jeopardized by the fault. Should the 6900-volt board incoming supply breaker trip on backup due to failure of the breaker nearest the fault, the 6900-volt shutdown board being supplied by that 6900-volt unit board will automatically transfer to the alternate 6900-volt unit board. Each 6900-volt unit board main bus is protected by bus differential relays which will isolate this bus in the event of a unit board bus fault. In this case also, the 6900-volt shutdown board fed by that unit board will transfer to its alternate 6900-volt unit board.

REPLACE w/ INSERT 8.2-11

In the event of a simultaneous LOCA on one generating unit and a full load rejection by the other generating unit while one CSSTR is out of service, the one remaining CSSTR will supply power to the emergency loads on the LOCA unit and to those loads on both units associated with normal operation which are not automatically tripped. These normal operating loads are subsequently reduced by action of the unit operators. However no operator action is assumed to be required during the first 10 minutes following a LOCA.

The temporary overload condition of the common station service transformer will cause no significant predicted loss of transformer life according to Tables 92-02.200M through 92-02.200P of ANSI Standard C57.92. Table 8.2-1 lists the equipment capabilities and worst case loads.

When a unit is tripped automatically due to a mechanical fault (including LOCA) such that the generator main circuit breaker

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wat 8 2/1

INSERT 8.2-10

The cables for alternate 1 and alternate 2 feeders from CSST's C and D are also physically independent as they are routed through separate conduits and cable trays.

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[illegible]

In the event of a simultaneous LOCA on one generating unit and a full load rejection by the other generating unit with one CSST not available, the remaining CSST's would supply power to the emergency loads for both units (CSST C and/or D) and to those loads on both units associated with normal operation which are not automatically tripped (CSST A and/or B). These normal operating loads would be subsequently reduced by action of the unit operators, however, no operator action would be required during the first 10 minutes following a LOCA. If either CSST A or B were not available, the other transformer would be automatically overloaded. This temporary overload condition would cause no significant predicted loss of transformer life according to Tables 92-02.200M through 92-02.200P of ANSI Standard C57.92. The overload would not cause degraded voltage on the safety-related buses, since they are automically connected to CSST C and D. If either CSST C or D were not available, the other transformer would supply the 6900V shutdown boards for both units, but would not be loaded above its rating. Table 8.2-1 lists the equipment capabilities and worst case loads.

When a unit is tripped automatically due to a mechanical fault (including LOCA) such that the generator main circuit breaker is not immediately tripped by a fault signal, this breaker remains closed for approximately 30 seconds to keep stable power available to the reactor coolant pumps. During this period the generator is driven as an unloaded synchronous motor since the turbine stop valves are closed. Transfer of the 6900V unit boards and RCP boards is delayed 30 seconds, and they are supplied through the unit station service transformers via the unit main transformer from the 500-kV switchyard. The 6900V shutdown boards immediately fast transfer to offsite power supplied via CSST's C and D for all unit trips.

~~is not immediately tripped by the fault signal, this breaker will remain closed for approximately 30 seconds to keep stable power available to the reactor coolant pumps. During this period the generator will be driven as an unloaded synchronous motor since the turbine stop valves will have been closed. The power to the 6900-volt unit boards, and thus to the 6900-volt shutdown boards, will be supplied through the unit station service transformers and via the unit main transformer from the 500-kV switchyard. The load on the unit station service transformer is less than for a full test of engineering safety features while the unit is running at full load. The loads started automatically are less in total than one reactor coolant pump. This presents no problem since the normal auxiliary power system is designed to prevent voltage drop greater than 15 percent on starting the largest motor and also to carry full test load of emergency equipment during normal operation.~~

In addition to compliance with the above standards for portions of the offsite power system, the 6.9-kV start board, 6.9-kV unit boards, 6.9-kV RCP boards, and the associated 6.9-kV buses were procured in accordance with certain TVA standards and industry standards. TVA specifications require conformance of this equipment to such standards as the following. The overall construction, ratings, tests, service conditions, etc., are required to be in conformance to ANSI C37.20 and NEMA SD-5; the power circuit breakers are referenced to ANSI C37.4 through C37.9 and NEMA SG-4; associated relays are specified to conform to ANSI C37.1, instrument transformers to ANSI C57.13 and NEMA EI-2 and wiring to IPCEA S-61-402 and NEMA WC5.

The design of the equipment arrangement was also implemented to comply with GDC 3 for fire protection and with GDC 18 and Regulatory Guide 1.22 for each of periodic tests and inspections.

Criterion 18

The offsite power system has been designed to permit appropriate periodic inspection and testing. Such testing can be accomplished without removing the main generators from service. Transmission line protective relaying will be inspected and 24
tested routinely and can be performed without removing the transmission lines from service. A common station service transformer may be removed from service for testing without disturbing the other offsite power source. Power can be transferred from the unit station service transformers to the common station service transformers to demonstrate operability of 30.13
the system.

8.2.2 Analysis

Each of the 161-kV circuits providing preferred offsite power to the WATTS Bar Nuclear Plant is supplied through two power circuit breakers connecting with separate ~~sections of the main~~

buses ~~bus~~ in the Watts Bar Hydro Plant Switchyard. At the load end of these feeders, each circuit terminates at a 161-6.9-kV common station service transformer. Each transformer has sufficient capacity to supply the essential safety auxiliaries of one unit under loss of coolant accident conditions in addition to the power required for shutdown of the nonaccident unit. Figure 8.2-8 shows the station service condition when normal power for the operation of the nuclear units is supplied from the unit station service transformers.

Physical separation of lines, primary and backup protection systems, and a strong transmission grid minimize the probability of simultaneous failures of offsite power sources. Results of steady-state, transient stability, and inertial pickup studies show that the offsite power sources remain intact as reliable sources to supply the onsite electric power system for the loss of either nuclear unit, the loss of 500-kV lines connecting either of these units into the transmission system and the loss of the next largest generating unit on the system, or the loss of the most critical 500-kV transmission line.

Transient stability studies included conditions of three-phase faults on transmission lines connecting the nuclear units into the transmission system. Studies of these faults included unsuccessful reclosures in which the line was removed from service, and stuck-breaker conditions in which one nuclear unit and its 500-kV lines were disconnected automatically from the transmission system. Transient stability studies of the 161-kV system supplying preferred power to the nuclear plant included three-phase faults, stuck-breaker conditions, and main bus section interruptions.

Due to the large number of diverse generating units and strong interconnections, the likelihood of an outage of a sufficient part of the transmission system to cause the loss of all sources of offsite power is considered to be extremely remote. An example considered to be the most severe condition of postulated transmission disturbances is one in which one nuclear unit is under loss-of-coolant accident conditions during the time when power is required for shutdown of the other nonaccident unit. The study of this contingency shows that the transmission system remians stable with negligible disturbance to the sources of offsite power supply as indicated by the Watts Bar Hydro 161-kV bus voltage and frequency response curves in Figures 8.2-9 and 8.2-10.

TABLE 8.2-1

OFFSITE POWER SYSTEM - EQUIPMENT CAPABILITIES AND WORST-CASE LOADS

(Loss of One Common Station Service Transformer, LOCA on one Unit, Full Loda Reject by Other Unit, First Ten Minutes)

Equipment	Rating or Nominal Limit	Computed Value	Allowable Operating Time at Computed Condition
Com Sta Serv Trans:			
161-kV Winding H	85.1 MVA (FA 65°C)	117.3 MVA (138%)	>4 hr.
6.9-kV Winding X	53.8 MVA (FA 65°C)	44 MVA (81.8%)	Continuous
6.9-kV Winding Y	53.8 MVA (FA 65°C)	73.3 MVA (136%)	>4 hr.
6.9-kV Start Bus Continuous Current	4000 Amps	3192 Amps	Continuous
6.9-kV RCP Bus Continuous Current	3000 Amps	1843 Amps	Continuous
6.9-kV Load Feeder ACB			
Interrupting MVA	500 ~~[illegible]~~ ~~800~~ MVA	482 MVA	Continuous
Momentary Current	80,000 Amps	58,264 Amps	Continuous
6.9-kV System Voltage			
Minimum Motor Operating Voltage	5940 Volts	6700 Volts	Continuous
Minimum Motor Starting Voltage	5280 Volts	5360 Volts	

TABLE 8.2-1

OFFSITE POWER SYSTEM
EQUIPMENT CAPABILITIES, WORST-CASE LOADS

Operating Mode: Two-Unit Full Load Rejection, Common Station Service Transformers A and B Available

Equipment	Rating or Nominal Limits	Computed Values	Allowable Operating Time at Computed Condition
Com Sta Serv XFMR A			
H-WDG	85.1 MVA	54.93 MVA	Continuous
X-WDG	53.8 MVA	24.68 MVA	Continuous
Y-WDG	53.8 MVA	30.40 MVA	Continuous
Com Sta Serv XFMR B			
H-WDG	85.1 MVA	50.44 MVA	Continuous
X-WDG	53.8 MVA	24.68 MVA	Continuous
Y-WDG	53.8 MVA	25.89 MVA	Continuous

Operating Mode: One Unit Loss of Coolant Accident, One Unit Full Load Rejection, Common Station Service Transformers C and D available

Equipment	Rating or Nominal Limits	Computed Values	Allowable Operating Time at Computed Condition
Com Sta Serv XFMR C			
H-WDG	50.4 MVA	12.13 MVA	Continuous
X-WDG	28.0 MVA	0 MVA	Continuous
Y-WDG	28.0 MVA	12.13 MVA	Continuous
Com Sta Serv XFMR D			
H-WDG	50.4 MVA	12.97 MVA	Continuous
X-WDG	28.0 MVA	12.97 MVA	Continuous
Y-WDG	28.0 MVA	0 MVA	Continuous

Sheet 1

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TABLE 8.2-1

OFFSITE POWER SYSTEM
EQUIPMENT CAPABILITIES, WORST-CASE LOADS

Operating Mode: Two-Unit Full Load Rejection, Common Station Service Transformers A and B Available.

RCP Start Bus A	3000 AMPS	2065 AMPS	Continuous
RCP Start Bus B	3000 AMPS	2065 AMPS	Continuous
Start Bus A	4000 AMPS	2544 AMPS	Continuous
Start Bus B	4000 AMPS	2166 AMPS	Continuous

Operating Mode: Two-Unit Full Load Rejection, Common Station Service Transformer A Available.

Equipment	Rating or Nominal Limits	Computed Values	Allowable Operating Time at Computed Condition
Com Sta Serv XFMR A			
H-WDG	85.1 MVA	105.37 MVA	4 hr.
X-WDG	53.8 MVA	49.36 MVA	Continuous
Y-WDG	53.8 MVA	56.29 MVA	4 hr.

Operating Mode: One-Unit LOCA, One-Unit FLR, Common Station Service Transformer D Available.

Com Sta Serv XFMR D			
H-WDG	50.4 MVA	25.10 MVA	Continuous
X-WDG	28.0 MVA	12.97 MVA	Continuous
Y-WDG	28.0 MVA	12.13 MVA	Continuous

Equipment Capabilities
Worst-Case Fault Currents

Operating Mode: Two-Unit Full Load Rejection, Common Station Service Transformers A & D Available.

Equipment	Rating or Nominal Limits	Computed Values
6.9-kV Unit BD ACB	500 MVA	506.17 MVA
6.9-kV RCP BD ACB	500 MVA	571.07 MVA[1]

Operating Mode: Two-Unit Full Load Rejection, Common Station Service Transformer D Available.

6.9-kV SHTDN BD ACB	500 MVA	377.10 MVA

Sheet 2

TABLE 8.2-1

OFFSITE POWER SYSTEM
EQUIPMENT CAPABILITIES, WORST-CASE LOADS

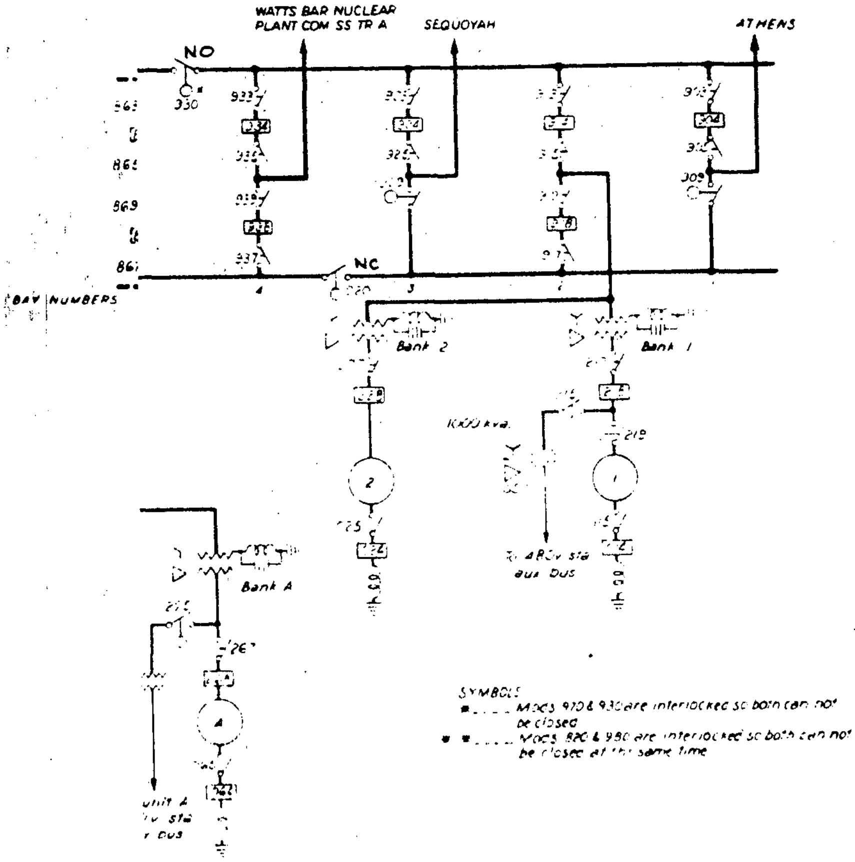
Equipment Capabilities
Voltage Limits

Equipment	Rating or Nominal Limits	Computed Values	Allowable Operating Time at Computed Condition
Balance of Plant Motors	6.6-kV Rated		
	Min Operating kV 5.940-kV	Min Anticipated 6.210 kV	Continuous
	Min Starting kV 5.610-kV	Min Anticipated 6.210 kV	Not Applicable
Class 1E Motors	6.6-kV Rated		
Low Voltage Considerations	Min Operating kV 5.940-kV	Min Anticipated[2] 6.555 kV	Continuous
	Min Starting kV 5.280-kV	Min Anticipated 5.865 kV	Not Applicable
High Voltage Considerations	Max Operating kV 7.260-kV	Max Anticipated[3] 7.610 kV	

Notes: 1. The maximum available fault on a reactor coolant pump board was computed for a two-unit full load rejection; at the same time one preferred offsite power circuit was out of service. This is worst case where both units' reactor coolant pumps are contributing to a fault on a single bus. These are very extreme contingencies that TVA does not expect to happen simultaneously. The maximum available fault on the inside terminals of a given reactor coolant pump circuit electric penetration with the above contingencies imposed results in a computed value at the electric penetration that is within the penetration rating and a computed value within the 6.9-kV RCP board circuit breaker rating.

2. Degraded voltage relaying setpoint.

3. Maximum anticipated when connected to common station service transformer C or D. The unit operator will receive an alarm signal at 7.260kV and have the option of transferring to common station service transformers A or B, which will be less than 7.260kV.



WATTS BAR NUCLEAR PLANT
FINAL SAFETY
ANALYSIS REPORT

WATTS BAR HYDRO PLANT
WIRING DIAGRAM
DEVELOPMENT SINGLE LINE
TVA DWG 45N501
FIGURE 8.2-1A

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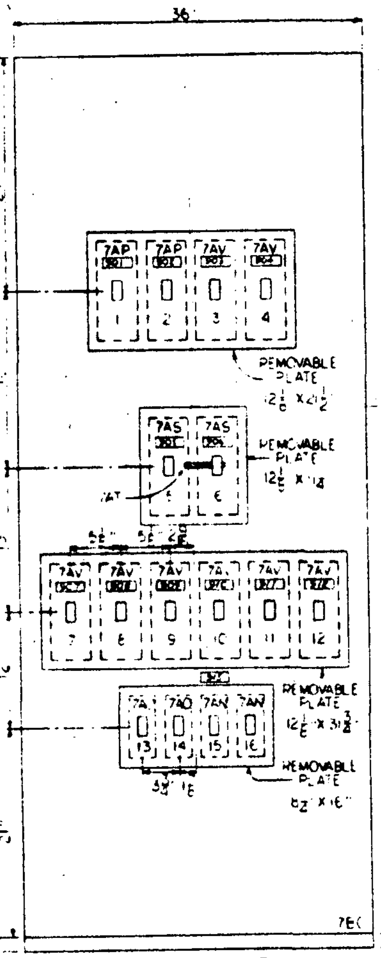


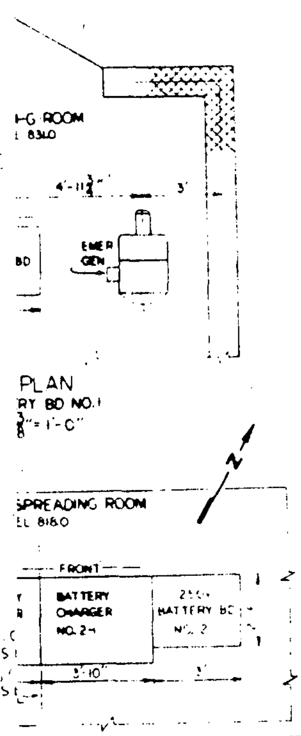
250V BATTERY BD NO.2
FRONT ELEVATION
(SEE NOTE 6)

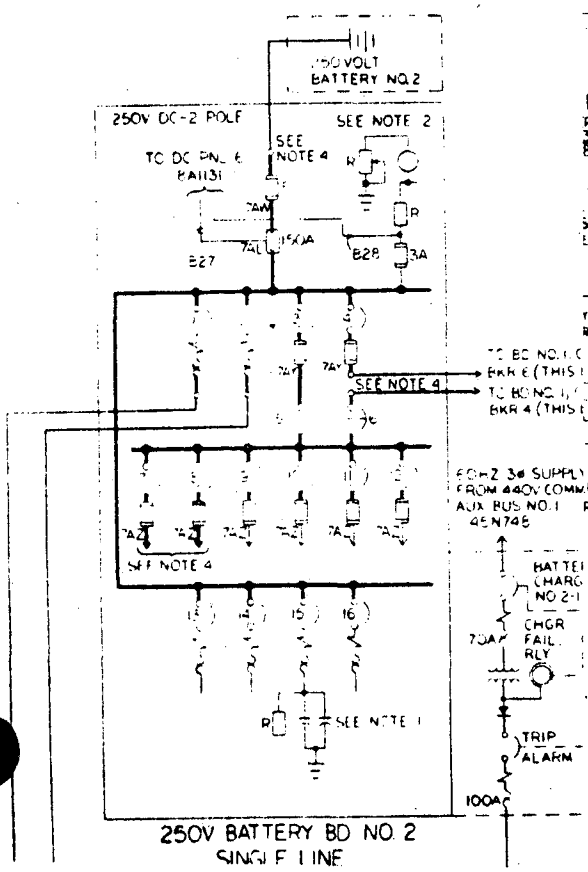
CIRCUIT SCHEDULE	
CIRCUIT	CABLE
-G SET NO 1	B147
-G SET NO. 2	B148
1 PRIMARY SUPPLY	
2 ALTERNATE SUPPLY	B150
1 PRIMARY SUPPLY	
1 ALTERNATE SUPPLY	B149
NO. 1-1	B151
NO. 1-2	B152
R NO. 1-1	B153
R NO. 1-2	B154
TEM NO. 1 PRIMARY SUPPLY	B155
TEM NO. 1 ALTERNATE SUPPLY	B156
R	

.2 CIRCUIT SCHEDULE	
CIRCUIT	CABLE
2	B246
2-1	B247
2-2	B248
NO. 2 PRIMARY SUPPLY	
NO. 1 ALTERNATE SUPPLY	E149
NO. 2 PRIMARY SUPPLY	
NO. 2 ALTERNATE SUPPLY	E150
R NO. 2-1	B251
R NO. 2-2	B252
ER NO. 2-1	B253
ER NO. 2-2	B254
YSTEM NO. 2 PRIMARY SUPPLY	B255
YSTEM NO. 2 ALTERNATE SUPPLY	B256
R	

NOTES

1. THE AC GROUND STABILIZER CIRCUITS FOR 250V DC SYSTEMS 1 AND 2 ARE TO BE INSTALLED BEHIND BOARDS NO.1 & NO.2 RESPECTIVELY BY SWITCHBOARD SUPPLIER PER DETAIL A
2. THE GROUND ALARM CIRCUIT FOR 250V DC SYSTEM 2 IS TO BE INSTALLED BEHIND BD NO.2 BY SWITCHBOARD SUPPLIER PER DETAIL B. ON BD NO. 1, SWITCHBOARD SUPPLIER WILL INSTALL 3 AMP FUSES ONLY. TVA WILL RELOCATE RELAY & RESISTORS FROM DC BD NO.1 IN CONTROL ROOM.
3. TVA TO RELOCATE ONE 250A/100MV BATTERY SHUNT AND TWO 200A/100MV BATTERY CHARGER M-G SET SHUNTS FROM CONTROL ROOM. DC DISTRIBUTION PANEL 3. SHUNTS TO BE INSTALLED IN POSITIVE LEG
4. TERMINALS ARE TO BE SIZED FOR 500 MCM CABLE.
5. CABLES WILL BE INSTALLED THROUGH TOP OF SWITCHBOARD BY TVA. TVA WILL DRILL NECESSARY HOLES FOR CABLE ENTRY.
6. FOR WIRING DIAGRAMS AND DETAILS OF 250V BATTERY BOARDS 1 & 2, SEE EL-TEX DRAWINGS D105H,-2. TVA CONTRACT 76P5-87308. FOR WIRING DIAGRAMS AND DETAILS OF 250V BATTERY CHARGERS 2-1 & 2-2, SEE POWER CONVERSION PRODUCTS, INC. DRAWING, TVA CONTRACT 76P13-87302.
7. THE GROUND ALARM CIRCUITS FOR BOARDS 1 & 2 ARE TO BE PARALLELED BY CABLE A156. THE CIRCUIT WILL BE ROUTED FROM BOARD 1 TO DC BOARD 3 IN CONTROL ROOM BY CABLE A157 (SEE 8A1131).





250V BATTERY BD NO. 2
SINGLE LINE

SCALE 1½" = 1'-0"
EXCEPT AS NOTED

WATTS BAR NUCLEAR PLANT
FINAL SAFETY
ANALYSIS REPORT

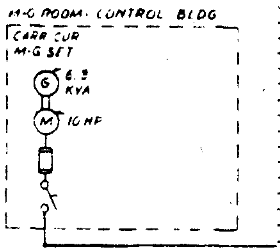
WATTS BAR HYDRO PLANT
WIRING DIAGRAM
DEVELOPMENT SINGLE LINE
TVA DWG 45W709
FIGURE 8.2-1B

1	2	10	11	12

ON SYSTEM NO 1 CIRCUIT SCHEDULE

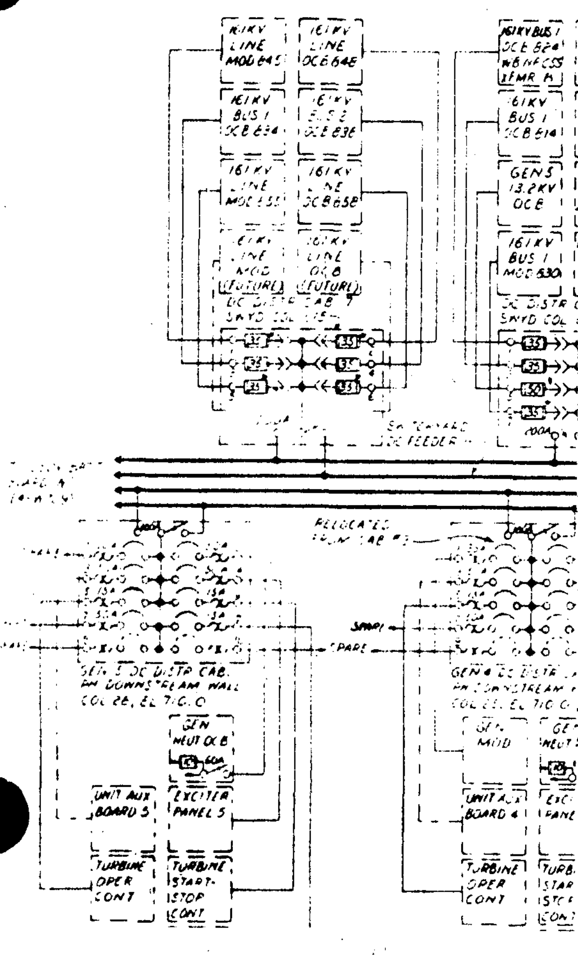
†	‡	CIRCUIT
	50	CARR CUR TEL M-G SET DC MOTOR SUPPLY
		SPARE
		SPARE
	50	SPARE
	50	SPARE
	50	LABORATORY
	50	ANNUNCIATOR SYSTEM SUPPLY
	50	SPARE
	50	SPARE
	150	SPARE
	150	SPARE
	◇	NORMAL SUPPLY-FROM 250V BAT BD NO 1
	◇	ALT SUPPLY FROM BAT BD NO 1
	35	161KV WBNP CSS XFMR B LINE RELAYS
	35	161KV WBNP CSS XFMR B TRAN & REM TRIP
	35	161KV WBNP CSS XFMR B RLY POT. TRANSFER
	35	161KV OCB 824 BREAKER FAILURE RELAY
	35	161KV OCB 828 BREAKER FAILURE RELAY
	35	161KV BUS 1-3 BREAKER FAILURE AUX RELAY
	35	GEN 4 & SS XFMR 2 RELAYS
	35	GEN 3 RELAYS
	35	XFMR 4 & 5 DIFF RELAYS
	35	161KV BUS 2-4 BREAKER FAILURE AUX RELAY
	35	WINCHESTER LINE RELAYS
	35	SPRING CITY LINE RELAYS
	35	ROCKWOOD LINE RELAYS
	35	161KV OCB 818 SPARE RELAYS
	35	161KV BUS 1-3 DIFF RELAYS
	35	161KV BUS 2-4 DIFF RELAYS
	35	MAIN RELAY BD TEST SUPPLY
	35	LOAD & FREQUENCY CONTROL
	35	OCB ALARM 161KV BAYS 1-16
	35	440V COM AUX BD-CONT HSE-SPARE ACB CONT
	35	BUS 1-3 BREAK-UP RELAYS
	35	BUS 2-4 BREAK-UP RELAYS
	35	161KV OCB 834 SPARE RELAYS
	35	XFMR C & D TIE LINE DIFF RELAYS
	35	161KV OCBS 814 & 818 BKR FAIL AUX RLY

NOTES
- * ---- ADAPTER FOR 35AMP FUSES
- ** ---- ADAPTER FOR 15AMP FUSES
- ‡ ---- ADAPTER FOR 50 AMP FUSES



...TING APPROXIMATELY TEN TIMES BREAKER RATING

...NG
...P ELEMENTS-MANUAL OPERATION ONLY
...& WIRED IN BREAKER LINE CIRCUIT
...D, BUT NOT WIRED IN CIRCUIT (FOR FUTURE USE)



ON SYSTEM NO.2 CIRCUIT SCHEDULE

	†	‡	CIRCUIT
		30	161KV WBNP CSS XFMR A LINE RELAYS
		15	161KV WBNP CSS XFMR A TRAN & REM TRIP
		15	161KV WBNP CSS XFMR A RLY POT. TRANSFER
		15	161KV OCB 934 BREAKER FAILURE RELAY
		15	161KV OCB 938 BREAKER FAILURE RELAY
		15	OSCILLOGRAPH
		15	GEN 1 & SS XFMR 1 DIFF RELAYS
		15	GEN 2 DIFF RELAYS
		15	XFMR 1 & 2 DIFF & GRD RELAYS
		15	GEN & XFMR 3 DIFF RELAYS
		15	XFMR A & B TIE LINE DIFF RELAYS
		15	161KV OCBS 984 & 988 BKR FAILURE AUX RELAY
		15	ATHENS LINE RELAYS
		15	SEQUOYAH LINE RELAYS
		15	161KV OCBS 934 & 938 BKR FAILURE AUX RELAY
		15	GREAT FALLS LINE RELAYS
		15	161KV OCB 516 SPARE RELAYS
		15	161KV OCB 554 SPARE RELAYS
		30	SPARE
		15	161KV BUS 1-1 DIFF RELAYS
		15	161KV BUS 2-2 DIFF RELAYS
		15	161KV BUS 1-1 BREAK-UP RELAYS
		15	161KV BUS 2-2 BREAK-UP RELAYS
		30	[illegible]
	◇		NORMAL SUPPLY-FROM 250V BAT BD NO 2
	◇		ALT SUPPLY-FROM 250V BAT BD NO 2
		15	[illegible]
		15	[illegible]
		15	[illegible]
		15	[illegible]
		15	[illegible]
		15	SPARE

...TTING APPROXIMATELY TEN TIMES BREAKER RATING
...ELEMENTS-MANUAL OPERATION ONLY

THIS DWG SUPERSEDES DWG 45N726-9

WATTS BAR NUCLEAR PLT
FINAL SAFETY
ANALYSIS REPORT

WATTS BAR HYDRO PLANT
WIRING DIAGRAM
DEVELOPMENT SINGLE LINE
TVA DWG 45W726

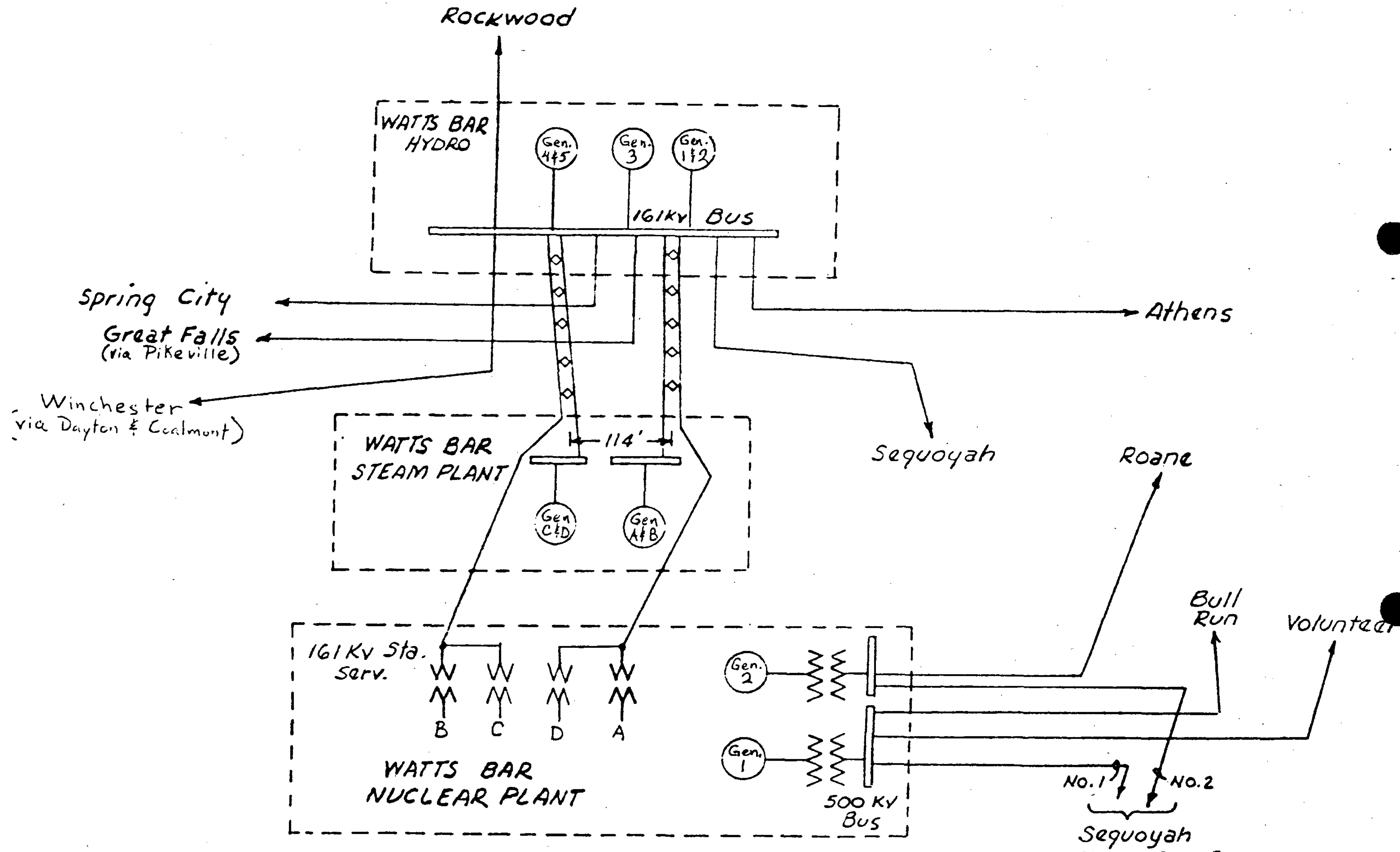


Figure 8.7-2

WATTS BAR NUCLEAR PLANT

500 & 161Kv Transmission Arrangement

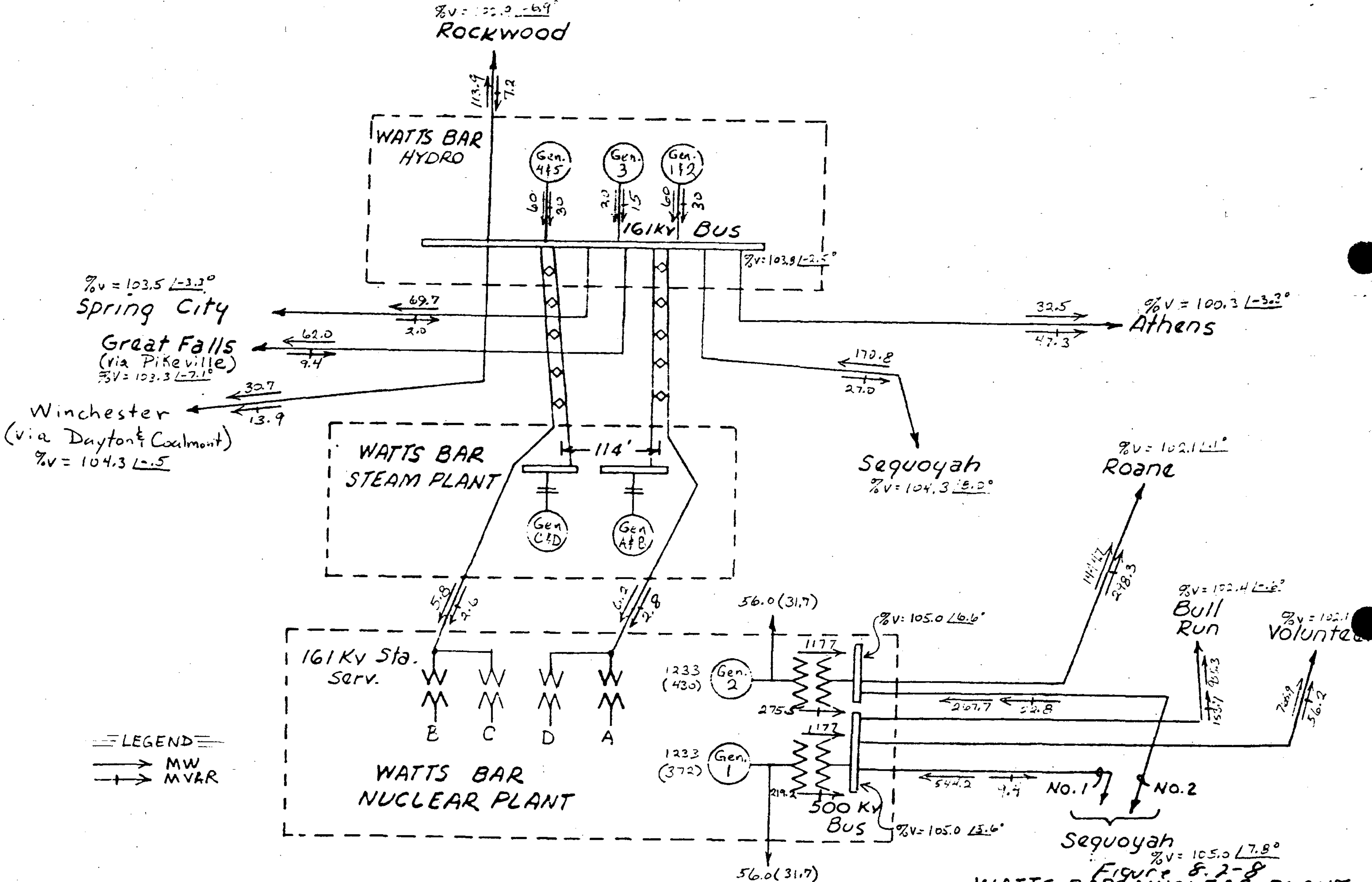


Figure 8.2-8

WATTS BAR NUCLEAR PLANT

Power Flow Plot Normal System

8.3 ONSITE (STANDBY) POWER SYSTEM

8.3.1 A.C. Power System

The onsite a.c. power system is a Class IE system which consists of: (1) the Standby A.C. Power System, and (2) the 120V Vital A.C. System. The safety function of the Standby Power System is to supply power to permit functioning of components and systems required to assure that (1) fuel design limits and reactor coolant pressure boundary design conditions are not exceeded due to anticipated operational occurrences, and (2) the core is cooled and vital functions are maintained in event of postulated accidents, subject to loss of the Preferred Power System and subject to any single failure in the Standby Power System. The safety function of the 120V Vital A.C. System is to supply power continuously to reactor protection, instrumentation, and control systems; engineered safety features instrumentation and control systems; and other safety-related components and systems, subject to loss of all a.c. power and any single failure within the Vital A.C. System.

8.3.1.1 Description

Standby A.C. Power System

The Standby A.C. Power System is a safety-related system which continuously supplies power for energizing all a.c.-powered electrical devices essential to safety. Power continuity to the 6.9-kV shutdown boards is maintained by switching among the nuclear unit source (the normal source), the preferred (offsite) source, and the standby (onsite) source. Source selection is accomplished by automatically transferring from the nuclear unit source to the preferred source to the standby source, in that order. The reverse transfers are manual. The circuits connecting the normal, preferred, and standby sources to the distribution portion of the Standby Power System are shown in Figure 8.1-2. The normal and preferred power circuits and the transfer scheme used to effect the source switching for these circuits is further discussed in Section 8.2.

System Structure

Figures 8.1-2 and 8.1-2a are ~~is~~ the single line representation of the plant a.c. auxiliary power distribution system. The standby (onsite) portion of the system is identified as the diesel generators,

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load groups

Each load group is composed of two

the 6.9-kV shutdown boards, the 480V shutdown boards, and all motor control centers supplied by the 480V shutdown boards for both units.

(train-1A and-2A; train-1B and-2B) and supplies

the plant / plant

The Standby Power System serving ~~each unit~~ is divided into two redundant ~~power trains~~. ~~These~~ power trains ~~(train A and train B for each unit) supply~~ power to all plant safety-related equipment. The power train assignment for safety-related electrical boards is indicated by use of a -A or -B suffix following its designation of all drawings and documents. Loads supplied from these boards are always safety-related unless designated on the single line drawings with a triangle symbol. Equipment shown on schematic drawings is safety-related when designated with a train assignment of A or B. The sources and boards comprising each power train are shown in Figure 8.1-2 a. Nonsafety-related loads are also supplied from the Standby Power System through Class IE breakers.

Physical Arrangement of Components

The boards, motor control centers, and transformers comprising the system are arranged to provide physical independence and electrical separations between power trains necessary for eliminating credible common mode failures. The power train assignment for safety-related electrical equipment is indicated by use of an -A or -B suffix following its designation on all drawings and documents.

The specific arrangements of these major components are described as follows:

Reference: Figures 8.3-1 through 8.3-4.

Diesel Generators

The physical arrangement of the four diesel generators and all support equipment provides physical independence by isolation as indicated in Figure 8.3-1. Each diesel and its associated support equipment is separated from all other units by missile and fire barrier type walls.

6900-Volt Shutdown Boards 1A-A, 1B-B, 2A-A, and 2B-B

These boards are located in the Auxiliary Building at elevation 757.0. They are arranged electrically into two power trains with two boards associated with each train and each unit. The boards comprising train A are located in the Unit 1 area and

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those of train B are located in the Unit 2 area. The train A boards are separated from the train B boards by an 8-inch reinforced concrete wall extended to the ceiling. The minimum distance between train A and train B boards is 8 feet 11-1/2 inches. The two boards associated with train A or train B are separated from each other by a distance of 19 feet 9 inches.

6900-480-Volt Shutdown Board Transformers 1A1-A, 1A-A, 1A2-A, 1B1-B, 1B-B, 1B2-B, 2A1-A, 2A-A, 2A2-A, 2B1-B, 2B-B, ~~and~~ 2B2-B, 1E-A, 1E-B, 2E-A and 2E-B

These transformers are located in the Auxiliary Building at elevation 772.0. Four rooms have been provided so that the transformers associated with train A and B of both nuclear units are in separate rooms. The walls isolating these rooms are made of 8-inch reinforced concrete and extend to the ceiling. The three transformers associated with one train of each unit are located in one of the four rooms.

480-Volt Shutdown Boards 1A1-A, 1A2-A, 1B1-B, 1B2-B, 2A1-A, 2A2-A, 2B1-B, and 2B2-B

Separate rooms for the 1A, 2A, 1B and 2B boards and their respective 480-volt Control/Auxiliary Building Vent boards are located in the Auxiliary Building at elevation 757.0. The 480-Volt Shutdown boards are divided into two sections each.

480-Volt Reactor MOV Boards 1A1-A, 1A2-A, 1B1-B, 1B2-B, 2A1-A, 2A2-A, 2B1-B and 2B2-B

These boards are located in the Auxiliary Building at elevation 772.0. They are located in separate rooms on a unit and train basis and are located in the same room as the reactor vent boards associated with the same unit and train. The 480-volt Auxiliary Building common board is in the room with MOV boards 1A1-A and 1A2-2. The isolating walls of these rooms are constructed of 8-inch reinforced concrete extended to the ceiling.

480-Volt Reactor Vent Boards 1A-A, 1B-B, 2A-A, and 2B-B

These boards are located in the rooms with the 480-volt reactor MOV boards described above.

480-Volt Control/Auxiliary Building Vent Boards 1A1-A, 1A2-A, 1B1-B, 1B2-B, 2A1-A, 2A2-A, 2B1-B and 2B2-B

These boards are located in the rooms with the 480-volt shutdown boards described above.

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480-Volt Diesel Auxiliary Boards 1A1-A, 1A2-A, 1B1-B, 1B2-B, 2A1-A, 2A2-A, 2B1-B and 2B2-B

These boards are located in the diesel generator building at elevation 760. They are located in separate rooms on a unit and train basis. The isolating walls of the rooms are reinforced, poured-in-place concrete. Interconnecting doorways are protected by selfclosing fire-resistant doors.

6900-480-Volt Pressurizer Heater Transformers 1A-A, 1B-B, 1C 1D, 2A-A, 2B-B, 2C, and 2D

These transformers are located in the Auxiliary Building at elevation 782.0. Transformers 1A-A, 2A-A, 1D and 2D are located in one room in the Unit 1 area. Transformers 1B-B, 2B-B, 1C and 2C are located in one room in the Unit 2 area.

System Operation

The 6.9-kV shutdown boards in each power train derive power from either of two circuits from the 6.9-kV unit boards, or from their respective standby power source. The feeders connecting each shutdown board with these three sources are termed the normal, alternate, and standby feeders. The normal and alternate feeders can derive power from the nuclear unit via a unit station service transformer and separate 6.9-kV unit boards. The normal and alternate feeders can also derive power from the separate preferred source circuits, via separate windings (on either of two separate common station service transformers) and separate 6.9-kV unit boards. During conditions where neither nuclear unit nor preferred (offsite) power is available, each 6.9-kV shutdown board is energized from a separate standby diesel generator via the standby feeder.

The alignment of each unit's standby distribution system is determined by plant conditions, the sources selected to energize it, and the status of components within the distribution system.

A loss of voltage on a normal feeder to a 6.9-kV shutdown board initiates an automatic transfer to the alternate feeder, if the alternate feeder has normal voltage. The transfer is delayed until the residual voltage has decreased to 30 percent of normal. The return transfer to the normal feeder is initiated manually and is a high-speed transfer, completed in five cycles or less. A typical transfer scheme is shown schematically in Figure 8.3-5 for 6.9-kV shutdown board 1A-A.

REPLACE w/ INSERT 8.3-1

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INSERT 8.3-1

The standby Class 1E ac power system for each unit is divided into two redundant power trains. Each train includes a 6900-volt shutdown board powering the larger safety-related motors, pressurizer-heaters, and three 480-volt distribution subsystems. The 480-volt subsystems each include a 6900 - 480-volt power transformer, 480-volt switchgear, and 480-volt motor control centers. The Class 1E 480-volt subsystems supply both safety-related and non safety-related electric equipment. A fourth 6900 - 480-volt transformer will be provided in each power train as an installed spare. It will not normally be connected to either the 6900-volt shutdown board or to the 480-volt buses.

Each 6900-volt shutdown board can be powered through one of four supply breakers. For normal unit startup and operation, the power is from the 6900-volt unit board connection, the breaker shown normally closed on Fig. 8.1-2a ~~sketch APS 2~~. Shown normally open are the first and second alternate supply breakers connecting to the offsite power circuits, and the standby breaker connecting to a diesel generator. As stated above, for unit trips both 6900-volt shutdown boards for the tripped unit automatically fast transfer to offsite power via their first alternate breakers.

Each 6900-volt shutdown board is equipped with loss-of-voltage relaying and degraded voltage relaying. The loss-of-voltage relays initiate slow bus transfers (supervised by residual voltage relays (set to operate at 30%)) from the normal source to the first alternate, second alternate, or standby supply, in that order of preference. When a 6900-volt shutdown board is powered from an alternate supply, the loss-of-voltage relays will initiate automatic transfer from first alternate to second alternate or standby supply, or from second alternate to standby supply. Relays monitor each source and permit connection only if adequate power is available. Protective relays are provided in each shutdown board that lock out all supply breakers if the loss of voltage is caused by overload or electrical fault. Transfer between power sources in the reverse order are operator controlled only. The first alternate power connection for train A shutdown boards is to common transformer C, winding Y, and for train B shutdown boards is to common transformer D, winding X. The second alternate power connection for train A shutdown boards is transformer D, winding Y. For train B shutdown boards, the second alternate connection is to transformer C, winding X. Either transformer C or D can supply the Class 1E power system for both units, with one unit in a design basis accident and the other unit in a concurrent full load rejection, without exceeding its self-cooled power rating.

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INSERT 8.3-1 CONT'D

~~generator, via the standby feeder~~. A loss of voltage (decrease to 60 percent or less of nominal voltage) on a normal feeder to a 6.9-kV shutdown board initiates an automatic transfer to alternate No. 1 feeder or alternate No. 2 depending on the presence of adequate voltage. The initiating relays' contacts close in 3 seconds upon loss of voltage. The transfer is delayed until the residual voltage has decreased to 30 percent of nominal. The return transfer to the normal feeder is initiated manually and is a high speed transfer, completed in five cycles or less.

The sustained low-voltage relays will trip the connected feeder breaker thereby causing the loss of voltage relays to initiate a transfer to either the alternate feeders or the standby diesel generator supply. A typical transfer scheme is shown schematically in Figure 8.3-5 for 6.9-kV shutdown board 1A-A.

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A sustained loss (longer than 1.5 seconds) of voltage on the 6.9-kV shutdown board starts the diesel generator and initiates (after an additional 3.5 seconds) logic that trips the normal or alternate feeder breaker, all 6900V loads (except the 480V shutdown board transformers), and the major 480V loads. Table 8.3-2 shows the loads that are automatically stripped. Figures 8.3-6 thru 8.3-13 show the load stripping schematically. When the diesel generator has reached rated speed and voltage, the generator will be automatically connected to the 6.9-kV shutdown board bus. (Refer to Figure 8.3-14.) This return of voltage to the 6.9-kV shutdown bus initiates logic which connects the required loads in sequence. Table 8.3-3 shows the order of applied loads. The standby (onsite) power system's automatic sequencing logic is designed to automatically connect the required loads in proper sequence should the logic receive an accident signal prior to, concurrent with, or following a loss of all nuclear unit and preferred (offsite) power. ADD INSERT 8.3-2

There are no automatic transfers of board supplies between redundant power sources. All 480V shutdown boards and all motor control centers have alternate feeders to their respective board buses. Transfers between the normal and alternate feeders are manual. Some manual transfers of loads between power trains are used. These transfers are at the 480V level and involve 10 loads which are tabulated in Table 8.3-10. ← INSERT C

A means of manually interconnecting power sources at the 6.9-kV level is provided. This is provided by the shutdown utility bus, shown on Figure 8.1-2, which allows any 6.9-kV shutdown board to be connected to any other or all other 6.9-kV shutdown boards. All circuit breakers connected to this bus are normally open and disconnected (racked out). Use of the bus requires manual insertion and closing of two of the breakers. The purpose of this utility bus is to increase the flexibility of the Standby Power System.

A manual means of supplying power to the 480V Auxiliary Building common board (which is not normally supplied power from the diesel generators during a condition where offsite power is lost) is provided. Provisions have been made to manually connect this board to the 480V shutdown boards 1B2-B and 2B2-B. This is shown in Figure 8.3-15. The purpose of these feeders is to provide power to operate the ice condenser refrigeration units, located on the 480V auxiliary common, and glycol pumps, located on the 480V Auxiliary Building common MCC B and C, during the unlikely condition of a loss of offsite power that exceeds two to three days. The two normal bus feeder breakers

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INSERT 8.3-2

The staff degraded voltage positions are addressed as follows:

1. Overvoltage relays alarm in the control room. Undervoltage relays operate if a 6900-volt shutdown board bus voltage drops below the level required to successfully start all safety-related equipment that would be started for a SIS. The undervoltage relays initiate two time delay sequences. The first sequence will ride through normal system voltage transients, but is short enough to allow safety-related equipment to be powered within the time required by the safety analysis. At the end of the first sequence, the undervoltage will be alarmed in the control room, and if a SIS has been initiated, or is subsequently initiated, the shutdown board will transfer to its diesel generator. The second time delay is long enough to allow operator action but not allow damage to connected safety-related equipment. At the end of the second sequence, the shutdown board will transfer to its diesel generator. The undervoltage relaying system design meets all the staff requirements.

2. Degraded voltage relaying will not open the standby supply breaker and will not initiate load shedding and resequencing if a 6900-volt shutdown board is supplied by its diesel generator. The loss-of-voltage relays will initiate load shedding and resequencing. However, the voltage set point and time delay for these relays prevent their operation for any motor starting transients when adequate power is being supplied to the shutdown board. Maximum and minimum limits for the loss-of-voltage relay set points will be included in the Technical Specifications.

3. The auxiliary power system analyses for Watts Bar Nuclear Plant satisfy the staff position and TVA's Quality Assurance requirements for documentation. ~~The analyses will be issued in a formal report.~~

4. The auxiliary power system analyses will be verified in the preoperational test program.

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must be moved from their normal compartments to the compartments which are connected to the 480V shutdown boards 1B2-B and 2B2-B.

System Instrumentation

Remote instrumentation of the 6.9-kV shutdown boards consist of transducer driven ammeters for the normal and alternate feeders, diesel generator feeder, and all motor loads. Also included are bus voltmeters and various annunciations which are located in the Main Control Room and Auxiliary Control Room. This is shown on Figures 8.3-16 through 8.3-19. The diesel generator feeder has a watt transducer and a var transducer mounted on the 6.9-kV shutdown board which drives remotely located meters in the Main and Auxiliary Control Rooms. The diesel generator feeder voltage is also monitored remotely.

All of this instrumentation is used in testing the deisel generator and in monitoring the 6.9-kV shutdown boards during normal conditions and loss of offsite power conditions.

Remote instrumentation of the 480-volt shutdown boards consists of bus voltmeters and various annunciations all of which are located in the Main Control Room and Auxiliary Control room. This is shown in Figures 8.3-20 through 8.3-23. All the boards have locally mounted ammeters which monitor the normal and alternate feeders.

Remote instrumentation of the 480-volt motor control centers consists of annunciation in the Main and Auxiliary Control Rooms upon loss of board voltage.

System Reliability

The redundant power trains shown in Table 8.3-1 and Figure 8.1-2a have loads connected to corresponding distribution boards in each train such that failure of any one component or the entire train will not prevent the redundant system from performing the required safety function. The equipment requiring a.c. power during a loss of offsite power and/or accident condition is supplied from the 6.9-kV shutdown board directly or indirectly through the transformers at a lower voltage. At the 480-volt level each power train ~~has two 480-volt shutdown boards. Each 480-volt shutdown board is supplied power~~ from the 6.9-kV shutdown board through a 2000-kVA, 6900-480-volt transformer. A single spare transformer is provided for the ~~two~~ normal transformers and is manually placed in service when one of the normal transformers is taken out of service for maintenance.

is divided into three distribution systems, with each 480-volt distribution system supplied

three

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~~Each 480-volt shutdown board supplies power to a group of motor control centers in addition to the large 480-volt motor loads. A motor control center is normally fed from one of the 480-volt shutdown boards and has an alternate feed from the other shutdown board of the same power train. Manual selection between the normal and alternate feeders is made at the motor control center.~~

The pressurizer heaters are divided into four groups. Two groups are supplied from each redundant power train 6.9-kV shutdown board through individual 500-kVA, 6900-480-volt transformers. This is shown on Figures 8.3-16 through 8.3-19.

Equipment Identification

Redundant major electrical equipment carries the same name in each power train with the exception that the board designation also has either -A or -B suffix depending upon the power train assignment. For example, 6.9-kV shutdown board 1A-A and 6.9-kV shutdown board 1B-B are redundant to each other. Similar designations are used for safety-related loads being supplied from safety-related (onsite) boards. For example, RHR (Residual Heat Removal) pump 1A-A and RHR pump 1B-B are redundant to each other. Further description of the equipment identification scheme used appears in Section 8.3.1.4.5.

Equipment Capacities

Tables 8.3-4 through 8.3-7 present the bus rating, connected load, and maximum demand load for each electrical distribution board in the standby (onsite) power system. The connected load and maximum demand load for each major transformer in the standby (onsite) power system is given in Table 8.3-8. The diesel generator rating is 4400 kW continuous or ~~5225~~ 4840 kW for two hours ~~and~~ at a power factor of 0.8.

The equipment capacities used in Table 8.3-~~2~~ 1 through 8.3-8 are based on nameplate horsepower of the individual loads. Engineering experience indicates that motors less than 50 hp have an efficiency of less than 90 percent while those over 50 hp have an efficiency greater than 90 percent. Therefore, a 90 percent figure is deemed conservative for use in deriving the demand loadings. The .83 power factor used in the tables is based on engineering judgment and experience and is considered conservative. Using these two figures for efficiency and power factor, 1 kVA is then equated to 1 horsepower for purposes of the calculations used to determine data in these tables. Section 8.3.1.2.1 pertaining to the a.c. power system analysis will discuss the adequacy of the components in the system.

System Controls

Table 8.3-9 shows the vital 125V d.c. control power sources for each onsite shutdown board. Each board has a normal and emergency (or backup) control bus, with each bus having access to two 125V batteries by way of a manual transfer switch located in the boards. The normal control bus supplies power for Main Control Room operation. The emergency control bus supplies power for Auxiliary Control Room operating modes. This is shown on Figures 8.3-16 through 8.3-23.

The control power for onsite motor control centers is single phase 120V a.c. supplied either from the center's own bus through a 480-120V transformer or from each individual load feeder through a 480-120V transformer.

System Testing

Located adjacent to each 6.9-kV shutdown board is a test panel equipped with the necessary selector switches, pushbutton switches, and indicating lights for testing the automatic load stripping and load sequencing logic for that particular power train. The tests are to be performed on only one of the ~~two~~ four power trains per ~~unit~~ plant at any one time. Testing of one power train does not prevent the remaining power train from performing ~~its~~ their intended safety function.

Testing of the onsite power distribution system is divided into three categories:

1. Simulated "Loss of Preferred Power" test.
2. Group tests for equipment that can be tested during power operation.
3. Group tests for equipment that cannot be tested during power operation.

Test 1 can be performed at any time since no equipment is actually operated and the test does not prevent an accident signal from performing the intended function. Indicating lights are used to verify the test.

Group tests (test 2) during power operation for testable type equipment will only be performed when the system parameters will permit the starting, stopping, and restarting of the loads within the load group under test. The testing of one group of functions within a power train does not prevent the other groups within the same or redundant power train from performing their intended safety function in the event of a simultaneous accident and/or loss of offsite power signal.

Group tests during power operation for nontestable type equipment will only be performed when the system parameters will permit blocking of the functions within the group under test. The testing of any one group does not prevent operation of any other group or redundant group in the event of a simultaneous accident and/or loss of preferred power.

Figures 8.3-6 thru 8.3-13 show a schematic representation of the ability to test groups as described above.

Standby Diesel Generator Operation

The diesel generator system is shown on single line diagram, Figure 8.3-24. The schematic of the engine start and stop circuits is shown in Figures 8.3-25 thru 8.3-28 remote control of the engine from the Main Control Room is accomplished through interposing relays located in the diesel building. The schematic for this control is shown in Figure 8.3-29.

The 6.9-kV shutdown boards in each power train derive power from ~~either of two~~ circuits from the 6.9-kV units boards, or from their respective standby power source. During conditions where neither the nuclear unit nor preferred (offsite) power are available, each 6.9-kV shutdown board is energized from a separate standby diesel generator set.

A sustained (longer than 1.5 seconds) loss of voltage on the 6.9-kV shutdown board starts the diesel generator and initiates (after an additional 3.5 seconds) logic that trips the normal or alternate feeder breaker, all 6900V loads except the 480V shutdown board transformers, and the major 480V loads. Table 8.3-2 shows the loads that are automatically tripped. When the diesel generator set has reached rated speed and voltage, it is automatically connected to the 6.9-kV shutdown board bus. The return of voltage to the 6.9-kV shutdown bus initiates logic which connects the required loads in sequence. Table 8.3-3 shows the order in which loads are applied.

As shown in Table 8.3-3, there are two loading sequences. One, which is applied in the absence of a "safety injection signal (SIS)," the "nonaccident condition," and the other, the "Accident condition," applied when a safety injection signal is received prior to or coincident with a sustained loss of voltage on the 6.9-kV shutdown board. A safety injection signal received during the course of a nonaccident shutdown loading sequence will cause the actions described below:

1. Loads already sequentially connected which are not required for an accident will be disconnected.

2. Loads already sequentially connected which are required for an accident will remain connected.

3. Loads awaiting sequential loading that are not required for an accident will not be connected.

4. Loads awaiting sequential loading that are required for an accident will have their sequential timers reset to time zero from which they will then be sequentially loaded.

A safety injection signal received in the absence of a sustained loss of voltage on a 6.9-kV shutdown board will start the diesel generators but not connect them to the shutdown boards. There are no automatic transfers of shutdown boards between standby power supplies in compliance with Regulatory Guide 1.6. The events which initiate a safety injection signal are discussed in Chapter 7.

For test and exercise purposes, a diesel generator may manually be paralleled with the normal power source. A loss of offsite power or a safety injection signal will automatically override the manual controls and establish the appropriate alignment.

The diesel can be started by manually operated emergency start switches located on the unit control board in the Main Control Room and Auxiliary Control Room. (The engine also has a local manual start switch as well as remote start from the Main Control Room for test purposes.) Automatic starting is from an

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The diesel can be stopped by manually operated emergency stop switches located in the Main Control Room, Auxiliary Control Room, and on the diesel control panel in the diesel building. A manual stop switch is provided in the Main Control Room for stopping the engine under normal conditions such as conclusion of a test or upon return to the nuclear unit or preferred (offsite) power source. Under accident or loss of offsite power conditions this stop switch is automatically disconnected from the stop circuit. The normal stopping of the engine will position the hydraulic governor at the lower limit and allows the engine to run for 10 minutes at idle speed (~~400~~ 450 rpm) before bringing the engine to zero speed. Emergency stopping bypasses this 10 minute idle speed time and brings the engine directly to zero speed. Should an emergency start signal be initiated during the 10 minute idle speed time of a normal stop condition the engine will automatically return to synchronous speed and emergency operation. 40 | 41

Diesel engine speed and generator voltage are manually controlled remotely from the Main Control Room only during testing of the unit. An emergency start signal automatically disconnects these manual controls and returns both to automatic operation.

A "Local-Remote" manual selector switch, located in the diesel building, must be in the "Remote" position for all manual remote control from the control room to be in effect, with the exception of emergency start. Similarly, for the manual controls located in the diesel building to be in effect the switch must be in the "Local" position. The switch is manually operated from the "Remote" to the "Local" position. This operation, however, requires an electrical permissive interlock signal initiated from the Main Control Room. The switch is manually operated from the "Local" to the "Remote" position. These operations are shown in Figure 8.3-24.

Diesel Generator Description

Each diesel-generator set is furnished by ~~EMD Diesels, Incorporated~~ Power Systems- A Morrison-Knudsen Div., and consists of two 16-cylinder engines (~~model 999-16, type~~ EMD 16-645E4) directly connected to a 6.9-kV Electric Products generator. The continuous rating of each set of 4400 kW at 0.8 power factor, 6.9-kV, 3-phase, and 60 Hz. Each diesel-generator set also has an additional rating of ~~5225~~ 4840 kW for -2-hour

Control Room, Auxiliary Control Room, and locally in the diesel building. The instrumentation is not essential for automatic operation of the diesel.

Diesel Generator Control Power

The control circuit voltage for the diesel generators is 125 volts d.c. Indicating lights and contacts for the 125-volt d.c. service show when the diesel generator is: (1) ready for automatic start but not running, (2) cranking, or (3) running. The source of the 125-volt control power is a battery, and each diesel generator has its own battery. The battery is of the lead- 42
acid type and has 57 cells connected in series and divided into 20 units, every unit having three cells. The battery is type 3DCU-9, furnished by the C&D Batteries Division of Eltra Corporation. The battery system is capable of supplying the control loads for 30 minutes when the battery is at the lowest expected temperature. Each battery has an independent battery charger operating on a 480-volt, 60-Hz, 3-phase power supply. 40
This battery charger is of the staticrectifier type and is equipped to maintain the battery fully charged at all times.

Diesel Generator Capacity

In compliance with Regulatory Guide 1.9, the table below compares worst case loading of the diesel generators with their continuous rating and 90 percent of their 2-hour rating. Worst case loading occurs for a simultaneous loss of offsite power and a loss-of-coolant accident on Unit 1. As shown, adequate margin exists, in all cases, between worst case loading and diesel capacity.

	Diesel Generator			
	1A-A	1B-B	2A-A	2B-B
Worst case loading (kW)	3740	3762	3771	3747
2000-hr rating (kW)	4750	4750	4750	4750
Margin (kW)	1010	988	979	1003
90 Percent of 1/2-hour rating (kW)	4500	4500	4500	4500
Margin (kW)	760	738	729	753

INSERT G

The following will be the replacement for the existing paragraph under "Diesel Generator Control Power" as an amendment to the FSAR on page 8.3-16:

Diesel Generator Control Power

The 125-volt dc diesel-generator battery system is a Class 1E system whose function is to provide control power for control and field flashing of the diesel-generator sets.

There are four diesel-generator battery systems (one per diesel-generator set). Each system consists of a battery charger (which supplies the normal steady-state dc loads and maintains the battery in a fully charged state and is capable of recharging the battery from the design minimum discharge of 105 volts dc while supplying the normal steady-state dc loads), a battery (for control and field flushing of the diesel-generator set), and a distribution board (which facilitates the dc loads and provides circuit protection). Each battery system is ungrounded and incorporates ground detection devices. Each battery system is physically and electrically independent (see ~~pages 8.3-57, -58,~~ and figure 8.3-46) ~~for physical separation).~~ (section 8.3.2.1.1

Each battery is of the lead-acid type and has 57 cells connected in series and divided into 19 units, every unit having three cells. The battery is a type 3DCU-9, furnished by the C&D Batteries Division of Eltra Corporation, rated at 26 ampere-hours at 60°F for a 30-minute discharge rate. With the battery in the fully charged condition, the battery has the capacity to supply 48 amperes (A) for two seconds and 25 amperes for 30 minutes. The estimated design loads on the battery, during a loss of ac power, is 48 amperes (field flash) for two seconds and 12 amperes (control) for 30 minutes. Each battery is normally required to supply loads only during the time interval between loss of normal feed to its charger and the receipt of emergency power to the charger from its respective diesel-generator.

The normal supply of dc current to the battery boards is from the battery charger. Each charger maintains a floating voltage of approximately 128 volts on the associated battery board bus (the battery is continuously connected to this bus also) and is capable of maintaining 133 volts during an equalizing charge period (all loads can tolerate the 133-volt equalizing voltage). The charger supplies normal steady-state load demand on the battery board and maintains the battery in a charged state. AC power for each charger is supplied from its respective 480-volt ac, 3-phase diesel generator auxiliary board. Each charger has access to a normal and alternate ac supply (see figures 8.3-30 and -31, typical), from the two respective 480-volt ac diesel generator auxiliary boards. If the normal circuit is unavailable, the alternate circuit is selected by a manual transfer. The charger is a solid-state type which converts a 3-phase 480-volt ac input to a nominal 125-volt dc output having a rated capacity of 20 amperes. Over this output current range the dc output voltage will vary no more than +1.0 percent for a supply voltage

INSERT 8.3-3

Analysis of Diesel Generator 125-Volt DC Control Power System

Reference: SER Section 8.3.2.4

The diesel generator 125-volt dc control power system is designed to comply with the requirements set forth in GDC 2, 4, 5, 17, and 18. The design also conforms with Regulatory Guides 1.32 and 1.6 and IEEE Std. 308-1971. The following paragraphs discuss each of the requirements:

General Design Criteria 2 and 4

The diesel generator 125-volt dc control power system is comprised of four physically and electrically independent battery systems (see figure 8.3-1). These systems are located in the diesel generator building, which is a seismic Category I structure. This structure will provide protection from the effects of tornadoes, tornado missiles, and external floods.

All components of this system are seismically qualified and have been designated as Class 1E equipment. ~~Environmental qualification of this system will be detailed in TVA response to NUREG 0588 Category II for Class 1E equipment in a mild environment.~~ (Refer to Section 3.11)

General Design Criteria 5

The four diesel generator 125-volt dc battery systems are located in individual rooms on elevation 742.0 of the diesel generator building. They are located in the room with the diesel generator with which each is associated. Each room is equipped with its own heating and ventilating system independent of all others and each room is separated from the others by missile and fire barrier-type walls. Also, as stated above, the four battery systems are electrically independent (one per diesel-generator set). Therefore, the structures, systems, and components important for safe operation of this system are not shared.

General Design Criteria 17

The diesel generator 125-volt dc battery system's design, equipment location, separation, redundancy, and testability enables the system to perform its intended safety function assuming a single failure.

General Design Criteria 18

The diesel generator 125-volt dc battery system is designed to permit appropriate periodic inspection and testing of important areas and features, in order to assess the continuity of the system and the condition of its components. In addition, prior to placing the system into service, it will be preoperationally tested and thereafter periodically tested to ensure the proper operation of all components.

Also, under conditions as close to design as practical, the full operational sequence that requires the battery system's operation will be tested periodically as a part of the diesel generator periodic system test.

Regulatory Guide 1.32

The diesel generator 125-volt dc battery system's chargers have the capacity to continuously supply all steady-state loads and maintain the batteries in the design maximum charged state or to fully recharge the batteries from the design minimum discharge state within an acceptable time interval, irrespective of the status of the plant during which these demands occur. In addition, a capacity test will be performed periodically on each diesel generator battery system, as recommended by IEEE 450-1975.

Regulatory Guide 1.6

Each of the four diesel generator battery systems supply power only to the loads of the diesel generator in which it is associated with. Therefore, the battery systems' safety loads are separated into redundant load groups such that loss of any one group will not prevent the minimum safety functions from being performed. Also, there are no provisions for manually or automatically interconnecting the redundant load groups of this system.

IEEE 308-1971

As discussed in the above paragraphs, the overall system design of the diesel generator 125-volt dc control power system incorporates appropriate function requirements, redundancy, capability and surveillance in order to comply fully with this criteria. In addition, the system design is such that the battery is immediately available during normal operations and following loss of power from the alternating-current system. Also, each battery has sufficient capacity to meet the power demand and time requirement of each connected load.

certified to operate within the environmental requirement called
for in the design criteria. (Refer to Section 3.11). The
arrangement of circuit interrupters and switches permits easy
isolation of the installed assemblies for future test and main-
tenance purposes.

8.3.1.2.3 Safety-Related Equipment in Potentially Hostile Environment

Electrical equipment located inside containment has been designed
to maintain equipment safety functions and to prevent
unacceptable spurious actuations. All power cables feeding
equipment inside containment are provided with individual
breakers to protect the power sources (both IE and non-IE) from 28
the effects of electrical shorts. Additionally, each power cable
is provided with a cable protector fuse which, in the event of a
breaker failure, is designed to protect the containment
penetration. These breakers and protector fueses ensure that,
should an electrical short occur inside containment, the
electrical power source will not be affected.

A listing of major nonsafety-related electrical components
located inside containment that may be inundated following a LOCA
appears in Table 8.3-28 along with an explanation of the safety
significance of the failure of the equipment due to flooding. In
addition to the electrical equipment listed in the table, the
water level inside containment may also flood nonsafety-related 35
local control stations, electrical sensors, electric motors for
motor operated valves, and electric solenoids for air-operated
valves. The following paragraphs illustrate how the flooding of 40.61
this equipment does not affect the plant safety. All local
control stations located inside containment are provided with
manual throw switches located outside containment at the motor
control center. These manual switches are used to remove control
power from the local control stations during normal operation.
In order to utilize the local control stations during operating 28
conditions where containment access is permitted, the manual
switch must be closed to provide power to the local stations.
Indications are provided in the main control room whenever the
manual throw switches are in the closed position. Thus, spurious
operation of safety-related equipment due to post-LOCA
submergence of the local control station is prevented.

There are no electric motor-operated valves located inside
containment below the maximum LOCA water level that are required
to function for other than containment isolaton. Valves used for
containment isolation will close prior to submergence. The
submergence of a motor-operated valve will not cause the valve to
change from its safe position. 35

The control air supply is automatically isolated outside
containment in the event of a LOCA. therefore, the submergence
of electric solenoids serving air-operated valves cannot affect
the safe positioning of these valves. 40.64

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There are no electric motor-operated valves located inside containment below the maximum LOCA water level that are required to function for other than containment isolation. Valves used for containment isolation will receive a signal to close on the initiation of the accident signal. The valves will close in 10 seconds and will remain closed since failure of the control circuitry can only yield operation in the closed direction. ~~from the motors before the flooding takes place.~~ Therefore, these valves will ~~not be required to operate during or after the flooding.~~ operate before flooding occurs and remain in their safe ~~shutdown~~ position after flooding.

The plant operator ~~are~~ [is] instructed to rely on ~~the~~ qualified post accident monitors following a LOCA so that any spurious indications from nonqualified electrical sensors that could become submerged would not jeopardize appropriate operator actions. 35

[delete] ~~There is no Class 1E equipment required to operate during or after a LOCA or MSLB that will be submerged. Such equipment is designed to meet the average~~ [worst] ~~possible containment envrionmental conditions, as given in FSAR Section 3.11.~~ 40.64

The safety-related electrical equipment that must operate in a hostile environment during and/or subsequent to an accident is identified below. 28

Inside Primary Containment

Low Voltage Power and Control Cables

The single- and multiple-conductor cables, insulated and jacketed with flame-retardant thermoplastic compounds, thermosetting compounds, or rubber, are suitable for installation in a nuclear 35 environment. 40.58

Auxiliary power cables and control cables at voltages not exceeding 600 volts between conductors, either d.c. or 60 Hertz a.c., are insulated with silicon rubber for 125 C conductor temperature. Single conductors are jacketed with asbestos braid. Single conductors of a multiple-conductor cable are jacketed with a glass braid and the cable has an overall asbestos braid jacket.

Signal cable, at voltages not exceeding 600 volts, is insulated with cross-linked polyethylene (or other material meeting TVA 35 approval) and jacketed with heat and light stabilized chlorosulfonated polyethylene (or other self-extinguishing, radiation-resistant, and low-moisture absorbing material meeting TVA approval. The conductors are twisted together and then an overall 35 shield (with copper drain wire) applied under the jacket.

Pressurizer Heater Cable

The low-voltage power cable, not exceeding 600 volts between conductors, is insulated with silicone rubber for 200 C conductor temperature. The cable is jacketed with [illegible] braid.

Electrical Penetration Cables

The cables are derated and sized according to their ampacities for the penetration ambient temperatures. [illegible]

See revision to Insert submitted in PK 3(2)

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Separations

The four channels are electrically and physically separated so that a single failure in one channel will not cause a failure in another channel. Each channel has a charger, a battery, and a load distribution board.

Capacity

The system has the capacity to continuously supply all normal loads and maintain the battery in a fully charged condition. With the batteries in the fully charged condition, the system has the capacity to supply the connected loads for a minimum of two hours with a loss of all a.c. power. The manufacturer's catalog specifies a 2-hour discharge rating of 696 amperes at 60°F when discharged to a minimum terminal voltage of 105 volts. This rating will be confirmed by TVA acceptance tests, and the batteries will be retested periodically, in accordance with the technical specifications, to assure that they maintain adequate capacity 44

Charging

The chargers have the capacity to continuously supply the normal loads and maintain the batteries in the design maximum charged state or to recharge the batteries from the design discharge state within acceptable time interval while supplying the normal loads. Each charger may be replaced by a spare charger. One spare charger is provided for each two normal chargers.

Ventilation

Each battery room has redundant ventilation systems to prevent the accumulation of explosive gases. In addition to the ventilation systems provided to prevent accumulation of the hydrogen produced by the battery, there are voltmeters, high voltage alarms, and administrative procedures for control of equalizing charges that will provide additional protection. Also, as an added precaution, all cells are of the sealed type and have a special safety vent that prevents the ignition of gases within the cell from a spark or flame outside the cell.

Loading

Loads are assigned according to their divisional requirements. Loads requiring four divisions of separation are assigned to the four channels. Loads requring two divisions of separation are assigned to Channels I or III and II or IV. Two-divisional

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The Watts Bar FSAR (page 8.3-54, paragraphs 2 and 3) will be revised to read as follows:

Capacity

The system has the capacity to continuously supply all steady state loads and maintain the battery in a fully charged condition. With the batteries in the fully charged condition, the system has the capacity to supply the connected loads for a minimum of two hours with a loss of all ac power. The battery rating stated by the manufacturer is a minimum 2-hour discharge rating of 600 amperes at 60°F when discharged to a minimum terminal voltage of 105 volts. This rating will be confirmed by TVA acceptance tests.

Charging

The chargers have the capacity to continuously supply all steady state loads and maintain the batteries in the design maximum charged state or to recharge the batteries from the design discharge state within acceptable time interval ~~while supplying the normal loads~~. Each charger may be replaced by a spare charger. One spare charger is provided for each two normal chargers.

irrespective of the status of the plant during which these demands occur.

all others. The heating and ventilating systems are designed to provide an ambient room temperature between 60°F and 104°F and a maximum relative humidity of 98 percent.

Normal D.C. Supply

Reference: Figure 8.1-3

The normal supply of d.c. current to the battery boards is from the battery charger in each channel. Each charger maintains a floating voltage of approximately 135 volts on the associated battery board bus (the battery is continuously connected to this bus also) and is capable of maintaining 140 volts during an equalizing charge period (all loads can tolerate the 140-volt equalizing voltage). The charger supplies normal [steady state dc] load demand on the battery board and maintains the battery in a charged state. Normal recharging of the battery from the design discharged condition can be accomplished in 12 hours (with accident loads being supplied) following a 30-minute a.c. power outage and in approximately 36 hours (with normal loads being supplied) following a 2-hour a.c. power outage. Two spare chargers are available for the four channels (one each for two channels). Each spare charger can be connected to either of its two assigned channels. It can substitute for or operate in parallel with the normal charger in that channel.

A.c. power for each charger is derived from the station auxiliary power system via two 480-volt a.c., 3-phase circuits which are physically and electrically independent. Each circuit has access to a preferred (offsite) and a standby (onsite) source. If the normal circuit supplying a charger is unavailable, the ~~other~~ alternate circuit is selected by a manual transfer. [Placement of the transfer switch in the alternate position and/or the closure of the 480-volt a.c. breaker supplying the alternate circuit (normally in open position) will alarm in the main control room.] Each charger is equipped with a d.c. voltmeter, d.c. ammeter, and charger failure alarm. Malfunction of a charger is annunciated in the Main Control Room. Upon loss of normal power to a charger, each may be energized from the standby power system.

The charger is a solid-state type which converts a 3-phase 480-volt a.c. input to a nominal 125-volt d.c. output having a rated capacity of 200 amperes. Over this output current range the d.c. output voltage will vary no more than ±1.0 percent for a supply voltage amplitude variation of ±7.5 percent and frequency variation of ±2.0 percent.

Some operational features of the chargers are: (1) an output voltage adjustable over the range of 125 to 140 volts, (2) equalize and float modes of operation (the charger normally

TABLE 8.3-3

DIESEL GENERATOR LOAD SEQUENTIALLY APPLIED FOLLOWING A LOSS OF NUCLEAR UNIT AND PREFERRED (OFFSITE) POWER

Equipment Name	Time in Seconds*	Total HP Load	Starting kVA	Load Applied: Nonaccident Condition	Load Applied: Accident Condition	
Miscellaneous Loads	0			Yes	Yes	
Centrifugal Charging Pump & AHU	2	603	3840	Yes	Yes	
Safety Injection Pump & AHU	5	403		No	Yes	
Residual Heat Removal Pump & AHU	10	403	2240	No	Yes	
Essential Raw Cooling Water Pump	15	800	4060	Yes	Yes	
Component Cooling System Pump	20	350**	1810	Yes	Yes	
Fire Pump	25	200		Yes	Yes	
Auxiliary Feedwater Pump	30	600	3240	Yes	Yes	32
Containment Spray Pump & AHU	35	705		No	Yes	
Pressurizer Heaters	90	485 kw	485 kw	Yes	No	

Diesel Generator Set Rating: ~~[illegible]~~ 4400 kw continuous ~~or [illegible]~~ and 4840 kw for ~~X~~ 2 hours out of 24

*Time is Measured from the time of closing of the generator breaker connecting the diesel generator to the shutdown board. Values given are nominal times. Actual times are consistent with the diesel generator loading analyses and will be verified during preoperational testing. 41

**Diesel generator 1A or 2B will have two component cooling system pumps loaded 32

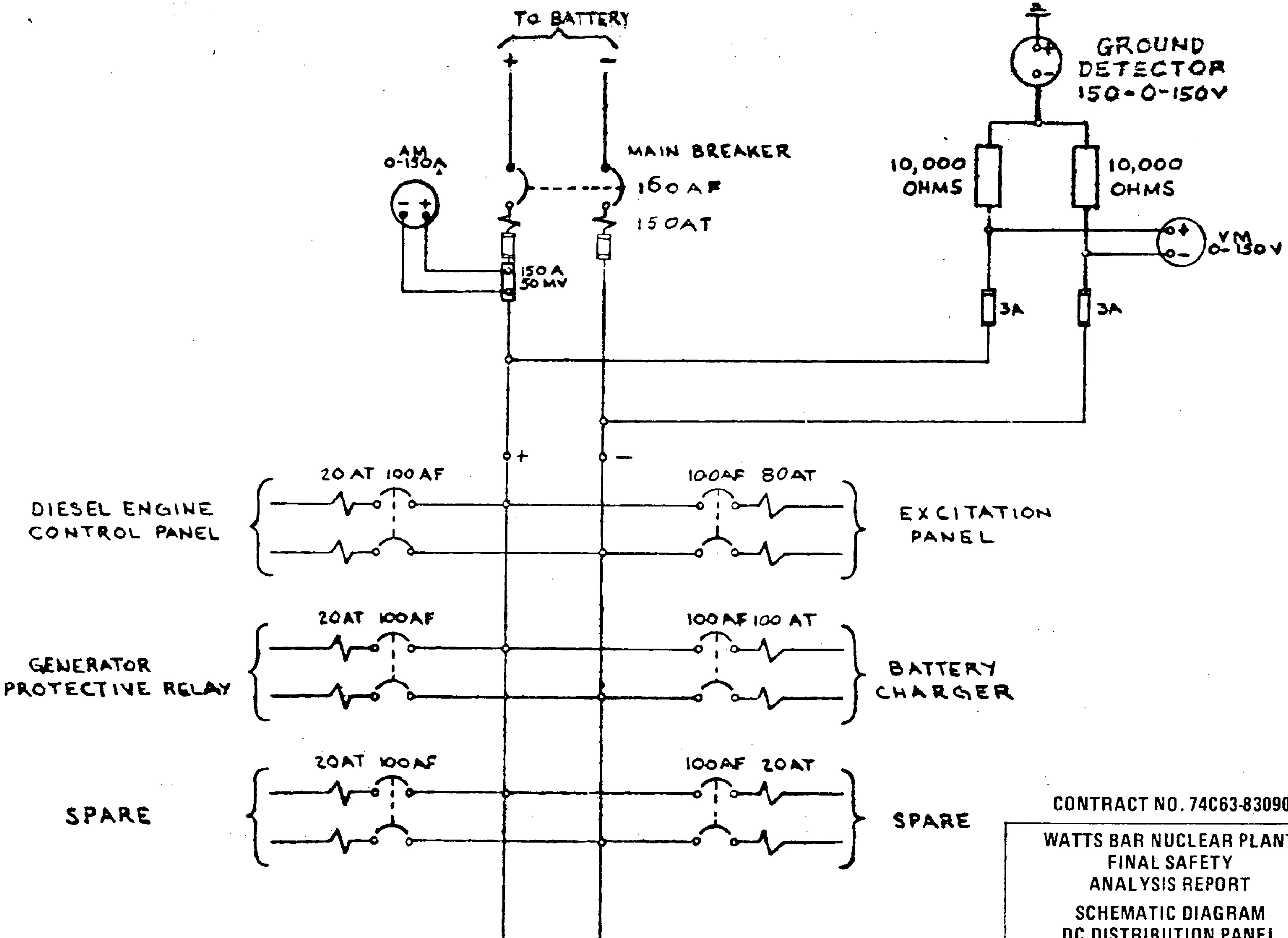
AHU - Air Handling Unit

TABLE 8.3-10

LOADS HAVING MANUAL TRANSFER BETWEEN POWER TRAINS

Load	Normal Supply	Alternate Supply
125V Bat Chgr I & Inverters	480V Shutdown Bd 1A1-A	480V Shutdown Bd 1B1-B
125V Bat Chgr II & Inverters	480V Shutdown Bd 1B2-B	480V Shutdown Bd 1A2-A
125V Bat Chgr III & Inverters	480V Shutdown Bd 2A1-A	480V Shutdown Bd 2B1-B
125V Bat Chgr IV & Intervers	480V Shutdown Bd 2B2-B	480V Shutdown Bd 2A2-A
125V Spare Bat Chgr 1	Con & Aux Bldg Vent Bd 1A1-A*	Con & Aux Bldg Vent Bd 1B1-B*
125V Spare Bat. Chgr 2	Con & Aux Bldg Vent Bd 2A1-A*	Con & Aux Bldg Vent Bd 2B1-B*
Component Cooling System Pump C-S	480V Shutdown Bd 2B2-B	480V Shutdown Bd 1A2-A
Spent Fuel Pit Pump C-S	480V Shutdown Bd 1A1-A*	480V Shutdown Bd 2B1-B*
~~[illegible] CAP Sys Bat Chgr~~	~~Reactor MOV Bd 1A1-A~~	~~Reactor MOV Bd 2A1-A~~
~~[illegible] CAP Sys Bat Chgr~~	~~Reactor MOV Bd 1B1-B~~	~~Reactor MOV Bd 2B1-B~~

*These boards are neither the normal nor alternate supply but are the available boards from which the loads can be supplied.



Added by Amendment 47

CONTRACT NO. 74C63-83090

WATTS BAR NUCLEAR PLANT
FINAL SAFETY
ANALYSIS REPORT

SCHEMATIC DIAGRAM
DC DISTRIBUTION PANEL
DWG NO. C379C11501
FIGURE 8.3-55