GE Nuclear Energy

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

May 11, 1993

Docket No. STN 52-001

Chet Poslusny, Senior Project Manager
Standardization Project Directorate
Associate Directorate for Advanced Reactors
and License Renewal
Office of the Nuclear Reactor Regulation

Subject: Submittal Supporting Accelerated ABWR Review Schedule - **Chapter 8 Modifications**

Dear Chet:

Enclosed are SSAR markups to Chapter 8 material that resulted from the GE/NRC conference call on May 7, 1993.

Please send a copies of this transmittal to John Knox and Dale Thatcher.

Sincerely,

Jack Fox

Jack Fox
Advanced Reactor Programs

cc: Bob Strong (GE)
Norman Fletcher(DOE)

170040

JF93-147

D050

MARK-UP TEXT INSERTS

INSERT X (Needed to backup tech specs)**

The signals generated from high drywell pressure and low reactor vessel level are arranged in two-out-of-four logic combinations, and are utilized to sense the presence of a LOCA condition and subsequently start the diesel. These signals also initiate the emergency core cooling systems.

The loss of voltage condition and the degraded voltage condition are sensed by independent sets of three undervoltage relays (one on each phase of the 6.9 kV bus) which are configured such that two-out-of-three trip states will start the diesel generator. The primary side of each of the instrument potential transformers (PTs) is connected phase-to-phase (i.e., a "delta" configuration) such that a loss of a single phase will cause two of the three undervoltage relays to trip, thus satisfying the two-out-of-three logic. (For more information on the degraded voltage condition and associated time delays, etc., see Subsection (8) of 8.3.1.1.7.)

INSERT Y (NRC request to close new item 8.2.3.8-1 per 5-7-93 phone call)

Switching and lightning surge protection is provided by the station grounding and surge protection systems described in Appendix 8A, and by the independent feeds (i.e., normal and alternate preferred power circuits described in 8.2.1.2). Maximum and minimum voltage ranges are specified in 8.2.3(2) and transformers are designed per 8.2.1.2. Allowable frequency variation or stability limitations are addressed in 8.2.3. Surge and EMI protection for Class 1E systems, equipment and components is described in Appendix 7A. Protection for degraded voltage conditions is discussed in 8.3.1.1.7(8).

Unit synchronization will normally be through the main generator circuit breaker. A coincidental three-out-of-three logic scheme and synchro-check relays are used to prevent faulty synchronizations. Dual trip coils are provided on the main generator circuit breaker and control power is supplied from redundant load groups of the non-Class 1E onsite 125V DC power system.

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

There are three unit auxiliary transformers. Each transformer has 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-Class 1E buses and one Class 1E 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 (FOA) rating is 62.5 and 31.25/31.25Mva respectively. The normal loading of the six secondary windings of the 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 21.6Mva, which is about two thirds of its forced air/forced oil rating.

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 fed from 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 reserve auxiliary transformer provides 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-Class 1E buses and the other winding supplies reserve power to the three Class 1E buses. The combined load of the three Class 1E buses is equal to the oil/air the rating of the 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. The operational configurations are such that the FOA ratings of the reserve auxiliary transformer, or any unit auxiliary transformer, will not be exceeded under any operating mode (See 8.2.4.5).

The unit auxiliary transformers and the reserve auxiliary transformer are designed with sufficient capacity and capability to limit the voltage variation of the onsite power distribution system to plus or minus 10 percent of load rated voltage during all modes of steady state operation and a voltage dip of no more than 20 percent during motor starting.

The unit auxiliary transformers are designed and constructed to withstand the mechanical and thermal stresses produced by external short circuits. In

enters the reactor building on the Division II side of the reactor building. From there it continues on to the respective switchgear rooms in the reactor building.

Instrument and control cables associated with the normal preferred power distribution are separated [i.e., by 15.24 meters (50 feet), or by walls or floors] from the instrument and control cables associated with the alternate preferred power distribution; with exception of the circuits in the control room, and the interlock circuitry required to prevent paralleling of the two offsite sources. However, these circuits are electrically isolated and separated to the extent practical. The reserve auxiliary transformer power, instrument and control cables do not share raceways with any other cables. and are not routed together in the same raceway.

The instrumentation and control cables for the unit auxiliary transformers and the main generator circuit breaker may be routed in the raceways corresponding to the load group of their power source.

Feeder circuit breakers from the unit auxiliary and reserve auxiliary transformers to the medium voltage (6.9 kV) switchgear are interlocked to prevent paralleling the normal and alternate power sources. With exception of these interlocks, there are no electrical interconnections between the instrument and control circuits associated with the normal preferred circuits, and those of the alternate preferred circuits.

Class 1E rotating equipment, which could produce potential missile hazards, are not located in the same rooms as feeder circuits from the offsite to the Class 1E busses, unless protective barriers are installed to preclude possible interaction between offsite and onsite systems.

A combustion turbine generator (CTG) supplies standby power to the non-Class 1E buses which supply the non-Class 1E plant investment protection (PIP) 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. In addition, manually controlled breakers provide the capability of connecting the combustion turbine generator to any of the emergency buses if all other AC power sources are lost.

In this way, the CTG provides a second "offsite" power source to any Class 1E bus being fed from the reserve auxiliary transformer while the associated unit auxiliary transformer is out of service.

The combustion turbine generator (CTG) is located in the turbine building, and is shown on Figure 8.2-1, Sheet 2. The CTG standby power feed and instrument and control cables for the turbine building are routed directly to the switchgear rooms in the turbine building. The power feeders and instrument and control cables to the reactor building are routed adjacent to the alternate preferred feeds across the control and reactor buildings.

8.2.2 Analysis

In accordance with the NRC Standard Review Plan (NUREG 0800), Table 8-1 and Section 8.2, the offsite power distribution system 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;

Each circuit of the preferred power supply is designed to provide sufficient capacity and capability to power equipment required to ensure that: 1) Fuel design limits and design conditions of the reactor coolant pressure boundary will not be exceeded as a result of anticipated operational occurrences, and 2) In the event of plant design-basis accidents, the core will be cooled, and containment integrity and other vital functions will be maintained.

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 transmission system (via the main power transformer and 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 yard, the turbine building, control building and reactor building to their destinations in the emergency electrical rooms. Although these preferred power sources are non-Class 1E, such separation assures the physical independence requirements of GDC 17 are preserved.

The transformers are provided with separate oil collection pits and drains to a safe disposal area. Separation of offsite equipment is discussed in 8.2.1.3. The plant fire protection system is discussed in 9.5.1. Insert Y

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

All equipment can be tested, as necessary, to assure continued and safe operation of the plant. For equipment which cannot be tested during plant operation, the reliability will be such that testing can be performed during plant shutdown (for example, the main generator circuit breaker). See 8.2.4 for COL license information.

Isolated and non-segregated phase bus ducts provide access for inspection and maintenance. They also have provisions for excluding debris and fluids, and for draining condensates.

The ABWR is designed to provide testing and/or verification capability as described above, including the items identified in 8.2.4.1).

(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.

Appropriate plant operating procedures will be imposed whenever the Reserve Auxiliary Transformer or a Unit auxiliary transformer is out of service.

~~When a Unit Auxiliary Transformer is out of service such that only the alternate offsite source is available to the downstream Class 1E bus, appropriate plant operating procedures will be imposed unless all of the following conditions coexist:~~

~~(1) The combustion turbine generator (CTG) is available,~~

~~(2) The bus arrangement is aligned such that the CTG can serve as a backup 'offsite' power source to the affected Class 1E bus, and~~

~~(3) Both of the remaining Class 1E buses are functional and have access to both the normal and alternate offsite sources.~~

8.2.4.3 Offsite Power Systems Design Bases

Interface requirements for the COL applicant offsite power systems design bases are provided in Subsection 8.2.3.

8.2.4.4 Offsite Power Systems Scope Split

Interface requirements for the COL applicant pertaining to offsite power systems scope split are provided in Subsection 8.2.3.

8.2.4.5 Capacity of Auxiliary Transformers

Appropriate plant procedures shall be provided to assure FOA ratings of the reserve auxiliary transformer, or any unit auxiliary transformer, will not be exceeded under any operating mode (see 8.2.1.2).

8.2.5 Conceptual Design

The conceptual design consists of two separated offsite transmission lines and switching stations as described in 8.2.1.1, with interface requirements defined in 8.2.3.

8.2.6 References

(1) ANSI Std C37.06, Preferred Ratings and Related Capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

(2) ANSI Std C57.12.00, General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.

time that the available fault current at a bus exceeds the equipment rating.

7.0 Multi-Unit Considerations — The ABWR is a single unit design, therefore there is no sharing of preferred power supplies between units.

8.3 ONSITE POWER SYSTEMS

(See 8.3.3 for information generally applicable to all onsite power equipment.)

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 (6.9kV) switchgear. It is a three load group system with each load group consisting of a non-Class 1E and a Class 1E portion. The three load groups of the Class 1E power system (i.e., the three divisions) are independent of each other. The principal elements of the auxiliary ac electric power systems are shown on the single line diagrams (SLD) in Figures 8.3-1 through 8.3-3.

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.

Insert X

(Backs up Tech specs for redundant undervoltage D/G trip)

Standby power is provided to permanent non-Class 1E loads in all three load groups by a combustion turbine generator 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 COL license information

8.3.1.0 Non-Class 1E AC Power System

8.3.1.0.1 Non-Class 1E Medium Voltage Power Distribution System

The non-Class 1E 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

the normal over-current tripping of these load breakers, Class 1E zone selective interlocking is provided between them and the upstream Class 1E bus feed breakers.

If fault current flows in the non-Class 1E load, it is sensed by the Class 1E current device for the load breaker and a trip blocking signal is sent to the upstream Class 1E feed breakers. This blocking lasts for about 75 milliseconds. This allows the load 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 breakers are free to trip. For fault currents of lesser magnitude, the blocking delay will time out without either bus feeder or load breakers tripping, but the load breaker will eventually trip and always before the upstream feeder breaker. This order of tripping is assured by the coordination between the 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.

Power is supplied to each FMCRD load group from either the Division I Class 1E bus or the non-Class 1E PIP bus through a pair of interlocked transfer switches located between the power sources and the 6.9kV/480v transformer feeding the FMCRD MCC. These transfer switches are classified as Class 1E associated, and are treated as Class 1E. Switch-over to the non-Class 1E PIP bus source is automatic on loss of power from the Class 1E diesel bus source. Switching back to the Class 1E diesel bus power is by manual action only.

The design minimizes the probability of a single failure affecting more than one FMCRD group by providing three independent Class 1E feeds (one for each group) directly from the Division I Class 1E 6.9 kV bus (see sheet 3 of Figure 8.3-1).

The Class 1E load breakers in conjunction with the zone selective interlocking feature (which is also Class 1E), provide the needed isolation between the Class 1E bus and the non-Class 1E loads. The feeder circuits on the upstream side of the Class 1E load breakers are Class 1E. The FMCRD circuits on the load side of the Class 1E load breakers down to and including the transfer switches are Class 1E Associated. Control power for the transfer switches is provided from Division I. The feeder circuits from the non-Class 1E PIP bus to the transfer switch, and circuits downstream of the transfer switch, are non-Class 1E.

Non-Class 1E loads being supplied from a Class 1E bus exists only in Division I, as described above for the FMCRD's. Non-Class 1E loads are not permitted on Divisions II or III. This prevents any possibility of interconnection between Class 1E divisions.

8.3.1.1.2 **Low Voltage Class 1E Power Distribution System**

8.3.1.1.2.1 **Power Centers**

(7) an output power monitor which monitors the 120 Vac power from the CVCF power supply to its output power distribution cabinet. If the voltage or frequency of the ac power gets out of its design range, the power monitor trips and interrupts the power supply to the distribution cabinet. The purpose of the power monitor is to protect the scram solenoids from voltage levels and frequencies which could result in their damage.

Backs up tech specs for EPA

(8) In addition, an external electrical protection assembly (EPA) is provided as which performs similar function as the monitor described in (7) above (see Figure 8.3-3, sheet 1).

8.3.1.1.4.2.3 Operating Configuration

The four 120 Vac Class 1E power supplies operate independently, providing four divisions of CVCF power supplies for the SSLC which facilitate the two-out-of-four logic. The normal lineup for each division is through an Class 1E 480 Vac power supply, the ac/dc rectifier, the inverter and the static transfer switch. 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 solenoids for the MSIVs are powered from the Division I CVCF; and the #2 solenoids, 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.

(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. See Subsection 8.3.4.12 for COL license information.

(2) Power sources, distribution systems and branch circuits are designed to maintain voltage and frequency within acceptable limits. A capacity and voltage drop analysis will be performed in accordance with IEEE 141 to assure that power sources and distribution equipment will be capable of transmitting sufficient energy to start and operate all required loads for all plant conditions.

(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 medium voltage Class 1E switchgear is selected to accommodate the available short-circuit current at the switchgear terminals. Circuit breaker and applications are in

conditions, the only protective devices which shut down the diesel are the generator differential relays, and the engine over-speed trip. These protection devices are retained under accident conditions to protect against possible, significant damage. Other protective relays, such as loss of excitation, anti-motoring (reverse power), over-current 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, and during periodic tests. The relays are automatically isolated from the tripping circuits during LOCA conditions. However, all of these bypassed parameters are annunciated in the main control room (see Subsection 8.3.1.1.8.5). The bypasses are testable, meet all IEEE 603 requirements, and are manually reset as required by Position 7 of Reg. Guide 1.9. No trips are bypassed during LOPP or testing. See Subsection 8.3.4.22 for COL license information.

Synchronizing interlocks are provided to prevent incorrect synchronization whenever the diesel generator is required to operate in parallel with the preferred power supply (see Section 5.1.4.2 of IEEE 741). Such interlocks are capable of being tested, and shall be periodically tested per 8.3.4.23).

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 (≤70% bus voltage) or degraded voltage 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 Class 1E equipment is designed to sustain operation for this 3-second period without damage to the equipment. 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, a bus transfer is initiated and the signal will trip the supply breaker, and start the diesel generator. When the bus voltage decays to 30%, large pump motor breakers are tripped. The transfer then 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, following the tripping of the large motors ~~(i.e., when voltage decays to 30%)~~. This accomplishes 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 equipment 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 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 regardless 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, the diesel-generator breaker is automatically tripped. 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. If the bus voltage increases to 110% of its rated value, the over-voltage will be annunciated in the control room. When the bus voltage degrades to 90% or below of its rated value and after a time delay (to prevent triggering by transients), under-voltage will be annunciated in the control room. Simultaneously, a protective relay timer is started to allow the operator to take corrective action. The timer settings are based on the system load analysis* such that the respective feeder breaker trips before any of the Class 1E loads experience degraded conditions exceeding those for which the equipment is qualified. This assures such loads will restart when the diesel generator assumes the degraded bus and sequences its loads. If the bus voltage recovers within the time delay period, the protective timer will reset. Should a LOCA occur during the time delay, the feeder breaker with the under-voltage will be tripped instantly.

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 COL license information.

8.3.1.2 Analysis

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~~ Power Systems for Nuclear Power Plants

Fuses cannot be periodically tested to verified setpoints, and are exempt from such requirements per Section 4.1.7 of IEEE 741.

Section 5.2 of IEEE 308 is addressed for the ABWR as follows:

Those portions of the Class 1E power system that are required to support safety systems in the performance of their safety functions meet the requirements of IEEE 603. In addition, those other normal components, equipment, and systems (that is, overload devices, protective relaying, etc.) within the Class 1E power system that have no direct safety function and are only provided to increase the availability or reliability of the Class 1E power system meet those requirements of IEEE 603 which assure that those components, equipment, and systems do not degrade the Class 1E power system below an acceptable level. However, such elements are not required to meet

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

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

Fuses cannot be periodically tested to verified setpoints, and are exempt from such requirements per Section 4.1.7 of IEEE 741.

(k) RG 1.155 - Station Blackout

(See Appendix 1C)

(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 8.1.4.1)

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

This policy issue states that "...an alternate power source be provided to a sufficient string of non-safety loads so that forced circulation could be maintained, and the operator would have available to him the complement of non-safety equipment that would most facilitate his ability to bring the plant to a stable shutdown condition, following a loss of the normal power supply and plant trip." (Quote from EPRI Evolutionary SER, Section 4.2.1, Page 11.4-4, May 1992.)

The ABWR reserve auxiliary transformer has the same rating as the three unit auxiliary transformers, and therefore can assume the full load of any one unit auxiliary transformer (see 8.2.1.2). The interconnection capability for the ABWR is such that any plant loads can be manually connected to receive power from any of the six sources (i.e., the two switchyards, the combustion turbine, and the three diesel generators). Administrative controls are provided to prevent paralleling of sources

(see 8.3.4.15). The ABWR therefore exceeds the requirements of the policy issue.

(5) Other Criteria

(a) IEEE 741 - "Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations"

The ABWR fully meets the requirements of this standard

8.3.2 DC Power Systems

8.3.2.1 Description

8.3.2.1.1 General Systems

A DC power system is provided for switchgear control, control power, instrumentation, critical motors and emergency lighting in control rooms, switchgear rooms and fuel handling areas. Four independent Class 1E 125 Vdc divisions, three independent non-Class 1E 125 Vdc load groups and one non-Class 1E 250 Vdc computer and motor power supply are provided. See Figures 8.3-4 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.

All batteries are sized so that required loads will not exceed warranted capacity at end-of-installed-life with 100 percent design demand.

The capacity of each of the four redundant Class 1E battery chargers is based on the largest combined demands of the various continuous steady-state loads, plus charging capacity to restore the battery from the design minimum charge state to the fully charged state within 12 hours (per technical specifications), regardless of the status of the plant during which these demands occur (see 8.3.4.35).

8.3.2.1.1.1 Class 1E 125 Vdc System

The 125 Vdc system provides a reliable control and switching power source for the Class 1E systems.

Each 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 discharged 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.

The batteries are installed in accordance with industry recommended practice as defined in IEEE 484, and meet the recommendations of Section 5 of IEEE 946 (see 8.3.4.32).

In accordance with this standards, each of the four Class 1E 125-volt batteries:

1) is capable of starting and operating its required steady state and transient loads,

ABWR is designed in accordance with all 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. 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

Fuses cannot be periodically tested to verified setpoints, and are exempt from such requirements per Section 4.1.7 of IEEE 741.

(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

The DC emergency standby lighting system circuits up to the lighting fixtures are Class 1E associated and are routed in seismic Category I raceways. However, the lighting fixtures themselves are not seismically qualified, but are seismically supported. This is acceptable to the Class 1E power supply because of over-current protective device coordination. The cables and circuits from the power source to the lighting fixtures are Class 1E associated. The bulbs cannot be seismically qualified. This is why the circuits are Class 1E associated. The bulbs can only fail open and therefore do not represent a hazard to the Class 1E power sources.

Besides the emergency lighting circuits, any other associated circuits added beyond the certified design must be specifically identified and justified. 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.

(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 overload protection devices in force during normal

plant operation but the overloads are bypassed under accident conditions per Regulatory Position 1.(b) of the guide. These overload bypasses meet the requirements of IEEE 603, and are capable of being periodically tested (see 8.3.4.24).

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

(h) RG 1.128 - Installation Designs and Installation of Large Lead Storage Batteries for Nuclear Power Plants

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

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

Fuses cannot be periodically tested to verified setpoints, and are exempt from such requirements per Section 4.1.7 of IEEE 741.

(k) RG 1.155 - Station Blackout

(See Appendix 1C)

The Class 1E DC power system is designed in accordance with the listed Regulatory Guides. It is designed with sufficient capacity, independence and redundancy to assure that the required 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.

(3) Branch Technical Positions (BTPs):

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.

(5) Other Criteria

(a) IEEE 946 "Recommended Practice for the Design of Safety-Related DC Auxiliary Power Systems for Nuclear Power Generating Stations"

(b) IEEE 741 "Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations"

(c) IEEE 485 "Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations"

The ABWR fully meets the requirements of ~~this~~ these standards.

8.3.3 General Onsite Power System Information

The NRC Standard Review Plan (SRP) format identifies sections 8.3.1 and 8.3.2 as ac and dc power systems, respectively. However, some information is applicable to both ac and dc systems. This information is presented in this section in order to avoid the need for repetition in sections 8.3.1 and 8.3.2.

8.3.3.1 Physical Separation and Independence

All cables are supported in raceways (i.e., tray, conduit, or wireways). 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 Class 1E or associated cables of different safety divisions or between Class 1E or associated cables and non-Class 1E cables if the vertical separation distance is less than 1.5 meters (five feet), the horizontal separation distance is less than 0.9 meters (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 and must be separated by at least 2.54 cm (1 inch.).

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 protective actions (that is, the initiation of a signal with the sense and command features, or the operation of equipment within the execute features, for the purpose of accomplishing a safety function) of each redundant load group is electrically independent of the protective actions provided by redundant load groups. Cross talk between divisions to facilitate the two-out-of-four logic for the Safety System Logic and Control (SSLC) is accomplished by fiber-optic medium.

The Class 1E divisional ac switchgear, power centers, battery rooms and dc distribution panels and MCCs are located to provide separation and electrical

isolation devices (i.e., fiber optic medium) 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 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) 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 2.54 cm (1 inch) from the conduit of any other scram group, and from metal enclosed raceways which contain either divisional or non-Class 1E (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 by 0.9 m (3 ft.) horizontal, or 1.5 m (5 ft.) vertical, or with an additional barrier separated by 2.5 cm (1 inch).

That is   from any raceway

(7) Any scram group conduit may be routed alongside of any cable or raceway containing either Class 1E circuits (of any division), or any cable or raceway containing non-Class 1E circuits, as long as the conduit itself is not within the boundary of any raceway ~~which contains~~ either the divisional or the non-Class 1E circuits and is physically separated from said cables and raceway boundaries as stated in (6) above. 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 2.5 cm (one inch) 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.

(7) Containment penetrations are so arranged that no design basis event can disable cabling in more than one division. Penetrations do 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 a Class 1E isolation device. The output circuit from this isolation device is classified as non-divisional.

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

8.3.3.7 Electrical Penetration Assemblies

When the vendor-unique characteristics of the penetrations are known, the following will be provided:

1) 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, along with an analysis showing proper coordination of these curves;

2) a simplified one-line diagram showing the location of the protective devices in the penetration circuit, with indication of the maximum available fault current of the circuit;

3) specific identification and location of power supplies used to provide external control power for tripping primary and backup electrical penetration breakers (if utilized);

4) an analysis demonstrating the thermal capability of all ~~electrical conductors within~~ penetrations is preserved and protected by one of the following:

   a) The maximum available fault current (including single-failure of an upstream device) is less than the maximum continuous current capacity of the ~~(based on no damage to the penetration) of the conductor within the~~ penetration; or

   b) 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 ~~(based on no damage to the penetration)~~ 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 adversely affect the other. Furthermore, they must not be dependent on the same power supply.

The functional operation of ~~C~~current-limiting devices designed to protect the penetrations shall be periodically ~~tested~~ verified (see 8.3.4.4).

8.3.3.8 Fire Protection of Cable Systems

systems provided should assure that a fire of this magnitude does not occur, however.

Maximum separation of equipment is provided through location of redundant equipment in separate fire areas. The Class 1E divisional AC unit substations, motor control centers, and DC distribution panels are located to provide separation and electrical isolation between the divisions. Clear access to and from the main switchgear rooms is also provided. Cable chases are ventilated and smoke removal capability is provided. Local instrument panels and racks are separated by safety division and located to facilitate required separation of cabling.

8.3.3.8.3 Fire Detection and Protection Systems

All areas 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. The foam sprinkler systems are dry pipe systems with pre-action valves which are actuated by compensated rate of heat rise and ultraviolet flame detectors. Individual sprinkler heads are opened by their thermal links.

8.3.4 COL License Information

8.3.4.1 Interrupting Capacity of Electrical Distribution Equipment

The interrupting capacity of the switchgear and circuit interrupting devices must be shown by the COL applicant to be compatible with the magnitude of the available fault current based on final selection of the transformer impedance, etc. (See Subsection 8.3.1.1.5(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 20 seconds after the signal to start. The COL applicant will 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 8.3.3.8.1 requires certified proof tests on cables to demonstrate 60-year life, and resistance to radiation, flame and the environment. The COL applicant will demonstrate the testing methodology to assure such attributes are acceptable for the 60-year life.

8.3.4.4 Current-Limiting Devices for Electrical Penetration Assemblies

(or analysis if testing is not practical) and calibration

Appropriate plant procedures shall include periodic testing of protective and/or current limiting devices (except fuses) to demonstrate their functional capability to perform their required safety functions.

Which will be inspected

8.3.4.5 (Deleted)