GE Nuclear Energy

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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Robert C. Pierson, Director
Standardization and Non-Power Reactor Project Directorate

Subject: **GE Responses to the Resolution of Issues Related to Chapter 8 of ABWR DSER SECY-91-355**

Reference: GE Responses to the Resolution of Issues Related to Chapter 8 of ABWR DSER SECY-91-355 (Proprietary Information), MFN. No. 080-92 dated April 3, 1992

Enclosed are thirty-four (34) copies of the GE responses to the subject issues.

Responses to the issue pertaining to Section 19E.2.1.2.2 (Attachment 4) contains information that is designated as General Electric Company proprietary information. This response is being submitted under separate cover (Reference).

In addition to the attached responses, the following comments are provided:

1. The battery sizing calculations, Tables 8.3-5 to 8.3-10 were deleted because GE considers it inappropriate to include detailed calculation such as these in the SSAR. The calculations were provided in a previous submittal for use by the NRC staff. A requirement to review the final battery sizing calculations will be included in the DC power system ITAAC.

2. After further consideration, GE has concluded that the Electrical protection assemblies (EPAs) requested by the NRC staff for the scram solenoid power are not appropriate for the ABWR design. GE plans to discuss this issue at the May 6th management meeting in Rockville.

Change: NRC PDR Ltr Encl 1 w/out Prop Encl

D028 1/1

It is intended that GE will amend the SSAR, where appropriate, with these responses in the future amendment.

Sincerely,

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ABWR Chapter 8 DSER Open Items Response

The following is submitted in response to NRC Staff concerns expressed in Chapter 8 of the ABWR DSER and concerns expressed in past SSAR Chapter 8 meetings with the NRC staff.

Attachment 1

Clean Revised Chapter 8 of the SSAR

The revisions to the chapter were so extensive that a marked copy of the text was very difficult to read. This clean text was prepared for readability. It is not the final typed version for the SSAR so its format is not the same as for the future SSAR submittal. The wording of this version and the version to be included in the appropriate SSAR amendment should be the same. Changes from earlier revisions are not marked in this text. See attachment 2 for the complete record of text changes.

Attachment 2

Marked Chapter 8 of the SSAR

The record of every change that was made in the text is shown on this marked version. Each change is coded as to origin and the complete change is marked. The rules for marking it were as follows:

a. All changes are underlined.

b. Changes were made by addition or deletion only.

c. The start and end of a text addition was marked with "|". An example of an addition is:
|This is an addition. |

d. The beginning of a deletion was marked with ">". The ending of a deletion was marked with "<". An example of a deletion is:
>This is a deletion. <

e. Super deletions were used and were marked with a ">#" at the beginning and a "<#" at the end. An example of a super deletion is:
>#This is a ~C |super| ~C >supper< deletion.<#

f. Each change was coded with a tilde (~) followed by an alpha character as follows:
   - ~A Revised prior to the January 21 and 22 meeting in Rockville.
   - ~B Revised as a result of the discussions in the January 21 and 22 meetings in Rockville.
   - ~C GE corrections discovered during the process of incorporating the "B" revisions.

g. Where applicable, each change was indexed back to the status summary issue number as follows:
   - ~B1.000 Where the "1." followed by three zeroes indicates the change applies to Issue #1 in general.
   - ~B1.03 Where the "1.03" indicates that the change was made in response to sub-issue three of Issue #1.

h. Tilde alpha chararcter codes without a juxtapositioned index number ("~B " for example) indicate a general change such as rewriting Section 8.1. and 8.2.

Attachment 3

<u>Marked Copy of Section 9.5.3, Lighting and Servicing Power Supply System</u>

A conventionally marked copy and inserts for Section 9.5.3, Lighting and Servicing Power Supply System, in response to Section 8.3.5 of the DSER.

Attachment 4

<u>Marked Copy of Section 19E.2.1.2.2, Station Blackout Performance</u>

Section 19E.2.1.2.2, Station Blackout Performance, marked in response to the concerns raised in Section 8.3.9 of the DSER. (Proprietary information, provided under separate cover)

Attachment 5

<u>Station Blackout Status Summary</u>

Summary of the status and basis for closing the open issues for station blackout.

Attachment 6

<u>Marked Copy of Chapter 8 of the DSER</u>

The revised SSAR section containing information which should be the basis for closing each open issue of the DSER is marked in the left margin of the enclosed copy of the DSER.

Attachment 1

Clean Revised Chapter 8 of the SSAR

8.1 INTRODUCTION

8.1.1 Utility Grid Description

The description of the utility grid system is out of the ABWR Standard Plant scope, however there are interface requirements contained in Section 8.2.3.1 which must be complied with by the Utility.

8.1.2 Electric Power Distribution System

8.1.2.1 Description of Offsite Electrical Power System

The scope of the offsite electrical power system includes the entire system from the termination of the transmission lines coming into the switchyard to the termination of the bus duct at the terminals of the main generator and at the input terminals of the circuit breakers for the 7.2KV switchgear. The applicant has design responsibility for portions of the offsite power system. The scope split is as defined in the detailed description of the offsite power system in Section 8.2.1.1.

The 1500MVA main power transformer is a bank of three single phase transformers. One single phase installed spare transformer is provided.

A generator breaker capable of interrupting the maximum available fault current is provided. This allows the generator to be taken off line and the main grid to be utilized as a power source for the unit auxiliary transformers and their loads, both Class 1E and non-Class 1E. This is also the start-up power source for the unit.

There are three unit auxiliary transformers, connected to supply power to three approximately equal load groups of equipment. The "Normal Preferred" power feed is from the unit auxiliary transformers so that there normally are no bus transfers required when the unit is tripped off the line.

One, three-winding 37.5 MVA unit reserve auxiliary transformer is supplied to provide power via one winding for the emergency buses as an alternate to the "Normal Preferred" power. The other secondary winding supplies reserve power to the non-safety-related buses in the turbine building. This is truly a reserve transformer because unit startup is accomplished from the normal preferred power, which is backfed from the offsite power grid over the main power circuit to the unit auxiliary transformers. The two low voltage windings of the reserve transformer are rated 18.75 MVA each. The other winding provides the second offsite power source for the non-safety-related buses in the turbine building.

8.1.2.2 Description of Onsite AC Power Distribution System

Three turbine building non safety-related buses per load group and one reactor building safety related bus per division receive power from the single unit auxiliary transformer assigned to each load group. Load groups A, B and C line up with divisions I, II and III, respectively. One winding of the reserve auxiliary transformer may be utilized to supply reserve power to each of the non-safety-related buses either directly or indirectly through bus tie breakers. The three safety-related buses may be supplied power from the other winding of the reserve auxiliary transformer.

A combustion turbine generator supplies standby power to permanent non-safety-related loads in the turbine building. These loads are grouped on one of the 6.9KV buses per load group. A power supply bus is also provided from the combustion turbine to the three Class 1E medium voltage buses in the reactor building via breakers that are normally racked out for Divisions I and III and remote manually closed under administrative control for Division II.

In general, motors larger than 300 KW are supplied from the 6.9Kv bus. Motors 300KW or smaller but larger than 100KW are supplied power from 480V power center switchgear. Motors 100KW or smaller are supplied power from 480V motor control centers. The 6.9KV and 480V switchgear single line diagrams are shown in Figure 8.3-1.

During normal plant operation all of the non-Class 1E buses and two of the Class 1E buses are supplied with power from the turbine generator through the unit auxiliary transformers. The third Class 1E bus is supplied from the reserve transformer. This third division is immediately available, without a bus transfer, if the normal preferred power is lost to the other two divisions.

Three diesel generator standby AC power supplies provide a separate onsite source of power for each class 1E load group when normal or alternate preferred power supplies are not available. The transfer from the normal preferred or alternate preferred power supplies to the diesel generator is automatic. The transfer back to the normal preferred or the alternate preferred power source is a manual transfer.

The Division I, II, and III standby AC power supplies consist of an independent 6.9Kv Class 1E diesel generator, one for each division. Each

DG may be connected to its respective 6.9Kv Class 1E switchgear bus through a main circuit breaker located in the switchgear.

The standby AC power system is capable of providing the required power to safely shutdown the reactor after loss of preferred power (LOPP) and/or loss of coolant accident (LOCA) or to maintain the safe shutdown condition and operate the Class 1E auxiliaries necessary for plant safety during and after shutdown with any one of the three power load groups.

The plant 480 VAC auxiliary power system distributes sufficient power for normal auxiliary and Class 1E 480 volt plant loads. All class 1E elements of the auxiliary power distribution system are supplied via the 6.9Kv Class 1E switchgear and, therefore, are capable of being fed by the normal preferred, alternate preferred, standby or combustion turbine generator power supplies.

The 120 VAC non-Class 1E instrumentation power system, Figure 8.3-4, provides power for non-Class 1E control and instrumentation loads.

The Class 1E 120 VAC instrument power system, Figure 8.3-4, provides power for Class 1E plant controls and instrumentation. The system is separated into Divisions I, II, and III with distribution panels fed from their respective divisional sources.

The 125V DC power distribution system provides four independent and redundant onsite sources of power for operation of Class 1E DC loads. The 125V DC non-Class 1E power is supplied from three 125V DC batteries located in the turbine building. Separate non-Class 1E 250V batteries are provided to supply uninterruptible power to the plant computers and non-Class 1E DC motors.

The safety system and logic control (SSLC) f RPS and MSIV derives its power from four uninterruptible 120 VAC buses. The SSLC for the ECCS derives its power from the four divis ns of 125V DC buses. The four buses provide the redundancy for various instrumentation, logic and trip circuits and solenoid valves. The SSLC power supply is further described in Subsection 8.1.3.1.1.2.

8.1.2.3 Safety Loads

The safety loads utilize various Class 1E AC and/or DC sources for instrumentation and motive or control power or both for all systems required for safety. Combinations of power sources may be involved in performing a single safety function. For example, low voltage DC power in the control logic may provide an actuation signal to control a 6.9kV circuit breaker to drive a large AC-powered pump motor. The systems required for safety are listed below:

(1) Safety System Logic and Control Power Supplies including the Reactor Protection System

(2) Core and Containment Cooling Systems

(a) Residual Heat Removal System (RHR)

(b) High Pressure Core Flooder (HPCF) System

(c) Automatic Depressurization System (ADS)

(d) Leak Detection and Isolation System (LDS)

(e) Reactor Core Isolation Cooling System (RCIC)

(3) ESF Support Systems

(a) Diesel generator Sets and Class 1E AC/DC power distribution systems.

(b) HVAC Emergency Cooling Water System (HECW)

(c) Reactor Building Cooling Water (RCW) System

(d) Spent Fuel Pool Cooling System

(e) Standby Gas Treatment System (SGTS)

(f) Reactor Building Emergency HVAC System

(g) Control Building HVAC System

(h) High Pressure Nitrogen Gas Supply System

(4) Safe Shutdown Systems

(a) Standby Liquid Control System (SLCS)

(b) Nuclear Boiler System

(i) Safety/Relief Valves (SRVs)
(ii) Steam Supply Shutoff Portion

(c) Residual Heat Removal (RHR) system decay heat removal

(5) Essential Monitoring Systems

(a) Neutron Monitoring System

(b) Process Radiation Monitoring System

(c) Containment Atmosphere Monitoring System

(d) Suppression Pool Temperature Monitoring System

For detailed listings of Division I, II and III loads, see Tables 8.3-1 and 8.3-2.

8.1.3 Design Bases

8.1.3.1 Safety Design Bases--Onsite Power

8.1.3.1.1 General Functional Requirements

8.1.3.1.1.1 Onsite Power Systems--General

The unit's total safety-related load is divided into three divisions of load groups. Each load group is fed by an independent 6.9Kv Class 1E bus, and each load group has access to two offsite and one onsite power source. An additional onsite power source is provided by the combustion turbine generator (CTG).

Each of the two normally energized power feeders are provided for the Division 1, 2 and 3 Class 1E systems. Normally two load groups are fed from the normal preferred power source and the third load group is fed from the alternate preferred power source. Both feeders are used during normal plant operation to prevent simultaneous deenergization of all divisional buses on the loss of only one of the offsite power supplies. The transfer to the alternate preferred feeder is manual. During the interim, power is automatically supplied by the diesel generators.

The redundant Class 1E electrical load groups (Divisions I, II, and III) are provided with separate onsite standby AC power supplies, electric buses, distribution cables, controls, relays and other electrical devices. Redundant parts of the system are physically separated and independent to the extent that in any design basis event with any resulting loss of equipment, the plant can still be shut down with either of the remaining two divisions. Independent raceway systems are provided to meet load group cable separation requirements for Divisions I, II, and III.

Divisions I, II, and III standby AC power supplies have sufficient capacity to provide power to all their respective loads. Loss of the normal preferred power supply, as detected by 6.9Kv Class 1E bus under-voltage relays, will cause the standby power supplies to start and connect automatically, in sufficient time to maintain the reactor in a safe condition, safely shut down the reactor or limit the consequences of a design basis accident (DBA) to acceptable limits. The standby power supplies are capable of being started and stopped manually and are not to be stopped automatically during emergency operation unless required to preserve integrity. Automatic start will also occur on receipt of a level 1 1/2 signal (HPCF initiate).

The Class 1E 6.9Kv Divisions I, II, and III switchgear buses, and associated 6.9Kv diesel generators, 480 VAC distribution systems, 120 VAC and 125 VDC power and control systems conform to Seismic Category I requirements and are housed in Seismic Category I structures. Seismic Qualification is in accordance with IEEE Standard 344.

8.1.3.1.1.2 SSLC (Safety System Logic and Control) Power Supply System Design Bases

In order to provide redundant, reliable power of acceptable quality and availability to support the safety logic and control functions during normal, upset and accident conditions, the following design bases apply:

(1) SSLC power has four separate and independent Class 1E inverter constant voltage constant frequency (CVCF) power supplies each backed by seperate Class 1E batteries.

(2) Provision is made for automatic switching to the alternate bypass supply from its division in case of a failure of the inverter power supply. The inverter power supply is synchronized in both frequency and phase with the alternate bypass supply, so that unacceptable voltage spikes will be avoided in case of an automatic transfer from normal to alternate supply. The SSLC uninterruptible power supply complies with IEEE Std. 944.

8.1.3.1.2 Regulatory Requirements

The following list of criteria is addressed in accordance with Table 8.1-1 which is based on Table 8-1 of the Standard Review Plan. In general, the ABWR is designed in accordance with all criteria. Any exceptions or clarifications are so noted.

8.1.3.1.2.1 General Design Criteria

(1) GDC 2 - Design Bases for Protection against Natural Phenomena;

(2) GDC 4 - Environmental and Missile Design Bases;

(3) GDC 5 - Sharing of Structures, Systems and Components;

The ABWR is a single unit plant design. Therefore, this GDC is not applicable.

(4) GDC 17 - Electric Power Systems;

(5) GDC 18 - Inspection and Testing of Electrical Power Systems;

(6) GDC 50 - Containment Design Bases.

8.1.3.1.2.2 NRC Regulatory Guides

(1) RG 1.6 - Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems;

(2) RG 1.9 - Selection, Design and Qualification of Diesel generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants;

(3) RG 1.32 - Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants;

(4) RG 1.47 - Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems;

(5) RG 1.63 - Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants;

(6) RG 1.75 - Physical Independence of Electric Systems;

Isolation between Class 1E power supplies and non-Class 1E loads is discussed in Subsection 8.3.1.1.1.

(7) RG 1.81 - Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants;

The ABWR is designed as a single-unit plant. Therefore, this Regulatory Guide is not applicable.

(8) RG 1.106 - Thermal Overload Protection for Electric Motors on Motor-Operated Valves;

(9) RG 1.108 - Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants;

(10) RG 1.118 - Periodic Testing of Electric Power and Protection Systems;

(11) RG 1.153 - Criteria for Power, Instrumentation, and Control Portions of Safety Systems;

(12) RG 1.155 - Station Blackout

8.1.3.1.2.3 Branch Technical Positions

(1) BTP ICSB 4 (PSB) - Requirements on Motor-Operated Valves in the ECCS Accumulator Lines;

This BTP is written for Pressurized Water Reactor (PWR) plants only and is therefore not applicable to the ABWR.

(2) BTP ICSB 8 (PSB) - Use of Diesel generator Sets for Peaking;
The diesel generator sets are not used for peaking in the ABWR design. Therefore, this criteria is satisfied.

(4) BTP ICSB 18 (PSB) - Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves;

(5) BTP ICSB 21 - Guidance for Application of Regulatory Guide 1.47;

(6) BTP PSB 1 - Adequacy of Station Electric Distribution System Voltages; [See Subsection 8.3.1.1.7 (8)]

(7) BTP [illegible] 2 - Criteria for Alarms and [illegible]tions Associated with Diesel-[illegible]tor Unit Bypassed and Inoperable Status;

8.1.3.1.2.4 Other SRP Criteria

(1) NUREG/CR 0660 - Enhancement of Onsite Diesel Generator Reliability;

Operating procedures and the training of personnel are outside the scope of the ABWR Standard Plant. NUREG/CR 0660 is therefore imposed as an interface requirement for the applicant. See Subsection 8.1.4.2 for interface requirement.

(2) TMI Action Item II.E.3.1. - Emergency Power Supply for Pressurizer Heater;

This criteria is applicable only to PWRs and does not apply to the ABWR.

(3) TMI Action Item II.G.1-Emergency Power for Pressurizer Equipment;

This criteria is applicable only to PWRs and does not apply to the ABWR.

8.1.4 Interfaces

8.1.4.1 Stability of Offsite Power Systems

BTP ICSB 11 (PSB) pertaining to the stability of offsite power systems shall be addressed (See Subsection 8.1.3.1.2.3(3).

8.1.4.2 Diesel Generator Reliability

NUREG/CR 0660 pertaining to the enhancement of onsite diesel generator reliability through operating procedures and training of personnel will be addressed by the applicant (see Subsection 8.1.3.1.2.4(1)).

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ı provides a description of the system design and the performance r-quirements for the offsite power system. The offsite power system consists of the electrical circuits and associated equipment for interconnection to the offsi.e transmission sy .em, the plant main generator, and the onsite power distributic systems. Included are the plant switchyards, the main step-up transformers, the unit auxiliary transformers, the reserve transformer, the high voltage tie lines from the switchyards to the transforme s, the isolated phase buses with their auxiliary systems including relays and local instrumentation and controls, and the non-segregated phase bus ducts from the unit auxiliary and reserve tra sformers to the medium voltage switchgear.

The offsite power system begins at the terminals on the transmission system side of the circuit breakers which connect the switching stations to the offs. ce transmission system and ends at the terminals of the plant main generator and at the circuit breaker input terminals of the medium voltage (6.9Kv) switchgear.

Portions of the offsite power system fall un ign responsibility of the applicant or . and are not included in the design of the ABWR standard plant. It is the responsibility of al concerned parties to insure that the total completed design of equipment and systems falling within the scope of this SSAR section be in line with the description and requirements stated in this SSAR, however. See Section 8.2.3.1.for a detailed listing and description of the power interface requirements.

8.2.1.2 Description of Offsite Power System

The offsite electrical power system within the scope of the ABWR standard design consists of the isolated phase bus duct up to the low voltage terminals of the main power transformer, isolated phase bus duct to the unit auxiliary transformers, a low voltage generator breaker, three unit auxiliary transformers, a reserve auxiliary transformer, and 6.9Kv connections from the unit auxiliary and reserve transformers to the input terminals of the medium voltage (7.2Kv, 500MVA) switchgear, as indicated on the single line diagram, Figure 8.3-1. The main power transformer, the high voltage leads to the switchyards, the switchyards and the auxiliary equipment for these portions of the system are in the scope of the applicant. See Section 8.2.3.1 for the interface requirements for the equipment in the scope of the applicant.

Air cooled isolated phase bus duct rated 36Ka is provided for a power feed to the main power transformer.

A generator breaker is provided in the isolated phase bus duct at an intermediate location between the main generator and the main power transformer. The generator breaker provided is capable of interrupting a maximum fault current of 275KA symmetrical and 340KA asymmetrical at 5 cycles after initiation of the fault. This corresponds to the maximum allowable interface fault current specified in Section 8.2.3. The low voltage generator breaker allows the generator to be taken off line and the main grid to be utilized as a power source by backfeeding to the unit auxiliary transformers and their loads, both Class 1E and non-Class 1E. This is also the start-up power power source for the unit.

Unit sychronization will normally be through the low voltage generator breaker. A coincidental three-out-of-three logic scheme and synchrocheck relays are used to prevent faulty synchronizations. Dual trip coils are provided on the breaker and control power is supplied from redundant load groups of the non-safety-related onsite 125V DC power.

It is an interface requirement that synchronization be possible through the switching station's circuit breakers (See Section 8.2.3).

There are three unit auxiliary transformers. The transformers have three windings and each transformer feeds one Class 1E bus directly, two Non-Class 1E buses directly, and one Non-Class 1E bus indirectly through a Non 1E to Non 1E bus tie. The medium voltage buses are in a three load group arrangement with three non-safety-related buses and one safety-related bus per load group. Each unit auxiliary transformer has an oil/air rating at 65 degrees centigrade of 37.5Mva for the primary winding and 18.75Mva for each secondary winding. The forced air/forced oil rating is 62.5 and 31.25/31.25Mva respectively. The normal loading of the six transformers is balanced with the heaviest loaded winding carrying a load of 17.7Mva The heaviest transformer loading occurs when one of the three unit auxiliary transformers is out of service with the plant operating at full power. Under these conditions the heaviest loaded winding experiences a load of 21.6Kva, which is about two thirds of its forced air/forced oil rating. See Table 8.2-jem1 for a more detailed summary of the loads.

Disconnect links are provided in the isolated phase bus duct feeding the unit auxiliary transformers so that any single failed transformer may be taken out of service and operation continued on the other two unit auxiliary transformers. One of the buses normally fed by the failed transformer would have to be picked up on the reserve auxiliary transformer in order to keep all reactor internal pumps operating so as to attain full power. The reserve auxiliary transformer is sized for this type of service.

One, three-winding 37.5MVA unit reserve transformer is supplied to provide power as an alternate to the "Normal Preferred" power. One of the equally rated secondary windings supplies reserve power to the nine (three through cross-ties) non-safety-related buses and the other winding supplies reserve power to the three safety-related buses. The combined load of the three safety-related buses is equal to the oil/air rating of transformer winding serving them. This is equal to 60% of the forced air/forced oil rating of the transformer winding. The transformer is truly a reserve transformer because unit startup is accomplished from the normal preferred power, which is backfed over the main power circuit to the unit auxiliary transformers. The reserve auxiliary transformer serves no startup function.

8.2.1.3 Separation

The location of the main transformer, unit auxiliary transformers, and reserve auxiliary transformer are shown on Figure 8.2-1. The reserve auxiliary transformer is separated from the unit auxiliary transformers by a minimum distance of 50 feet. It is a requirement that the 50 foot minimum separation be maintained by the incoming tie lines, also. The transformers are provided with oil collection pits and drains to a safe disposal area.

Reference is made to Figures 8.3-1 for the single line diagrams showing the method of feeding the loads. Separation of the normal preferred and alternate preferred power feeds is accomplished by floors and walls over their routes through the turbine, control and reactor buildings except within the switchgear rooms where they must be routed to the same switchgear lineups. The normal preferred feeds are routed around the outside of the turbine building in an electrical tunnel from the unit auxiliary transformers to the turbine building switchgear rooms as shown on Figure 8.2-1. (An underground duct bank is an acceptable alternate.) From there the feeds to the reactor building exit the turbine building and continue across the roof on the divisions 1 and 3 side of the control building (Figure 8.3-1). They drop down the side of the control building in the space between the control and reactor buildings where they enter the reactor building and continue on through the divisions 1 and 3 side of the reactor building to the respective safety-related switchgear rooms in the reactor building.

The alternate preferred feeds from the reserve auxiliary transformer are routed inside the turbine building. The turbine building switchgear feed from the reserve auxiliary transformer is routed directly to the turbine building switchgear rooms. The feed to the control building is routed in corridors outside of the turbine building switchgear rooms. It exits the turbine building and crosses the control building roof on the opposite side of the control building from the route for the normal preferred power feeds. The steam tunnel is located between the normal preferred feeds and the alternate preferred feeds across the stepped roof of the control building. The alternate preferred power feed turns down between the control and reactor building and enters the reactor building on the division 2 side of the reactor building. From there it continues on to the respective switchgear rooms in the reactor building.

Instrument and control cables for the unit auxiliary transformer are to be routed in solid metal raceways and separate from the normal preferred power cable raceways by a separation that is equivalent to that provided for the power feeds. The reserve auxiliary cables may not share raceways with any other cables, however. The instrumentation and controls for the unit auxiliary transformers and generator breaker may be routed in the raceways corresponding to the load group of their power source.

A combustion turbine supplies standby power to the non-safety-related turbine building buses which supply the permanent non-safety-related loads. It is a 9MW rated self-contained unit which is capable of operation without external auxiliary systems. Although it is located on site, it is treated as an additional offsite source in that it supplies power to multiple load groups of electrical buses.

Manually controlled breakers provide the capability of connecting the combustion turbine generator to any one of the emergency buses if all other power sources are lost.

The location of the combustion turbine generator (CTG) is shown on Figure 8.2-1. The CTG standby power feed for the turbine building is routed directly to the switchgear rooms in the turbine building. The branch to the reactor building is routed adjacent to the alternate preferred feeds across the control and reactor buildings.

As indicated in Section 8.1, the utility grid and the main power transformer are not within the ABWR Standard Plant scope. The interface requirements at the main power transformer are given in Subsection 8.2.3. All other equipment downstream of the main power transformer is included in the ABWR Standard Plant scope. This includes the auxiliary transformers, switchyard components, the main generator, etc., which are assigned by SRP Section 8.2 as being part of the "preferred power system", also called the "offsite power system." Since GE considers these components to be "onsite", their description is provided in Subsection 8.1.2.1.

8.2.2 Analysis

In accordance with the NRC Standard Review Plan (NUREG 0800), Table 8-1 and Section 8.2, the power distribution system between the main transformer and the Class 1E distribution system interfaces is designed consistent with the following criteria, so far as it applies to the non-Class 1E equipment. Any exceptions or clarifications are so noted.

8.2.2.1 General Design Criteria

(1) GDC 5 and RG 1.81 - Sharing of Structures, Systems and Components;

The ABWR is a single unit plant design. Therefore, these criteria are not applicable.

(2) GDC 17 - Electric Power Systems;

As shown in Figure 8.3-1, each of the Class 1E divisional 6.9 KV M/C buses can receive power from multiple sources. There are separate utility feeds from the station grid (via the main transformer), and the offsite line (via the reserve auxiliary transformer). The unit auxiliary transformer output power feeds and the reserve auxiliary transformer output power feeds are routed by two completely separate paths through the turbine building, control building and reactor building to their destinations in the emergency electric rooms. Although these load groups are non-Class 1E, such separ- ation assures the physical independence requirements of GDC 17 are preserved.

The transformers are provided with oil collection pits and drains to a safe disposal area. This separation meets the requirements of BTP CMEB 9.5-1 and is therefore deemed adequate.

(3) GDC 18 - Inspection and Testing of
Electrical Power Systems;

The low voltage generator breaker must open on a turbine trip to maintain the normal preferred power supply to the safety buses. This breaker cannot be tested during normal operation of the plant. Generator breakers are extremely reliable. There are published test results showing a reliability number of 0.9967 for 50 close operations per year. This compares favorably with the probability of failure from other causes of the normal preferred power supply.

All other equipment can either be tested during normal plant operation or it is continually tested by virtue of its operation during normal plant operation and it remaining in the same state to supply normal preferred power to the safety buses following a turbine trip.

(4) RG's 1.32, 1.47, and BTP ICSB 21;

These distribution load groups are non-Class 1E and non-safety related. Therefore, this criteria is not applicable.

(5) RG 1.153--Criteria For Power, Instrumentation and Control Portions of Safety Systems

(6) RG 1.155--Station Blackout

(7) BTP ICSB 11 (PSB) - Stability of Offsite Power Systems;

See Subsection 8.2.3 for interface requirement.

(9) Appendix A to SRP Section 8.2

It is a requirement that the design, testing and installation of the low voltage generator breaker meet the specific guidelines of this appendix, therefore compliance with the appendix is assured.

8.2.3 Interfaces

8.2.3.1 Offsite Power System Desinn Requirements

The standard design of the ABWR is based on certain as: ptions concerning the design requirements which will be met by the applicant in designing the portion of the offsite power system in his scope, as defined in Section 8.2.1.1. Those assumptions are listed here as design interface requirements which the applicant should meet.

(1) In case of failure of the normal preferred power supply circuit, alternate preferred power should normally remain available to the reserve auxiliary transformer.

(2) Voltage variations shall be no more than plus or minus 10 percent of their nominal value during normal steady state operation. Their should be a voltage dip of no more than 20 percent during motor starting. It is expected that the sizing of the unit auxiliary and reserve auxiliary transformers, (See Section 8.2.1.2) will insure that this voltage dip requirement is met.

(3) Maintain the normal steady state frequency of the power system within plus or minus 2 cycles per second of 60 cycles per second during periods of system instability.

(4) Analyze the site specific configuration of the incoming power lines to assure that the expected availability of the offsite power is as good as the assumptions made in performing the plant probability risk analysis. If, during this analysis, it is determined that the availability of the power from the alternate preferred power source is significantly less reliable than the normal preferred power, normal operation of all plant buses from the normal preferred power source is acceptable and recommended.

(5) The main and reserve offsite power circuits shall be electrically independent and physically separated. They shall be connected to switching stations which are independent and separate. They shall be connected to different transmission systems.

(6) The switching station to which the main offsite power circuit is connected shall have at least two full capacity main buses arranged such that:

- (a) Any incoming or outgoing transmission line can be switched without affecting another line;
- (b) Any single circuit breaker can be isolated for maintenance without interrupting service to any circuit;
- (c) Faults of a single main bus are isolated without interrupting service to any circuit.

(7) The main power transformer shall be three normally energized single-phase transformers with an additional installed spare. Provisions shall be made to permit connecting and energizing the spare transformer in no more than 12 hours following a failure of one of the normally energized transformers.

(8) The main transformer shall be designed to meet the requirements of ANSI Standard C57.12.00, General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.

(9) Physical separation between transformers and oil collection shall be provided as stated for fire protection in Section 9A.4.6.

(10) Circuit breakers and disconnect switches shall be sized and designed in accordance with the latest revision of ANSI Standard C37.06, Preferred Ratings and Related Capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

(11) Although unit synchronization is normally through the low voltage generator circuit breaker, provisions shall be made to synchronize the unit through the switching station's circuit breakers.

(12) All relay schemes used for protection of the offsite power circuits and of the switching station's equipment shall be redundant and include backup protection features. All breakers shall be equipped with dual trip coils. Each redundant protection circuit which supplies a trip signal shall be connected to a separate trip coil. All equipment and cabling associated with each redundant system shall be physically separated.

(13) The dc power needed to operate redundant protection and control equipment of the offsite power system shall be supplied from two separate, dedicated switchyard batteries, each with a battery charger fed from a separate ac bus. Each battery shall be capable of supplying the dc power required for normal operation of the switching station's equipment.

(14) Two redundant low voltage ac power supply systems shall be provided to supply ac power to the switching station's auxiliary loads. Each system shall be supplied from separate, independent ac buses. The capacity of each system shall be adequate to meet the ac power requirements for normal operation of the switching station's equipment.

(15) Each transformer shall have primary and backup protective devices. Dc power to the primary and backup devices shall be supplied from separate dc sources.

8.2.3.2 Scope Split Interfaces

The interface point between the ABWR design and the utility design for the main generator output is at the connection of the isolated phase bus to the main power transformer low voltage terminals. The rated conditions for this interface is 1500 MVA at a power factor of 0.9 and a voltage of 26.325 KV plus or minus 10 per cent. It is a requirement that the utility provide sufficient impedance in the main power transformer and the high voltage circuit to limit the primary side maximum available fault current contribution from the system to no more than 275 KA symmetrical and 340 KA asymmetrical at 5 cycles from inception of the fault. These values should be acceptable to most utilities. When all equipment and system parameters are known, a refined calculation based on the known values with a fault located at the generator side of the generator breaker may be made. This may allow a lower impedance for the main power transformer, if desired.

The second power interface occurs at the high voltage terminals of the reserve auxiliary transformer. The rated load is 37.5 MVA at a 0.9 power factor. The voltage and frequency will be the utilities standard with the actual values to be determined at contract award. Tolerances are plus or minus 10 per cent of nominal for voltage and plus or minus 2 per cent of nominal for frequency. Frequency may vary plus or minus 2 cycles per second during periods of system instability. The maximum allowable voltage dip during the starting of large motors is 20 %.

Protective relaying interfaces for the two power system interfaces are to be defined during the detail design phase following contract award.

(To be supplied on a later transmittal).

Figure 8.2-1
Power Distribution
System Routing
Diagram.

8.3 ONSITE POWER SYSTEMS

8.3.1 AC Power Systems

The onsite power system interfaces with the offsite power system at the input terminals to the supply breakers for the normal and alternate power feeds to the medium voltage (7.2KV) switchgear. It is a three load group system with each load group consisting of a non-safety-related and a safety-related portion. The three load groups of the Class 1E power system are independent of each other. The principal elements of the auxiliary AC electric power systems are shown on the single line diagrams (SLD) in Figure 8.3-1, 4, 5 and 7.

Each Class 1E division has a dedicated diesel generator, which automatically starts on high drywell pressure, low reactor vessel level or loss of voltage on the division's 6.9 kV bus. Each 6.9-kV Class 1E bus feeds it's associated 480V unit substation through a 6.9-kV/ 480/277V power center transformer.

Standby power is provided to permanent non-safety-related loads in all three load groups by a combustion gas turbine located in the turbine building.

AC power is supplied at 6.9KV for motor loads larger than 300KW and transformed to 480 V for smaller loads. The 480V system is further transformed into lower voltages as required for instruments, lighting, and controls. In general, motors larger than 300KW are supplied from the 6.9KV buses. Motors 300KW or smaller but larger than 100KW are supplied power form 480V switchgear. Motors 100KW or smaller are supplied power from 480V motor control centers.

See Subsection 8.3.4.9 for interface reqiurements.

8.3.1.0 Non-Safety-Related AC Power System

8.3.1.0.1 Non-Safety-Related Medium Voltage Power Distribution System

The non-safety-related medium voltage power distribution system consists of nine 6.9KV buses divided into three load groups. The three load group configuration was chosen to match the mechanical systems which are mostly three trains (Three feedwater pumps, three circulating water pumps, three turbine building supply and exhaust fans).

Within each load group there is one bus which supplies power production loads which do not provide water to the pressure vessel. Each one of these buses has access to power from one winding of its assigned unit auxiliary transformer. It also has access to the reserve auxiliary transformer as an alternate source if its unit auxiliary transformer fails or during maintenance outages for the normal feed. Bus transfer is manual dead bus transfer and not automatic.

Another bus within each load group supplies power to pumps which are capable of supplying water to the pressure vessel during normal power operation (i.e., the condensate and feedwater pumps). These buses normally receive power from the unit auxiliary transformer and supply power to the third bus (plant investment protection (PIP)) in the load group through a cross-tie. The cross-tie automatically opens on loss of power but may be manually reclosed if it is desired to operate a condensate or feedwater pump from the combustion turbine or the reserve auxiliary transformer which are connectable to the PIP buses. This cross-tie arrangement allows advantage to be taken of the fact that the feedwater pumps are motor driven through an adjustable speed drive so that they have low starting currents and can be started and run at low power. The combustion turbine and reserve auxiliary transformer have sufficient capacity to start either or both the reactor feedwater and condensate pumps in a load group. This provides three load groups of non-safety grade equipment in addition to the divisional 1E load groups which may be used to supply water to the reactor vessel in emergencies.

A third bus supplies power to permanent non-safety loads such as the turbine building HVAC, the turbine building service water and the turbine building closed cooling water systems. On loss of normal preferred power the cross-tie to the power production bus is automatically tripped open and the permanent non-safety related bus is automatically transferred (two out of the three buses in the load groups transfer) via a dead bus transfer to the combustion turbine which automatically starts on loss of power. The permanent service systems for each load group automatically restart to support their load groups.

The buses are comprised of 7.2KV 500MVA metal clad switchgear with a bus full load rating of 2000A. Maximum calculated full load short time current is 1700A. Bus ratings of 3000 amperes are available for the switchgear as insurance against future load growth, if necessary. The required interrupting capacity is 41,000 amperes.

The 6.9kV buses supply power to adjustable speed drives for the feedwater and reactor internal pumps. These adjustable speed drives are designed to the requirements of IEEE Std 519, Guide for Harmonic Control and Reactive Compensation of Static Power Converters. Voltage distortion limits are as stated in Table 4 of the IEEE Std.

8.3.1.0.2
Non-Safety-Related Low Voltage Power Distribution System

Power for the 480V auxiliaries is supplied from power centers consisting of 6.9KV/480 volt transformers and associated metalclad switchgear, Figure 8.3-1. There are six non-safety-related, two per load group, power centers. One power center per load group is supplied power from the permanent non-safety bus for the load group.

8.3.1.0.3 Non-Class 1E Vital AC Power Supply System

The function of the Non-Class 1E Vital AC Power Supply System is to provide reliable 120V uninterruptible AC power for important non-safety related loads that are required for continuity of power plant operation. The system consists of three 120V AC uninterruptible constant voltage, constant frequency (CVCF) power supplies, each including a static inverter, AC and DC static transfer switches, a regulating stepdown transformer (as an alternate AC power supply), and a distribution panel (Figure 8.3-5). The primary source of power comes from the non-Class 1E AC motor control centers. The secondary source is the non-Class 1E 125 VDC central distribution panels.

There are three automatic switching modes for the CVCF power supplies, any of which may be initiated manually. First, the frequency of the output of the inverter is normally synchronized with the input AC power. If the frequnecy of the input power goes out of range, the power supply switches over to internal synchronization to restore the frequency of its output. Switching back to external synchronization is automatic and occurs if the frequency of thew AC power has been restored and maintained for approximately 60 seconds.

The second switching mode is from AC to DC for the power source. If the voltage of the input AC power is less than 88% of the rated voltage, the input is switched to the DC power supply. The input is switched back to the AC power after a confirmation period of approximately 60 seconds.

The third switching mode is between the inverter and the voltage regulating transformer. If any of the conditions listed below occur, the power supply is switched to the voltage regulating transformer.

(a) Output voltage out of rating by more than plus or minus 10 per cent
(b) Output frequency out of rating by more than plus or minus 3 per cent
(c) High temperature inside of panel
(d) Loss of control power supply
(e) Commutation failure
(f) Overcurrent of smoothing condenser
(g) Loss of control power for gate circuit
(h) Incoming MCCB trip
(i) Cooling fan trip

Following correction of any of the above events transfer back is by manual initiation only.

8.3.1.0.4 Computer Vital AC Power Supply System (Non-Safety Related)

Two constant voltage and constant frequency power supplies are provided to power the process computers. Each of the power supplies consists of an AC to DC rectifier, and a DC to AC inverter, a bypass transformer and DC and AC solid state transfer switches (Figure 8.3-5). The normal feed for the power supplies is from non-Class 1E power center supplied from the permanent non-safety-related buses which receive power from the combustion turbine if offsite power is lost. The backup for the normal feeds is from the 250VDC battery. Each power supply is provided with a backup AC feed though isolation transformers and a static transfer switch. The backup feed is provided for alternate use during maintenance periods. Switching of the power supply is similar to that described for the Non-vital AC power supply system, above. See Section 8.3.1.0.3.

8.3.1.0 Safety-Related AC Power Distribution System

8.3.1.1.1 Medium Voltage Safety-Related Power Distribution System

Class 1E AC power loads are divided into three divisions (Divisions I, II, and III), each fed from an independent 6.9-kV Class 1E bus. During normal operation (which includes all modes of plant operation; i.e., shutdown, refueling, startup, and run.), two of the three divisions are fed from an offsite normal preferred power supply. The remaining division shall be fed from the alternate power source (See Subsection 8.3.4.9).

Each 6.9 kV bus has a safety grounding circuit breaker designed to protect personnel during maintenance operations (see Figure 8.3-1). During periods when the buses are energized, these breakers are racked out (i.e., in the disconnect position). A control room annunciator sounds whenever any of these breakers are racked in for service.

The interlocks for the bus grounding devices are as follows:

(1) Undervoltage relays must be actuated.

(2) Bus Feeder breakers must be in the disconnect position.

(3) Voltage for bus instrumentation available.

Conversely, the bus feeder breakers are inetrlocked such that they cannot close unless their associated grounding breakers are in their disconnect positions.

Standby AC power for Class 1E buses is supplied by diesel generators at 6.9 kV and distributed by the Class 1E power distribution system. Division I, II and III buses are automatically transferred to the diesel generators when the normal preferred power supply to these buses is lost.

The division I safety-related bus has one non-safety-related load on it. The load is a power center which supplies power to the fine motion control rod drive (FMCRD) motors. Although these motors are not safety-related, the drives may be inserted as a backup to scram and are of special importance because of this. It is important that the first available standby power be available for the motors, therefore, a diesel supplied bus was chosen as the first source of standby ac power and the combustion turbine as the second backup source. Division I was chosen because it was the most lightly loaded diesel generator.

The load breaker in the division I switchgear is part of the isolation scheme between the safety-related power and the non-safety-related load. In addition to the normal overcurrent tripping of this isolation breaker, zone selective interlocking is provided between it and its upstream Class 1E bus feed breaker.

If fault current flows in the non-Class 1E load, it is sensed by the Class 1E current device for the isolation breaker and a trip blocking signal is sent to the upstream Class 1E feed breaker. This blocking lasts for about 75 milliseconds. This allows the isolation breaker to trip in its normal instantaneous tripping time of 35 to 50 milliseconds, if the magnitude of the fault current is high enough. This assures that the fault current has been terminated before the Class 1E upstream breaker is free to trip. For fault currents of lesser magnitude, the blocking delay will time out without either breaker tripping, but the isolation breaker will eventually trip and always before the upstream breaker. This order of tripping is assured by the coordination between the two breakers provided by long-time pickup, long-time delay and instantaneous pickup trip device characteristics. Tripping of the Class 1E feed breaker is normal for faults which occur on the Class 1E bus it feeds. Coordination is provided between the bus main feed breakers and the load breakers.

The zone selective interlock is a feature of the trip unit for the breaker and is tested when the other features such as current setting and long-time delay are tested.

A pair of interlocked breakers are provided at the input to the power center transformer to supply power to the transformer from either the safety-related diesel generator backed bus or the non-safety-related combustion turbine backed bus. Switchover is automatic on loss of power from the safety-related source. Switching back to the safety-related power is by manual action only. The breaker in the safety-related leg of the power supply is division I associated. The breaker in the non-safety-related leg is non-safety-related on the basis of the electrical isolation of its controls, the fact that there are two breakers between it and the Class 1E 6.9KV bus and that the transfer breakers are interlocked so that only one can be in the closed condition.

The circuits on the output side of the power center transformer are non-safety-related on the basis of the isolation provided by the two upstream breakers and the power center transformer. It is also a requirement that they cannot be classified anything other than non-safety-related so that they can never be routed as associated with cables of any safety-related division.

8.3.1.1.2 Low Voltage Safety-Related Power Distribution System

8.3.1.1.2.1 Power Centers

Power for 480V auxiliaries is supplied from power centers consisting of 6.9-kV/480V transfor- mers and associated metal clad switchgear, Fig- ure 8.3-1.

centers supplying Class 1E loads are arranged as independent radial sys- tems, with each 480V bus fed by its own power transformer. Each 480V Class 1E bus in a divi- sion is physically and electrically independent of the other 480V buses in other divisions.

The 480V unit substation breakers supply motor control centers and motor loads up to and including 300KW. Switchgear for the 480V load centers is of indoor, metal-enclosed type with drawout circuit breakers. Control power is from the Class 1E 125 VDC power system of the same division.

8.3.1.1.2.2 Motor Control Centers

The 480 MCCs feed motors 90KW and smaller, control power transformers, process heaters, motor-operated valves and other small electrically operated auxiliaries, including 480-120V and 480-240V transformers. Class 1E motor control centers are isolated in separate load groups corresponding to divisions established by the 480V unit substations.

Starters for the control of 460V motors smaller than 90KW are MCC-mounted, across-the- line magnetically operated, air break type. Circuits leading from the electrical penetration assemblies into the containment area have a fuse in series with the circuit breakers as a backup protection for a fault current in the penetration in the event of circuit breaker overcurrent or fault protection failure.

8.3.1.1.3 120/240V Distribution System

Individual transformers and distribution panels are located in the vicinity of the loads requiring 120/240V power. This power is used for lighting, 120V receptacles and other 120V loads.

8.3.1.1.4 Instrument Power Supply Systems

8.3.1.1.4.1 120V AC Safety-Related Instrument Power System

Individual transformers supply 120V AC instrument power Figure 8.3-4. Each Class 1E divisional transformer is supplied from a 480V MCC in the same division. There are three divisions, each backed up by its divisional diesel generator as the source when the offsite source is lost. Power is distributed to the individual loads from distribution panels, and to logic level circuits through the control room logic panels.

8.3.1.1.4.2 120V AC Safety Related Vital AC Power Supply System

8.3.1.1.4.2.1 Constant Voltage, Constant Frequency (CVCF) Power Supply for the Safety System Logic and Control (SSLC)

The power supply for the SSLC is shown in Figure 8.3-5, with each of the four buses supplying power for the independent trip systems of the SSLC system. Four constant voltage, constant frequency (CVCF) control power buses (Divisions I, II, III, and IV) have been established. They are each normally supplied independently from inverters which, in turn, are normally supplied power via a static switch from a rectifier which receives 480V divisional power. A 125V DC battery provides an alternate source of power through the static switch.

For Divisions I, II, and III, the AC supply is from a 480 V MCC for each division. The backup DC supply is via a static switch and a DC/AC inverter from the 125VDC central/distribution board for the division. A second static switch also is capable of transferring from the inverter to a direct feed through a voltage regulating transformer from a 480V motor control center for each of the three divisions.

Since there is no 480V AC Division IV power, Division IV is fed from a Division I motor control center. Otherwise, the AC supply for the Division IV CVCF power supply is similar to the other three divisions. The DC supply for Division IV is backed up by a separate Division IV battery.

The CVCF power supply buses are designed to provide logic and control power to the four-division SSLC system that operates the RPS. [The SSLC for the ECCS derives its power from the 125 VDC power system (Figure 8.3-7)]. The AC buses
8.3.1.1.4.2.3 Operating Configuration

The four 120 VAC essential power supplies operate independently, providing four divisions of CVCF power supplies for the SSLC. The normal also supply power to neutron monitoring system and parts of the process radiation monitoring system and MSIV function in the leak detection system. Power distribution is arranged to prevent inadvertent operation of the reactor scram initiation or MSIV isolation upon loss of any single power supply.

Routine maintenance can be conducted on equipment associated with the CVCF power supply. Inverters and solid state switches can be inspected, serviced and tested channel by channel without tripping the RPS logic.

8.3.1.1.4.2.4 (Moved to 8.3.1.0.4)

Components

Each of the four Class 1E CVCF power supplies includes the following components:

(1) a power distribution cabinet, including the CVCF 120 VAC bus and circuit breakers for the SSLC loads;

(2) a solid-state inverter, to convert 125 VDC power to 120 VAC uninterruptible power supply;

(3) a solid-state transfer switch to sense inverter failure and automatically switch to alternate 120 VAC power;

(4) a 480V/120V bypass transformer for the alternate power supply;

(5) a solid-state transfer switch to sense AC input power failure and automatically switch to alternate 125 VDC power.

(6) a manual transfer switch for maintenance.

8.3.1.1.4.2.6 (Deleted)

lineup for each division is through an essential 480 VAC power supply, the AC/DC rectifier, the inverter and the static transfer switch.

There are three automatic switching modes for the CVCF power supplies, any of which may be initiated manually. First, the frequency of the output of the inverter is normally synchronized with the input AC power. If the frequnecy of the input power goes out of range, the power supply switches over to internal synchronization to restore the frequency of its output. Switching back to external synchronization is automatic and occurs if the frequency of thew AC power has been restored and maintained for approximately 60 seconds.

The second switching mode is from AC to DC for the power source. If the voltage of the input AC power is less than 88% of the rated voltage, the input is switched to the DC power supply. The input is switched back to the AC power after a confirmation period of approximately 60 seconds.

The third switching mode is between the inverter and the voltage regulating transformer. If any of the conditions listed below occur, the power supply is switched to the voltage regulating transformer.

(a) Output voltage out of rating by more than plus or minus 10 per cent
(b) Output frequency out of rating by more than plus or minus 3 per cent
(c) High temperature inside of panel
(d) Loss of control power supply
(e) Commutation failure
(f) Overcurrent of smoothing condenser
(g) Loss of control power for gate circuit
(h) Incoming MCCB trip
(i) Cooling fan trip

Following correction of any of the above events transfer back is by manual initiation only.

8.3.1.1.4.2.4 Class 1E RPS and MSIV Soleniods Power Supply

Three of the CVCF power supply buses provide power to the RPS scram and MSIV solenoid valves as a part of their load. The bus for the RPS A solenoids is supplied by the Division II CVCF power supply. The RPS B solenoids bus is supplied from the Division III CVCF power supply. The #3 soleniods for the MSIVs are powered from the Division I CVCF; and the #2 soleniods, from the Division II CVCF power supply.

8.3.1.1.5 Class 1E Electric Equipment Considerations

The following guidelines are utilized for

Class 1E equipment.

8.3.1.1.5.1 Physical Separation and Independence

All electrical equipment is separated in accordance with IEEE Std 384, Regulatory Guide 1.75 and General Design Criterion 17, with the following clarifying interpretations of IEEE Std 384:

(1) Enclosed solid metal raceways are required for separation between safety-related or associated cables of different safety divisions or between safety-related or associated cables and non safety-related cables if the vertical separation distance is less than five feet, the horizontal separation distance is less than three feet and the cables are in the same fire area;

(2) Both groupings of cables requiring separation per item one must be enclosed in solid metal raceways.

To meet the provisions of Policy Issue SECY-89-013, which relates to fire tolerance, three hour rated fire barriers are provided between areas of different safety divisions throughout the plant except in the primary containment and the control room complex. See Section 9.5.1.0 for a detailed description of how the provisions of the Policy Issue are met.

The overall design objective is to locate the divisional equipment and its associated control, instrumentation, electrical supporting systems and interconnecting cabling such that separation is maintained among all divisions. Redundant divisions of electric equipment and cabling are located in separate rooms or fire areas wherever possible.

Electric equipment and wiring for the Class 1E systems which are segregated into separate divisions are separated so that no design basis event is capable of disabling more than one division of any ESF total function.

The safety-related divisional AC switchgear, power centers, battery rooms and DC distribution panels and MCCs are located to provide separation and electrical isolation among the divisions. Separation is provided among divisional cables being routed between the equipment rooms, the Main Control Room, containment and other processing areas. Equipment in these areas is divided into Divisions I, II, III and IV and separated by barriers formed by walls, floors, and ceilings. The equipment is located to facilitate divisional separation of cable trays and to provide access to electrical penetration assemblies. Exceptions to this separation objective are identified and analyzed as to equivalency and acceptability in the fire hazard analysis. (See Appendix 9A.5)

The penetration assemblies are located around the periphery of the containment and at different elevations to facilitate reasonably direct routing to and from the equipment. No penetration carries cables of more than one division.

Separation within the main control room is designed in accordance with IEEE 384, and is discussed in Subsection 8.3.1.4.1.

8.3.1.4.2.2.3.

Wiring for all Class 1E equipment indicating lights is an integral part of the Class 1E cables used for control of the same equipment and are considered to be Class 1E circuits.

Associated cables , if any, are treated as Class 1E circuits and routed in their corresponding divisional raceways. Separation requirements are the same as for Class 1E circuits.Associated cables are required to meet all of the requirements for Class 1E cables.

The careful placing of equipment is important to the necessary segregation of circuits by division. Deliberate routing in separate fire areas on different floor levels, and in embedded ducts is employed to achieve physical independence.

8.3.1.1.5.2 Class 1E Electric Equipment Design Bases and Criteria

(1) Motors are sized in accordance with NEMA standards. The manufacturers' ratings are at least large enough to produce the starting, pull-in and driving torque needed for the particular application, with due consideration for capabilities of the power sources. Plant design specifications for electrical equipment require such equipment be capable of continuous operation for voltage fluctuations of +/- 10%. In addition, Class 1E motors must be able to withstand voltage drops to 70% rated during starting transients.

(2) Power sources, distribution systems and branch circuits are designed to maintain voltage and frequency within acceptable limits.

(3) The selection of motor insulation such as Class F, H or B is a design consideration based on service requirements and environment. The Class 1E motors are qualified by tests in accordance with IEEE Std 334.

(4) Interrupting capacity of switchgear, power centers, motor control centers, and distribution panels is equal to or greater than the maximum available fault current to which it is exposed under all modes of operation.

Interrupting capacity requirements of the 6.9kV Class 1E switchgear is selected to accommodate the available short-circuit current at the switchgear terminals. Circuit breaker and applications are in accordance with ANSI Standards. (See Subsection 8.3.4.1 for interface requirements)

Unit substation transformers are sized and impedances chosen to facilitate the selection of low-voltage switchgear, MCCs and distribution panels, which are optimized within the manufacturer's recommended ratings for interrupting capacity and coordination of overcurrent devices. Impedance of connecting upstream cable is factored in for a specific physical layout.

8.3.1.1.5.3 Testing

The design provides for periodically testing the chain of system elements from sensing devicec through driven equipment to assure that Class 1E equipment is functioning in accordance with design requirements. Such on-line testing is greatly enhanced by the design, which utilizes three independent divisions, any one of which can safely shut down the plant. The requirements of IEEE Std 379 Regulatory Guide 1.118 and IEEE 338 are met.

8.3.1.1.6 Circuit Protection

8.3.1.1.6.1 Philosophy of Protection

Simplicity of load grouping facilitates the use of conventional, protective relaying practices for isolation of faults. Emphasis has been placed on preserving function and limiting loss of Class 1E equipment function in situations of power loss or equipment failure.

Circuit protection of the Class 1E buses contained within the nuclear island is interfaced with the design of the overall protection system outside the nuclear island.

8.3.1.1.6.2 Grounding Methods

The medium voltage (6900V) system is low resistance grounded except that each diesel generator is high resistance grounded to maximize availability.

8.3.1.1.6.3 Bus Protection

Bus protection is as follows:

(1) 6.9kV bus incoming circuits have inverse time overload, ground fault, bus differential and undervoltage protection.

(2) 6.9kV feeders for power centers have instantaneous, inverse time overload and ground fault protection.

(3) 6.9kV feeders for heat exchanger building substations have inverse time overload and ground fault protection.

(4) 6.9kV feeders used for motor starters have instantaneous, inverse time overload, ground fault and motor protection.

(5) 480V bus incoming line and feeder circuits have inverse time overload and ground fault protection.

8.3.1.1.6.4 Protection Requirements

When the diesel-generators are called upon to operate during LOCA conditions, the only protective devices which shut down, the diesel are the generator differential relays, and the engine overspeed trip . These protection devices are retained under accident conditions to protect against possible, significant damage.

Other protective relays, such as loss of excitation, antimotoring (reverse power) overcurrent voltage restraint, low jacket water pressure high jacket water temperature and low lube oil pressure, are used to protect the machine when operating in parallel with the normal power system, during periodic tests. The relays are automatically isolated from the tripping circuits during LOCA conditions. However, all bypassed parameters are annunciated in the main control room (see Subsection 8.3.1.1.8.5). The bypasses are testable and are manually reset as required by Position 7 of Reg. Guide 1.9 No trips are bypassed during LOPP or testing.

8.3.1.1.7 Load Shedding and Sequencing on Class 1E Buses

This subsection addresses Class 1E Divisions I, II, and III. Load shedding, bus transfer and sequencing on a 6.9kV Class 1E bus is initiated on loss of bus voltage. Only LOPP signals are used to trip the loads. However, the presence of a LOCA during LOPP reduces the time delay for initiation of bus transfer from 3 seconds to 0.4 seconds. The load sequencing for the diesels is given on Table 8.3-4.

Load shedding and buses ready to load signals are generated by the control system for the electrical power distribution system. Individual timers for each major load are reset and started by their electrical power distribution systems signals.

(1) Loss of Preferred Power (LOPP) : The 6.9kV Class 1E buses are normally energized from the normal or alternate preferred power supplies. Should the bus voltage decay to below 70% of its nominal rated value for a predetermined time a bus transfer is initiated and the signal will trip the supply breaker, and start the diesel generator. As the bus voltage decays, large pump motor breakers are tripped. The transfer proceeds to the diesel generator. If the standby diesel generator is ready to accept load (i.e., voltage and frequency are within normal limits and no lockout exists, and the normal and alternate preferred supply breakers are open), then the diesel-generator breaker is signalled to close, accomplishing automatic transfer of the Class 1E bus to the diesel generator. Large motor loads will be sequence started as required and shown on Table 8.3-4.

(2) Loss of Coolant Accident (LOCA): When a LOCA occurs, with or without a LOPP, the load sequence timers are started if the 6.9 KV emergency bus voltage is greater than 70% and loads are applied to the bus at the end of preset times.

Each load has an individual load sequence timer which will start if a LOCA occurs and the 6.9 KV emergency bus voltage is greater than 70%, regardless of whether the bus voltage source is normal or alternate preferred power or the diesel generator. The load sequence timers are part of the low level circuit logic for each LOCA load and do not provide a means of common mode failure that would render both onsite and offsite power unavailable. If a timer failed, the LOCA load could be applied manually provided the bus voltage is greater than 70%.

(3) LOPP following LOCA: If the bus voltage (normal or alternate preferred power) is lost during post-accident operation, transfer to diesel generator power occurs as described in (1) above.

(4) LOCA following LOPP: If a LOCA occurs following loss of the normal or alternate preferred power supplies, the LOCA signal starts ESF equip- ment as required. Running loads are not tripped. Automatic (LOCA + LOPP) time delayed load sequencing assures that the diesel-generator will not be overloaded.

(5) LOCA when diesel generator is parallel with preferred power source during test: If a LOCA occurs when the diesel generator is paralled with either the normal preferred power or the alternate preferred power source, the D/G will automatically be disconnected from the 6.9 KV emergency bus regradless of whether the test is being conducted from the local control panel or the main control room.

(6) LOPP during diesel generator paralleling test: If the normal preferred power supply is lost during the diesel-generator paralleling test, the diesel-generator circuit breaker is automatically tripped. Transfer to the diesel generator then proceeds as described in (1).

If the alternate preferred source is used for load testing the diesel generator, and the alternate preferred source is lost (and no LOCA signal exists), the diesel-generator breaker will trip on overcurrent, and LOPP condition will exist. Load shedding and bus transfer will proceed as described in (1).

(7) Restoration of offsite power: Upon restoration of offsite power, the Class 1E bus(es) can be transferred back to the offsite source by manual operation only.

(8) Protection against degraded voltage: For protection of the Division I, II and III electrical equipment against the effects of a sustained degraded voltage, the 6.9 kV ESF bus voltages are monitored. When the bus voltage degrades to 90% or below of its rated value and after a time delay (to prevent triggering by transients), undervoltage will be annunciated in the control room. Simultaneously a 5-minute timer is started, to allow the operator to take corrective action. After 5 minutes, the respective feeder breaker with the undervoltage is tripped. Should a LOCA occur during the 5-minute time delay, the feeder breaker with the undervoltage will be tripped instantly. Subsequent bus transfer will be as desribed above.

8.3.1.1.8 Standby AC Power System

The diesel generators comprising the Divisions I, II and III standby AC power supplies are designed to quickly restore power to their respective Class 1E distribution system divisions as required to achieve safe shutdown of the plant and/or to mitigate the consequences of a LOCA in the event of a coincident LOPP. Figure 8.3-1 shows the interconnections between the preferred power supplies and the Divisions I, II and III diesel-generator standby power supplies.

8.3.1.1.8.1 Redundant Standby AC Power Supplies

Each standby power system division, including the diesel generator, its auxiliary systems and the distribution of power to various Class 1E loads through the 6.9kV and 480V systems, is segregated and separated from the other divisions. No automatic interconnection is provided between the Class 1E divisions. Each diesel generator set is operated independently of the other sets and is connected to the utility power system by manual control, only during testing or for bus transfer.

8.3.1.1.8.2 Ratings and Capability

The size of each of the diesel-generators serving Divisions I, II and III satisfies the requirements of NRC Regulatory Guide 1.9 and IEEE Std 387 and conforms to the following criteria:

(1) Each diesel generator is capable of starting, accelerating and supplying its loads in the sequence shown in Table 8.3-4.

(2) Each diesel generator is capable of starting, accelerating and supplying its loads in their proper sequence without exceeding a 25% voltage drop at its terminals.

(3) Each diesel generator is capable of starting, accelerating and running its largest motor at any time after the automatic loading sequence is completed, assuming that the motor had failed to start initially.

(4) The criterie is for each diesel generator to be capable of reaching full speed and voltage within 20 seconds after receiving a signal to start, and cap- able of being fully loaded within the next 65 seconds as shown in Table 8.3-4. The limiting condition is for the RHR and HPCF injection valves to be open 36 seconds after the receipt of a high drywell or low reactor vessel level signal. Since the motor operated valves are not tripped off the buses, they start to open, if requested to do so by their controls, when power is restored to the bus at 20 seconds. This gives them an allowable travel time of 16 seconds, which is attainable for the valves.

(5) Each diesel generator has a continuous load rating of 6.25 MVA @ 0.8 power factor (see Figure 8.3-1). The overload rating is 110% of the rated output for a two-hour period out of a 24-hour period.

See Subsection 8.3.4.2 for interface requirements.

8.3.1.1.8.3 Starting Circuits and Systems

Diesel generators I, II and III start automatically on loss of bus voltage. Under-voltage relays are used to start each diesel engine in the event of a drop in bus voltage below preset values for a predetermined period of time. Low-water-level switches and drywell high-pressure switches in each division are used to initiate diesel start under accident conditions. Manual start capability (without need of D.C. power) is also provided. The transfer of the Class 1E buses to standby power supply is automatic should this become necessary on loss of all preferred power. After the breakers connecting the buses to the preferred power supplies are open the diesel-generator breaker is closed when required generator voltage and frequency are established.

Diesel generators I, II and III are designed to start and attain rated voltage and frequency within 20 seconds. The generator, and voltage regulator are designed to permit the set to accept the load and to accelerate the motors in the sequence within the time requirements. The voltage drop caused by starting the large motors does not exceed the requirements set forth in Regulatory Guide 1.9, and proper acceleration of these motors is ensured. Control and timing circuits are provided, as appropriate, to ensure that each load is applied automatically at the correct time. Each diesel generator set is provided with two independent starting air systems.

8.3.1.1.8.4 Automatic Shedding, Loading and Isolation

The diesel generator is connected to its Class 1E bus only when the incoming preferred source breakers have been tripped (subsection 8.3.1.1.7). Under this condition, major loads are tripped from the Class 1E bus, except for the Class 1E 480V unit substation feeders, before closing the diesel generator breaker.

The large motor loads are later reapplied sequentially and automatically to the bus after closing of the diesel-generator breaker.

8.3.1.1.8.5 Protection Systems

The diesel generator is shut down and the generator breaker tripped under the following conditions during all modes of operation and testing operation:

(1) engine overspeed trip; and

(2) generator differential relay trip.

These and other protective functions (alarms and trips) of the engine or the generator breaker and other off-normal conditions are annunciated in the main control room and/or locally as shown in Table 8.3-11. Local alarm/annunciation points have auxiliary isolated switch outputs which provide inputs to alarm/annunciator refresh units in the main control room which identifies the diesel generator and general anomaly concerned. Those anomalies which cause the respective D/G to become inoperitive are so indicated in accordance with Regulatory Guide 1.47 and BTP PSB-2.

tion in the diesel generator area by operating key switches at that station.

8.3.1.1.8.6 Local and Remote Control

Each diesel generator is capable of being started or stopped manually from the main control room. Start/stop control and bus transfer control may be transferred to a local control sta-

8.3.1.1.8.7 Engine Mechanical Systems and Accessories

Descriptions of these systems and accessories are given in Section 9.5.

8.3.1.1.8.8 Interlocks and Testability

Each diesel generator, when operating other than in test mode, is totally independent of the preferred power supply. Additional interlocks to the LOCA and LOPP sensing circuits terminate parallel operation test and cause the diesel generator to automatically revert and reset to its standby mode if either signal appears during a test. A lockout or maintenance mode removes the diesel generator from service. The inoperable status is indicated in the control room.

8.3.1.1.8.9 Reliability Qualification Testing

The qualification tests are performed on the diesel generator per IEEE Std. 387 as modified by Regulatory Guide 1.9 requirements.

See Subsection 8.3.4.10 for interface requirements.

8.3.1.2 Analysis

8.3.1.2.1 General AC Power Systems

The general AC power systems are illustrated in Figure 8.3-1. The analysis demonstrates compliance of the Class 1E AC power system to NRC General Design Criteria (GDC), NRC Regulatory Guides and other criteria consistent with the Standard Review Plan (SRP).

Table 8.1-1 identifies the onsite power system and the associated codes and standards applied in accordance with Table 8-1 of the SRP. Criteria are listed in order of the listing on the table, and the degree of conformance is discussed for each. Any exceptions or clarifications are so noted.

(1) General Design Criteria (GDC):

(a) Criteria: GDCs 2, 4, 17, 18 and 50.

(b) Conformance: The AC power system is in compliance with these GDCs . The GDCs are generically addressed in Subsection 3.1.2.

(2) Regulatory Guides (RGs):

(a) RG 1.6 - Independence Between Redundant Standby (Onsite) Power Sources and Between their Distribution Systems

(b) RG 1.9 - Selection, Design, and Qualification of Diesel-Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants

(c) RG 1.32 - Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants

(d) RG 1.47 - Bypassed and Inoperable Status I[illegible]ration for Nuclear Power Plant Safety Systems

(e) RG 1.63 - Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants

(f) RG 1.75 - Physical Independence of Electric Systems

(g) RG 1.106 - Thermal Overload Protection for Electric Motors on Motor-Operated Valves

Safety functions which are required to go to completion for safety have their thermal oveload protection devices in force during normal plant operation but the overloads are bypassed under accident conditions per Regulatory Postion 1.(b) of the guide.

(h) RG 1.108 - Periodic Testing of Diesel Generator Units Used as On-site Electric Power Systems at Nuclear Power Plants

(i) RG 1.118 - Periodic Testing of Electric P[illegible]r and Protection Systems

(j) RG 1.153 -
Criteria for Power, Instrumentation, and Control Portions of Safety Systems

(k) RG 1.155 -
Station Blackout

Regarding Position C-1 of Regulatory Guide 1.75, see Section 8.3.1.1.1, the non-safety related FMCRD motors and brakes are supplied power from the division 1 Class 1E safety-related bus through a dedicated power center transformer. The Class 1E load breaker for the bus is tripped by fault current for faults in the non-safety load. There is also a zone selective interlock provided from the load breaker to the Class 1E bus supply breaker so that the supply breaker is blocked from tripping while fault current is flowing in the non-safety load feeder. This meets the intent of the Regulatory Guide position in that the main supply breaker is prevented from tripping on faults in the non-safety related loads. A second isolation device is provided by the power center transformer, which is associated and meets 1E requirements.

There are three 6.9 KV electrical divisions which are independent load groups backed by individual diesel-generator sets. The low voltage AC systems consists of four divisions which are backed by independent DC battery, charger and inverter systems.

The standby power system redundancy is based on the capability of any one of the divisions 1, 2 or 3 load groups to provide the minimum safety functions necessary to manually shut down the unit from the control room in case of an accident and maintain it in the safe shutdown condition.Two of the four divisions are required to be functional to accomplish an automatic safe shutdown.

There is no sharing of standby power system components between load groups, and there is no sharing of diesel-generator power sources between units, since the ABWR is a single-plant design.

Each standby power supply for each of the three load groups is composed of a single generator driven by a diesel engine having fast-start characteristics and sized in accordance with Regulatory Guide 1.9.

Table 8.3-1 and 8.3-2 show the rating of each of the Division I, II and III diesel generators, respectively, and the maximum coincidental load for each.

(3) Branch Technical Positions (BTPs):

(a) BTP ICSB 8 (PSB) - Use of Diesel-Generator Sets for Peaking

(b) BTP ICSB 18 (PSB) - Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves.

(c) BTP ICSB 21 - Guidence for Application of Regulatory Guide 1.47

(d) BTP PSB 1 - Adequacy of Station Electric Distribution System Voltages

(e) BTP PSB 2 - Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status

The onsite AC power system is designed consistent with these positions.

identification method shall be placed on color coding. All markers within a division shall have the same color. For associated cables (if any) treated as Class 1E (see Note 1), there shall be an A appended to the divisional desig- nation (e.g., A1). The latter A stands for as- sociated and ND for nondivisional. Associated cables are uniquely identified by a longitudinal stripe or other color coded method and the data on the label. The color of the cable marker for associated cables shall be the same as the related Class 1E cable. Divisional separation requirements of individual pieces of hardware are shown in the system ele- mentary diagrams. Identification of raceways, cables, etc., shall be compatible with the iden- tification of the Class 1E equipment with which it interfaces. Location of identification shall be such that points of change of circuit classi- fication (at isolation devices, etc.) are readi- ly identifiable."

Note 1 Associated circuits added beyond the certified design must be specifically identified and justified per Subsection 8.3.4.13. Associated circuits are defined in Section 5.5.1 of IEEE 384-1981, with the clarification for Items (3) and (4) that non-Class 1E circuits being in an enclosed raceway without the required physical separation or barriers between the enclosed raceway and the Class 1E or associated cables makes the circuits (related to the non-Class 1E cable in the enclosed raceway) associated circuits.

8.3.1.3.1.1 Equipment Identification

Equipment (Panels, racks, junction or pull boxes) of each division of the Class 1E electric system and various CVCF power supply divisions are identified as follows:

(1) The background of the nameplate for the equipment of a division has the same color as the cable jacket markers and the raceway markers associated with that division.

(2) Power system distribution equipment (e.g., motor control centers, switchgear, trans-

(4) Other SRP Criteria:

(a) NUREG/CR 0660 - Enhancement of Onsite Diesel Generator Reliability

As indicated in Subsection 8.1.3.1.2.4, the operating procedures [illegible] of personnel are outside of the [illegible] scope of supply. NUREG/CR 0660 [illegible] posed as an inte[illegible] applicant. (See Subsection [illegible].1.4.7)

(b) NRC Policy Issue On Alternate Power for Non-safety Loads

This policy issue states that "An evolutionary ALWR design should include an alternate power source to the non-safety loads unless the design can demonstrate that the design margins in the evolutionary ALWR will result in transients for a loss of non-safety power event that are no more severe than those associated with the turbine-trip-only event in current existing plant designs." A subsequent clarification stated that the transfer should be an automatic slow bus transfer to pickup at least one of the non MG set driven RIPs for an ABWR.

An automatic transfer has not been provided for two reasons:

(1) The coast down provided by the MG sets is equivalent to the coastdown provided by the recirculation pump inertia on the current plants.

(2) The manner in which the ABWR functions on the loss of offsite power does not require a bus transfer. The four RIPs which are not supplied from the high inertia MG sets receive a trip command immediately on tripping of the unit. This trip command originates from turbine/load rejection trip, low vessel water level (level 3) trip or high vessel dome pressure trip. The supply breakers to the high inertia MG sets are also tripped to prevent power being drawn from the flywheels by the other large motors on the buses. The remaining six RIPs continue to operate to optimize the rate of recirculation flow reduction until the MG sets have coasted down to the ASD cut off point, at which time the remaining RIPs are tripped.

The only need to restart a RIP is in preparation for restart of the plant, at which time normal power must have been restored to the non-safety buses. The operator may then restart any of the RIPs, providing that the temperature difference between the vessel dome (as indicated by the dome pressure indicator) and the bottom head is within allowable limits. A start inhibit interlock is provided to insure that the temperature limits are satisfied before a RIP is started.

Any non-safety loads which should be restarted immediately are on the plant investment protection (PIP) buses. These buses are picked up automatically by the combustion turbine. For the remaining non-safety buses there is no requirement to immediately restore power and for simplicity considerations automatic transfers are not provided.

8.3.1.2.3 Quality Assurance Requirements

A planned quality assurance program is provid- ed in Chapter 17. This program includes a comprehensive system to ensure that the purchased material, manufacture, fabrication, testing and quality control of the equipment in the emergency electric power system conforms to the evaluation of the emergency electric power system equipment vendor quality assurance programs and preparation of procurement specifications incorporating qual- ity assurance requirements. The administrative responsibility and control provided are also des- cribed in Chapter 17.

These quality assurance requirements include an appropriate vendor quality assurance program and organization, purchaser surveillance as re- quired, vendor preparation and maintenance of appropriate test and inspection records, certi- ficates and other quality assurance documenta- tion, and vendor submittal of quality control records considered necessary for purchaser retention to verify quality of completed work.

A necessary condition for receipt, installation and placing of equipment in service has been the signing and auditing of QA/QC verification data and the placing of this data in permanent onsite storage files.

8.3.1.2.4 Environmental Considerations

In addition to the effects of operation in normal service environment, all Class 1E equipment is designed to operate during and after any design basis event, in the accident environment expected in the area in which it is located. All Class 1E electric equipment is qualified to IEEE 323 (see Section 3.11)

8.3.1.3 Physical Identification of Safety-Related Equipment

8.3.1.3.1 Power, Instrumentation and Control Systems

Electrical and control equipment, assemblies, devices, and cables grouped into separate divisions shall be identi- fied so that their electrical divisional assign- ment is apparent and so that an observer can vi- sually differentiate between Class 1E equipment and wiring of different divisions, and between Class 1E and non-Class 1E equipment and wires. The

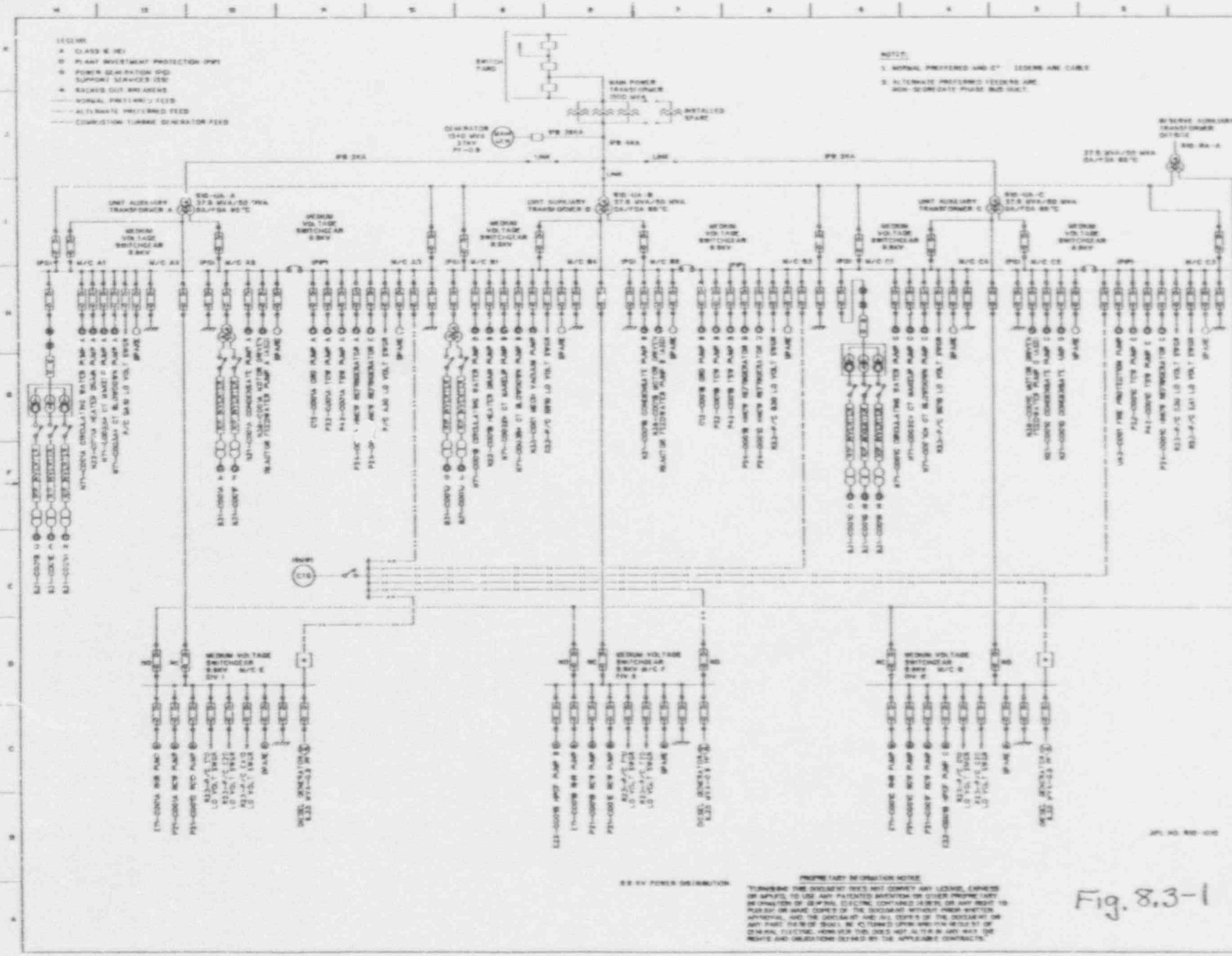
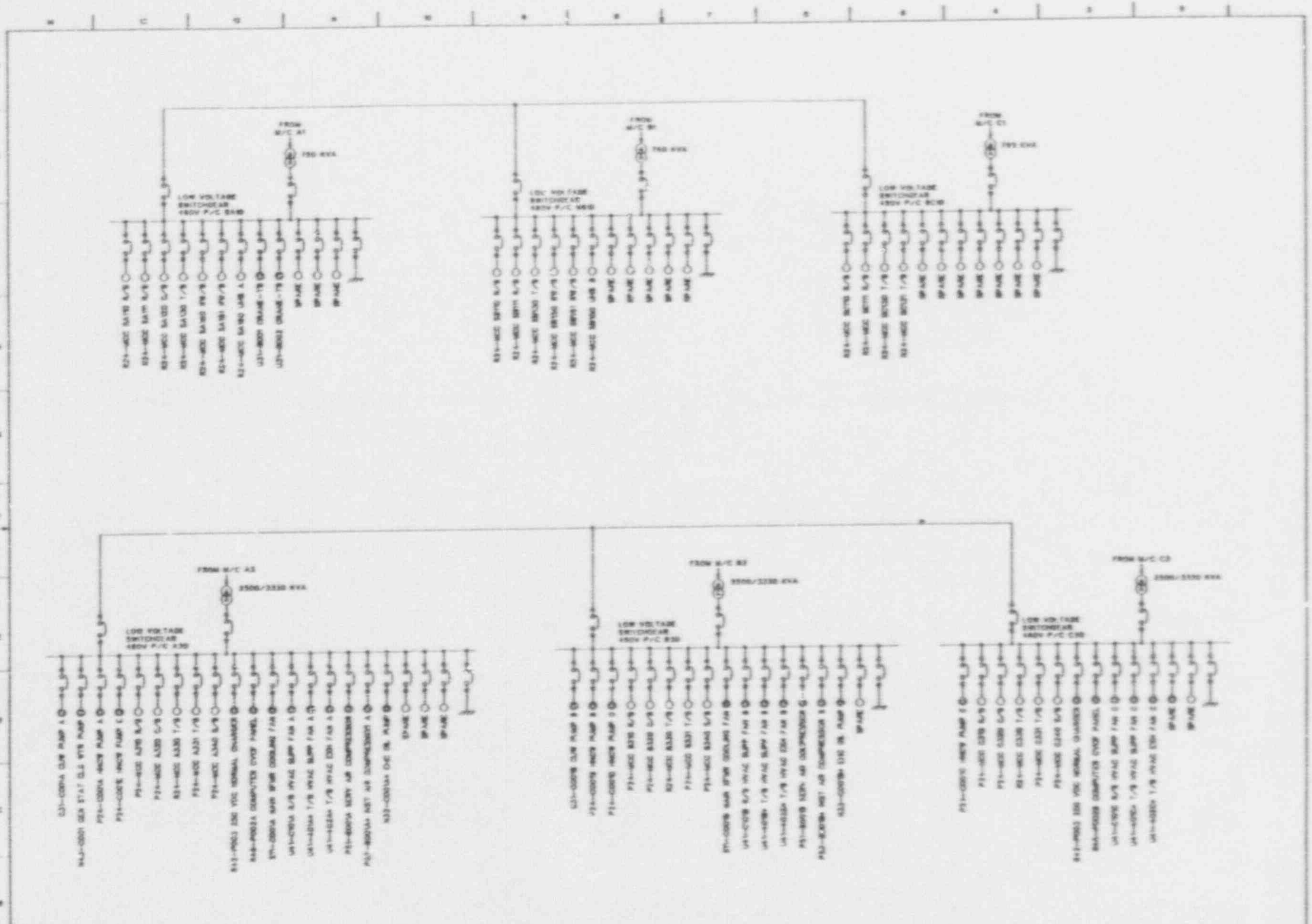


Fig. 8.3-1

R10-1010 1



480V NON-1E POWER DISTRIBUTION

GENERAL ELECTRIC COMPANY
PROPRIETARY INFORMATION
CLASS III

Fig. 8.3-1

810-1010 2

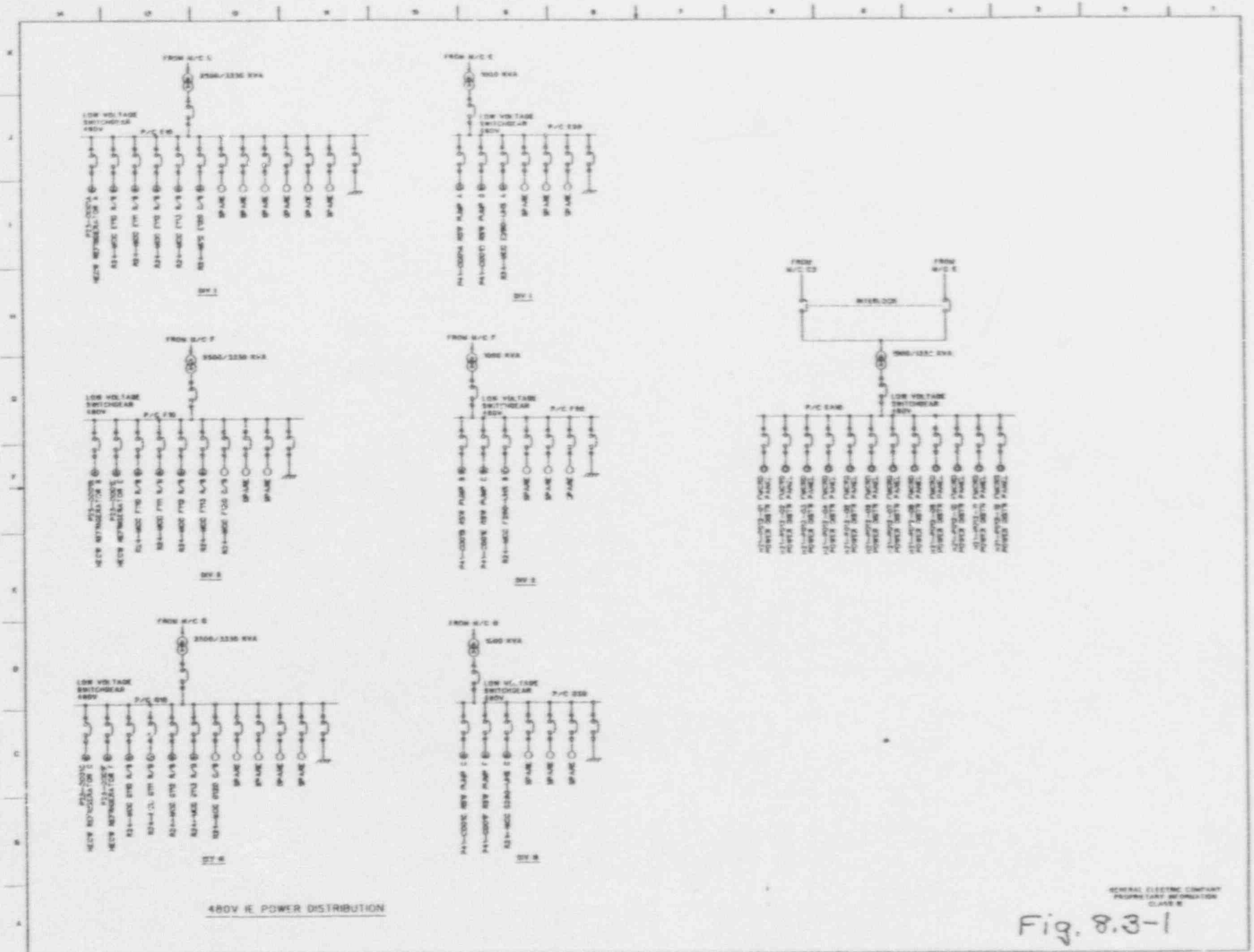
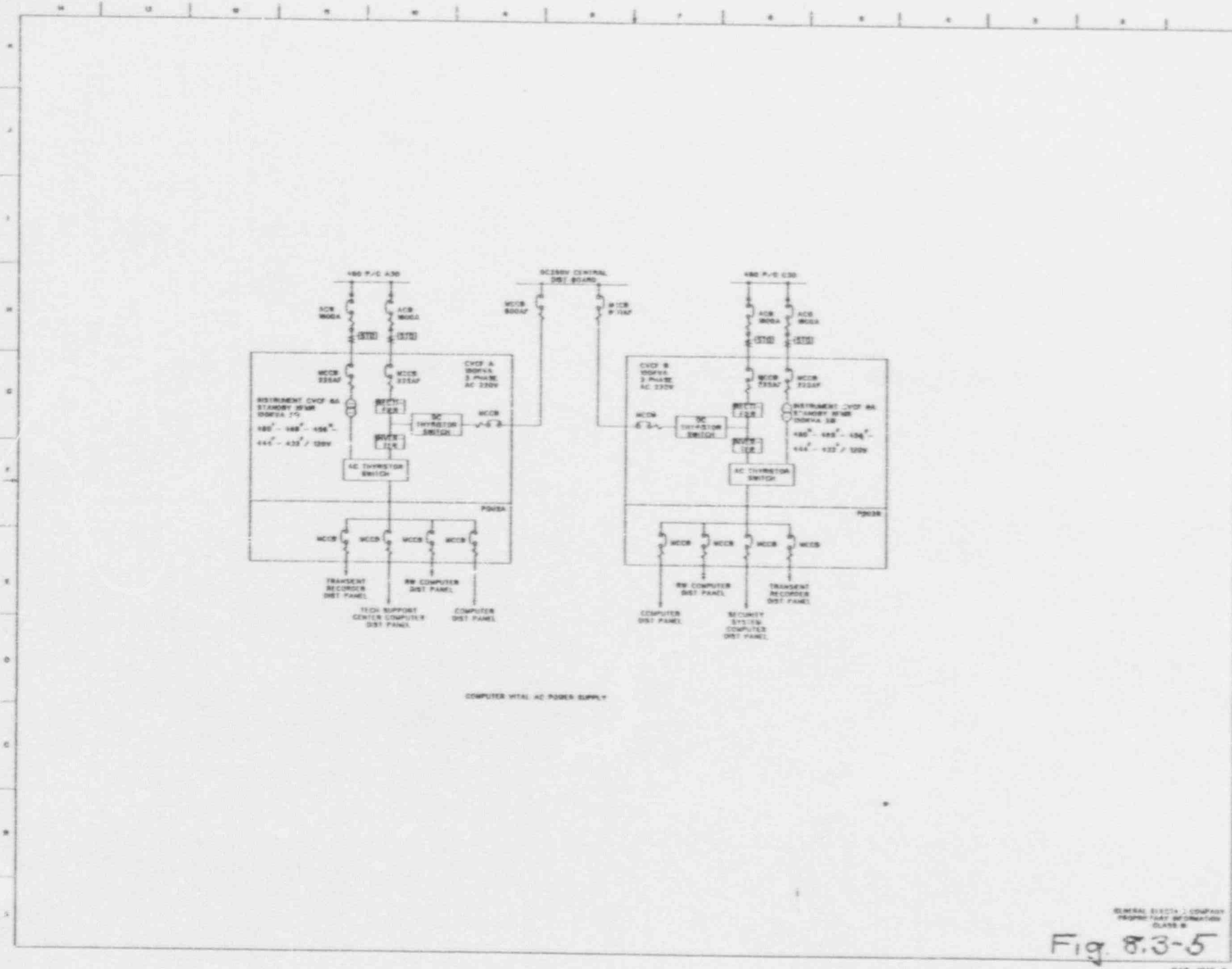

FROM M/C C
LOW VOLTAGE SWITCHGEAR 480V
SPARE
DIV I
DIV II
DIV III
DIV IV
FROM M/C F
FROM M/C B
INTERLOCK
480V IE POWER DISTRIBUTION
GENERAL ELECTRIC COMPANY
PROPRIETARY INFORMATION
CLASS III

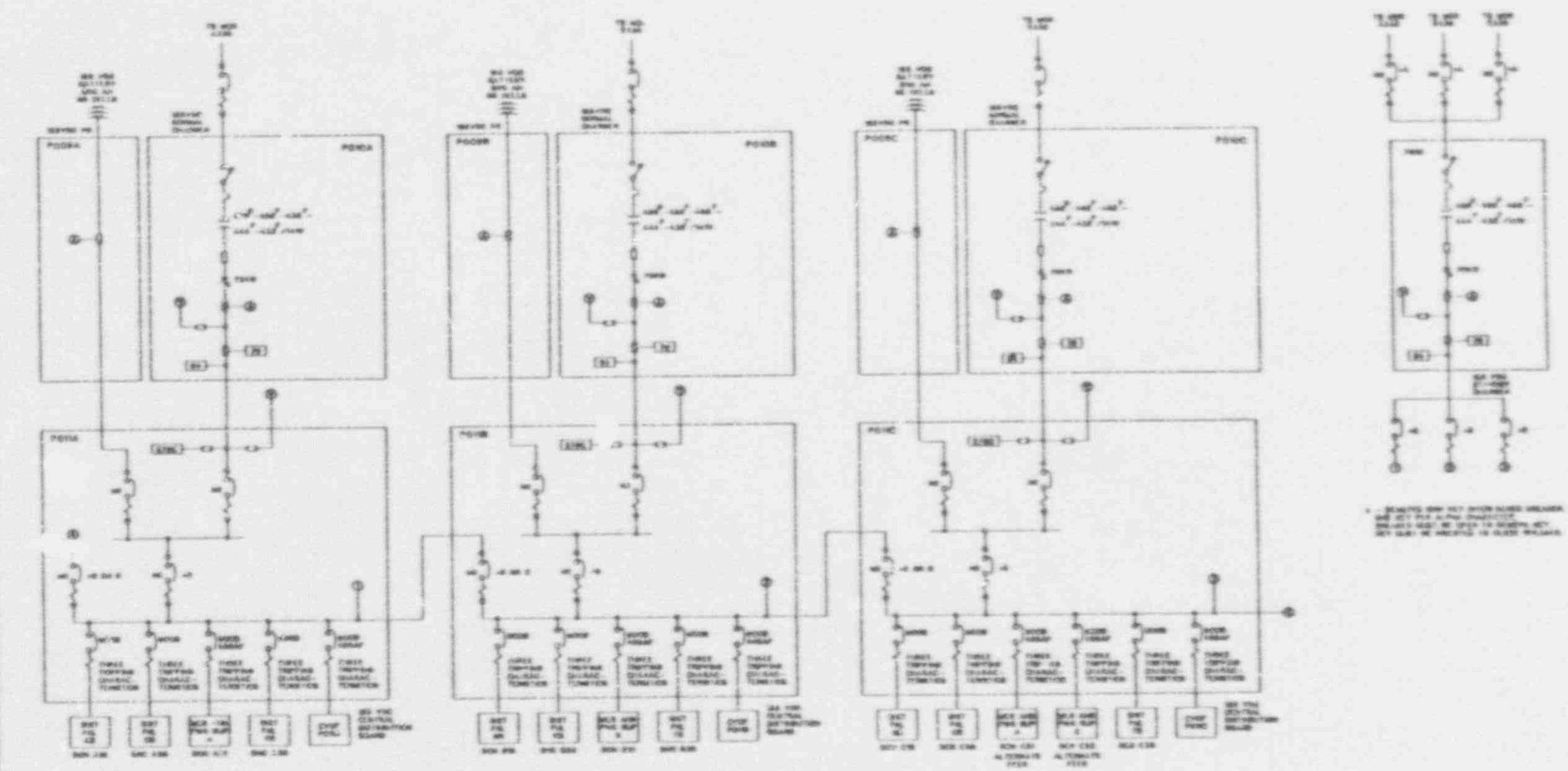
Fig. 8.3-1



COMPUTER VITAL AC POWER SUPPLY

GENERAL ELECTRIC COMPANY
PROPRIETARY INFORMATION
CLASS III

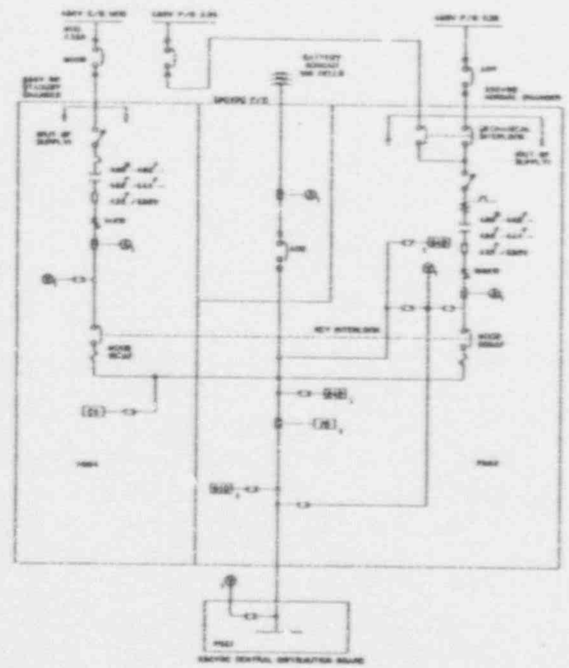
Fig. 8.3-5



125 VDC NON SAFETY RELATED POWER SUPPLY

Fig. 8.3-7

842-1010 2



250 VDC POWER SUPPLY

GENERAL ELECTRIC COMPANY
PROPRIETARY INFORMATION
CLASS III

Fig. 8.3-7

Attachment 2

Marked Chapter 8 of the SSAR

8.1 INTRODUCTION

8.1.1 Utility Grid Description

~B |The description of the utility grid system is out of the ABWR Standard Plant scope, however there are interface requirements contained in Section 8.2.3.1 which must be complied with by the Utility. |~B >Out of ABWR Standard Plant Scope.<

8.1.2 ~B >Onsite <Electric Power ~B |Distribution |System

8.1.2.1 Description of ~B |Offsite |Electrical Power System

The scope of the offsite electrical power system includes the entire system ~B |from the termination of the transmission lines coming into the switchyard to the termination of the bus duct at the terminals of the main generator and at the input terminals of the circuit breakers for the 7.2KV switchgear. The applicant has design responsibility for portions of the offsite power system. The scope split is as defined in the detailed description of the offsite power system in Section 8.2.1.1. |~B >on the plant side of the low voltage terminals of the main power transformer and the connection at the high voltage bushings of the reserve transformer, as indicated on the single line diagram, Figure 8.3-1. The main power transformer is not in scope. The combustion turbine generator (CTG) is within scope.

The electrical interface requirements are shown on the single line diagram.<

~B |The 1500MVA main power transformer is a bank of three single phase transformers. One single phase installed spare transformer is provided. |

A generator breaker capable of interrupting the maximum available fault current is provided. This allows the generator to be taken off line and the main grid to be utilized as a power source for the unit auxiliary transformers and their loads, both Class 1E and non-Class 1E. This is also the start-up power ~C |source |~C>train <for the unit.

There are ~B |three |~B >four<unit auxiliary transformers, ~B |connected to supply power to three approximately equal load groups of equipment. |~B >two to feed the non-Class 1E buses and two to feed the Class 1E buses. <The "Normal Preferred" power feed is from the unit auxiliary transformers so that there normally are no bus transfers required when the unit is tripped off the line.

One, three-winding ~B |37.5|~B >30 <MVA unit reserve ~C |auxiliary |transformer is supplied to provide power ~B |via one winding |for the emergency buses as an alternate to the "Normal Preferred" power. ~B |The other secondary winding supplies reserve power to the non-safety-related buses in the turbine building. |This is truly a reserve transformer because unit startup is accomplished from the normal preferred power, which is backfed ~C |from the offsite power grid |over the main power circuit to the unit auxiliary transformers. The two low voltage windings of the reserve transformer are rated ~B |18.75|~B >15 <MVA each. ~B >#One winding provides the second offsite power source for Divisions I<~B |, II and III|.~B >and II< The other winding provides the second offsite power source for ~B |the non-safety-related buses in the turbine building.|~B >Division III and non-safety bus B2 which supplies investment protection loads.<# ~B |8.1.2.2 Description of Onsite AC Power Distribution System |~ ># There is also a combustion turbine which supplies standby power to ~A |one |turbine building buses ~A |which feeds the |plant investment protection loads~A |.|~A >are grouped on the two turbine building buses.< Manually controlled breakers provide the capability of connecting the combustion turbine generator to any one of the emergency buses if all other power sources are lost.<#

~B |Three turbine building non safety-related buses per load group and one reactor building safety related bus per division receive power from the single unit auxiliary transformer assigned to each load group. Load groups A, B and C line up with divisions I, II and III, respectively. One winding of the reserve auxiliary transformer may be utilized to supply reserve power to each of the non-safety-related buses either directly or indirectly through bus tie breakers. The three safety-related buses may be supplied power from the other winding of the reserve auxiliary transformer. |

A combustion turbine generator supplies standby power to permanent non-safety-related loads in the turbine building. These loads are grouped on one of the 6.9KV buses per load group. A power supply bus is also provided from the combustion turbine to the three Class 1E medium voltage buses in the reactor building via breakers that are normally racked out for Divisions I and III and remote manually closed under administrative control for Division II.
|

~B > The reactor building is supplied with three divisions of class 1E AC power (Figure 8.3-1). Each of the Division I, II, and III Class 1E 6.9 kv buses have two feeders ~B |per division |from the offsite sour- ces--normal preferred and alternate preferred power. The Class 1E AC power system is divided into three independent divisions to provide AC power to the three divisions of Class 1E loads.<
~B |

_| In general, motors larger than 300 KW are supplied from the 6.9Kv bus. Motors 300KW or smaller but larger than 100KW are supplied power from 480V ~C |power center |switchgear. ~A >460V<~A |M|~A >m<otors 100KW or smaller are supplied power from 480V motor control centers. The 6.9KV and 480V switchgear single line diagrams are shown ~C |in Figure 8.3-1. |~C >on Figures 8.3-1, 8.3-2 and 8.3-3.<

During normal plant operation all of the non-Class 1E buses and two of the Class 1E buses are supplied with power from the turbine generator through the unit auxiliary transformers. The third Class 1E bus is supplied from the reserve transformer. This third division is immediately available, without a bus transfer, if the normal preferred power is lost to the other two divisions. ~B >Either of the normal preferred or the alternate preferred AC power sources are capable of providing power to all Division I, II, and III Class 1E loads in addition to some selected non-Class 1E loads.<

~B |Three diesel generator |~B >The three <standby AC power supplies provide a separate onsite source of power for each class 1E load group when normal ~C |or | ~C>and <alternate preferred power supplies are not available. The transfer from the normal preferred or alternate preferred power supplies to the diesel generator is automatic. The transfer back to the normal preferred or the alternate preferred power source is a manual transfer.

The Division I, II, and III standby AC power supplies consist of an independent 6.9Kv Class 1E diesel generator, one for each division. Each

-C |DG |may be connected to its respective 6.9Kv Class 1E switchgear bus through a main circuit breaker located in the sw tchgear.

The standby AC power system is capable of providing the required power to safely shutdown the reactor after loss of preferred power (LOPP) and/or loss of coolant accident (LOCA) or to maintain the safe shutdown condition and operate the Class 1E auxiliaries necessary for plant safety during and after shutdown-B | with any one of the three power load groups|.

The plant 480 VAC auxiliary power system distributes sufficient power for normal auxiliary and Class 1E 480 volt plant loads. All class 1E elements of the auxiliary power distribution system are supplied via the 6.9Kv Class 1E switchgear and, therefore, are capable of being fed by the normal preferred, alternate preferred, standby or combustion turbine generator power supplies.

The 120 VAC non-Class 1E instrumentation power system, Figure 8.3-4, provides power for non-Class 1E control and instrumentation loads.

The Class 1E 120 VAC instrument power system, Figure 8.3-4, provides power for Class 1E plant controls and instrumentation. The system is separated into Divisions I, II, and III with distribution panels fed from their respective divisional sources.

The 125V DC power distribution system provides four independent and redundant onsite sources of power for operation of Class 1E DC loads. The 125V DC non-Class 1E power is -B |supplied from three 125V DC batteries located in the turbine building. |-B >taken from the Class 1E batteries. Class 1E isolation is provided by DC-to-DC converters. <Separate non-Class 1E 250V batteries are provided to supply uninterruptible power to the plant computers and non-Class 1E DC motors.

The safety system and logic control (SSLC) for RPS and MSIV derives its power from four uninterruptible 120 VAC buses. The SSLC for the ECCS derives its power from the four divisions of 125V DC buses. The four buses provide the redundancy for various instrumentation, logic and trip circuits and solenoid valves. The SSLC power supply is further described in Subsection 8.1.3.1.1.2.

-B >#-A |8.1.2.1.1 Separation

The locations for the main transformer, unit auxiliary transformers, and reserve auxiliary transformer are shown on Figure 1.1-25. The reserve auxiliary transformer will be separated from the unit auxiliary transformers by 50 feet or shadow fire wall.

Reference is made to Figure 8.3-1 for the single line diagrams showing the method of feeding the loads. Separation of the normal preferred and alternate preferred power feeds is accomplished by floors and walls over their routes through the turbine, control and reactor buildings except within the switchgear rooms where they must be routed to the same switchgear lineups. The normal preferred feeds are routed within the turbine building from the unit auxiliary transformers to the turbine building switchgear and to the control building. From there, the normal preferred feeds continue across the divisions 1 and 3 sides of the control and reactor buildings to the respective safety-related switchgear rooms in the reactor building.

The alternate preferred feeds from the reserve auxiliary transformer are routed alongside the turbine building. The feed from the non-safety related switchgear peels off and enters the load group A switchgear room at grade to pick up the switchgear at that elevation, and then rises on up to the load group B switchgear room above. The other alternate preferred feed, which is for the safety-related buses, continues on outside of the turbine building until it enters the clean access corridor (Figure 1.2-24) just below grade between the turbine and control buildings. It crosses the turbine building in the top of the clean access tunnel and then enters the divisions 2 and 4 side of the control building. From there, it crosses the divisions 2 and 4 sides of the control and reactor building to access the switchgear rooms within the reactor building. The normal preferred power feeds are not allowed to be in or through the clean access corridor.

The location of the combustion turbine generator (CTG) is shown on Figure 1.2-26. The standby power feed from the CTG is routed directly to the switchgear rooms in the turbine building.

The branch to the reactor building is routed adjacent to the alternate preferred feeds across the control and reactor buildings.|<#

~A |8.1.2.3 |~A >8.1.2.1.1<Safety Loads

The safety loads utilize various Class 1E AC and/or DC sources for instrumentation and motive or control power or both for all systems required for safety. Combinations of power sources may be involved in performing a single safety function. For example, low voltage DC power in the control logic may provide an actuation signal to control a 6.9kV circuit breaker to drive a large AC-powered pump motor. The systems required for safety are listed below:

(1) Safety System Logic and Control Power Supplies including the Reactor Protection System

(2) Core and Containment Cooling Systems

(a) Residual Heat Removal System (RHR)

(b) High Pressure Core Flooder (HPCF) System

(c) Automatic Depressurization System (ADS)

(d) Leak Detection and Isolation System (LDS)

(e) Reactor Core Isolation Cooling System (RCIC)

(3) ESF Support Systems

(a) Diesel generator Sets and Class 1E AC/DC power distribution systems.

(b) HVAC Emergency Cooling Water System (HECW)

(c) Reactor Building Cooling Water (RCW) System

(d) Spent Fuel Pool Cooling System

(e) Standby Gas Treatment System (SGTS)

(f) Reactor Building Emergency HVAC System

(g) Control Building HVAC System

(h) High Pressure Nitrogen Gas Supply System

(4) Safe Shutdown Systems

(a) Standby Liquid Control System (SLCS)

(b) Nuclear Boiler System

(i) Safety/Relief Valves (SRVs)
(ii) Steam Supply Shutoff Portion

(c) Residual Heat Removal (RHR) system decay heat removal

(5) Essential Monitoring Systems

(a) Neutron Monitoring System

(b) Process Radiation Monitoring System

(c) Containment Atmosphere Monitoring System

(d) Suppression Pool Temperature Monitoring System

~A >8.1.2.3.2 Division of Safety Loads <

For detailed listings of Division I, II and III loads, see Tables 8.3-1 and 8.3-2.

8.1.3 Design Bases

8.1.3.1 Safety Design Bases--Onsite Power

8.1.3.1.1 General Functional Requirements

8.1.3.1.1.1 Onsite Power Systems--General

The unit's total safety-related load is divided into three divisions of load groups. Each load group is fed by an independent 6.9Kv Class 1E bus, and each load group has access to two offsite and one onsite power source. An additional onsite power source is provided by the combustion turbine generator (CTG).

Each of the two normally energized power feeders are provided for the Division 1, 2 and 3 Class 1E systems. ~C |Normally two load groups are fed from the normal preferred power source and the third load group is fed from the alternate preferred power source. |~A |Both feeders are used during normal plant operation to prevent simulteneous deenergization of all divisional buses on the loss of only one of the offsite power supplies.|~A >The normal preferred feeder is used during the plant operation, with the alternate preferred feeder used when the former is lost.< The transfer to the alternate preferred feeder is manual. During the interim, power is automatically supplied by the diesel generators.

The redundant Class 1E electrical load groups (Divisions I, II, and III) are provided with separate onsite standby AC power supplies, electric buses, distribution cables, controls, relays and other electrical devices. Redundant parts of the system are physically separated -A |and independent |to the extent -A |that in |-A >that a single credible event.<

~A3.100 |any d. .gn basis event with any resulting loss of equipment |~R3.100 >~A3.100 |and single failure|<, ~B3.100 |the plant can still be shut down with either of the remaining two divisions. |~B3.100 >~A3.100 |sufficient remaining safety systems will be available to effect a safe plant shutdown for all allowable modes of plant operation.|<~A3.100 >including a single electrical failure, cannot cause loss of power to redundant load groups.< Indnpendent raceway systems are provided to meet load group cable separation requirements for Divisions I, II, and III.

Divisions I, II, and III standby A" power supplies have sufficient capacity to provide power to all their respective loads. Loss of the normal preferred power supply, as detected by 6.9Kv Class 1E bus under-voltage relays, will cause the standby power supplies to start and connect automatically, in sufficient time to maintain the reactor in a safe condition, safely shut down the reactor or limit the consequences of a design basis accident (DBA) to acceptable limits. The standby power supplies are capable of being started and stopped manually and are not to be stopped automatically during emergency operation unless required to preserve integrity. Automatic start will also occur on receipt of a level 1 1/2 signal (HPCF initiate).

The Class 1E 6.9Kv Divisions I, II, and III switchgear buses, and associated 6.9Kv diesel generators, 480 VAC distribution systems, 120 VAC and 125 VDC power and control systems conform to Seismic Category I requirements and are housed in Seismic Category I structures. Seismic Qualification is in accordance with IEEE Standard 344.

8.1.3.1.1.2 SSLC (Safety System Logic and Control) Power Supply System Design Bases

In order to provide redundant, reliable power of acceptable quality and availability to support the safety logic and control functions during normal, upset and accident conditions, the following design bases apply:

(1) SSLC power has four separate and independent Class 1E inverter constant voltage constant frequency (CVCF) power supplies each backed by separate Class 1E batteries.

(2) Provision is made for automatic switching to the alternate bypass supply from its division in case of a failure of the inverter power supply. The inverter power supply is synchronized in both frequency and phase with the alternate bypass supply, so that unacceptable voltage spikes will be avoided in case of an automatic transfer from normal to alternate supply. The SSLC uninterruptible power supply complies with IEEE Std. 944.

8.1.3.1.2 Regulatory Requirements

The following list of criteria is addressed in accordance with Table 8.1-1 which is based on Table 8-1 of the Standard Review Plan. In general, the ABWR is designed in accordance with all ~A >applicable<criteria. Any exceptions or clarifications are so noted.

8.1.3.1.2.1 General Design Criteria

(1) GDC 2 - Design Bases for Protection against Natural Phenomena;

(2) GDC 4 - Environmental and Missile Design Bases;

(3) GDC 5 - Sharing of Structures, Systems and Components;

The ABWR is a single-unit plant design. Therefore, this GDC is not applicable.

(4) GDC 17 - Electric Power Systems;

(5) GDC 18 - Inspection and Testing of Electrical Power Systems;

(6) GDC 50 - Containment Design Bases.

8.1.3.1.2.2 NRC Regulatory Guides

(1) RG 1.6 - Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems;

(2) RG 1.9 - Selection, Design and Qualification of Diesel generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants;

(3) RG 1.32 - Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants;

(4) RG 1.47 - Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems;

(5) RG 1.63 - Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants;

(6) RG 1.75 - Physical Independence of Electric Systems;

Isolation between Class 1E power supplies and non-Class 1E loads is discussed in Subsection ~B |8.3.1.1.1. |~B >8.3.1.1.2.1. <

(7) RG 1.81 - Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants;

The ABWR is designed as a single-unit plant. Therefore, this Regulatory Guide is not applicable.

(8) RG 1.106 - Thermal Overload Protection for Electric Motors on Motor-Operated Valves;

(9) RG 1.108 - Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants;

(10) RG 1.118 - Periodic Testing of Electric Power and Protection Systems;

~A >(11) RG 1.128 Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants;

(12) RG 1.129 - Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants;<

~81.000 |(11) RG 1.153 - Criteria for Power, Instrumentation, and Controll Portions of Safety Systems;

(12) RG 1.155 - Station Blackout

|8.1.3.1.2.3 Branch Technical Positions

(1) BTP ICSB 4 (PSB) - Requirements on Motor-Operated Valves in the ECCS Accumulator Lines;

This BTP is written for Pressurized Water Reactor (PWR) plants only and is therefore not applicable to the ABWR.

(2) BTP ICSB 8 (PSB) - Use of Diesel generator Sets for Peaking;
The diesel generator sets are not used for peaking in the ABWR design. Therefore, this criteria is satisfied.

~A >(3) BTP ICSB 11 (PSB) - Stability of Offsite Power Systems;

See Subsection 8.1.4.1 for interface requirement.<

(4) BTP ICSB 18 (PSB) - Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves;

(5) BTP ICSB 21 - Guidance for Application of Regulatory Guide 1.47;

(6) BTP PSB 1 - Adequacy of Station Electric Distribution System Voltages;
[See Subsection 8.3.1.1.7 (8)]

(7) BTP PSB 2 - Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status;

8.1.3.1.2.4 Other SRP Criteria

(1) NUREG/CR 0660 - Enhancement of Onsite Diesel Generator Reliability;

Operating procedures and the training of personnel are outside the scope of the ABWR Standard Plant. NUREG/CR 0660 is therefore imposed as an interface requirement for the applicant. See Subsection 8.1.4.2 for interface requirement.

(2) TMI Action Item II.E.3.1. - Emergency Power Supply for Pressurizer Heater;

This criteria is applicable only to PWRs and does not apply to the ABWR.

(3) TMI Action Item II.G.1-Emergency Power for Pressurizer Equipment;

This criteria is applicable only to PWRs and does not apply to the ABWR.

8.1.4 Interfaces

8.1.4.1 Stability of Offsite Power Systems

BTP ICSB 11 (PSB) pertaining to the stability of offsite power systems shall be addressed (See Subsection 8.1.3.1.2.3(3).

8.1.4.2 Diesel Generator Reliability

NUREG/CR 0660 pertaining to the enhancement of onsite diesel generator reliability through operating procedures and training of personnel will be addressed by the applicant (see Subsection 8.1.3.1.2.4(1)).

~B >#(These requirements are covered in Section 8.2 and confirmed by an ITAAC.)~A |8.1.4.3 Separated Power Feeds For 6.9 KV Switchgear

Instrumentation and controls associated with the preferred and alternate 6.9 KV buses feeding the non-Class 1E loads shall be powered by separate non-Class 1E DC sources, with power and instrument cables run in separate trays. |~B >~A |Separated non-Class 1E DC power sources are available from any two of the four DC-to-DC converters shown on Figure 8.3-7.|<<#

8.2 OFFSITE POWER SYSTEMS

8.2.1. Description

~B1.01 ~B1.02 |

8.2.1.1 Scope

This section provides a description of the system design and the performance requirements for the offsite power system. The offsite power system consists of the electrical circuits and associated equipment for interconnection to the offsite transmission system, the plant main generator, and the onsite power distribution systems. Included are the plant switchyards, the main step-up transformers, the unit auxiliary transformers, the reserve transformer, the high voltage tie lines from the switchyards to the transformers, the isolated phase buses with their auxiliary systems including relays and local instrumentation and controls, and the non-segregated phase bus ducts from the unit auxiliary and reserve transformers to the medium voltage switchgear.

The offsite power system begins at the terminals on the transmission system side of the circuit breakers which connect the switching stations to the offsite transmission system and ends at the terminals of the plant main generator and at the circuit breaker input terminals of the medium voltage (6.9Kv) switchgear.

Portions of the offsite power system fall under the design responsibility of the applicant or his agent and are not included in the design of the ABWR standard plant. It is the responsibility of all concerned parties to insure that the total completed design of equipment and systems falling within the scope of this SSAR section be in line with the description and requirements stated in this SSAR, however. See Section 8.2.3.1 for a detailed listing and description of the power interface requirements. |

~B1.02 |8.2.1.2

Description of Offsite Power System

The offsite electrical power system within the scope of the ABWR standard design consists of the isolated phase bus duct up to the low voltage terminals of the main power transformer, isolated phase bus duct to the unit auxiliary transformers, a low voltage generator breaker, three unit auxiliary transformers, a reserve auxiliary transformer, and 6.9Kv connections from the unit auxiliary and reserve transformers to the input terminals of the medium voltage (7.2Kv, 500MVA) switchgear, as indicated on the single line diagram, Figure 8.3-1. The main power transformer, the high voltage leads to the switchyards, the switchyards and the auxiliary equipment for these portions of the system are in the scope of the applicant. See Section 8.2.3.1 for the interface requirements for the equipment in the scope of the applicant.

Air cooled isolated phase bus duct rated 36Ka is provided for a power feed to the main power transformer.

A generator breaker is provided in the isolated phase bus duct at an intermediate location between the main generator and the main power transformer. The generator breaker provided is capable of interrupting a maximum fault current of 275KA symmetrical and 340KA asymmetrical at 5 cycles after initiation of the fault. This corresponds to the maximum allowable interface fault current specified in Section 8.2.3. The low voltage generator breaker allows the generator to be taken off line and the main grid to be utilized as a power source by backfeeding to the unit auxiliary transformers and their loads, both Class 1E and non-Class 1E. This is also the start-up power power source for the unit.

Unit sychronization will normally be through the low voltage generator breaker. A coincidental three-out-of-three logic scheme and synchrocheck relays are used to prevent faulty synchronizations. Dual trip coils are provided on the breaker and control power is supplied from redundant load groups of the non-safety-related onsite 125V DC power.

It is an interface requirement that synchronization be possible through the switching station's circuit breakers (See Section 8.2.3).

There are three unit auxiliary transformers. The transformers have three windings and each transformer feeds one Class 1E bus directly, two Non-Class 1E buses directly, and one Non-Class 1E bus indirectly through a Non 1E to Non 1E bus tie. The medium voltage buses are in a three load group arrangement with three non-safety-related buses and one safety-related bus per load group. Each unit auxiliary transformer has an oil/air rating at 65 degrees centigrade of 37.5Mva for the primary winding and 18.75Mva for each secondary winding. The forced air/forced oil rating is 62.5 and 31.25/31.25Mva respectively. The normal loading of the six transformers is balanced with the heaviest loaded winding carrying a load of 17.7Mva. The heaviest transformer loading occurs when one of the three unit auxiliary transformers is out of service with the plant operating at full power. Under these conditions the heaviest loaded winding experiences a load of 21.6Kva, which is about two thirds of its forced air/forced oil rating. ˆB1.09Z ˆSee Table 8.2-item1 for a more detailed summary of the loads.ˆ

Disconnect links are provided in the isolated phase bus duct feeding the unit auxiliary transformers so that any single failed transformer may be taken out of service and operation continued on the other two unit auxiliary transformers. One of the buses normally fed by the failed transformer would have to be picked up on the reserve auxiliary transformer in order to keep all reactor internal pumps operating so as to attain full power. The reserve auxiliary transformer is sized for this type of service.

One, three-winding 37.5MVA unit reserve transformer is supplied to provide power as an alternate to the "Normal Preferred" power. One of the equally rated secondary windings supplies reserve power to the nine (three through cross-ties) non-safety-related buses and the other winding supplies reserve power to the three safety-related buses. The combined load of the three safety-related buses is equal to the oil/air rating of transformer winding serving them. This is equal to 60% of the forced air/forced oil rating of the transformer winding. The transformer is truly a reserve transformer because unit startup is accomplished from the normal preferred power, which is backfed over the main power circuit to the unit auxiliary transformers. The reserve auxiliary transformer serves no startup function.|

ˆB1.04a ˆB1.04b ˆB1.04c ˆB1.05 ˆB1.06 |8.2.1.3 Separation

The location of the main transformer, unit auxiliary transformers, and reserve auxiliary transformer are shown on Figure 8.2-1. The reserve auxiliary transformer is separated from the unit auxiliary transformers by a minimum distance of 50 feet. It is a requirement that the 50 foot minimum separation be maintained by the incoming tie lines, also. The transformers are provided with oil collection pits and drains to a safe disposal area.

Reference is made to Figures 8.3-1 for the single line diagrams showing the method of feeding the loads. Separation of the normal preferred and alternate preferred power feeds is accomplished by floors and walls over their routes through the turbine, control and reactor buildings except within the switchgear rooms where they must be routed to the same switchgear lineups. The normal preferred feeds are routed around the outside of the turbine building in an electrical tunnel from the unit auxiliary transformers to the turbine building switchgear rooms as shown on Figure 8.2-1. (An underground duct bank is an acceptable alternate.) From there the feeds to the reactor building exit the turbine building and continue across the roof on the divisions 1 and 3 side of the control building (Figure 8.3-1). They drop down the side of the control building in the space between the control and reactor buildings where they enter the reactor building and continue on through the divisions 1 and 3 side of the reactor building to the respective safety-related switchgear rooms in the reactor building.

The alternate preferred feeds from the reserve auxiliary transformer are routed inside the turbine building. The turbine building switchgear feed from the reserve auxiliary transformer is routed directly to the turbine building switchgear rooms. The feed to the control building is routed in corridors outside of the turbine building switchgear rooms. It exits the turbine building and crosses the control building roof on the opposite side of the control building from the route for the normal preferred power feeds. The steam tunnel is located between the normal preferred feeds and the alternate preferred feeds across the stepped roof of the control building. The alternate preferred power feed turns down between the control and reactor building and enters the reactor building on the division 2 side of the reactor building. From there it continues on to the respective switchgear rooms in the reactor building.

|

~B1.06 | Instrument and control cables for the unit auxiliary transformer are to be routed in solid metal raceways and separate from the normal preferred power cable raceways by a separation that is equivalent to that provided for the power feeds. The reserve auxiliary cables may not share raceways with any other cables, however. The instrumentation and controls for the unit auxiliary transformers and generator breaker may be routed in the raceways corresponding to the load group of their power source.|

~B1.04c | A combustion turbine supplies standby power to the non-safety-related turbine building buses which supply the permanent non-safety-related loads. It is a 9MW rated self-contained unit which is capable of operation without external auxiliury systems. Although it is located on site, it is treated as an additional offsite source in that it supplies power to multiple load groups of electrical buses.

Manually controlled breakers provide the capability of connecting the combustion turbine generator to any one of the emergency buses if all other power sources are lost.

The location of the combustion turbine generator (CTG) is shown on Figure 8.2-1. The CTG standby power feed for the turbine building is routed directly to the switchgear rooms in the turbine building. The branch to the reactor building is routed adjacent to the alternate preferred f[illegible]s the control and reactor buildings.

~B1.01 ># As indicated in Section 8.1, the utility grid and the main power transformer are not within the ABWR Standard Plant scope. The interface requirements at the main power transformer are given in Subsection 8.2.3. All other equipment downstream of the main power transformer is included in the ABWR Standard Plant scope. This includes the auxiliary transformers, switchyard components, the main generator, etc., which are assigned by SRP Section 8.2 as being part of the "preferred power system", also called the "offsite power system." Since GE considers these components to be "onsite", their description is provided in Subsection 8.1.2.1.

<#

(3) GDC 18 - Inspection and Testing of Electrical Power Systems;

8.2.2 Analysis

In accordance with the NRC Standard Review Plan (NUREG 0800), Table 8-1 and Section 8.2, the power distribution system between the main transformer and the Class 1E distribution system interfaces is designed consistent with the following criteria, so far as it applies to the non-Class 1E equipment. Any exceptions or clarifications are so noted.

8.2.2.1 General Design Criteria

(1) GDC 5 and RG 1.81 - Sharing of Structures, Systems and Components;

The ~C |ABWR |~C >ALWR <is a single unit plant design. Therefore, these criteria are not applicable.

(2) GDC 17 - Electric Power Systems;

As shown in Figure 8.3-1, each of the Class 1E divisional 6.9 KV M/C buses can receive power from multiple sources. There are separate utility feeds from the station grid (via the main transformer), and the offsite line (via the reserve auxiliary transformer). The ~B1.000 >two emergency <unit auxiliary transformer output power feeds ~B1.00 |and the reserve auxiliary transformer output power feeds |are routed by two completely separate paths through the turbine building, control building and reactor building to their destinations in the emergency electric rooms. ~B1.000 >Separation is provided by routing each train on a dif- ferent floor in each building. <Although these ~C |load groups| ~C >trains< are non-Class 1E, such separation assures the physical independence requirements of GDC 17 are preserved.

~B1.000 |

The transformers are provided with oil collection pits and drains to a safe disposal area. This separation meets the requirements of BTP CMEB 9.5-1 and is therefore deemed adequate.|

˜B1.08 ˜B31.07 j The low voltage generator breaker must open on a turbine trip to maintain the normal preferred power supply to the safety buses. This breaker cannot be tested during normal operation of the plant. Generator breakers are extremely reliable. There are published test results showing a reliability number of 0.9967 for 50 close operations per year. This compares favorably with the probability of failure from other causes of the normal preferred power supply.

All other equipment can either be tested during normal plant operation or it is continually tested by virtue of its operation during normal plant operation and it remaining in the same state to supply normal preferred power to the safety buses following a turbine trip.
|
~B1.08 >

All equipment can be inspected and tested in accordance with this GDC.

<(4) RG's 1.32, 1.47, and BTP ICSB 21;

These distribution ~C |load groups|~C >trains< are non-Class 1E and non-safety related. Therefore, this criteria is not applicable.

(5)~B1.000 |
RG 1.153--Criteria For Power, Instrumentation and Control Portions of Safety Systems

(6) RG 1.155--Station Blackout

(7)|~B1.000 >(5)<
BTP ICSB 11 (PSB) - Stability of Offsite Power Systems;

See Subsection ~B1.000 |8.2.3 |~B1.000>8.1.4.1 <for interface requirement.

B |(9) Appendix A to SRP Section 8.2

It is a requirement that the design, testing and installation of the low voltage generator breaker meet the specific guidelines of this appendix, therefore compliance with the appendix is assured.|

8.2.3 Interfaces

8.2.3.1 ~B1.03 >Power Interfaces

<

~B1.03 |
Offsite Power System Design Requirements

The standard design of the ABWR is based on certain assumptions concerning the design requirements which will be met by the applicant in designing the portion of the offsite power system in his scope, as defined in Section 8.2.1.1. Those assumptions are listed here as design interface requirements which the applicant should meet.

(1) In case of failure of the normal preferred power supply circuit, alternate preferred power should normally remain available to the reserve auxiliary transformer.

(2) Voltage variations shall be no more than plus or minus 10 percent of their nominal value during normal steady state operation. Their should be a voltage dip of no more than 20 percent during motor starting. It is expected that the sizing of the unit auxiliary and reserve auxiliary transformers, (See Section 8.2.1.2) will insure that this voltage dip requirement is met.

(3) Maintain the normal steady state frequency of the power system within plus or minus 2 cycles per second of 60 cycles per second during periods of system instability.

(4) Analyze the site specific configuration of the incoming power lines to assure that the expected availability of the offsite power is as good as the assumptions made in performing the plant probability risk analysis. If, during this analysis, it is determined that the availability of the power from the alternate preferred power source is significantly less reliable than the normal preferred power, normal operation of all plant buses from the normal preferred power source is acceptable and recommended.

(5) The main and reserve offsite power circuits shall be electrically independent and physically separated. They shall be connected to switching stations which are independent and separate. They shall be connected to different transmission systems.

(6) The switching station to which the main offsite power circuit is connected shall have at least two full capacity main buses arranged such that:

(a) Any incoming or outgoing transmission line can be switched without affecting another line;

(b) Any single circuit breaker can be

isolated for maintenance without interrupting service to any circuit;

(c) Faults of a single main bus are isolated without interrupting service to any circuit.

(7) The main power transformer shall be three normally energized single-phase transformers with an additional installed spare. Provisions shall be made to permit connecting and energizing the spare transformer in no more than 12 hours following a failure of one of the normally energized transformers.

(8) The main transformer shall be designed to meet the requirements of ANSI Standard C57.12.00, General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.

(9) Physical separation between transformers and oil collection shall be provided as stated for fire protection in Section 9A.4.6.

(10) Circuit breakers and disconnect switches shall be sized and designed in accordance with the latest revision of ANSI Standard C37.06, Preferred Ratings and Rel[illegible]ed Capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basi[illegible]

(11) Although unit synchronization is normally through the low voltage generator circuit breaker, provisions shall be made to synchronize the unit through the switching station's circuit breakers.

(12) All relay schemes used for protection of the offsite power circuits and of the switching station's equipment shall be redundant and include backup protection features. All breakers shall be equipped with dual trip coils. Each redundant protection circuit which supplies a trip signal shall be connected to a separate trip coil. All equipment and cabling associated with each redundant system shall be physically separated.

(13) The dc power needed to operate redundant protection and control equipment of the offsite power system shall be supplied from two separate, dedicated switchyard batteries, each with a battery charger fed from a separate ac bus. Each battery shall be capable of supplying the dc power required for normal operation of the switching station's equipment.

(14) Two redundant low voltage ac power supply systems shall be provided to supply ac power to [illegible] switching station's auxiliary loads. Each system shall be supplied from separate independent ac buses. The capacity of each system shall be adequate to meet the ac power requirements for normal operation of the switching station's equipment.

(15) Each transformer shall have primary and backup protective devices. Dc power to the primary and backup devices shall be supplied from separate dc sources.|

~B |8.2.3.2 Scope Split Interfaces
|

The interface point between the ABWR design and the utility design for the main generator output is at the connection of the isolated phase bus to the main power tra.sformer low voltage terminals. The rated conditions for this interface is 1500 MVA ~B1.000 |at a power factor of 0.9 and a voltage of |~B1.[illegible]0 ≥and ≤26.325 KV~B1.09 | plus or minus 10 per cent|. It is a requirement that the utility provide sufficient impedance in the main power transformer and the high voltage circuit to limit the primary side maximum available fault current contribution from the system to no more than 275 KA symmetrical and 340 KA asymmetrical at 5 cycles from inception of the fault. These values should be acceptable to most utilities. When all equipment and system parameters are known, a refined calculation based on the known values with a fault located at the generator side of the generator breaker may be made. This may allow a lower impedance for the main power transformer, if desired.

The second power interface occurs at the high voltage terminals of the reserve auxiliary transformer. The rated load is ~B1.000 |≥/.5 |~B1.000 ≥30 <MVA at a 0.9 power factor. The voltage and frequency will be the utilities standard with the actual values to be determined at contract award. ~B1.09 | Tolerances are plus or minus 10 per cent of nominal for voltage and plus or minus 2 per cent of nominal for frequency. Frequency may vary plus or minus 2 cycles per second during periods of system instability. The maximum allowable voltage dip during the starting of large motors is 20 %.

Protective relaying interfaces for the two power system interfaces are to be defined during the detail design phase following contract award.

(To be supplied on a later transmittal).

Figure 8.2-1
Power Distribution
System Routing
Diagram.

8.3 ONSITE POWER SYSTEMS

8.3.1 AC Power Systems

-B >8.3.1.1 Description
<

-B1.000 |The onsite power system interfaces with the offsite power system at the input terminals to the supply breakers for the normal and alternate power feeds to the medium voltage (7.2KV) switchgear. It is a three load group system with each load group consisting of a non-safety-related and a safety-related portion.|-B1.000 > The auxiliary electric power system includes three independent Class 1E AC electric power sys- tems for nuclear safety-related loads.<-B1.000 |The three load groups of the Class 1E power system are independent of each other.| The prin- cipal elements of the auxiliary AC electric power systems are shown on the single line diagrams (SLD) in Figure 8.3-1, -C |4, 5 and 7.| -C >2, 3, 4 and 5.<

Each Class 1E division has a dedicated diesel generator, which automatically starts -C |on high drywell pressure, low reactor vessel level |-C >in case of a level trip and/<or loss of voltage on the divi- sion's 6.9 kV bus. Each 6.9-kV Class 1E bus feeds it's associated 480V unit substation through a 6.9-kV/ 480/277V power center trans- former.

-B1.000 |
Standby power is provided to permanent non-safety-related loads in all three load groups by a combustion gas turbine located in the turbine building.

AC power is supplied |-C >and utilized <-B1.000 |at 6.9KV for motor loads larger than 300KW and transform- ed to 480 V for smaller loads. The 480V system is further transformed into lower voltages as re- quired for instruments, lighting, and controls. In general, motors larger than 300KW are supplied from the 6.9KV buses. Motors 300KW or smaller but larger than 100KW are supplied power form 480V switchgear. Motors 100KW or smaller are supplied power from 480V motor control centers.
|

See Subsection 8.3.4.9 for interface reqiurements.

-B1.000 |8.3.1.0
Non-Safety-Related AC Power System

8.3.1.0.1
Non-Safety-Related Medium Voltage Power

Distribution System

The non-safety-related medium voltage power distribution system consists of nine 6.9KV buses divided into three load groups. The three load group configuration was chosen to match the mechanical systems which are mostly three trains (Three feedwater pumps, three circulating water pumps, three turbine building supply and exhaust fans).

Within each load group there is one bus which supplies power production loads which do not provide water to the pressure vessel. Each one of these buses has access to power from one winding of its assigned unit auxiliary transformer. It also has access to the reserve auxiliary transformer as an alternate source if its unit auxiliary transformer fails or during maintenance outages for the normal feed. Bus transfer is manual dead bus transfer and not automatic.

Another bus within each load group supplies power to pumps which are capable of supplying water to the pressure vessel during normal power operation (i.e., the condensate and feedwater pumps). These buses normally receive power from the unit auxiliary transformer and supply power to the third bus (plant investment protection (PIP)) in the load group through a cross-tie. The cross-tie automatically opens on loss of power but may be manually reclosed if it is desired to operate a condensate or feedwater pump from the combustion turbine or the reserve auxiliary transformer which are connectable to the PIP buses. This cross tie arrangement allows advantage to be taken of the fact that the feedwater pumps are motor driven through an adjustable speed drive so that they have low starting currents and can be started and run at low power. The combustion turbine and reserve auxiliary transformer have sufficient capacity to start either or both the reactor feedwater and condensate pumps in a load group. This provides three load groups of non-safety grade equipment in addition to the divisional 1E load groups which may be used to supply water to the reactor vessel in emergencies.

A third bus supplies power to permanent non-safety loads such as the turbine building HVAC, the turbine building service water and the turbine building closed cooling water systems. On loss of normal preferred power the cross-tie to the power production bus is automatically tripped open and the permanent non-safety related bus is automatically transferred (two out of the three buses in the load groups transfer) via a dead bus transfer to the combustion turbine which automatically starts on loss of power. The permanent service systems for each load group automatically restart to support their load groups.

The buses are comprised of 7.2KV 500MVA metal clad switchgear with a bus full load rating of 2000A. Maximum calculated full load short time current is 1700A. Bus ratings of 3000 amperes are available for the switchgear as insurance against future load growth, if necessary. The required interrupting capacity is 41,000 amperes.

The 6.9kV buses supply power to adjustable speed drives for the feedwater and reactor internal pumps. These adjustable speed drives are designed to the requirements of IEEE Std 519, Guide for Harmonic Control and Reactive Compensation of Static Power Converters. Voltage distortion limits are as stated in Table 4 of the IEEE Std.

8.3.1.0.2
Non-Safety-Related Low Voltage Power Distribution System

Power for the 480V auxiliaries is supplied from power centers consisting of 6.9KV/480 volt transformers and associated metalclad switchgear, Figure 8.3-1. There are six non-safety-related, two per load group, power centers. One power center per load group is supplied power from the permanent non-safety bus for the load group.|

-81.000 |8.3.1.0.3 Non-Class 1E Vital AC Power Supply System

The function of the Non-Class 1E Vital AC Power Supply System is to provide reliable 120V uninterruptible AC power for important non-safety related loads that are required for continuity of power plant operation. The system consists of three 120V AC uninterruptible constant voltage, constant frequency (CVCF) power supplies, each including a static inverter, AC and DC static transfer switches, a regulating stepdown transformer (as an alternate AC power supply), and a distribution panel (Figure 8.3-5). The primary source of power comes from the non-Class 1E AC motor control centers. The secondary source is the non-Class 1E 125 VDC central distribution panels.

There are three automatic switching modes for the CVCF power supplies, any of which may be initiated manually. First, the frequency of the output of the inverter is normally synchronized with the input AC power. If the frequnecy of the input power goes out of range, the power supply switches over to internal synchronization to restore the frequency of its output. Switching back to external synchronization is automatic and occurs if the frequency of thew AC power has been restored and maintained for approximately 60 seconds.

The second switching mode is from AC to DC for the power source. If the voltage of the input AC power is less than 88% of the rated voltage, the input is switched to the DC power supply. The input is switched back to the AC power after a confirmation period of approximately 60 seconds.

The third switching mode is between the inverter and the voltage regulating transformer. If any of the conditions listed below occur, the power supply is switched to the voltage regulating transformer.

(a) Output voltage out of rating by more than plus or minus 10 per cent
(b) Output frequency out of rating by more than plus or minus 3 per cent
(c) High temperature inside of panel
(d) Loss of control power supply
(e) Commutation failure
(f) Overcurrent of smoothing condenser
(g) Loss of control power for gate circuit
(h) Incoming MCCB trip
(i) Cooling fan trip

Following correction of any of the above events transfer back is by manual initiation only.

|-81.000 |8.3.1.0.4 Computer Vital AC Power Supply System (Non-Safety Related)

Two constant voltage and constant frequency power supplies are provided to power the process computers. Each of the power supplies consists of an AC to DC rectifier, and a DC to AC inverter, a bypass transformer and DC and AC solid state transfer switches (Figure 8.3-5). The normal feed for the power supplies is from non-Class 1E power center supplied from the permanent non-safety-related buses which receive power from the combustion turbine if offsite power is lost. The backup for the normal feeds is from the 250VDC battery. Each power supply is provided with a backup AC feed though isolation transformers and a static transfer switch. The backup feed is provided for alternate use during maintenance periods. Switching of the power supply is similar to that described for the Non-vital AC power supply system, above. See Section 8.3.1.0.3.

|

~B1.000 |8.3.1.1 c

Safety-Related AC Power Distribution System

8.3.1.1.1 Medium Voltage Safety-Related Power Distribution System

|

~B1.000 > AC power is supplied and utilized at 6.9 kV for motor loads larger than 300 KW and transform- ed to 480 V for smaller loads. The 480V system is further transformed into lower voltages as re- quired for instruments, lighting, and controls. The 6.9-kV system includes normal and alternate preferred power supply feeders.

≤ Class 1E AC power loads are divided into three divisions (Divisions I, II, and III), each fed from an independent 6.9-kV Class 1E bus. During normal operation ~A >,<~21.11 ~A1.08 ~A1.11 |(which includes all modes of plant operation; i.e., shutdown, refueling, startup, and run.), two of the three divisions |~A1.08 ~A1.11 >Division I, Division II and Di- vision III loads<are fed from an offsite normal preferred power supply. ~A1.08 ~A1.11 |The remaining division shall be fed from the alternate power source (See Subsection 8.3.4.9).|

~A12.01 |Each 6.9 kV bus has a safety grounding circuit breaker designed to protect personnel during maintenance operations (see Figure 8.3-1). During periods when the buses are energized, these breakers are racked out (i.e., in the disconnect position). A control room annunciator sounds whenever any of these breakers are racked in for service.

The interlocks for the bus grounding devices are as follows:

(1) Undervoltage relays must be actuated.

(2) Bus Feeder breakers must be in the disconnect position.

(3) Voltage for bus instrumentation available.

Conversely, the bus feeder breakers are inetrlocked such that they cannot close unless their associated grounding breakers are in their disconnect positions.|

~B12.01 | Standby AC power for Class 1E buses is sup- plied by diesel generators at 6.9 kV and distri- buted by the Class 1E power distribution system. Division I, II and III buses are automatically transferred to the diesel generators when the normal preferred power supply to these buses is lost.

|

~B8.03c |The division I safety-related bus has one non-safety-related load on it. The load is a power center which supplies power to the fine motion control rod drive (FMCRD) motors. Although these motors are not safety-related, the drives may be inserted as a backup to scram and are of special importance because of this. It is important that the first available standby power be available for the motors, therefore, a diesel supplied bus was chosen as the first source of standby ac power and the combustion turbine as the second backup source. Division I was chosen because it was the most lightly loaded diesel generator.

The load breaker in the division I switchgear is part of the isolation scheme between the safety-related power and the non-safety-related load. In addition to the normal overcurrent tripping of this isolation breaker, zone selective interlocking is provided between it and its upstream Class 1E bus feed breaker.

If fault current flows in the non-Class 1E load, it is sensed by the Class 1E current device for the isolation breaker and a trip blocking signal is sent to the upstream Class 1E feed breaker. This blocking lasts for about 75 milliseconds. This allows the isolation breaker to trip in its normal instantaneous tripping time of 35 to 50 milliseconds, if the magnitude of the fault current is high enough. This assures that the fault current has been terminated before the Class 1E upstream breaker is free to trip. For fault currents of lesser magnitude, the blocking delay will time out without either breaker tripping, but the isolation breaker will

. ntually trip and always before the upstream breaker. This order of tripping is essured by the coordination between the two breakers provided by long-time pickup, long-time delay and instantaneous pickup trip device characteristics. Tripping of the Class 1E feed breaker is normal for faults which occur on the Class 1E bus it feeds. Coordination is provided between the bus main feed breakers and the load breakers.

The zone selective interloc' is a feature of the trip unit for the breaker and is tested when the other features such as cu rent setting and long-time delay are tested.

A pair of interlocked breakers re provided at the input to the power center transformer to supply power to the transformer from either the safety-related diesel generator backed bus or the non-safety-related combustion turbine backed bus. Switchover is automatic on loss of power from the safety-related source. Switching back to the safety-related power is by manual action only. The breaker in the safety-related leg of the power supply is division I associated. The breaker in the non-safety-related leg is non-safety-related on the basis of the electrical isolation of its controls, the fact that there are two breakers between it and the Class 1E 6.9KV bus and that the transfer breakers are interlocked so that only one can be in the closed condition.

The circuits on the output side of the power center transformer are non-safety-related on the basis of the isolation provided by the two upstream breakers and the power center transformer. It is also a requirement that they cannot be classified anything other than non-safety-related so that they can never be routed as associated with cables of any safety-related division.|

8.3.1.1.2 Low Voltage ~B |Safety-Related | Power Distribution System

8.3.1.1.2.1 Power Centers

Power for 480V auxiliaries is supplied from ~C |power |~C >load <centers consisting of 6.9-kV/480V transfor- mers and associated metal clad switchgear, Fig- ure 8.3-~C |1|~C >3<.

~B16.01 ># There are three 480 VAC non-Class 1E power centers which are respectively and individually fed from Division I, II and III 6.9KV Class 1E buses. Isolation breakers are provided between the Class 1E and non-Class 1E buses. In addition to normal overcurrent tripping of the isolation breaker, zone selective interlocking is provided between each isolation breaker and its upstream Class 1E feed breaker. If fault current flows in the non Class 1E bus, it is sensed by the Class 1E current device for the isolation breaker and a trip blocking signal is sent to the upstream Class 1E feed breaker. This blocking lasts for about 75 milliseconds. This allows the isolation breaker to trip in its normal instantaneous tripping time of 35 to 50 milliseconds, if the magnitude of the fault current is high enough. This assures that the fault current has been terminated before the Class 1E upstream breaker is free to trip. For fault currents of lesser magnitude, the blocking delay will time out without either breaker tripping, but the isolation breaker will eventually trip and always before the upstream breaker. This order of tripping is assured by the coordination between the two breakers provided by long-time pickup, long-time delay and instantaneous pickup trip device characteristics. This coordination is carried through to the non-Class 1E load breakers so that for a load fault the load breaker would normally trip without the bus isolation breaker tripping.

Tripping of the Class 1E feed breaker is normal for faults which occur on the Class 1E bus

1

New Section

8.3.5 References

In addition to those codes and standards required by the SRP the following codes an standards will be used and have been referenced in the text of this chapter of the SSAR.

IEEE Std 323	Qualifying Class 1E Equipment for Nuclear Power Generating Stations
IEEE Std 334	Standard for Type Test of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations
IEEE Std 379	Standard Application of the Single-Failure Criterion to Nuclear Power Generating Stations
IEEE Std 382	Standard for Qualification of Safety-Related Valve Actuators
IEEE Std 383	Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Station
IEEE Std 387	Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations
IEEE Std 450	Recommended Practice for Large Lead Storage Batteries for Generating Stations and Substations
IEEE Std 485	Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations
IPCEA S-66-402	Thermoplastic Insulated Wire & Cable for the Transmission and Distribution of Electrical Energy
IPCEA -54-440/ NEMA WC-51	Ampacities Cables in Open-top Cable Trays
IPCEA S-66-524/ NEMA WC-7	Cross-Linked-Thermosetting-Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

A partial listing of other common industry standards which may be used as applicable is given below. There are many more standards referenced in the standards which are listed here.

Motor Control Centers

NEMA ICS-2	Standards for Industrial Control Devices, Controllers and Assemblies

Underwriter's Laboratories Standard No. 845

Low Voltage Circuit Breakers

ANSI C37.13	Low Voltage Power Circuit Breakers
ANSI C37.16	Preferred Ratings and Related Requirements for Low Voltage AC Power Circuit Breakers and AC Power Service Protectors
ANSI C37..17	Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers
ANSI C37.50	Test Procedures for Low Voltage AC Power Circuit Breakers Used in Enclosures

Molded Case Circuit Breakers

UL 489 Branch Circuit and Service Circuit Breakers

NEMA AB-1 Molded Case Circuit Breakers

7.2Kv Metalclad Switchgear

ANSI C37.01	Application Guide for Power Circuit Breakers
ANSI C37.04	AC Power Circuit Breaker Rating Structure
ANSI C37.06	Preferred Ratings of Power Circuit Breakers
ANSI C37.09	Test Procedure for Power Circuit Breakers
ANSI C37.11	Power Circuit Breaker Control Requirements
ANSI C37.20	Switchgear Assemblies and Metal-Enclosed Bus
ANSI C37.100	Definitions for Power Switchger

Transformers

ANSI C57.12 General Requirements for Distribution, Power, and Regulating Transformers

ANSI C57.12.11 Guide for Installation of Oil-immersed Transformers (10MVA and larger, 69-287 kV rating)

ANSI C57.12.80 Terminology for Power and Distribution Transformers

ANSI C57.12.90 Test Code for Distribution, Power, and Regulating Transformers

~A16.01 >or its Class 1E loads.<~A16.01 ~A19.000|it feeds. C^ordination is providec between the bus mai.) feed breakers and the load breakers.<#

Class 1E 480V ~C |power |~C >load <centers supplying Class 1E loads are arranged as independent radial sys- tems, with each 480V bus fe by its own power transformer. Each 480V Class 1E bus in a divi- sion is physical'y and electrically independent of the other 480V buses in other divisions.

The 480V unit substation breakers supply mo- tor control centers and ~A >460V<motor loads up to

and including 300KW. Switchgear for the 480V load centers is of indoor, metal-enclosed type with drawout circuit breakers. Control power is from the Class 1E 125 VDC power system of the same division.

8.3.1.1.2.2 Motor Control Centers

The 480 MCCs feed motors 90KW and smaller, control power transformers, process heaters, motor-operated valves and other small electrically operated auxiliaries, including 480-120V and 480-240V transformers. Class 1E motor control centers are isolated in separate load groups corresponding to divisions established by the 480V unit substations.

Starters for the control of 460V motors smaller than 90KW are MCC-mounted, across-the- line magnetically operated, air break type. Circuits leading from the electrical penetration assemblies into the containment area have a fuse in series with the circuit breakers as a backup protection for a fault current in the penetration in the event of circuit breaker overcurrent or fault protection failure.

8.3.1.1.3 120/240V Distribution System

Individual transformers and distribution panels are located in the vicinity of the loads requiring 120/240V power. This power is used for lighting, 120V receptacles and other 120V loads.

8.3.1.1.4 Instrument Power Supply Systems

8.3.1.1.4.1 120V AC Safety-Related Instrument Power System

Individual transformers supply 120V AC instrument power Figure 8.3-4. Each Class 1E divisional transformer is supplied from a 480V MCC in the same division. There are three divisions, each backed up by its divisional diesel generator as the source when the offsite source is lost. Power is distributed to the individual loads from distribution panels, and to logic level circuits through the control room logic panels.

8.3.1.1.4.2 120V AC Safety Related ~C |Vital AC Power Supply System |~C >Uninterruptible Power Supplies (UPS)<

8.3.1.1 4.2.1 Constant Voltage, Constant Frequency (CVCF) Power Supply for the Safety System Logic and Control (SSLC)~C > for the Reactor Protection System (RPS)<

The power supply for the ~C >RPS <SSLC is shown in Figure 8.3-~C |5|~C >6>, with each of the four buses supplying power for the independent trip systems of the SSLC system. Four constant voltage, constant frequency (CVCF) control power buses (Divisions I, II, III, and IV) have been established. They are each normally supplied independently from inverters which, in turn, are ~C |normally supplied power via a static switch from a rectifier which receives 480V divisional power. A 125V DC battery provides an alternate source of power through the static switch. |~C >#supplied from four independent and redundant ~A26.000 >AC and<DC supplies ~A >.<~A26.000

|,and three independent and redundant AC supplies.|<#

For Divisions I, II, and III, the AC supply is from a 480 V MCC for each division. The backup DC supply is via ~C |a static switch and |a DC/AC inverter from the 125VDC central/distribution board for the division. A ~C |second |static switch also is capable of transferring from the inverter to a direct feed through a voltage regulating transformer from a 480V motor control center for each of the three divisions.

Since there is no 480V AC Division IV power, Division IV is fed from a Division I motor control center. Otherwise, the AC supply for the Division IV CVCF power supply is similar to the other three divisions. The DC supply for Division IV is backed up by a separate Division IV battery.

The CVCF power supply buses are designed to provide logic and control power to the four-division SSLC system that operates the RPS. [The SSLC for the ECCS derives its power from the 125 VDC power system (Figure 8.3-7)]. The AC buses also supply power to neutron monitoring system and parts of the process radiation monitoring system and MSIV function in the leak detection system. Power distribution is arranged to prevent inadvertent operation of the reactor scram initiation or MSIV isolation upon loss of any single power supply.

Routine maintenance can be conducted on equipment associated with the CVCF power supply. Inverters and solid state switches can be inspected, serviced and tested channel by channel without tripping the RPS logic.

~B1.000 >|(Moved to 8.3.1.1.4.2.4)|8.3.1.1.4.2.2 Class 1E RPS and MSIV Soleniods Power Supply

Three of the CVCF power supply buses are designed to provide power to the RPS scram and MSIV solenoid valves. The bus for the RPS A solenoids is supplied by the Division II CVCF power supply. The RPS B solenoids bus is supplied from the Division III CVCF power supply. The #3 soleniods for the MSIVs are powered from the Division I CVCF; and the #2 soleniods, from the Division II CVCF power supply.<

~B1.000 >#8.3.1.1.4.2.3 ~B1.000 |(Moved to 8.3.1.0.3)|~B1.000 Process Computer Constant Voltage, Constant Frequency (CVCF) Power Supply

Two constant voltage and constant frequency power supplies are provided to power the process computers. Each of the power supplies consists of an AC to DC rectifier, and a DC to AC inverter, a bypass transformer and DC and AC solid state transfer switches (Figure 8.3-5). The normal feed for the power supplies is from a non-Class 1E power center supplied from the Division I diesel generator for one power supply and from a non-Class 1E power center supplied from the Division II diesel generator for the other power supply. The backup for the normal feeds is from the 250VDC battery. Each power supply is provided with a backup AC feed though isolation transformers and a static transfer switch. The backup feed is provided for alternate use during maintenance periods.
<#

8.3.1.1.4.2.4 ~B1.000 |(Moved to 8.3.1.0.4)|~B1.000 >Non-Class 1E Vital AC Power System<

~B1.000 ># The function of the Non-Class 1E Vital AC Power Supply System is to provide reliable 120V<#

-81.000 >#uninterruptible AC power for important non-safety related loads that are required for continuity of power plant operation. The system consists of two 120V AC uninterruptible CVCF power supplies, each including a static inverter, AC and DC static transfer switches, a regulating stepdown transformer (as an alternate AC power supply), and a distribution panel (Figure 8.3-6). The primary source of power comes from the non-Class 1E AC power centers. The secondary source is the non-Class 1E 125 VDC central distribution panels.

If the inverter fails, the AC static switch transfers to the regulating transformer without interruption (not more than 4 msec). If the AC source or rectifier fails, the DC thyrister switch transfers to the DC source without interuption.<#

8.3.1.1.4.2.-B |2| -B >5< Components

Each of the four Class 1E CVCF power supplies includes the following components:

(1) a power distribution cabinet, including the CVCF 120 VAC bus and circuit breakers for the SSLC loads;

(2) a solid-state inverter, to convert 125 VDC power to 120 VAC uninterruptible power supply;

(3) a solid-state transfer switch to sense inverter failure and automatically switch to alternate 120 VAC power;

(4) a 480V/120V bypass transformer for the alternate power supply;

(5) a solid-state transfer switch to sense -C >rectifier or <AC -C |input |power failure and automatically switch to alternate 125 VDC power.

(6) a manual transfer switch for maintenance.

8.3.1.1.4.2.6 (Deleted)

8.3.1.1.4.2.-B |3|-B >7< Operating Configuration

The four 120 VAC essential power supplies operate independently, providing four divisions of CVCF power supplies for the SSLC. The normal lineup for each division is through an essential 480 VAC power supply, the AC/DC rectifier, the inverter and the static transfer switch. -C >Transfer from the inverter, directly to the essential AC source is done automatically in case of inverter failure, or to the DC source in case of rectifier or AC power failure. Annunciation in the control room is provided for any of the alternate operating modes. Three of the four divisions supply independent power to the RPS scram solenoids and the MSIV solenoids for isolation. <

-C | There are three automatic switching modes for the CVCF power supplies, any of which may be initiated manually. First, the frequency of the output of the inverter is normally synchronized with the input AC power. If the fregunecy of the input power goes out of range, the power supply switches over to internal synchronization to restore the frequency of its output. Switching back to external synchronization is automatic and occurs if the frequency of thew AC power has been restored and maintained for approximately 60 seconds.

The second switching mode is from AC to DC for the power source. If the voltage of the input AC power is less than 88% of the rated voltage, the input is switched to the DC power supply. The input is switched back to the AC power after a confirmation period of approximately 60 seconds.

The third switching mode is between the inverter and the voltage regulating transformer. If any of the conditions listed below occur, the power supply is switched to the voltage regulating transformer.

- (a) Output voltage out of rating by more than plus or minus 10 per cent
- (b) Output frequency out of rating by more than plus or minus 3 per cent
- (c) High temperature inside of panel
- (d) Loss of control power supply
- (e) Commutation failure
- (f) Overcurrent of smoothing condenser
- (g) Loss of control power for gate circuit
- (h) Incoming MCCB trip
- (i) Cooling fan trip

Following correction of any of the above events transfer back is by manual initiation only.

|-C |8.3.1.1.4.2.4 Class 1E RPS and MSIV

Soleniods Power Supply

Three of the CVCF power supply buses provide power to the RPS scram and MSIV solenoid valves as a part of their load.|-C > Three of the CVCF power supply buses are designed to provide power to the RPS scram and MSIV solenoid valves.<-C | The bus for the RPS A solenoids is supplied by the Division II CVCF power supply. The RPS B solenoids bus is supplied from the Division III CVCF power supply. The #3 soleniods for the MSIVs are powered from the Division I CVCF; and the #2 leniods, from the Division II CVCF power supply.|

8.3.1.1.5 Class 1E Electric Equipment Considerations

The following guidelines are utilized for Class 1E equipment.

8.3.1.1.5.1 Physical Separation and Independence

~B4.000 ~B6.000 ~B10.01b | All electrical equipment is separated in accordance with IEEE Std 384, Regulatory Guide 1.75 and General Design Criterion 17, with the following clarifying interpretations of IEEE Std 384:

(1) Enclosed solid metal raceways are required for separation between safety-related or associated cables of different safety divisions or between safety-related or associated cables and non safety-related cables if the vertical separation distance is less than five feet, the horizontal separation distance is less than three feet and the cables are in the same fire area;

(2) Both groupings of cables requiring separation per item one must be enclosed in solid metal raceways.

To meet the provisions of Policy Issue SECY-89-013, which relates to fire tolerance, three hour rated fire barriers are provided between areas of different safety divisions throughout the plant except in the primary containment and the control room complex. See Section 9.5.1.0 for a detailed description of how the provisions of the Policy Issue are met. |

~B4.000 ~B6.000 > Equipment of one division is segregated from equipment of other divisions and nondivisional equipment, in accordance with IEEE Std 384, Re- gulatory Guide 1.75 and General Design Criterion 17.< The overall design objective is to locate the divisional equipment and its associated con- trol, instrumentation, electrical supporting systems and interconnecting cabling such that separation is maintained among all divisions. ~B4.00 ~B6.000 >Divisional separation is achieved through the use of ~A6.000 |three-hour fire rated |barriers <~A >, spatial separation,<~B4.000 ~B6.000 ~B10.01a >and totally enclosed raceways. ~A4.05 |Class 1E to non-Class 1E separation is designed in accordance with the requirements of IEEE 384. (See Subsection 9.5.1.0)|

<Redundant divisions of electric equipment and cabling are located in separate rooms or fire areas wherever possible. ~B4.000 >In some ~A3.000 |specific|instances spa- tial separation is provided such that no single event may disable more than one of the redundant divisions or prevent safe shutdown of the plant with either of the remaining two power divisions. ~A |These are analized and justified in Appendix 9A.5.5|<

Electric equipment and wiring for the Class 1E systems which are segregated into separate divisions are separated ~B4.000 ~B6.000 >~A6.000 |and barriered|< so that no design basis event is capable of disabling more than one division of any ESF total function.

The safety-related divisional AC switchgear, ~C |power |~C >load <centers, battery rooms and DC distribution panels and MCCs are located to provide separa- tion and electrical isolation among the divi- sions. Separation is provided among divisional cables being routed between the equipment rooms, the Main Control Room, containment and other processing areas. Equipment in these areas is divided into Divisions I, II, III and IV and separated by barriers formed by walls, floors, and ceilings. The equipment is located to facili- tate divisional separation of cable trays and to provide access to electrical penetration assem- blies. Exceptions to this separation objective are identified and analyzed as to equivalency and acceptability in the fire hazard analysis. ~A |(See Appendix 9A.5)|

The penetration assemblies are located around the periphery of the containment and at diffe- rent elevations to facilitate reasonably direct routing to and from the equipment. penetra- tion carries cables of more than one division.

~A7.01 |Separation within the main control room is designed in accordance with IEEE 384, and is discussed in Subsection 8.3.1.4.1.

8.3.1.4.2.2.3.|

-A7.01 >Divisional cables to and from the containment and to and from the dedicated divisional equipment in the reactor building are routed in separated cable raceways for each division. Routing is maintained up to the terminal cabinets in the main control room.<

Wiring for all Class 1E equipment indicating lights is an integral part of the Class 1E cables used for control of the same equipment and are considered to be Class 1E circuits.

Associated cables -A8.000 |, if any,| are treated as Class 1E circuits and routed in their corresponding divisional raceways. Separation requirements are the same as for Class 1E circuits.-B8.000 |Associated cables are required to meet all of the requirements for Class 1E cables.|

The careful placing of equipment is important to the necessary segregation of circuits by division. Deliberate routing in separate fire areas on different floor levels, and in embedded ducts is employed to achieve physical independence.

8.3.1.1.5.2 Class 1E Electric Equipment Design Bases and Criteria

(1) Motors are sized in accordance with NEMA standards. The manufacturers' ratings are at least large enough to produce the starting, pull-in and driving torque needed for the particular application, with due consideration for capabilities of the power sources. -A13.06 |Plant design specifications for electrical equipment require such equipment be capable of continuous operation for voltage fluctuations of +/- 10%. In addition, Class 1E motors must be able to withstand voltage drops to 70% rated during starting transients.|

(2) Power sources, distribution systems and branch circuits are designed to maintain voltage and frequency within acceptable limits.

(3) The selection of motor insulation such as Class F, H or B is a design consideration based on service requirements and environment. The Class 1E motors a·- qualified by tests in accordance with IEEE Std 334.

(4) Interrupting capacity of switchgear, -C |power |-C >load <centers, motor control centers, and distri- bution panels is -A21.01 |equal to or greater than the maximum available fault current to which it is exposed under all modes of operation.|-A6.000 >compatible with the short- circuit current available at the Class 1E buses.<

Interrupting capacity requirements of the 6.9kV Class 1E switchgear is selected to accommodate the available short-circuit current at the switchgear terminals. Circuit breaker and applications are in accordance with ANSI Standards. (See Subsection 8.3.4.1 for interface requirements)

Unit substation transformers are sized and impedances chosen to facilitate the selection of low-voltage switchgear, MCCs and distribution panels, which are optimized within the manufacturer's recommended ratings for interrupting capacity and coordination of overcurrent devices. Impedance of connecting -A21.01 |upstream |cable is factored in for a specific physical layout.

8.3.1.1.5.3 Testing

The design provides for periodically testing the chain of system elements from sensing devices through driven equipment to assure that Class 1E equipment is functioning in accordance with design requirements. -A31.01 |Such on-line testing is greatly enhanced by the design, which utilizes three independent divisions, any one of which can safely shut down the plant. | The requirements of IEEE Std 379 -A31.01 |Regulatory Guide 1.118 and IEEE 338 |are met.

8.3.1.1.6 Circuit Protection

8.3.1.1.6.1 Philosophy of Protection

Simplicity of load grouping facilitates the use of conventional, protective relaying practices for isolation of faults. Emphasis has been placed on preserving function and limiting loss of Class 1E equipment function in situations of power loss or equipment failure.

Circuit protection of the Class 1E buses contained within the nuclear island is interfaced with the design of the overall protection system outside the nuclear island.

8.3.1.1.6.2 Grounding Methods

The medium voltage (6900V) system is low resistance grounded except that each diesel generator is high resistance grounded to maximize availabi- lity.

8.3.1.1.6.3 Bus Protection

Bus protection is as follows:

(1) 6.9kV bus incoming circuits have inverse time overload, ground fault, bus differential and undervoltage protection.

(2) 6.9kV feeders for ~C |power |~C >load <centers have instantaneous, inverse time overload and ground fault protection.

(3) 6.9kV feeders for heat exchanger building substations have inverse time overload and ground fault protection.

(4) 6.9kV feeders used for motor starters have instantaneous, inverse time overload, ground fault and motor protection.

(5) 480V bus incoming line and feeder circuits have inverse time overload and ground fault protection.

8.3.1.1.6.4 Protection Requirements

When the diesel-generators are called upon to operate during LOCA conditions, the only protective devices ~A17.01 |which shut down, the diesel |~A17.01 >for the diesel generator<are the generator ~A >and bus<differential relays, ~A |and |the engine overspeed trip ~A17.04 |.|~A17.04 >, low diesel cooling water pressure (two out of two sensors) and low differential pressure of secondary cooling water (two out of two sensors).< These protection devices are retained under accident conditions to protect against possible, signif~A >if<icant damage.

Other protective relays, such as loss of excitation, antimotoring (reverse power) overcurrent voltage restraint, ~A17.01 |low jacket water pressure| high jacket water temperature and low lube oil pressure, are used to protect the machine when operating in parallel with the normal power system, during periodic tests. The relays are automatically isolated from the tripping circuits during LOCA conditions. ~A17.03 |However, all bypassed parameters are annunciated in the main control room (see Subsection 8.3.1.1.8.5). The bypasses are testable and are manually reset as required by Position 7 of Reg. Guide 1.9| No trips are bypassed during LOPP or testing.

8.3.1.1.7 Load Shedding and Sequencing on Class 1E Buses

This subsection addresses Class 1E Divisions I, II, and III. Load shedding, bus transfer and sequencing on a 6.9kV Class 1E bus is initiated on loss of bus voltage. Only LOPP signals are used to trip the loads. However, the presence of a LOCA during LOPP reduces the time delay for initiation of bus transfer from 3 seconds to 0.4 seconds. The load sequencing for the diesels is given on Table 8.3-4.

Load shedding and buses ready to load signals are generated by the control system for the electrical power distribution system. Individual timers for each major load are reset and started by their electrical power distribution systems signals.

(1) Loss of Preferred Power (LOPP) : The 6.9kV Class 1E buses are normally energized from the normal ~A1.08 |or alternate |preferred power suppl ~A>y<~A |ies|. Should the bus voltage decay to below 70% of its nominal rated value for a predetermined time a bus transfer is initiated and the signal will trip the supply breaker, and start the diesel generator. As the bus voltage decays, large pump motor breakers are tripped. The transfer proceeds to the diesel generator. If the standby diesel generator is ready to accept load (i.e., voltage and frequency are within normal limits and no lockout exists, and the normal and alternate preferred supply breakers are open), then the diesel-generator breaker is signalled to close, accomplishing automatic transfer of the Class 1E bus to the diesel generator. Large motor loads will be sequence started as required and shown on Table 8.3-4.

(2) Loss of Coolant Accident (LOCA): When a LOCA occurs, with or without a LOPP, the load sequence timers are started if the 6.9 KV emergency bus voltage is greater than 70% and loads are applied to the bus at the end of preset times.

Each load has an individual load sequence timer which will start if a LOCA occurs and the 6.9 KV emergency bus voltage is greater than 70%, regardless of whether the bus voltage source is "C |normal or alternate |preferred power or the diesel generator. The load sequence timers are part of the low level circuit logic for each LOCA load and do not provide a means of common mode failure that would render both onsite and offsite power unavailable. If a timer failed, the LOCA load could be applied manually provided the bus voltage is greater than 70%.

(3) LOPP following LOCA: If the bus voltage (normal "A1.08 |or alternate |preferred power) is lost during post-accident operation, transfer to diesel generator power occurs as described in (1) above.

(4) LOCA following LOPP: If a LOCA occurs following loss of the normal "A1.08 |or alternate |preferred power supplies, the LOCA signal starts ESF equip- ment as required. "B16.13 |Running loads are not tripped.| Automatic (LOCA + LOPP) time delayed load sequencing assures that the diesel-generator will not be overloaded.

(5) LOCA when diesel generator is parallel with preferred power source during test: If a LOCA occurs when the diesel generator is paralleled with either the normal preferred power or the alternate preferred power source, the D/G will automatically be disconnected from the 6.9 KV emergency bus regradless of whether the test is being conducted from the local control panel or the main control room.

(6) LOPP during diesel generator paralleling test: If the normal preferred power supply is lost during the diesel-generator paralleling test, the diesel-generator circuit breaker is automatically tripped. Transfer to the diesel generator then proceeds as described in (1).

If the alternate preferred source is used for load testing the diesel generator, and the alternate preferred source is lost (and no LOCA signal exists), the diesel-generator breaker will trip on overcurrent, and LOPP condition will exist. Load shedding and bus transfer will proceed as described in (1).

(7) Restoration of offsite power: Upon restoration of offsite power, the Class 1E bus(es) can be transferred back to the offsite source by manual operation only.

(8) Protection against degraded voltage: For protection of the Division I, II and III electrical equipment against the effects of a sustained degraded voltage, the 6.9 kV ESF bus voltages are monitored. When the bus voltage degrades to 90% or below of its rated value and after a time delay (to prevent triggering by transients), undervoltage will be annunciated in the control room. Simultaneously a 5-minute timer is started, to allow the operator to take corrective action. After 5 minutes, the respective feeder breaker with the undervoltage is tripped. Should a LOCA occur during the 5-minute time delay, the feeder breaker with the undervoltage will be tripped instantly. Subsequent bus transfer will be as desribed above.

8.3.1.1.8 Standby AC Power System

The diesel generators comprising the Divisions I, II and III standby AC power supplies are designed to quickly restore power to their respective Class 1E distribution system divisions as required to achieve safe shutdown of the plant and/or to mitigate the consequences of a LOCA in the event of a coincident LOPP. Figure 8.3-1 shows the interconnections between the preferred power supplies and the Divisions I, II and III diesel-generator standby power supplies.

8.3.1.1.8.1 Redundant Standby AC Power Supplies

Each standby power system division, including the diesel generator, its auxiliary systems and the distribution of power to various Class 1E loads through the 6.9kV and 480V systems, is segregated and seperated from the other divisions. No automatic interconnection is provided between the Class 1E divisions. Each diesel generator set is operated independently of the other sets and is connected to the utility power system by manual control, only during testing or for bus transfer.

8.3.1.1.8.2 Ratings and Capability

The size of each of the diesel-generators serving Divisions I, II and III satisfies the requirements of NRC Regulatory Guide 1.9 and IEEE Std 387 and conforms to the following criteria:

(1) Each diesel generator is capable of starting, accelerating and supplying its loads in the sequence shown in Table 8.3-4.

(2) Each diesel generator is capable of starting, accelerating and supplying its loads in their proper sequence without exceeding a 25% voltage drop at its terminals.

(3) Each diesel generator is capable of starting, accelerating and running its largest motor at any time after the automatic loading sequence is completed, assuming that the motor had failed to start initially.

(4) ~B36.01 |The criteria is for |~B >E<~B |e|ach diesel generator ~B36.01 |to be |~B36.01 >is<capable of reaching full speed and voltage within ~A31.10 >13<~A31.10 |20 |seconds after receiving a signal to start, and cap- able of being fully loaded within the next ~A31.10 >30<~A31.10 |65 |seconds ~A31.10 |as shown in Table 8.3-4|.~B36.01 | The limiting condition is for the RHR and HPCF injection valves to be open 36 seconds after the receipt of a high drywell or low reactor vessel level signal. Since the motor operated valves are not tripped off the buses, they start to open, if requested to do so by their controls, when power is restored to the bus at 20 seconds. This gives them an allowable travel time of 16 seconds, which is attainable for the valves.|

~A36.04

|(5) Each diesel generator has a continuous load rating of 6.25 MVA @ 0.8 power

factor (see Figure 8.3-1). The overload rating is 110% of the rated output for a two-hour period|~836.03 | out of a 24-hour period.|

See Subsection 8.3.4.2 ~8 >and 8.3.4.8 <for interface requirements.

8.3.1.1.8.3 Starting Circuits and Systems

Diesel generators I, II and III start automatically on loss of bus voltage. Under-voltage relays are used to start each diesel engine in the event of a drop in bus voltage below preset values for a predetermined period of time. Low-water-level switches and drywell high-pressure switches in each division are used to initiate diesel start under accident conditions. Manual start capability (without need of D.C. power) is also provided. The transfer of the Class 1E buses to standby power supply is automatic should this become necessary on loss of all preferred power. After the breakers connecting the buses to the preferred power supplies are open the diesel-generator breaker is closed when required generator voltage and frequency are established.

Diesel generators I, II and III are designed to start and attain rated voltage and frequency within 20 seconds. The generator, and voltage regulator are designed to permit the set to accept the load and to accelerate the motors in the sequence within the time requirements. The voltage drop caused by starting the large motors does not exceed the requirements set forth in Regulatory Guide 1.9, and proper acceleration of these motors is ensured. Control and timing circuits are provided, as appropriate, to ensure that each load is applied automatically at the correct time. Each diesel generator set is provided with two independent starting air systems.

8.3.1.1.8.4 Automatic Shedding, Loading and Isolation

The diesel generator is connected to its Class 1E bus only when the incoming preferred source breakers have been tripped (subsection 8.3.1.1.7). Under this condition, major loads are tripped from the Class 1E bus, except for the Class 1E 480V unit substation feeders, before closing the diesel generator breaker.

The large motor loads are later reapplied sequentially and automatically to the bus after closing of the diesel-generator breaker.

8.3.1.1.8.5 Protection Systems

The diesel generator is shut down and the generator breaker tripped under the following conditions during all modes of operation and testing operation:

(1) engine overspeed trip; and

(2) generator differential relay trip.

~A17.000 > The generator breaker is tripped under the following conditions during normal operations and testing:

(1) generator ground overcurrent;

(2) generator voltage restrained overcurrent;

(3) bus underfrequency;

(4) generator reverse power; and

(5) generator loss of field.

In addition, during diesel-generator normal operations or testing, the diesel generator is shut down due to:

(1) high jacket water temperature;

(2) generator high bearing temperature;

(3) generator loss of excitation;

(4) reverse power;

(5) low turbo oil pressure;

(6) high vibration;

(7) high lube oil temperature;

(8) low lube oil pressure;

(9) high crankcase pressure; and

(10) low jacket water pressure.<

~A17.000 >The following<~A17.000 |These and other |protective functions ~A |(alarms and trips)| ~A >(trips)<of the engine or the generator breaker and other off-normal conditions are annunciated in the main control room and/or locally ~A17.000 |as shown in Table 8.3-11|. ~A17.000 >Items marked with asterisk (*) are annunciated directly in the main control room. Otherwise,<~A >l<~A |L|ocal alarm/annunciation points have auxiliary isolated switch outputs which provide inputs to ~A17.000 >a single<alarm/annunciator refresh unit~A |s |in the main control room which identifies the diesel generator ~A17.000 |and general anomaly |concerned. Those anomalies which cause the respective D/G to become inoperitive are so indicated in accordance with Regulatory Guide 1.47 and BTP PSB-2.

~A17.05 >(1) low level--jacket water;

(2) low pressure--jacket water;

(3) low-low pressure--jacket water;

(4) low temperature--jacket water in;

(5) high temperature--jacket water out;

(6) high-high temperature--jacket water out;

(7) low level--lube oil mark;

(8) low temperature--lube oil in;

(9) high temperature--lube oil out;

(10) high-high temperature--lube oil;

(11) high differential pressure--lube oil filter;<

-A >(12) low pressure--turbo oil right/left bank;

(13) low-low pressure--turbo oil;

(14) low pressure--lube oil;

(15) low-low pressure--lube oil;<

~A >(16) high temperature D/G bearings;

(17) high pressure--crankcase;

(18) excessive D/G bearing vibration;

(19) engine overspeed;

(20) contorl circuit fuse failure*;

(21) D/G overvoltage *;

(22) low pressure--starting air;

(23) in maintenance mode;

(24) unit fails to start;

(25) D/G underfrequency;

(26) D/G phase overcurrent*;

(27) out of service;

(28) diesel engine shutdown;

(29) lock out relay operated;

(30) emergency start;

(31) D/G voltage restraint overcurrent*;

(32) low-high level--fuel day tank;

(33) low pressure--fuel oil;

(34) high differential pressure--fuel filter;

(35) generator reverse power*;

(36) in local control only;

(37) generator differential trip;<

8.3.1.1.8.6 Local and Remote Control

Each diesel generator is capable of being started or stopped manually from the main control room. Start/stop control and bus transfer control may be transferred to a local control station in the diesel generator area by operating key switches at that station.

8.3.1.1.8.7 Engine Mechanical Systems and Accessories

Descriptions of these systems and accessories are given in Section 9.5.

8.3.1.1.8.8 Interlocks and Testability

Each diesel generator, when operating other than in test mode, is totally independent of the preferred power supply. Additional interlocks to the LOCA and LOPP sensing circuits terminate parallel operation test and cause the diesel generator to automatically revert and reset to its standby mode if either signal appears during a test. A lockout or maintenance mode removes the diesel generator from service. The inoperable status is indicated in the control room.

8.3.1.1.8.9 Reliability Qualification Testing

The qualification tests are performed on the diesel generator per IEEE Std. 387 as modified by Regulatory Guide 1.9 requirements.

See Subsection 8.3.4.10 for interface requirements.

8.3.1.2 Analysis

8.3.1.2.1 General AC Power Systems

The general AC power systems are illustrated in ~C |Figure 8.3-1|~C >Figures 8.3-1 through 8.3-3<. The analysis demonstrates compliance of the Class 1E AC power system to ~A3.000 >applicable<NRC General Design Criteria (GDC), NRC Regulatory Guides and other criteria consistent with the Standard Review Plan (SRP).

Table 8.1-1 identifies the onsite power system and the associated codes and standards applied in accordance with Table 8-1 of the SRP. ~A3.000 >Applicable c<~A |C|riteria are listed in order of the listing on the table, and the degree of conformance is discussed for each. Any exceptions or clarifications are so noted.

(1) General Design Criteria (GDC):

(a) Criteria: GDCs 2, 4, 17, 18 and 50.

(b) Conformance: The AC power system is in compliance with these GDCs ~A |.|~A3.000 >, in part, or as a whole, as applicable.< The GDCs are generically addressed in Subsection 3.1.2.

(2) Regulatory Guides (RGs):

(a) RG 1.6 - Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems

(b) RG 1.9 - Selection, Design, and Qualification of Diesel-Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants

(c) RG 1.32 - Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants

(d) RG 1.47 - Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems

(e) RG 1.63 - Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants

(f) RG 1.75 - Physical Independence of Electric Systems

(g) RG 1.106 - Thermal Overload Protection for Electric Motors on Motor-Operated Valves

~B18.000 |

Safety functions which are required to go to completion for safety have their thermal oveload protection devices in force during normal plant operation but the overloads are bypassed under accident conditions per Regulatory Postion 1.(b) of the guide.|

(h) RG 1.108 - Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants

(i) RG 1.118 - Periodic Testing of Electric power and Protection Systems

~B1.000 |

(j) RG 1.153 - Criteria for Power, Instrumentation, and Control Portions of Safety Systems

(k) RG 1.155 - Station Blackout

|

Regarding Position C-1 of Regulatory Guide 1.75, see Section ~B16.000 |8.3.1.1.1, the non-safety related FMCRD motors and brakes are supplied power from the division 1 Class 1E safety-related bus through a dedicated power center transformer. The Class 1E load breaker on the bus is tripped by fault current for faults in the non-safety load. There is also a zone selective interlock provided from the load breaker to the Class 1E bus supply breaker so that the supply breaker is blocked from tripping while fault current is flowing in the non-safety load feeder. This meets the intent of the Regulatory Guide position in that the main supply breaker is prevented from tripping on faults in the non-safety related loads. A second isolation device is provided by the power center transformer, which is associated and meets 1E requirements.

|~B16.000 >#8.3.1.1.2.1. Although the AC isolation is fault-current actuated, the intent of Regulatory Guide 1.75 is met through the zone selective interlocking technique. Therefore, the onsite AC power system is designed in accordance with recommendations of this guide, and with the other listed Regulatory Guides. <# There are three 6.9 KV electrical divisions which are independent load groups backed by individual diesel-generator sets. The low voltage AC systems consists of four divisions which are backed by independent DC battery, charger and inverter systems.

The standby power system redundancy is based on the capability of any one of the ~A435.024 |divisions 1, 2 or 3 load groups |~A435.024 >four divi- sions (one of three load groups) <to provide the minimum safety functions necessary to ~A435.024 |manually |shut down the unit ~A >form<~A |from |the control room in case of an accident and maintain it in the safe shutdown condition.~A435.024 |Two of the four divisions are required to be functional to accomplish an automatic safe shutdown.|

There is no sharing of standby power system components between load groups, and there is no sharing of diesel-generator power sources between units, since the ABWR is a single-plant design.

Each standby power supply for each of the three load groups is composed of a single generator driven by a diesel engine having fast-start characteristics and sized in accordance with Regulatory Guide 1.9.

Table 8.3-1 and 8.3-2 show the rating of each of the Division I, II and III diesel generators, respectively, and the maximum coincidental load for each.

(3) Branch Technical Positions (BTPs):

(a) BTP ICSB 8 (PSB) - Use of Diesel-Generator Sets for Peaking

(b) BTP ICSB 18 (PSB) - Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves.

(c) BTP ICSB 21 - Guidance for Application of Regulatory Guide 1.47

(d) BTP PSB 1 - Adequacy of Station Electric Distribution System Voltages

(e) BTP PSB 2 - Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status

The onsite AC power system is designed consistent with these positions.

(4) Other SRP Criteria:

(a) NUREG/CR 0660 - Enhancement of Onsite Diesel Generator Reliability

As indicated in Subsection 8.1.3.1.2.4, the operating procedures and training of personnel are outside of the Nuclear Island scope of supply. NUREG/CR 0660 is therefore imposed as an interface requirement for the applicant.(See Subsection 8.1.4.2)

~B2.100 | (b)
NRC Policy Issue On Alternate Power for Non-safety Loads

This policy issue states that "An evolutionary ALWR design should include an alternate power source to the non-safety loads unless the design can demonstrate that the design margins in the evolutionary ALWR will result in transients for a loss of non-safety power event that are no more severe than those associated with the turbine-trip-only event in current existing plant designs." A subsequent clarification stated that the transfer should be an automatic slow bus transfer to pickup at least one of the non MG set driven RIPs for an ABWR.

An automatic transfer has not been provided for two reasons:

(1) The coast down provided by the MG sets is equivalent to the coastdown provided by the recirculation pump inertia on the current plants.

(2) The manner in which the ABWR functions on the loss of offsite power does not require a bus transfer. The four RIPs which are not supplied from the high inertia MG sets receive a trip command immediately on tripping of the unit. This trip command originates from turbine/load rejection trip, low vessel water level (level 3) trip or high vessel dome pressure trip. The supply breakers to the high inertia MG sets are also tripped to prevent power being drawn from the flywheels by the other large motors on the buses. The remaining six RIPs continue to operate to optimize the rate of recirculation flow reduction until the MG sets have coasted down to the ASD cut off point, at which time the remaining RIPs are tripped.

The only need to restart a RIP is in preparation for restart of the plant, at which time normal power must have been restored to the non-safety buses. The operator may then restart any of the RIPs, providing that the temperature difference between the vessel dome (as indicated by the dome pressure indicator) and the bottom head is within allowable limits. A start inhibit interlock is provided to insure that the temperature limits are satisfied before a RIP is started.

Any non-safety loads which should be restarted immediately are on the plant investment protection (PIP) buses. These buses are picked up automatically by the combustion turbine. For the remaining non-safety buses there is no requirement to immediately restore power and for simplicity considerations automatic transfers are not provided.

|~B1.000 >#8.3.1.2.2 Class 1E Constant Voltage, Constant Frequency (CVCF) Power Supply

The CVCF power supply oneline diagram is illustrated in Figure 8.3-6. The following analysis indicates compliance of the Class 1E CVCF power supply to ~A >applicable<NRC General Design Criteria (GDC), NRC Regulatory Guides and other criteria consistent with the Standard Review Plan (SRP).

Table 8.1-1 identifies the Class 1E CVCF power supply and the associated codes and standards applied in accordance with Table 8-1 of the SRP. ~A >Applicable c<~A |C|riteria are listed in order of the listing on the table, and the degree of conformance is discussed for each. Any exceptions or clarifications are so noted.

(1) General Design Criteria (GDC):

(a) Criteria: GDCs 2, 4, 17, and 18.

(b) Conformance: The Class 1E CVCF power supply is in compliance with these GDCs -A3.01 >in compliance with these GDC's in part, or as a whole, as applicable<. The GDCs are generically addressed in Subsection 3.1.2

(2) Regulatory Guides (RGs):

(a) RG 1.6 - Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems

(b) RG 1.32 - Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants

(c) RG 1.47 - Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems

(d) RG 1.75 - Physical Independence of Electric Systems

(e) RG 1.118 - Periodic Testing of Electric Power and protection Systems

Regarding Position C-1 of Regulatory guide 1.75, see Section 8.1.3.1.2.2 (6). Otherwise, the Class 1E CVCF power system is designed in accordance with recommendations of this guide, and with the other listed Regulatory Guides.

There are four independent electrical divisions, each with its own individual power supply as illustrated on Figure 8.3-5. The normal uninterruptible power (UPS) to each of the four CVCF divisions is provided by its divisional rectifier and inverter powered by its divisional AC bus. The AC/DC rectifier powered by a 480 VAC bus provides the normal DC power with the 125 VDC division as a backup. The Class 1E CVCF power supplies are not shared among multiple reactor units since the ABWR is a single-unit plant design.

The Class 1E CVCF power supply redundancy is based on the capability of any one of the four divisions to provide the minimum safety functions necessary to shut down the unit from the control room in case of an accident and maintain it in the safe shutdown condition.

The Class 1E CVCF power supply system is designed to permit inspection and testing of all important equipment and features, and all automatic and manual switching functions.

(3) Branch Technical Positions (BTPs):

(a) BTP ICSB 21 - Guidance for Application of Regulatory Guide 1.47

(b) BTP PSB 1 - Adequacy of Station Electric Distribution System Voltages

With regred to BTP PSB1, protection against degraded voltage is discussed in Subsection 8.3.1.1.7(8). The CVCF power supply is designed consistent with these BTPs.

<#8.3.1.2.3 Quality Assurance Requirements

A planned quality assurance program is provided in Chapter 17. This program includes a comprehensive system to ensure that the purchased material, manufacture, fabrication, testing and quality control of the equipment in the emergency electric power system conforms to the evaluation of the emergency electric power system equipment vendor quality assurance programs and preparation of procurement specifications incorporating quality assurance requirements. The administrative responsibility and control provided are also described in Chapter 17.

These quality assurance requirements include an appropriate vendor quality assurance program and organization, purchaser surveillance as required, vendor preparation and maintenance of appropriate test and inspection records, certificates and other quality assurance documentation, and vendor submittal of quality control records considered necessary for purchaser retention to verify quality of completed work.

A necessary condition for receipt, installation and placing of equipment in service has been the signing and auditing of QA/QC verification data and the placing of this data in permanent onsite storage files.

8.3.1.2.4 Environmental Considerations

In addition to the effects of operation in normal service environment, all Class 1E equipment ~A13.01 >, which is essential to limiting the consequences of a LOCA,<is designed to operate ~A13.01 |during and after any design ba... event, |in the ~A13.01 >post- <accident environment expected in the area in which it is located. ~A13.01 |All Class 1E e|~A >E<lectric equipment is qualified to IEEE ~A >344<~A |323 |(see Section 3.11)

~B13.04 ># All cables specified for Class 1E systems ~A >,<and ~A13.01 >associated<circuits ~A >,<are moisture and radiation resistant, are highly flame resistant and evidence little corrosive effect when subjected to heat or flame, or both. Certified proof tests are performed on cable samples to:

(1) certify 60 year life by thermal aging;

(2) prove the radiation resistance by exposure of aged specimens to integrated dosage;

(3) prove mechanical/electrical tests of cable for environmental conditions specified;

(4) prove flame resistance by the vertical tray, 70,000 Btu/hr flame test for 8 minutes (minimum); and

(5) show acceptable levels of gas evolution by an acid gas generation test.

The directives which also govern the qualification are:

IEEE Std 317 -	Electric Penetration Assemblies
IEEE Std 323 -	Class 1E Equipment Qualification
IEEE Std 334 -	Continuous Duty Class 1E Motors
IEEE Std 382 -	Class 1E Electric Valve Operators
IEEE Std 383 -	Class 1E Cables, Splices and Connectors
IEEE Std 387 -	Diesel-Generator Standby Power Supplies

See Subsection 8.3.4.3 for interface reqmts.

<# 8.3.1.3 Physical Identification of Safety-Related Equipment

8.3.1.3.1 Power~B9.01 |, Instrumentation and Control |Systems

~B9.01 ^ ~B9.01d >Major e<~B9.01d |E|lectrical and control equipment, as- semblies, devices, and cables grouped into sepa- rate divisions ~A4.000 >per Table 8.3-1<shall be identi- fied so that their electrical divisional assign- ment is apparent and so that an observer can visually differentiate between Class 1E ~A >(or 1E- associated)<equipment and wiring of different divisions, and between Class 1E and non-Class 1E ~A >(or between 1E-associated and non-Class 1E)<equipment and wires. The

identification method shall be placed on color coding. All markers within a division shall have the same color. For associated cables -A |(if any) |treated as Class 1E -A |(see Note 1) |, there shall be an A appended to the divisional desig- nation (e.g., A1). The letter A stands for as- sociated and ND for nondivisional. Associated cables are uniquely identified by a longitudinal stripe -A9.02 |or other color coded method |and -A >/orsthe data on the label. The color of the cable marker for associated cables shall be the same as the related Class 1E cable. Divisional separation requirements of individual pieces of hardware are shown in the system elementary diagrams. Identification of raceways, cables, etc., shall be compatible with the identification of the Class 1E equipment with which it interfaces. Location of identification shall be such that points of change of circuit classification (at isolation devices, etc.) are readily identifiable."

-A |

Note 1 Associated circuits added beyond the certified design must be specifically identified and justified per Subsection 8.3.4.13. Associated circuits are defined in Section 5.5.1 of IEEE 384-1981, with the clarification for Items (3) and (4) that non-Class 1E circuits being in an enclosed raceway without the required physical separation or barriers between the enclosed raceway and the Class 1E or associated cables makes the circuits (related to the non-Class 1E cable in the enclosed raceway) associated circuits.|

-B7.000 |8.3.1.3.1.1 Equipment Identification

Equipment (Panels, racks, junction or pull boxes)| of each division of the Class 1E electric system and various CVCF power supply divisions are identified as follows:

(1) The background of th[illegible]ate for the equipment of a divis[illegible] has the same color as the cable jacket markers and the raceway markers associated with that division.

(2) Power system distribution equipment (e.g., motor control centers, switchgear, trans-

formers, distribution panels, batteries, chargers) is tagged with an equipment number the same as indicated on the single-line diagrams.

(3) The nameplates are laminated black and white plastic, arranged to show black engraving on a white background for non-Class 1E equipment. For Class 1E equipment, the nameplates have color coded background with black engraving.

~B7.000 |8.3.1.3.1.2 Cable Identification

| All cables for Class 1E systems and ~A >associated<~B6.000 |associated |circuits (except those routed in conduits) are tagged every 5 ft prior to (or during) installation. All cables are tagged at their terminations with a unique identifying num- ber (cable number), in addition to the marking characteristics shown below.

~A7.03 ~A9.. |Cables shall be marked in a manner of sufficient durability to be ligible throughout the life of the plant, and to facilitate initial verification that the installation is in conformance with the separation criteria.

Such markings shall be colored to uniquely identify the division (or non-division) of the cable. Generally, individual conductors exposed by stripping the jacket are also color coded or color tagged (at intervals not to exceed 1 foot) such that their division is still discernable. Exceptions are permitted for individual conductors within cabinets or panels where all wiring is unique to a single division|~B7.02 |. Any non-divisional cable within such cabinets shall be appropriately marked to distinguish it from the divisional cables.|~B7.02 >~A |(or is non-divisional).|<

~B7.000 |8.3.1.3 3 Raceway Identifcation

| All conduit is similarly tagged with a unique conduit number, in addition to the marking characteristics shown below, at 15 ft intervals, at discontinuities, at pull boxes, at points of entrance and exit of rooms and at origin and destination of equipment. Conduits containing cables operating at above 600V (i.e., 6.9kV) are also tagged to indicate the operating voltage. These markings are applied prior to the installation of the cables.

All ~A9.01 |Class 1E |cable ~B9.01b |raceways |~B9.01b >trays <are marked ~A9.01 |with the division color, and |with their proper raceway identification at 15 ft intervals on straight sections, at turning points and at points of entry and exit from enclosed areas. Cable trays are marked prior to installation of their cables.

To help distinguish the neutron-monitoring and scram solenoid cables from other type cables, the following unique voltage class designations ~B.01c |and markings |are used~B9.01c > in the cable routing programs:

Type of Special Cables	Unique Voltage Class
Neutron-monitoring	VN
Scram solenoid cables	VS

Neutron-monitoring cables are run in their own divisional conduits and cable trays, separately from all other power, instrumentation and control cables. Scram solenoid cables are run in a se- parate conduit for each rod scram group.

~9.01 > In addition, the cables of the rod control and information system in the hydraulic control unit (HCU) are also placed in separate conduits and cable trays.

< The redundant Class 1E, equipment and circuits, assigned to redundant Class 1E divisions and non-class 1E system equipment and circuits are readily distinguishable from each other without the necessity for consulting reference materials. This is accomplished by color coding of equipment, nameplates, cables and raceways, as described above.

~B9.01 >#8.3.1.3.2 Instrumentation and Control Systems

<8.3.1.3.2~B9.01 >.1< Identification

(1) Panels and racks

color of engraving fill. The marker plates shall include identification of the proper division of the equipment included.

(2) Junction or pull boxes

Junction and/or pull boxes enclosing wiring for the nuclear safety-related systems shall have identification similar to and compatible with the panels and racks.

(3) Cables

~A7.03 ~A9.03 |Cables shall be marked in a manner of sufficient durability to be legible throughout the life of the plant, and to facilitate initial verification that the installation is in conformance with the separation criteria.

Such markings shall be colored to uniquely identify the division (or non-division) of the cable. Generally, individual conductors exposed by stripping the jacket are also color coded or color tagged (at intervals not to exceed 1 foot) such that their division is still discernable. Exceptions are permitted for individual conductors within cabinets or panels where all wiring is unique to a single division (or is non-divisional).|

~A7.03 >Cables external to cabinets and/or panels for the safety-related systems shall be marked, as indicated in Subsection 8.3.1.3.1, to distinguish them from other cables and identify their separate division as applicable. This identification requirement does not apply to individual conductors.<

(4) Raceways

Those trays or conduits which carry nuclear safety-related system wiring shall be identified as indicated in Subsection 8.3.1.3.1, at room entrance points through which they pass (and exit points unless the room is small enough to facilitate convenient following of cable) with a permanent marker identifying their assigned division.

(5)<#~B7.000 8.3.1.3.1.4 Sensory equipment grouping and designation letters

Redundant sensory logic/control and actuation equipment for safety-related systems shall be identified by suffix letters.~B9.01 |Sensing lines are discussed in Section 7.7.1.1.|

8.3.1.4 Independence of Redundant Systems

8.3.1.4.1 Power Systems

The Class 1E onsite electric power systems and major components of the separate power divisions is shown on Figure 8.3-1.

Independence of the electric equipment and raceway systems between the different divisions is maintained primarily by firewall-type separation ~A6.000 |as decribed in Subsection 8.3.1.4.2. Any exceptions are justified in Appendix 9A, Subsection 9A.5.5.5.|~A6.000 >where feasible and by spatial separation, in accordance with criteria given in Subsection 8.3.1.4.2, where firewalls are not feasible. Where spatial separation cannot be maintained in hazardous areas (e.g., potential missile areas), physical isolation between electrical equipment of different divisions is achieved by use of a 6-inch minimum thickness reinforced concrete barrier.<

The physical independence of electric power systems complies with the requirements of IEEE Standards ~B3.02 >279, <308, 379, 384, General Design Criteria 17, 18 and 21 and NRC Regulatory Guides 1.6 and 1.75.

8.3.1.4.1.1 Class 1E Electric Equipment Arrangement

(1) Class 1E electric equipment and wiring is segregated into separate divisions so that no single credible event is capable of disabling enough equipment to hinder reactor shutdown~B3.104 >, removal of decay heat from the core, or <~B3.104 | and removal of decay heat by either of two unaffected divisional load groups or prevent |isolation of the containment in the event of an accident. Separation require- ments are applied to control power and motive power for all systems involved.

(2) Equipment arrangement and/or protective barriers are provided such that no locally generated force or missile can destroy any redundant RPS, NSSS, ECCS, or ESF functions.

In addition, arrangement and/or separation barriers are provided to ensure that such disturbances do not affect both HPCF and RCIC systems.

(3) Routing of wiring/cabling is arranged such as to eliminate, insofar as practical, all potential for fire damage to cables and to separate the redundant divisions so that fire in one division will not propagate to another division. ~A10...' |Class 1E and non-Class 1E cables are separated in accordance with IEEE 384 and R.G. 1.75 (see Figures 9A.4-1 through 9A.4-16).|

(4) An independent raceway system is provided for each division of the Class 1E electric system. The raceways are arranged, physically, top to bottom, as follows (based on the function and the voltage class of the cables):

(a) V4 = Medium voltage power, 6.9kV (8kv insulation class).

(b) V3 = Low voltage power including 480 VAC, 120 VAC, 125 VDC power and all instrumentation and control power supply feeders (600V insulation class).

(c) V2 = High level signal and control, including 125 VDC and 120 VAC controls which carry less than 20A current and 250 VDC or AC for relay contactor control.

(d) V1 = Low level signal and control, including ~A >ans~A10.01a |fiber-optic cables and metallic cables with |analog signals up to 55 VDC and digital signal up to 12 VDC.

~B10.02 |

Power cables (V3) are routed in flexible metallic conduit under the raised floor of the control room.|

8.3.1.4.1.2 Electric Cable Installation

(1) Cable Derating and cable tray fill--Base ampacity rating of cables is established as described in Subsection 8.3.3.1. Electric cables of a discrete Class 1E electric system division are installed in a cable tray system provided for the same division. Cables are installed in trays in accordance with their voltage ratings and as described in Subsection 8.3.1.4.1. Tray fill is as established in Subsection 8.3.3.2.

(2) Cable routing in potentially hostile areas--Circuits of different safety divisions are not routed through the same potentially hostile area, with the exception of main steam line instrumentation and control circuits and main steam line isolation valves circuits which are exposed to possible steam line break and turbine missiles, respectively. ~A13.04 |Cable routing in the drywell is discussed in association with the equipment it serves in the "Special Cases" Section 9A.5.|~A13.04 > The drywell is not considered a hostile area because of the application of pipe whip and other restraints.<

(3) Sharing of cable trays--All divisions of Class 1E AC and DC systems are provided with independent raceway systems.

(4) Cable fire protection and detection--For details of cable fire protection and detection, refer to Subsections 8.3.3 and 9.5.1.

(5) Cable and raceway markings--All cables (except lighting and nonvital communi-cations) are tagged at their terminations with a unique identifying number. Colors used for identification of cables and race- ways are covered in Subsection 8.3.1.3.

(6) Spacing of wiring and components in control boards, panels and relay racks--Separation is accomplished by mounting the redundant devices or other components on physically separated control boards if, from a plant operational point of view, this is feasible. When operational design dictates that redundant equipment be in close proximity, separation is achieved by a barrier or enclosure to retard internal-fire or by a maintained air space in accordance with criteria given in Subsection 8.3.1.4.2.

In this case, redundant circuits which serve the same safety-related function enter the control panel through separated apertures and terminate on separate and separated terminal blocks. Where redundant circuits unavoidably terminate on the same device, barriers are provided between the device terminations to ensure circuit separation approved isolators (generally optical) are used.

(7) Electric penetration assembly--Electric penetration assemblies of different Class 1E divisions are separated by ~A5.01 |three hour fire rated barriers |~A5.01 >distances<, ~A5.01 |i.e., |sepa- rate rooms ~A5.01 >or barriers<and/or locations on separate floor levels ~A |)| ~A5.01 |Separation by distance (without barriers) is allowed only within the inerted containment. (See Section 20.3, RAI8, Response 435.31) Separation between division and non-divisional penetrations shall be in accordance with IEEE 384. | Grouping of circuits in penetration assemblies follows the same raceway voltage groupings as described in Subsection 8.3.1.4.1.

~A10.01 |Redundant overcurrent interrupting devices are provided for all electrical circuits (including all instrumentation and control devices, as well as power circuits) going through containment penetrations, if the maximum available fault current (including failure of upstream devices) is greater than the continuous current rating of the penetration. |~A5.01 >Power circuits going through electric pene- tration assemblies are protected against overcurrent by redundant overcurrent inter- rupting devices to<~A |This| avoid~A |s | penetration damage in the event of failure of any single over- current device to clear a fault within the penetration or beyond it. (See Subsection 8.3.4.4 for interface requirem .

8.3.1.4.1.3 Control of Compliance with Separation Criteria During Design and Installation

Compliance with the criteria which insures independence of redundant systems is a supervi- sory responsibility during both the design and installation phases. The responsibility is discharged by:

(1) identifying applicable criteria;

(2) issuing working procedure to implement these criteria;

(3) modifying procedures to keep them current and workable;

(4) checking the manufacturer's drawings and specifications to ensure compliance with procedures; and

(5) controlling installation and procurement to ensure compliance with approved and issued drawings and specifications.

The equipment nomenclature used on the ABWR standard design is one of the primary mechanism for ensuring proper separation. Each equipment and/or assembly of equipment carries a single number, (e.g., the item numbers for motor drivers are the same as the machinery drivens). Based on these identification numbers, each item can be identified as essential or nonessential, and each essential item can further be identified to its safety separation division. This is carried through and dictates appropriate treatment at the design level during preparation of the manufacturer's drawings.

Non-Class 1E equipment is separated where desired to enhance power generation reliability, although such separation is not a safety consideration.

Once the safety-related equipment has been identified with a Class 1E safety division, the divisional assignment dictates a characteristic color (Subsection 8.3.1.3) for positive visual identification. Likewise, the divisional identification of all ancillary equipment, cable and ~A >associated<raceways match the divisional assign- ment of the system it supports.

~B8.03b ># ~A >There are certain<~A |The standby and emergency lighting fixtures are|exceptions to the above where non-Class 1E equipment is connected to Class 1E power sources for functional design rea- sons ~A >(viz., the standby AC lighting)<. This is immediately apparent by the absence of essential classification identification of the connected equipment. The equipment is then designated "associated" per Regulatory Guide 1.75. Cables used to connect such equipment are safety grade and qualified and routed as "associated circuits" and marked as described in Subsection 8.3.1.3.

<# 8.3.1.4.2 Independence of Redundant Safety-Related Instrumentation and Control Systems

This subsection defines independence criteria applied to safety-related electrical systems and instrumentation and control equipment. Safety-related systems to which the criteria apply are those necessary to mitigate the effects of anticipated and abnormal operational transients or design basis accidents. This includes all those systems and functions enumerated in Subsections 7.1.1.3, 7.1.1.4, 7.1.1.5, and 7.1.1.6. The term "systems" includes the overall complex of actuated equipment, actuation devices (actuators), logic, instrument channels, controls, and interconnecting cables which are required to perform system safety functions. The criteria outlines the separation requirements necessary to achieve independence of safety-related functions compatible with the redundant and/or diverse equipment provided and postulated events.

8.3.1.4.2.1 General

Separation of the equipment for the systems referred to in Subsection 7.1.1.3, 7.1.1.4, 7.1.1.5, and 7.1.1.6 is accomplished so that they are in compliance with ~B3.02 >#~A3.000 >the substance and intent of<IEEE 279, <#10CFR50 Appendix A, General Design Criteria 3, 17, 21 and 22, and NRC Regulatory Guides 1.75 (IEEE 384) and 1.53 (IEEE 379).

Independence of mutually redundant and/or diverse Class 1E equipment, devices, and cables is achieved by ~A >physical separation<~A |three-hour fire-rated barriers |and ~A >/or<elec- trical isolation. ~A >Physical separation and/or electrical isolation<~A |This protection |is provided to maintain the independence of nuclear safety-related circuits and equipment so that the protective function required during and following a design basis event including a single fire anywhere in the plant or a single failure in any circuit or equipment can be accomplished. ~A | The exceptional cases where it is not possible to install such barriers have been analyzed and justified in Appendix 9A.5.|

8.3.1.4.2.2 Separation Techniques

The methods used to protect redundant safety systems from results of single failures or events are utilization of safety class structures, ~A >spa- tial separation and/or<~A |three-hour fire rated |protective barriers, and isolation devices.

8.3.1.4.2.2.1 Safety Class Structure

The basic design consideration of plant layout is such that redundant circuits and equipment are located in separate safety class areas ~A |(i.e., separate fire zones) |insofar as possible. The separation of Class 1E circuits and equipment is such that the required indepen- dence will not be compromised by the failure of mechanical systems served by the Class 1E elec- trical system. For example, Class 1E circuits are routed or protected so that failure of relat- ed mechanical equipment of one system cannot disable Class 1E circuits or equipment essential to the operation of a redundant system. This separation of Class 1E circuits and equipments make effective use of features inherent in the plant design such as using different rooms or ~A |floors.|~A >the opposite side of rooms or areas (distances).<

8.3.1.4.2.2.2 ~A >Spatial Separation and/or< ~A |Three-Hour Fire Rated |Protective Barriers

~A >Spatial (distance) separation and/or<~A |Three-hour fire rated |protec- tive barriers shall be such that no locally ge- nerated ~A >force<~A |fire, |or missile resulting from a design basis event (DBE) or from random failure of Seis- mic Category I equipment can disable a safety-re- lated function. ~A |The exceptional cases where it is not possible to install such barriers have been analzed and justified in Appendix 9A.5.|~A >In the absence of confirming analysis to support less stringent requirements, the following rules apply:

(1) In rooms or compartments having heavy ro- tating machinery (such as the turbine-ge- nerator or the reactor feedwater system pumps) or in rooms containing high-pressure feedwater piping or high pressure steam lines such as those between the reactor and the turbine, minimum separation of 20 feet or a 6-inch thick reinforced concrete wall is required between trays containing cables of different divisions. An exception is made in the steam tunnel where all four divisions of conduit are separated by about three or four feet for the steam line leakage detection instrumentation.

(2) Redundant switchgear or motor control equip- ment associated with redundant safety-re- lated systems is not located in a potential mechanical damage zone, such as discussed in (1).

(3) In any compartment containing an operating crane (such as the region above the reactor pressure vessel), there must be a minimum horizontal separation of 20 feet or a 6-inch thick reinforced concrete wall between trays containing cables from different divisions.

(4) Spatial separation in general plant area shall equal or exceed the minimum allowed by IEEE-384.(See Subsection 8.3.4.5 for interface requirements)<

~A10.03 >(5) Spatial s<~A |S|eparation in ~A |all safety equipment or cable areas |~A >cable spreading areas<shall equal or exceed the ~A |requirements of |~A >minimum allowed by<IEEE 384.~B >(See Subsection 8.3.4.5 for interface requirements)<

8.3.1.4.2.2.3 Main Control Room and Relay Room Panels

The protection system and ESF control, logic, and instrument panels/racks shall be located in a safety class structure in which there are no potential sources of missiles or pipe breaks that could jeopardize redundant cabinets and raceways.

Control, relay, and instrument panels/racks will be designed in accordance with the follow- ing general criteria to preclude ~A7.04 |failure of non-safety circuits from causing failure of any safety circuit and to preclude failure of one safety circuit from causing failure of any other redundant safety circuit. |~A7.04> the possibility of fire propagating between redundant circuits and preventing safe shutdown of the plant.< Single panels or instrument racks will not contain circuits or devices of the redundant protection system or ESF systems except:

(1) Certain operator interface control panels may have operational considerations which dictate that redundant protection system or ESF system circuits or devices be located in a single panel. These circuits and devices are separated horizontally and vertically by a minimum distance of 6 inches or by steel barriers or enclosures.

(2) Class 1E circuits and devices will also be separated from the non-Class 1E circuits and from each other horizontally and vertically by a minimum distance of 6 inches or by steel barriers or enclosures.

(3) Where electrical interfaces between Class 1E and non-Class 1E circuits or between Class 1E circuits of different divisions cannot be avoided, Class 1E isolation devices are used (Subsection 8.3.1.4.2.2.4).

(4) If two panels containing circuits of different separation divisions are less than 3 feet apart, there shall be a steel barrier between the two panels. Panel ends closed by steel end plates are considered to be acceptable barriers provided that terminal boards and wireways are spaced a minimum of 1 inch from the end plate.

(5) Penetration of separation barriers within a subdivided panel is permitted provided that such penetrations are sealed or otherwise treated so that fire generated by an electrical fault could not reasonably propagate from one section to the other and disable a protective function.

-C >(6) Local instrument racks on which flow trans- mitters for main steam or recirculation wa- ter are located are permitted to have redun- dant instruments on adjacent bays of a sin- gle rack in order to avoid superfluous in- strument piping from flow elements within the drywell. In these cases a spatially di- verse set of redundant transmitters shall be provided on a separate local instrument rack.

<8.3.1.4.2.2.4 Isolation Devices

Where electrical interfaces between Class 1E -A8.000 >or (1E-associated)<and non-Class 1E circuits or between Class 1E -A8.000 >or (1E-associated)<circuits of different divisions cannot be avoided, Class 1E isolation devices will be used.-B33.000 > DC isolation is provided by DC-to-DC converters.< AC isolation -B33.000 |(The FMCRD drives on Division 1 is the only case.) |is provided by interlocked circuit breaker coordi- nation -B33.000 |and an isolation transformer |as described in Subsection -B33.000 |8.3.1.1.1.| -B33.000 >8.3.1.1.2.1.<

Wiring from Class 1E -A8.000 >(or 1E-associated)<equipment or circuits which interface with non-Class 1E equipment circuits (i.e., annunciators or data loggers) is treated as Class 1E -A8.000 >(or 1E-as- sociated)<and retain its divisional identifica- tion up to and including its isolation device. The output circuits from this isolation device are classified as nondivisional and shall be physically separated from the divisional -A8.000 >(or 1E-associated)<wiring.

8.3.1.4.2.3 System Separation Requirements

Specific divisional assignment of safety-related systems and equipment is given in Table 8.3-1. Other separation requirements pertaining to the RPS and other ESF systems are given in the following subsections.

8.3.1.4.2.3.1 Reactor Protection (Trip) System (RPS)

The following separation requirements apply to the RPS wiring:

(1) RPS sensors, sensor input circuit wiring, trip channels and trip logic equipment will be arranged in four functionally independent and divisionally seperate groups designated Divisions I, II, II and IV. The trip channel wiring associated with the sensor input signals for each of the four divisions provides inputs to divisional logic cabinets which are in the same divisional group as the sensors and trip channels and which are functionally independent and physically seperated from the logic cabinets of the redundant divisions.

(2) Where trip channel data originating from sensors of one division are required for coincident trip logic circuits in other divisions, Class 1E isolation devices will be used as interface elements for signals sent from one division to another such as to

maintain electrical isolation between divisions.

(3) Sensor wiring for several trip variables associated with the trip channels of one division may be run together in the same conduits or in the same raceways of that same and only division. Sensor wiring associated with one division will not be routed with, or in close proximity to, any wiring or cabling associated with a redundant division.

(4) The scram solenoid circuits, from the actuation devices to the solenoids of the scram pilot valves of the CRD hydraulic control units, will be run in grounded steel conduits, with no other wiring contained within the conduits, so that each scram group is protected against a hot short to any other wiring by a grounded enclosure. Short sections (less than one meter) of flexible metallic conduit will be permitted for making connections within panels and the connections to the solenoids.

(5) Separate grounded steel conduits will be provided for the scram solenoid wiring for each of four scram groups. Separate grounded steel conduits will also be provided for both the A solenoid wiring circuits and for the B solenoid wiring circuits of the same scram group.

(6) ~A4.01 ~A4.02 | Scram group conduits will have unique identification and will be separately routed as Division II and III conduits for the A and B solenoids of the scram pilot valves, respectively. This corresponds to the divisional assignment of their power sources. The conduits containing the scram solenoid group wiring of any one scram group will also be physically separated by a minimum separation distance of 1 inch from the conduit of any other scram group, and from metal enclosed raceways which contain either divisional or non-safety-related (non-divisional) circuits. The scram group conduits may not be routed within the confines of any other tray or raceway system. The RPS conduits containing the scram group wiring for the A and B solenoids of the scram pilot valves (associated with Divisions II and III, respectively), shall be separated from non-enclosed raceways associated with any of the four electrical divisions or non-divisional cables in accordance with | ~B4.01 ~B4.02 |IEEE 384 and Regulatory Guide 1.75.|~B >~A |the normal division-to-division separation requirements of the plant. See Subsection 8.3.1.1.5.1)|<

~A4.000 >The scram group conduits will have unique identification and will be treated essentially as if they are separate enclosed raceways. The conduits containing the scram solenoid group circuit wiring will be physically separated by a minimum separation distance of one inch from either metal enclosed raceways or non-enclosed raceways which contain either divisional or "non-divisional" (non-safety-related) circuits.<

(7) Any scram group conduit may be routed alongside of any cable or raceway containing either safety-related circuits (of any division), or any cable or raceway containing non-safety-related circuits, as long as the conduit itself is not within the boundary of any raceway which contains either the divisional or the non-safety-related circuits and is physically separated from said cables and raceway boundaries ~A |as stated in (6) above|~A >by a minimum separation distance of one inch<. Any one scram group conduit may also be routed along with scram group conduits of the same scram group or with conduits of any of the three other scram groups as long as the minimum separation distance of one inch (2.5 cm) is maintained.

(8) The standby liquid control system redundant Class 1E controls will be run as Division I and Division II so that no failure of standby liquid control (SLC) function will result from a single electrical failure in a RPS circuit.

(9) The startup range monitoring (SRNM) subsystem cabling of the NMS ~9.01 >and the rod control and information system (RC&IS) <cabling under the vessel is treated as divisional. The SRNM cables will be assigned to Division I, II, III and IV~C > and the RC&IS cables to Division I and II<. Under the vessel, cables will ~A6.000 |be enclosed and separated as defined in Appendix 9A.5.5.5.|~A >not be placed in any enclosure which will unduly restrict capability of removing probe connectors for maintenance purposes.<

8.3.1.4.2.3.2 Other Safety-Related Systems

(1) Separation of redundant systems or portions of a system shall be such that no single failure can prevent initiation and completion of an engineered safeguard function.

(2) The inboard and outboard isolation valves are redundant to each other so they are made independent of and protected from each other to the extent that no single failure can prevent the operation of at least one of an inboard/outboard pair. ~~B4.00~~ >The MSL fail-safe solenoid circuits follow the cable separa- tion requirements described in Subsection 8.3.1.4.2.3.1 for RPS rod scram groups.<

(3) Isolation valve circuits require special attention because of their function in limiting the consequences of a pipe break outside the primary containment. Isolation valve control and power circuits are requir-

ed to be protected from the pipe lines that they are responsible for isolating.

Essential isolation valve wiring in the vicinity of the outboard valve (or downstream of the valve) shall be installed in conduits and routed to take advantage of the mechanical protection afforded by the valve operator or other available structural barriers not susceptible to disabling damage from the pipe line break. Additional mechanical protection (barriers) shall be interposed as necessary between wiring and potential sour- ces of disabling mechanical damage consequential to a break downstream of the outboard valve.

(4) The several systems comprising the ECCS have their various sensors, logics, actuating devices and power supplies assigned to divisions in accordance with Table 8.3-1 so that no single failure can disable a redundant ECCS function. This is accomplished by limiting consequences of a single failure to equipment listed in any one division of Table 8.3-1. The wiring to the ADS solenoid valves within the drywell shall run in one or more rigid conduits. ADS conduits for solenoid A shall be divisionally separated from solenoid B conduits. Short pieces (less than 2 feet) of flexible conduit may be used in the vicinity of the valve solenoids.

(5) Electrical equipment and raceways for systems listed in Table 8.3-1 shall not be located in close proximity to primary steam piping (steam leakage zone), or be designed for short term exposure to the high temperature and humidity associated with a steam leak.

(6) ~A14.01 |Class 1E electrical equipment located in the suppression pool level swell zone is limited to supopression pool temperature monitors, which have their terminations sealed such that operation would not be impaired by submersion due to pool swell or LOCA. Consistent with their Class 1E status, these devices are also qualified to the requirements of IEEE 323 for the environment in which they are located|~A14.01 >Any electrical equipment and/or raceways< for RPS or ESF located in the suppression pool level swell zone will be designed to satis- factorily complete their function before<

~A16.000 >being rendered inoperable due to exposure to the environment created by the level swell phenomena. This zone includes that space above the suppression pool normal level which sees the surge of water that could result from a high drywell-to-containment differential pressure.<

(7) Containment penetrations will be so arranged that no design basis event can disable cabling in more than one division. Penetrations will not contain cables of more than one divisional assignment.

(8) Annunciator and computer inputs from Class 1E equipment or circuits are treated as Class 1E and retain their divisional identification up to Class 1E isolation device. The output circuit from this isolation device is classified as nondivisional.

Annunciator and computer inputs from non-Class 1E equipment or circuits do not require isolation devices.

8.3.2 DC Power Systems

8.3.2.1 Description

~B2.01 |8.3.2.1.1 General Systems
|

A ~B2.01 >125 V<DC power system ~B2.01 >, Figure 8.3-7, <is pro- vided for switchgear control, control power, in- strumentation, critical motors and emergency lighting in control rooms, switchgear rooms and fuel handling areas.~B2.01 |Four independent Class 1E 125VDC divisions, three independent non-safety-related 125VDC load groups and one non-safety-related 250VDC computer and motor power supply are provided. See Figures 8.3-7 for the single lines.

Each battery is separately housed in a ventilated room apart from its charger and distribution panels. Each battery feeds a DC distribution switchgear panel which in turn feeds local distribution panels and DC motor control centers. An emergency eye wash is supplied in each battery room. |~B >(See Subsection 8.3.4.7 for interface requirements.)<

All batteries are sized so that required loads will not exceed 80% of nameplate rating, or warranted capacity at end-of-installed-life with 100% design demand.

All chargers are sized to supply the continuous load demand to their bus while restoring batteries to a fully charged state. |

~B2.01 >8.3.2.1.1 General Systems

<~B2.01 |8.3.2.1.1.1 Class 1E 125 VDC System
|
~B2.01 ># Four independent Class 1E 125 VDC systems are provided to supply normal and emergency DC power~B2.01 |, Figure 8.3-7|. The DC power systems provide adequate power for station emergency auxiliaries and for control and switching during all modes of operation.

<#~B2.01 >(Relocated in this section) The operating voltage range of Class 1E DC loads is 100 to 140V.

The maximum equalizing charge voltage for Class 1E batteries is 140 VDC.

The DC system minimum discharge voltage at the end of the discharge period is 1.75 VDC per cell.

< The 125 VDC system~B >s< provide~B |s| a reliable control and switching power source for the Class 1E systems.

~B2.01 >(Relocated to 8.3.2.1.1) All batteries are sized so that required loads will not exceed 80% of nameplate rating, or warranted capacity at end-of-installed-life with 100% design demand. <Each 125 VDC battery is provided with a charger, and a standby char- ger shared by two divisions, each of which is capable of recharging its battery from a dis- charged state to a fully charged state while handling the normal, steady-state DC load.

Batteries are sized for the DC load in accordance with IEEE Standard 485.

~C >#~B2.01 |8.3.2.1.1.1 Non-Class 1E 250V DC Power Supply
|<#
~B2.01 >(Relocated to 8.3.2.1.4) A non-class 1E 250VDC power supply, Figure 8.3-8, is provided for the computers and the turbine turning gear motor. The power supply consists of one 250VDC battery and two char- gers. The normal charger is fed by 480VAC from either the Division I or Division III load cen- ters. Selection of the desired AC supply is by a

mechanically interlocked transfer switch. The standby charger is fed from a control building motor control center. Selection of the normal or the standby charger is controlled by key interlocked breakers. A 250VDC central distribution board is provided for connection of the loads, all of which are non-class 1E.

See Subsection 8.3.4.6 for interface requirements.<

8.3.2.1.2 Class 1E DC Loads

The 125 VDC Class 1E power is required for emergency lighting, diesel-generator field flashing, control and switching functions such as the control of 6.9-kV and 480V switchgear, control relays, meters and indicators, -C |multiplexers, vital ac power supplies|, as well as DC components used in the reactor core isolation cooling system.

The four divisions that are essential to the safe shutdown of the reactor are supplied from four independent 125 VDC buses.

8.3.2.1.3 Station Batteries and Battery Chargers, General Considerations

The four ESF load groups are supplied from the four Class 1E 125 VDC systems.(See Figure 8.3-7)

Each of the ~B2.01 |Class 1E |125 VDC systems has a 125 VDC battery, a battery charger and a distribution panel. One standby battery charger ~A |can be connected to either of |~A >is shared by<two divisions and another standby battery charger ~A |can be connected to either of |~A >is shared by<two other divisions. ~B2.01 |Kirk key interlocks prevent cross connection between divisions. |The main DC distribution buses include distribution panels, drawout-type breakers and molded case circuit breakers.

~B2.01 >(Relocated to 8.3.2.1.1) Local distribution panels and motor control centers are fed from the DC distribution switch- gear.

< The ~B2.01 |Class 1E |125 VDC systems supply DC power to Divi- sions I, II, III and IV, respectively, and are designed as Class 1E equipment in accordance with IEEE Std 308. They are designed so that no sin- gle failure in any 125 VDC system will result in conditions that prevent safe shutdown of the plant~B2.01 | with either of the two remaining power divisions|. The plant design and circuit layout from these DC systems provide physical separation of the equipment, cabling and instrumentation essential to plant safety.

~B2.01 >(Relocated to 8.3.2.1.1) Each 125 VDC battery is separately housed in a ventilated room apart from its charger and distribution panel. <Each division of the system is lo- cated in an area separated physically from other divisions. All the components of Class 1E 125 VDC systems are housed in Seismic Category I structures. ~B2.01 >#(Relocated to 8.3.2.1.1) An emergency eye wash is supplied in each room. All chargers are sized to supply the continuous load demand to their ~A8.000 >associated<bus while restoring batteries to a fully charged state.(See Subsection 8.3.4.7 for interface requirements)

<#8.3.2.1.3.1 125 VDC Systems Configuration

Figure 8.3-7 shows the overall 125 VDC system provided for Class 1E Divisions I, II, III and IV. One divisional battery charger is used to supply each divisional DC distribution panel bus and its associated battery. The divisional bat- tery charger is normally fed from its divisional 480V MCC bus.

~B2.01 |Each Class 1E 125 VDC battery is provided with a charger, and a standby charger shared by two divisions, each of which is capable of recharging its battery from a dis- charged state to a fully charged state while handling the normal, steady-state DC load.

|~B2.01 >8.3.2.1.3.2 Battery Capacity Considerations

<

~B2.01 | The maximum equalizing charge voltage for Class 1E batteries is 140 VDC. The DC system minimum discharge voltage at the end of the discharge period is 1.75 VDC per cell (105 volts for the battery). The operating voltage range of Class 1E DC loads is 100 to 140V.

| ~A34.000 |As a general requirement, t|~A >T<hese batteries have sufficient stored energy to operate connected essential loads continuously for at least two hours without recharging. ~A34.000 |The division I battery, which controls the RCIC system, is sufficient for eight hours of coping during station blackout. During this event scenario, the load reductions on Division II, III, and IV also extend the times these batteries are available (See Appendix Subsection 19E.2.1.2.2).| Each distribution circuit is capable of transmitting sufficient energy to start and operate all required loads in that circuit.

~A34.000 |A load capacity analysis has been performed, based on IEEE 485-1978, for estimated |~B2.01 |Class 1E |~A34.000 |DC battery loads as of September, 1989. The results for both two hour and eight hours are provided as Tables 8.3-5 through 8.3-10.|

An initial composite test of onsite AC and DC power systems is called for as a prerequisite to initial fuel loading. This test will verify that each battery capacity is sufficient to sa- tisfy a safety load demand profile under the conditions of a LOCA and loss of preferred power.

Thereafter, periodic capacity tests may be con- ducted in accordance with IEEE Std 450. These tests will ensure that the battery has the ca- pacity to continue to meet safety load demands.

See Subsection 8.3.4.6 for interface requirements.

~B2.01 ~B2.02 ~B2.03 ~B33.000 |8.3.2.1.3 Non-Class 1E 125V DC Power Supply

A non-class 1E 125VDC power supply, Figure 8.3-7, is provided for non-safety-related switchgear, valves, converters, transducers, c...'s and instrumentation. The system has th... ...oups with ... battery, charger ... bus pe. load group. There are bus tie breakers between buses. Normal operation is with bus tie breakers open. Each load group's battery and charger may be removed from service as a unit fo: ma'ntenance o. testing. A battery can be recharged by its charger prior to being placed back into service.

One backup charger is provided and is connectable to any of the three buses, one bus at a time, under control of Kirk key interlocks to:

a) Perform extended maintenance on the normal charger for the load group.

b) To make a live transfer of a bus to supply power from the bus of another load group without paralleling the two batteries.

The chargers are load limiting battery replacement type chargers capable of operation without a battery connected to the bus. The backup charger may be supplied from the AC supply of any one of the three l...d groups. It may be used to charge any one battery at a given time. For example the load group B battery may be charged from load group A or B or C AC power via the buckup charger.

Each bus is connectable to either of the other two buses via Kirk key interlocked tie breakers. The Kirk key interlock system allows paralleling of chargers. Since the chargers are are self load limiting, parallel operation is acceptable. The Kirk key interlock system prevents parallel operation of batteries. This is to prevent the possibility of paralleling batteries which have different terminal voltages and experiencing a large circulating current as a result.

The battery output breaker has an overcurrent trip and interrupts fault current flow from the battery to a bus fault. A combination disconnect switch and fuse is an acceptable alternate for the battery output breaker. The charger output breaker and the bus input breaker do not have overcurrent trips. They are used as disconnect switches only. Bus load breakers have overcurrent trips coordinated with the battery output breaker. Tripping current for the load breakers is supplied by the battery.

|

~B2.01 |8.3.2.1.4 Non-Class 1E 250V DC Power Supply

A non-class 1E 250VDC power supply, Figure 8.3-7, is provided for the computers and the turbine turning gear motor. The power supply consists of one 250VDC battery and two char-...rs. The normal ch... is fed by 480VAC from either the |~B2.01 |L... group A or Load group ... turbine building |~B2.01 >Division I or Division III <load cen- ters. Selection of the desired AC supply is by a mechanically interlocked transfer switch. The standby charger is fed from a ~B2.01 |Load group A ...ontrol building motor control center. Selection of the normal or the standby charger is controlled by key interlocked breakers. A 250VDC central distribution board is provided for connection of the loads, all of which are non-class 1E.

~B2.01 > See Subsection 8.3.4.6 for interface re- quirements.<

8.3.2.1.3.3 Ventilation

Battery rooms are ventilated to remove the minor amounts of gas produced during the charging of batteries.

8.3.2.1.3.4 Sta~A |t|ion Blackout

Station blackout performance is discussed in Subsection 19E.2.1.2.2.

~B2.01 ># (Combined into sections above.)
~A33.000 |8.3.2.1.4 Non-Class 1E Loads

The 125VDC non-Class 1E power is used for operation of non-safety equipment such as 6.9 KV switchgear (see Subsection 8.3.4.3), valves, converters, transducers, controllers, etc. It also supplies power to non-Class 1E distribution panels and local racks housing non-safety instrumentation.

The 125 VDC non-Class 1E power distribution is shown on Figure 8.3-|~B2.01 |JEM3|~B2.01 >~A |7|<~A |. There are |~B2.01 >~A |four |<~B2.01 |three |~A |groups of non-Class 1E distribution panels which recieve their power |~B2.01 |from

the three non-Class 1E batteries. |<#-B2.01
>-A33.000 |through DC-to DC converters from the four Class-1E electrical divisions.

...e DC-toDC converters (or "power packs") act a... electrical isolators such that any anomalies in the non-Class 1E system will not affect the Class 1E system. Also, grounds on the output side (non-Class 1E) of the DC-to-DC converters do not appear on the input side (Class 1E).

These power packs fully comply with all the requirements of Regulatory Guide 1.75 and Section 7.2.2 of IEEE 384, and are therefore acceptable isolation devices. The non-Class 1E loads and their relationship to the power packs and Class 1E power supply buses are the same configuration as those illustrated in the #2 load circle of Figure 1 of IEEE 384.

The Class 1E 125 VDC systems are adequately sized to handle the non-Class 1E loads. Should a loss of all AC power occur, the non-Class 1E loads can be shed, as needed, to assure extended battery life for safe shutdown functions of the plant. (For battery capacity considerations, See Subsection 8.3.2.1.3.2.)|<

8.3.2.2 Analysis

8.3.2.2.1 General DC Power Systems

The 480 VAC power supplies for the divisional battery chargers are from the individual class 1E MCC to which the particular 125 VDC system belongs (Figure 8.3-7). In this way, separation between the independent systems is maintained and the AC power provided to the chargers can be from either preferred or standby AC power sour- ces. The DC system is so arranged that the pro- bability of an internal system failure resulting in loss of that DC power system is extremely low. Important system components are either self-alarming on failure or capable of clearing faults or being tested during service to detect faults. Each battery set is located in its own ventilated battery room. All abnormal condi- tions of important system parameters such as charger failure or low bus voltage are annun- ciated in the main control room and/or locally.

AC and DC switchgear power circuit breakers in each division receive control power from the batteries in the respective load groups ensuring the following:

(1) The unlikely loss of one 125 VDC system does not jeopardize the ~A |Class 1E feed |supply ~A >of preferred and standby AC power< to the Class 1E buses

of the other load groups.

(2) The differential relays in one division and all the interlocks associated with these relays are from one 125 VDC system only, thereby eliminating any cross connections between the redundant DC systems.

8.3.2.2.2 Regulatory Requirements

The following analyses demonstrate compliance of the Class 1E Divisions I, II, III and IV DC power systems to ~A3 10 >applicable<NRC General Design Criteria, NRC Regulatory Guides and other cri- teria consistent with the standard review plan. The analyses establish the ability of the system to sustain credible single failure and retain their capacity to function.

The following list of criteria is addressed in accordance with Table 8.1-1 which is based on Table 8-1 of the Standard Review Plan (SRP). In general, the ABWR is designed in accordance with all ~A3.000 >applicable<criteria. Any exceptions or clarifications are so noted.

(1) General Design Criteria (GDC):

(a) Criteria: GDCs 2, 4, 17, and 18.

(b) Conformance: The DC power system is in compliance with these GDCs ~A3.000 >, in part, or as a whole, as applicable<. The GDCs are generically addressed in Subsection 3.1.2.

(2) Regulatory Guides (RGs):

(a) RG 1.6 - Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems

(b) RG 1.32 - Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants

(c) RG 1.47 - Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems

(d) RG 1.63 - Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants

(e) RG 1.75 - Physical Independence of Electric Systems

~B8.03 | The DC safety-related standby lighting system circuits up to the lighting fixtures are Class 1E and are routed in seismic Category I raceways. However, the lighting fixtures themselves are not seismically qualified, but are seismically supported. The cables and circuits from the power source to the lighting fixtures are Class 1E. The bulbs cannot be seismically qualified. This is an exception to the requirement that all Class 1E equipment be seismically qualified. The bulbs can only fail open and therefore do not represent a hazard to the Class 1E power sources.

~B8.03b | Associated circuits added beyond the certified design must be specifically identified and justified per Subsection 8.3.4.13. Associated circuits are defined in Section 5.5.1 of IEEE 384-1981, with the clarification for Items (3) and (4) that non-Class 1E circuits being in an enclosed raceway without the required physical separation or barriers between the enclosed raceway and the Class 1E or associated cables makes the circuits (related to the non-Class 1E cable in the enclosed raceway) associated circuits.|

~B1.000 | (f) RG 1.106 - Thermal Overload Protection for Electric Motors on Motor-Operated Valves

Safety functions which are required to go to completion for safety have their thermal oveload protection devices in force during normal plant operation but the overloads are bypassed under accident conditions per Regulatory Postion 1.(b) of the guide.

~B1.000 >(f)< ~B1.000 |(g)|

RG 1.118 - Periodic Testing of Electric Power and P ..ection Systems

~B1.000 >(g)<~B1.000 |(h)|

RG 1.128 - Installation Designs and Installation of Large Lead Storage Batteries for Nuclear Power Plants

~B1.000 >(h)<~B1.000 |(i)|

RG 1.129 - Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants

~B1.000 | (j) RG 1.153 - Criteria for Power, Instrumentation, and Contr..l Portions of Safety Systems

(k) RG 1.155 - Station Blackout

↓

The Class 1E DC power system is designed in accordance with the listed Regulatory Guides. It is designed with sufficient capacity, inde- pendence and redundancy to assure that the re- quired power support for core cooling, containment integrity and other vital functions is maintained in the event of a postulated accident, assuming a single failure.

The batteries consist of industrial-type storage cells, designed for the type of service in which they are used. Ample capacity is available to serve the loads connected to the system for the duration of the time that alternating current is not available to the battery charger. Each division of Class 1E equipment is provided with a separate and independent 125 VDC system.

The DC power system is designed to permit inspection and testing of all important areas and features, especially those which have a standby function and whose operation is not normally demonstrated.

~B1.000 ↓

(i) RG 1.153 Criteria For Power, Instrumentation, and Control Portions of Safety Systems

(j) RG 1.155 Station Blackout

Credit is not taken for the CTG as an alternate ac source (AAC) so Section 3.3.5 of RG 1.155 is not required to be met. (The CTG does meet the requirements of Section 3.3.5, however.) See Section 19E.2.1.2.2 for a discussion of compliance with RG 1.155.

↓

(3) Branch Technical Positions (BTPs):

(a) BTP ICSB 21 - Guidance for Application of Regulatory Guide 1.47.

The DC power system is designed consistent with this criteria.

(4) Other SRP Criteria:

According to Table 8-1 of the SRP, there are no other criteria applicable to DC power systems.

8.3.3 Fire Protection of Cable Systems

The basic concept of fire protection for the cable system in the ABWR design is that it is incorporated into the design and installation rather than added onto the systems. By use of fire resistant and nonpropagating cables, conservative application in regard to ampacity ratings and raceway fill, and by separation, fire protection is built into the system. Fire suppression systems (e.g.; automatic sprinkler systems) are provided ~C |as listed in Table 9.5.1-1. |~C >for cable trays in areas of high combustible loads or possible transit fire loading.<

8.3.3.1 Resistance of Cables to Combustion

The electrical cable insulation is designed to resist the onset of combustion by limiting cable ampacity to levels which prevent overheating and insulation failures (and resultant possibility of fire) and by choice of insulation and jacket materials which have flame-resistive and self-extinguishing characteristics. Polyvinyl chloride or neoprene cable insulation is not used in the ABWR. All cable trays are fabricated from noncombustible material. Base ampacity rating of the cables was established as published in IPCEA-46-426/IEEE S-135 and IPCEA-54-440/NEMA WC-51. Each coaxial cable, each single conductor cable and each conductor in multi- conductor cable is specified to pass the vertical flame test in accordance with UL-44.

In addition, each power, control and instrumentation cable is specified to pass the vertical tray flame test in accordance with IEEE 383.

Power and control cables are specified to continue to operate at a conductor temperature not exceeding 90°C and to withstand an emergency overload temperature of up to 130°C in accordance with IPCEA S-66-524/NEMA WC-7 Appendix D. Each power cable has stranded conductor and flame-resistive and radiation-resistant covering. Conductors are specified to continue to operate at 100% relative humidity with a service life expectancy of 60 years. Also, Class 1E Cables are designed ~B15.03 |and qualified |to survive the LOCA ambient condition at the end of the 60-yr life

span. The cable installation ~A15.000 |(i.e., redundant divisions separated by fire barriers) |is such that direct impingement of fire suppressant will not prevent safe reactor shutdown~B15.000 |, even if failure of the cable occurs. Cables are specified to be submersible, however| ~A15.000 |(See the fourth requirement/compliance in Subsection 9.5.1.0.)|

8.3.3.2 Localization of Fires

In the event of a fire, the installation design will localize the physical effects of the fire by preventing its spread to adjacent areas or to adjacent raceways of different divisions. Localization of the effect of fires on the electric system is accomplished by separation of redundant cable systems and equipment as described in Subsection 8.3.1.4. Floors and walls are effectively used to provide vertical and horizontal fire-resistive separations between redundant cable divisions.

~B10.04 |In any given fire area an attempt is made to insure that there is equipment from only one safety-related division. This design objective is not always met due to other over-riding design requirements. IEEE Std 384 and Regulatory Guide 1.75 are always complied with, however. In addition an analysis is made and documented in Section 9A.5.5 to ascertain that the requirement of being able to safely shut the plant down with complete burnout of the fire area without recovery of the equipment is met. The fire detection, fire suppression and fire containment systems provided should assure that a fire of this magnitude does not occur, however.

|~B10.04 ># In special cases, spatial separation is used as a method of preventing the spread of fire between adjacent cable trays of different di- visions (e.g., inside primary containment). In special cases where minimum separation cannot be maintained between divisional cables in panels or at equipment, barriers are provided between the cable systems or ~A >justification is provided between the cable systems of<justification is provided (~A |Appendix 9A.5|~A >Subsection 9.5.1<). The objective is always to separate cable trays of different di- visions with structural fire barriers such as floors, ceilings and walls. Where this is not possible divisional trays are separated 3 ft horizontally and 5 ft vertically, which meets minimum separations allowed by

IEEE-384 and associated Regulatory Guide 1.75. ~A |These are specifically analzed and justified in Appendix 9A.5.| Fire rated barriers are used to separate divisional cable trays when they are separated by less than 3 ft horizontally and 5 ft vertically. Tray fill is limited to 40% cross-sectional area for all cables.

<# Maximum separation of equipment is provided through location of ~B23.000 |redundant |equipment in separate fire ~B23.000 |areas |~B23.000 >rated rooms<. The safety-related divisional AC unit substations, motor control centers, and DC distribution panels are located to provide sepa- ration and electrical isolation between the di- visions. Clear access to and from the main switchgear rooms is also provided. ~B10.04 |Cable chases are ventilated and smoke removal capability is provided. |~B23.000 >Separation is provided between the divisional cables and between divisional cables and nondivisional ca- bles being routed throughout the plant via sepa- rate fire rated compartments or embedments. <Local instrument panels and racks are ~B23.000 |separated by safety division and |located to

facilitate ~C |required |~C >adequate <separation of cabling.

8.3.3.3 Fire Detection and Protection Systems

All areas ~C |of the plant are covered by a fire detection and alarm system. Double manual hose coverage is provided throughout the buildings. Sprinkler systems are provided as listed on Table 9.5.1-1. The diesel generator rooms and day tank rooms are protected by foam sprinkler systems. |~C >except the diesel-generator room are protected by product of combustion detectors. The diesel-generator rooms are protected by carbon dioxide suppression, which is <~C |The foam sprinkler systems are dry pipe systems with pre-action valves which are |actuated by com- pensated rate of heat rise and ultraviolet flame detectors.~C | Individual sprinkler heads are opened by their thermal links.|

~C > Automatic wet standpipe, sprinklers, hose reels, and manual pull boxes for the operator's initiation of fire signals are provided in areas as described in subsection 9.5.1, which includes areas where cables and cable trays are routed.

<8.3.4 Interfaces

8.3.4.1 Interrupting Capacity of Electrical Distribution Equipment

The interrupting capacity of the switchgear and circuit interrupting devices must be shown to be compatible with the magnitude of the available fault current based on final selection of the transformer impedence, etc. (See Subsection 8.3.1.1.5.2(4)).

8.3.4.2 Diesel Generator Design Details

Subsection 8.3.1.1.8.2 (4) requires the diesel generators be capable of reaching full speed and voltage within ~A36.1 |20|~A36.1 >13<seconds after the signal to start. Demonstrate the reliability of the diesel generator start-up circuitry designed to accomplish this.

8.3.4.3 Certified Proof Tests on Cable Samples

Subsection 8.3.1.2.4 requires certified proof tests on cables to demonstrate 60-year life, and resistance to radiation, flame and the environment. Demonstrate the testing methodology to assure such attributes are acceptable for the 60-year life.

8.3.4.4 Electrical Penetration Assemblies

Subsection 8.3.1.4.1.2. (7) specifies design requirements for electrical penetration assemblies. Provide fault current clearing-time curves of the electrical penetrations' primary and secondary current interrupting devices plotted against the thermal capability (I^2t) curve of the penetration (to maintain mechanical integrity). ~A11.01 |Provide an analysis showing proper coordination of these curves.| Also, provide a simplified one-line diagram showing the location of the protective devices in the penetration circuit, and indicate the maximum available fault current of the circuit.

Provide specific identification ~A11.02 |and location |of power supplies used to provide external control power for tripping primary and backup electrical penetration breakers (if utilized).

~A11.01 | Provide an analysis demonstrating the thermal capability of all electrical conductors within penetrations is perserved and protected by one of the following:

(1) Show that maximum available fault current (including failure of upstream devices) is less than the maximum continuous current capacity |~B11.01 |(Baseed on no damage to the penetration.) |~A11.01 |of the conductor within the penetration; or

(2) Show that redundant circuit protection devices are provided, and are adequately designed and set to interrupt current, in spite of single failure, at a value below the maximum continuous current capacity |~B11.01 |(Based on no damage to the penetration.) |~A11.01 |of the conductor within the penetration. Such devices must be located in separate panels or be separated by barriers and must be independent such that failure of one will not adversly affect the other. Furthermore, they must not be dependent on the same power supply.|

8.3.4.5 ~B |(deleted)|~B >#Analysis Testing for Spatial
Seperation per IEEE 384

~A >Items (4) and (5) in<Subsection 8.3.1.4.2.2.2 state~A |s |that ~A |all safety equipment or cable |~A >spatial separation in general plant<areas ~A |shall |~A >and in cable spreading areas<equal or exceed the ~A |requirements of |~A >minimum allowed by<IEEE 384. Identify any specific instances where this requirement is met by testing and analysis (as opposed to actual ~A |separation barriers|~A >distance<).<#

8.3.4.6 DC Voltage Analysis

Provide a DC voltage analysis showing battery terminal voltage and worst case DC load terminal voltage at each step of the Class 1E battery loading profile. (See Subsection 8.3.2.1)

Provide the manufactuer's ampere-hour rating of the batteries at the two hour rate and at the eight hour rate, and provide the one minute ampere rating of the batteries (see Subsection 8.3.2.1.3.2).

8.3.4.7 ~B |(deleted|~B >#Seismic Qualification of Eyewash
Equipment

Subsection 8.3.2.1.3 specifies that an emergency eyewash shall be located in each battery room. Provide assurance that the eyewash and associated piping are seismically qualified, and that the eyewash is located such that water cannot splash on the battery.<#

8.3.4.8 ~B |(deleted)|~B >#Diesel Generator Load Table Changes

Tables 8.3-1 and 8.3-3 are generic. However, changes may be needed for specific<#

-B >#plant applications. Such changes, if any, shall be identified and addressed. (See Subsection 8.3.1.1.8.2)
<#

8.3.4.9 Offsite Power Supply Arrangement

Operating procedures shall require one of the three divisional buses of Figure 8.3-1 be fed by the alternate power source during normal operation; in order to prevent simultaneous deenergization of all divisional buses on the loss of only one of the offsite power supplies. -B1.000 |(See Section 8.2.3.1(4).)|

8.3.4.10 Diesel Generator Qualification Tests

The schedule for qualification testing of the diesel generators, and the subsequent results of those tests, must be provided. The tests shall be in accordance with IEEE 387 and Regulatory Guide 1.9. (See Susbsection 8.3.1.1.8.9)

8.3.4.11 -B |(deleted)|-B >#Defective Refurbished Circuit Breakers

NRC Bulliten No. 88-10 and NRC Information Notice No. 88-46 identify problems with defective refurbished circuit breakers. To ensure that refurbished circuit breakers shall not be used in safety related or non-safety related circuitry of the ABWR design, it is an interface requirement that new breakers be specified in the purchase specifications <#

8.3.4.12 Minimum Starting V-A |ol|-A >lo<tages for Class 1E Motors

Provide the minimum required starting voltages for Class 1E motors. Compare these minimum required voltages to the voltages that will be supplied at the motor terminals during the starting transient when operating on offsite power and when operating on the -C >e<diesel generators.
-A8.000 |
8.3.4.13 Identification and Justification of Associated Circuits

Prior to the implementation stage of the design, the only "associated circuits" (as defined by IEEE 384) known to exist in the ABWR Standard Plant design are |-B8.000 |for the FMCRD drive power feed taken from the division 1 6.9Kv safety-related bus (see Subsection 8.3.1.1.1). |-B8.000 <in the safety related lighting subsystems (see Subsection 9.5.3.2.2.1 and 9.5.3.2.3.1). <-A8.000 |In the implementation design, provide|-C | |-A8.000|1) assurance that this is still a true statement, or 2) specifically identifiy and justify any other such circuits in the ABWR SSAR; and show they meet the requirements of Regulatory Guide 1.75, position C.4.

|-A12.03 |8.3.4.14 Administrative Controls for Bus Grounding Circuit Breakers

Figure 8.3-1 shows bus grounding circuit breakers, which are intended to provide safety grounds during maintenance operations. Administrative controls shall be provided to keep these circuit breakers racked out (i.e., in the disconnect position) whenever corresponding buses are energized. Furthermore, annunciation shall be provided to alarm in the control room whenever the breakers are racked in for service.

|-A1?? |8.3.4.15 Testing of Thermal Overload Bypass Contacts for MOVs

As indicated in the response to 435.60, thermal overlaod protection for Class 1E MOVs is bypassed at all times except when the MOV is being tested. A means for testing the bypass function shall be implemented, in accordance with the requirements of Regulatory Guide 1.106. |-A3?? |
8.3.4.16 Emergency Operating Procedures for Station Blackout

Applicants refereing the ABWR Standard Plant should provide instructions in their plant Emergency Operating Procedures for operator actions during a postulated station blackout event. Specifically, if division 1 instrumentation is functioning properly, the redundant divisions II, III, and IV should be shut down in order to 1) reduce heat dissipation in the control room while HVAC is lost, and 2) conserve battery energy for additional SRV capacity, or other specific functions, as needed, throughout the event.

|-A21.01 |8.3.4.17 Common Industrial Standards Referenced in Purchase Specifications

In addition to the regulatory codes and standards required for licensing, purchase specifications shall contain a list of common industrail standards, as appropriate, for the assurance of quality manufacturing of both safety and non-safety related equipment. Such standards would include ANSI, ASTM, IEEE, NEMA, UL, etc.