GE Nuclear Energy

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

March 31, 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 - **DFSER Chapter 8 Responses**

Dear Chet:

Enclosed are the following attachments that address all of the DFSER Chapter 8 outstanding items:

Attachment 1 - Identifies each DFSER item, has the text of the NRC's March 10, 1993 letter on the left, and GE responses on the right. These responses provide the answers and direct the reviewer to the SSAR text or to the road map of Attachment 2.

Attachment 2 - A road map containing only the new additions and changes from the February 9, 1993 submittal. This attachment responds directly to DFSER text bullet.

Attachment 3 - Complete markup of all page changes associated with the review of Chapter 8. This includes Chapters 1,3,7 and 9 in addition to 8.

Attachment 4 - Typed version of the Chapter 8 text which incorporates all the changes from the markup.

Please provide a copy of this transmittal to John Knox.

Sincerely,

Jack Fox

Jack Fox
Advanced Reactor Programs

See attached distribution

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

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JF93-71

ATTACHMENT 1

DFSER CHAPTER 8 ISSUES & GE RESPONSES
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ITEM NUMBER	TYPE	REF	NRC SUMMARY REPORT	GE RESPONSE
8.2.1.3.1-1	OPEN	N1	8.2.1.3.1-1 New Item Interface Discussion GE indicated that Section 8.2.3 will be renamed as Interface Requirements and #s 1-16 will be included. #17 will be a COL Information Section included in 8.2.4. In addition, Section 8.2.5 will be renamed as Conceptual Design. This was acceptable to the staff.	Changes have been marked as agreed.
8.2.1.3.1-2	OPEN	N2	8.2.1.3-1-2. Conceptual Design. The staff indicated that a separate titled section is needed on the conceptual design for the offsite power system. GE agreed to provide additional description of the design with a cross reference to the interface requirements section. This was acceptable to the staff.	Section 8.2.5 (page 8.2-5.1) was changed to "Conceptual Design", and was rewritten, as agreed at the February meetings.
8.2.2.2-1	CONF	15	8.2.2.2-1 Isolation of I&C circuits Staff needs a discussion of the design of interlock interconnections. GE needs to explain why the interlocks do not violate the required independence and why it is acceptable. GE indicated that the circuits will be electrically isolated and separated to the extent practical. The staff indicated that a SSAR change to this effect would be acceptable.	The first sentence of the fifth paragraph of 8.2.1.3, page 8.2-2.1, was marked as follows: "...with exception of the circuits in the control room, and the interlock circuitry..." The second sentence (i.e., "Separation of I&C cable...etc.") was deleted, and replaced with the following: "However, these circuits are electrically isolated and separated to the extent practical."
8.2.2.3-1	CONF	16	8.2.2.3-1 Electrical independence This was tentatively resolved based on 8.2.2.2-1 above.	Page 8.2-2.1 was marked as agreed (i.e., same resolution is reference 15).
8.2.2.4-1	CONF	17	8.2.2.4-1 Testability requirements The staff did not approve of the use of the word "facilitate" and	1st Paragraph: The last sentence of 8.2.2.1(3), page 8.2-3.1, was modified as

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			recommended the use of "capability" for testing. GE proposed the revision of the wording. The staff was concerned that not all tests can be done at full power, and that GE has not specified all exceptions. GE agreed to revise its commitment and clarify the testiability and when it will be conducted to not adversely affect safe operation of the plant. In addition, a requirement for reliability will be added for equipment which will not be tested during power operation. The staff indicated that this would be acceptable.	follows: "The ABWR is designed to provide testing and/or verification capability as described above, including the items identified in 8.2.4.1." [Note 8.2.4.1 was formerly 8.2.3(17).] 2nd Paragraph: The first two paragraphs of 8.2.2.1(3) were replaced with the following: "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."
8.2.2.4-1	COL	17	8.2.2.4.1 Procedures for inspection and maintainence The staff indicated that GE needs to revise items listed in the DFSER to address the scope of inspection and maintenance of item (h) of 8.2.3 of the SSAR to include terminals and insulators. GE agreed to do this.	This portion of 8.2.3 has been moved to 8.2.4 per new open item 8.2.1.3.1-1 (reference N1). The new markup sentence added to item (h) [now item (8)], page 8.2-5, states: "Also, terminals and insulators shall be inspected, cleaned and tightened, as necessary."
8.2.2.5-1	COL	18	8.2.2.5-1 Procedures for generator breaker requirements The staff requested that GE revise paragraph (g) to clarify the intent of the testing of the generator breaker. GE agreed to do such.	Page 8.2-5, item (g) [now item (7) of Section 8.2.4] was modified per agreement at February meetings, as follows: "The generator breaker can open on demand. (Note: The breaker's actual opening and closing mechanisms are inherently confirmed during the shutdown and synchronizing processes. Trip circuits shall be periodically verified during shutdown periods while the breaker is open.)"
8.2.2.6-1	CONF	19	8.2.2.6-1 Capability/capacity of offsite power	1st Paragraph:

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			This confirmatory item required that GE include a set of commitments listed in the DFSER as bullets. All GE SSAR markups were found to be acceptable prior to the meeting with exception of the items which were discussed below.	(Introductory comment only - action implicated in successive paragraphs only.)
			Low voltage analysis did not appear to the staff as a COL item. GE indicated that this analysis will be an ITAAC item and that it would include a discussion of the methodology in the SSAR. In addition, GE committed to providing a reference to the IEEE Standard 141, Red Book, Chapter 3. This was acceptable to the staff.	2nd Paragraph: Item 8.3.4.31 was deleted, and the commitment for a load analysis per Chapter 3 of IEEE 141, and also IEEE's 242 and 399, was added as a footnote to 8.3.1.1.7(8), page 8.3-8.1, as follows: "A complete load analysis shall be performed in accordance with Chapter 3 of IEEE 141, and IEEE's 242 and 399, for the power distribution system to demonstrate proper sizing of power source and distribution equipment. Such analysis shall provide the basis for the degraded voltage protective relay timer settings and other protective relay settings."
			The staff indicated that GE neglected to address the DFSER bullet concerning normal and alternative circuits being subjected to steady-state and transient conditions. The staff stated that it would reconsider and reevaluate this item, and it remained unresolved. [UPDATE: Per telephone call March 25, 1993, the staff indicated this item was consolidated into New Item 8.2.3.8-1, and faxed GE a copy.]	3rd Paragraph: This item should be resolved. See New Item 8.2.3.8-1 for GE response.
			The bullet related to performance and operating characteristics of normal and alternate preferred power circuits to meet operability and design-basis requirements including short circuits, equipment capacity, voltage and frequency transient response was not addressed in the recent Chapter 8 markup. GE indicated the items listed in the bullet could be addressed by the set of analyses methodologies to be included in the SSAR in a future markup. This remained unresolved.	4th Paragraph: GE's notes and understanding from the February meetings apparently did not agree with those of the staff on this issue. Our records show this issue was resolved based on the action GE took per "2nd Paragraph" above, i.e., the commitment for non-COL analysis per IEEE's 141, 242, and 399. The staff should consider this issue closed per that action. [Update: a phone discussion with the staff on March 26 confirmed the issue is confirmatory, and should close pending review of this submittal.]

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8.2.2.6-1	COL	19	8.2.2.6-1 Capability and capacity of offsite power Operational restrictions for the reserve auxiliary transformer needed to be revised. GE indicated that when the reserve auxiliary is out of service restrictions would be imposed on the length of operation in this mode. The staff indicated that GE should add a statement to the SSAR and GE agreed to do so . Restrictions will apply whenever the normal and alternate offsite sources are not available to a Class 1E division. GE would need to indicate how the configuration would be established, and include a COL action item to establish the procedure to configure the power sources and a means to address station blackout. This was acceptable to the staff. Operational restrictions on the reserve auxiliary transformer supplying the non-class 1E load groups should prohibit the secondary winding from supplying loads greater than the winding oil/air rating. The staff indicated that GE should provide a clarification in the SSAR about the capacity limits on the reserve auxiliary transformer and that all preconcieved abnormal allowed configurations should be included in the design discussions. GE committed to adding the information to the SSAR. Regarding the separation bullet, GE indicated that alternate configurations do not violate separation requirements. The staff indicated that this is part of the design and no action is required. The staff will revise the DFSER. GE agreed to address the remaining bullets in a revised SSAR submittal.	1st Paragraph: The following was added to the COL License Information section (Page 8.2-5), as agreed at the February meetings: "8.2.4.2 Plant Procedures when a Reserve or Unit Auxiliary Transformer is Out of Service Appropriate plant operating procedures will be imposed whenever the Reserve 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." 2nd Paragraph: Recall that at the February meetings, GE argued that transformers should be allowed to operate within their FOA ratings without restrictions. Following some discussion, it was agreed the following sentence would be added to Section 8.2.1.2 (as now marked on page 8.2-2 of attached): "The operational configurations are such that the FOA ratings of the reserve auxiliary transformer, or any unit auxiliary transformers, will not be exceeded under any operating mode."

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				3rd Paragraph: (NRC action to revise the DFSER.) 4th Paragraph: All of the bullets of DFSER Section 8.2.2.6 were addressed per the "Roadmap" document submitted to the staff prior to the February meetings. The first set of bullets were addressed under "8.2.2.6-1 CONF" beginning on page 4 of the Roadmap. The second set of bullets were addressed under "8.2.2.6-1 COL" beginning on page 2 of the Roadmap. The disposition of each bullet was addressed in the "GE COMMENTS" column. Therefore, there are no "remaining bullets" except the two conclusion bullets at the end of both the confirmatory and COL segments, which state "Specified acceptable fuel design limits..." and "The core will be cooled,...". Since these latter two bullets are general statements of the NRC's conclusion "based on these above considerations," (i.e., all the other bullets already addressed), in comparison with the GDC's, it is apparent they were intended only for the SER. We therefore do not understand the staff notation that "GE agreed to address the remaining bullets..." unless this refers to the resolution actions already addressed per the above paragraphs.
8.2.3.2-1	CONF	24	8.2.3.2-1 Degraded offsite voltage The staff reviewed the recent GE submittal and stated that GE needs to add a statement about voltage less than 70% voltage. GE proposed a change to the SSAR to indicate that the Class 1E equipment is qualified to sustain operation for 3 seconds at 70% voltage without damage. This is acceptable to the staff.	The following statement was added to 8.3.1.1.7, page 8.3-7.1: "The Class 1E equipment is qualified to sustain operation for this 3-second period without damage to the equipment."
8.2.3.3-1	CONF	25	8.2.3.3-1 Automatic switch from test to operating The staff wanted the control logic for switchover from parallel to normal operation to have the capacity to be periodically	The following sentence was added to 8.3.1.1.8.8, page 8.3-10: "These interlocks are designed to be testable, and are periodically tested (see 8.3.4.21)."

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			tested reflected in the SSAR. GE agreed to add a statement to the SSAR section 8.3.1.1.8.8 to reflect this capability. This was acceptable to the staff.	
8.2.3.3-1	COL	25	8.2.3.3-1 Periodic testing of interlock design GE committed to add a COL action item to require procedures to perform the periodic testing of the interlocks in section 8.3.4.21. This was acceptable to the staff.	The following sentence was inserted in 8.3.4.21, page 8.3-23.4 per the agreement: "Interlocks which restore the units to emergency standby on event of a LOCA or LOPP shall also be tested."
8.2.3.3-4	CONF	28	Although considered closed per the February meetings, the staff made a subsequent phone call (3-23-93) to request "capability of being tested" for the synchronizing interlocks for the diesel generators.	The last sentence of 8.3.1.1.6.4, page 8.3-7, has been modified to: "Such interlocks are capable of being tested, and shall be periodically tested (see Subsection 8.3.4.23)."
8.2.3.8-1	NEW	N3	This section addresses, in part, the staff's evaluation of GE's response to DSER (SECY-91-355, Open Item 26 and DFSER (SECY-92-349) Confirmatory Item 8.2.2.6-1 and Open Item 8.2.2.6-1. During their operation, normal and alternate preferred power circuits can be subjected to the transmission system's steady-state and transient conditions (such as switching and lightning surges, maximum and minimum voltage ranges for heavy and light load conditions, frequency variation, or stability limits). Provisions will be included in the design of the offsite system to minimize the probability of losing electric power from any of the remaining sources as a result of these conditions. The Class 1E systems, equipment, and components will be appropriately protected such that Class 1E systems, equipment, and components will not be subject to these conditions if these conditions are beyond the limits for which the Class 1E systems, equipment, and components are designed. This is New Item 8.2.3.8-1. During February 23 to 25, 1993 meeting discussions, the staff	Switching and lightning surge protection is provided by the station grounding and surge protection systems described in Appendix 8A, and by the redundant 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. The SSAR therefore supports the criteria indicated by this bullet.

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			indicated that they would reconsider and reevaluate this item.	
8.2.4-1	COL	32	8.2.4-1 Operating procedures for offsite preferred power circuits GE provided a markup of the SSAR which was acceptable.	For the record, the subject sentence (the last sentence of 8.3.4.9, page 8.3-23.3) now states: "Continued plant operation will be appropriately limited when the reserve auxiliary transformer is inoperable (see 8.2.4 for COL information)."
8.3-1	CONF	33	Although considered closed per the February meetings, the staff made a subsequent phone call (3-23-93) to request the transfer switches identified in 8.3.1.1.1, page 8.3-3, be designated as "Class 1E Associated" per our February meeting agreements.	GE responded during the call, that this was being done already in association with the March markup submittal. The specific addition was made in association with DFSER confirmatory item 8.3.3.6-1 (Ref. 69 CONF). The last paragraph on page 8.3-3 has been modified as follows: "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 6.9 kV/480V transformer feeding the FMCRD MCC. These transfer switches are classified as Class 1E associated, and are treated as Class 1E." For clarification, the following sentence was added at the end of the third-to-last paragraph of 8.3.3.6-1 (top of page 8.3-4): "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 diesel generator backed 6.9 kV bus (see sheet 3 of Figure 8.3-1)."
8.3.1.1-1	CONF	35	8.3.1.1-1 Compliance with IEEE standards GE needs to commit IEEE standards 741 and 946. GE has reviewed the standards and would be able to commit to them completely. In addition the URD has committed to these standards. The staff	The ABWR commitment to fully meet IEEE's 741 and 946 was added to the SSAR per the mark-ups at 8.3.1.2, page 8.3-12 (insert E); and 8.3.2.2.2, page 8.3-23.1 (insert F).

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			indicated that a discussion of the standards in the text of Chapter 8 would be acceptable in a SSAR amendment.	
8.3.1.2-1	CONF	36	8.3.1.2-1 Protection requirement of GDC 2 and 4 The staff committed to review the recent markup of the SSAR to determine if GE has clarified the number of divisions needed to maintain the plant in a safe shutdown condition.	GE believes all such statements have been revised. NRC action to confirm, as stated.
8.3.2.1-1	CONF	37	8.3.2.1-1 Open tray separation The staff indicated that the use of barrier is not consistent with other committments in the SSAR. It was suggested that GE better define the separation and what the barrier would be. GE wanted to allow for non-1E cables maintained in open raceways and agreed to provide the change in a markup. This was acceptable to the staff.	The agreed markup has been made per the indicated reference. The last part of the last sentence of 8.3.3.6.2.3.1 (6) [formerly 8.3.1.4.2.3.1 (6), page 8.3-18] is now written: "...shall be separated from non-enclosed raceways associated with any of the four electrical divisions or non-divisional cables by .9 m (3 ft) horizontal, or 1.5 m (5 ft) vertical, or with an additional barrier separated by 2.5 cm (1 inch)."
8.3.2.2-1	CONF	38	Although considered closed per the February meetings, the staff made a subsequent phone call (3-23-93) to request the separation of NMS cables be clarified, as was done for the RPS scram groups.	NMS cables are not "separated" in the same sense as the RPS cable groupings in that with RPS, redundant divisions are involved. With the NMS, the unique handling of cables is within the same division for EMI purposes. GE suggested an addition of the reason for separateness (so as not be be confused with redundant divisional separation), and the NRC agreed. Therefore, the first sentence of the fifth paragraph of 8.3.3.5.1.3 (formerly 8.3.1.3.1.3, page 8.3-14) was modified as follows: "For EMI protection, neutron-monitoring cables are run in their own dedicated divisional conduits and cable trays."
8.3.2.3-1	CONF	39	Although considered closed per the February meetings, the staff made a subsequent phone call (3-23-93) to request clarification as to why dc lighting circuits do not share raceways with other circuits [see 9.5.3.1.1(7)(d), page 9.5-3.3]. This was in conjunction with ref. 38 CONF above.	The reference paragraph (d) was modified to: "To enhance lighting reliability, emergency dc lighting circuits shall not share raceways with any other circuits."

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8.3.2.4-1	CONF	40	Although considered closed per the February meetings, the staff made a subsequent phone call (3-23-93) to request a sentence, which appeared in Amendment 21 and was missed in subsequent amendments, be reinstated.	The sentence appeared at the end of the first paragraph of 8.3.1.4.1.2(7), page 8.3-15, and has been reinstated in the new section 8.3.3.6.1.2(7) as follows: "Grouping of circuits in penetration assemblies follows the same raceway voltage groupings as described in Subsection 8.3.3.6.1." (Note that the reference "8.3.1.4.1" has been changed to "8.3.3.6.1" consistent with where the same information is now found in the latest text.)
8.3.2.5-1	CONF	59	8.3.2.5-1 Separation of cables outside panels The staff indicated that cables inside panels need to be supported. GE stated that the SSAR would be amended to discuss support. This was acceptable to the staff.	The first sentence of the new section 8.3.3.1 (formerly 8.3.1.1.5.1, page 8.3-5) was rewritten as follows: "All cables are supported in raceways (i.e., tray, conduit, or wireways)."
8.3.2.6-1	CONF	60	8.3.2.6-1 Separation of cables inside panels The staff indicated that power cables need to be installed in a barrier separating them from I&C cables in accordance with IEEE 384. GE stated that the 120V control cable and power cables could be included in the same raceway and that the RG or IEEE does not specify this requirement. GE proposed that a statement be added in the SSAR to guarantee separation of power cables from any low-power I&C cabling or appropriate barriers. This was acceptable to the staff.	In accordance with the agreements at the February meetings, the new sentence added at the end of 8.3.3.6.1.1 (4) [formerly 8.3.1.4.1.1 (4), page 8.3-15] is: "For EMI considerations, power cables are routed in metallic conduit wherever they come in close proximity with the low level (V1) cables."
8.3.2.7-1	CONF	61	8.3.2.7-1 Separation of cables enter/exit cabinet This will be resolved based on resolution of 8.3.2.6-1. UPDATE: Per phone call 3/29/93, Knox reopened the issue requested bullets 2-6, and 8-11 to be identified in SSAR, Section 8.3.1.4.	All bullets have been addressed in new additions to roadmap (signified by "***") attached.

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8.3.2.8-1	CONF	62	8.3.2.8-1 Physical separation of equipment The staff indicated the need for a committment for a 3-hour fire barrier and missile barrier for everything up to the power distribution panels. The staff has reviewed the writeup in Appendix 9A and found the following inconsistencies. Section 9A.5 conflicts Chapter 8 statement that all Class 1E busses, distribution systems and power and control systems are located in seismic Category I buildings. GE agreed to list the exceptions listed in 9a.5.5 in Chapter in Section 8.1.3.1.1.1. GE committed to verifying if additional cross references to exceptions are needed in Chapter 7 and adding additional information to the SSAR, if required. This was acceptable to the staff. Section 9A.5.5.1 indicates that there are multiple divisions of scram solenoid fuse panels in the same fire areas. GE committed to clarifying the discussion in the section to add a statement that the panels are in seperate fire areas. GE agreed to provide a statement in section 8.3.1.4.2.2.2 indicating that the 3-hour fire barrier will be maintained from the power source up through the distribution panels. Exceptions for the loads are provided in 9A.5 This was acceptable to the staff. The staff provided a markup of 9A.5 to GE indicating sections which are inconsistent with other sections of the SSAR.	2nd Paragraph: The second-to-last sentence in 8.1.3.1.1.1 (page 8.1-3) has been modified, per the February meeting agreements, as follows: "This equipment is housed in Seismic Category I structures except for some control sensors associated with the Reactor Protection System (see 9A.5.5.1), and the Leak Detection System (see 9A.5.5.7)." Cross references to these sections were also added to 7.2.2.2.4(4) and 7.3.2.2.2(1), respectively, as shown in attached markups. 3rd Paragraph: The following sentence was added in the second paragraph of 9A.5.5.1, page 9A.5-1, per attached markup: "The Div. I rooms are located in separate fire zones from the Div. II rooms, which zones are separated by 3-hour fire barriers." The following clarification was added in the end of the first paragraph of 8.3.3.6.2.2.2 [formerly 8.3.1.4.2.2.2, page 8.3-17]: "The electrical equipment from the Class 1E power suppies to the distribution centers are separated by 3-hour fire barriers. Beyond the distribution centers, the exceptional cases where it is not possible to install such barriers have been analyzed and justified in Appendix 9A.5." 4th Paragraph:

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				(The consistency check was committed by end of April by Mo Nik-Ahd.)
8.3.3.1-1	CONF	64	8.3.3.1-1 Protection of electrical penetrations The staff expected a committment to bullets for protection of electrical penetrations in the design description. In addition, a committment to testing of fuses was also expected. GE indicated that additional information will be added to the SSAR to address the fuse testing and inspection. This was acceptable to the staff.	Most of the information formerly in section 8.3.4.4 has been moved from this "COL License Information" section to the main text under a new section 8.3.3.7 (see attached). However, the original paragraph (3) remained in 8.3.4.4, page 8.3-23.2, (which was newly titled "Testing of current-Limiting Devices for Electrical Penetration Assemblies"), but was modified to include fuse inspection as follows: "Appropriate plant procedures shall include periodic testing of protective and/or current limiting devices (except fuses, which will be inspected), to demonstrate their functional capability to perform their required safety functions."
8.3.3.1-1	COL	64	8.3.3.1-1 Periodic test of protective, current limiting devices The COL item was addressed in the confirmatory item 8.3.3.1-1 above.	(Addressed in 8.3.3.1-1 CONF.)
8.3.3.2-1	CONF	65	8.3.3.2-1 Protection of electrical equipment from design-basis events (DBEs) GE indicated that it would modify the SSAR to include a reference to IEEE 323-1974 for all electrical equipment. GE committed to address the bullets in the DFSER by including them in the SSAR. - - - - - - - - - - - - - - - These bullets are as follows: The staff understands that each type of Class 1E equipment will be:	In accordance with the agreements at the February meetings, the first sentence in 3.11.2 (page 3.11-1.1) has been changed as follows: "All safety-related electrical equipment is qualified by test or other methods as described in IEEE 323 and permitted by 10CFR50.49(f) (Reference 1)." 1st Bullet: This bullet is supported in 8.3.3.4 and 3.11.2 (first paragraph as modified per the above).

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			* qualified by analysis, successful use under similar conditions, or by actual test to demonstrate its ability to perform its function under normal and design basis event environmental and operational conditions, * designed and qualified to survive the combined effects of temperature, humidity, radiation, and other conditions related with a LOCA or other design-basis event environment at the end of their qualified and/or design life, * qualified to IEEE 344-1987, "Recommended Practices for Seismic Qualifications of Class 1E Equiment for Nuclear Power Generating Stations," * qualified by test and/or analyzed to demonstrate its ability to meet its performance requirements during and following the design-basis seismic event, * located in seismic Category I structures, * seismically supported, * designed and qualified to operate within allowable design basis limits or variations of voltage, frequency, and waveform in the Class 1E power systems during any mode of plant operation (for example, able to operate for a predetermined time when subject to voltage below 90 percent, to operate for a predetermined time when voltage is below 70 percent, to operate continuously when subjected to voltage variations of +/- 10 percent of nominal, or to operate at voltages between 100 to 140 volts at the dc system's 125-volt distribution panels.	2nd Bullet: This bullet was added as "Insert G" at the end of the first paragraph of 3.11.2 (page 3.11-2). 3rd Bullet: This bullet is committed by the last sentence of 8.1.3.1.1.1 (page 8.1-3), which references 3.10 which also commits to IEEE 344. 4th Bullet: This bullet is supported by the first paragraph of 3.10.2 (page 3.10-2). 5th and 6th Bullets: These bullets are supported by the last paragraph in 8.1.3.1.1.1 (page 8.1-3), and by 3.10.3 and its subsections (beginning on page 3.10-5). Note, also, the modification per confirmatory item 8.3.2.8-1 (Reference # 62 CONF.). 7th Bullet: The ac portion of the bullet is supported by the last paragraph of 8.3.1.1.7(8), page 8.3-8.1. The dc portion is supported by the third paragraph of 8.3.2.1.3.1, page 8.3-21.
8.3.3.3-1	CONF	66	8.3.3.3-1 Seismic qualification of light bulbs	1st Paragraph:

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			The staff indicated that GE still needs to show how the non-seismic fixture will not affect the Class 1E circuits. GE indicated that the breaker protection will protect the circuits in the design and this information would be included in the SSAR. This was acceptable to the staff. The staff stated that it still has a problem with light bulbs not being seismically qualified. The staff will verify if this subject has been covered by the RG 1.29 review. This item remained open.	The following sentence was added in three places following the mention of fixtures being seismically supported: "This is acceptable to the Class 1E power supply because of overcurrent protective device coordination." The three places referenced are 8.3.2.2.2(2)(e) (page 8.3-23), 9.5.3.2.2.1 (page 9.5-3.5), and 9.5.3.2.3.1 (page 9.5-3.6). 2nd Paragraph: Per the phone discussion with the staff on march 26, 1993, the staff agreed the bulbs are not required to be seismically qualified, but GE needs to add a commitment for protection of personnel due to shattering glass, etc. Therefore, the following sentence has been added to the end of 9.5.3.1.1(3), page 9.5-3: "Light fixtures in safety areas are seismically supported, and are designed with appropriate grids or diffusers, such that broken material will be contained and will not become a hazard to personnel or safety equipment during or following a seismic event."
8.3.3.4-1	CONF	67	8.3.3.4-1 Submergence of electrical equipment The staff indicated that GE should list the fact that temperature monitoring cabling and their terminations in the supression pool are qualified to be submerged. GE agreed to add this fact in the SSAR. This was acceptable to the staff.	The first sentence of subsection (6) of 8.3.3.6.2.3.2 [was 8.3.1.4.2.3.2(6), page 8.3-19] has been split into two sentences as follows: "Class 1E electrical equipment located in the suppre ion pool level swell zone is limited to suppression pool [illegible] ature monitors and their feeder cables. The terminations [illegible] sealed such that operation would not be impaired by submer [illegible] due to pool swell or LOCA."

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8.3.3.5-1	OPEN	68	8.3.3.5-1 Redundant class 1E systems (environments) The staff indicated that in Table 9A.5.2 there is a list of reactor building special cases with redundant equipment or circuits in the same fire area. Electrical codes are listed to provide separation guidance. Some circuits list N/A under applicable codes which do not indicate the basis for protection of the equipment or circuits. GE indicated that the scram solonoids are addressed in 9A.5. That was acceptable to the staff. For other examples, GE provided an explanation for clarification and no revision to the SSAR was required. The staff questioned the protection of the power supply to the remote shutdown panel from a fire in the main control room. GE indicated that in SSAR section 7.4.1.4.4, it states that all necessary power supply circuits are manually transferred to other sources after a control room short circuit. The discussion of the SLCS in 9A.5 indicates that the SLCS will be lost in one fire. There is not discussion on the protection of the Class 1E electrical systems. GE agreed to modify the writeup to address this issue and do similar for the flammability control system, SGTS, among others to discuss the required protection of Class 1E power supplies. This was acceptable to the staff. The staff indicated that SPLB and SICB should also review the section. This becomes an interim confirmatory item based on the above items.	1st Paragraph: The statement in 7.4.1.4.4 (page 7.4-7.1 attached) has been marked up as follows: "Control of all necessary power supply circuits is also transferred to the remote shutdown system." 2nd Paragraph: (Mo Nik-Ahd agreed to provide the 9A.5 modifications by end of April.)
8.3.3.6-1	CONF	69	8.3.3.6-1 Associated circuits design information The staff indicated that GE had not included DFSER bullets in its SSAR markup clearly. GE indicated that it would include the DFSER bullets in a SSAR revision and would identify lighting as the only associated circuits with exceptions noted and justified. This was acceptable to the staff.	1st Paragraph: Bullets 1a, 1b and 2 (as identified at left) have been added as a single paragraph to replace the second-to-last paragraph in section 8.3.3.1 (formerly 8.3.1.1.5.1, page 8.3-6). With regard to the 3rd bullet, GE has taken the position that no separation should be required between onsite circuits that are

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[The DFSER bullets mentioned above are:

1a) Associated Class 1E will remain with or be physically separated in the same manner as those Class 1E circuits with which they are associated; OR

1b) Associated Class 1E circuits will remain with or be physically separated in the same manner as those Class 1E circuits with which they are associated, from the Class 1E equipment to and including an isolation device.

2) Associated Class 1E circuits (including their isolation devices or their connected safety or non-safety system loads without isolation devices) will be subject to all requirments placed on Class 1E circuits.

3) Non-Class 1E circuits that are powered from a Class 1E division and are considered isolated through isolation devices described in IEEE 384 (such as fuses, breakers, and power packs) shall be physically and electrically independent of non-Class 1E circuits that are powered through a IEEE 384 isolation device from a different Class 1E division.]

In addition, GE indicated that it would provide a further description of how it meets IEEE 384 relating to the FMCRD circuits. GE still is seeking credit for the zone selective interlock, but the staff has problems with this. GE indicated that it would describe the zone selective interlocks as Class 1E in the SSAR. The staff was concerned that the zone selective interlock transfer switches should be Class 1E to protect the Class 1E from parallel operation, but they are not. GE indicated that they would classify the transfer switches as associated 1E, and the loads downsteam of the switches and feeds from non-1E as non-Class 1E. This would be acceptable to the staff to cover the final aspect of this item.

purely non-Class 1E. To this end, GE modified the design so that only Division I has a non-Class 1E load, namely, the FMCRD drive motors. Therefore, this bullet would present an inconsistency to the SSAR. Non-Class 1E loads are simply not allowed for Divisions II and III. This emphasis has been added in the new last paragraph of 8.3.1.1.1, page 8.3-4 (insert N).

Note 1 of 8.3.3.5.1 (page 49 of typed draft) (formerly 8.3.1.3.1, page 8.3-13) and the last paragraph of 8.3.2.2.2(2)(e), page 8.3-23 have been modified to identify the emergency lighting circuits as the only per-certification associated circuits. The subject paragraphs also require any other associated circuit additions (i.e., post-certification) to be specifically identified and justified.

2nd Paragraph:

The last two paragraphs of 8.3.1.1.1, page 8.3-4 (insert N), have been modified as follows:

"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. The feeder circuits from the non-Class 1E PIP bus to the transfer switch, and circuits [illegible]stream 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."

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8.3.3.8-1	CONF	43	8.3.3.8-1 Overload protection of Class 1E MOVs The staff indicated that it needed a statement that the bypass circuitry for the overloads needs to be addressed for testability and meeting the positions of IEEE 603. GE indicated that it would modify the SSAR to include this information.	The following sentence was added as "insert H" in 8.3.1.2(2)(g), page 8.3-11; and 8.3.2.2.2(2)(f), page 8.3-23: "These overload bypasses meet the requirements of IEEE 603, and are capable of being periodically tested (see 8.3.4.24)." References to both places was also added to the COL License Information section 8.3.4.24, page 8.3-23.4.
8.3.3.10-1	CONF	71	8.3.3.10-1 Periodic testing of protective relaying A discussion concerning the need to clarify the meeting of the requirements of IEEE 603 was held. The staff wanted the identification of Class 1E equipment not performing a safety function. GE indicated that this could not be done until the final design has been completed. GE needs to discuss the areas where they cannot meet IEEE 603 and committed to provide a general discussion of cases where the design will not meet IEEE 603. GE indicated that the commitment to the standard IEEE 308 Paragraph 5.2 will be provided in the SSAR.	As discussed in the February meetings, all except the first paragraph of 8.3.1.2(2)(c), page 8.3-10.1, has been replaced with the following paraphrase of IEEE 308, Section 5.2 (see insert I): "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 criteria as defined in IEEE 603 for: operating bypass, maintenance bypass, and bypass indication."
8.3.3.13-1	CONF	47	8.3.3.13-1 Fire protection of cable systems The staff had expected additional detailed information about separation in accordance with IEEE 384. GE committed to adding a reference to the specific 3-feet, 5-feet separation included in another section of the SSAR (8.3.1.1.5.1). This was acceptable	The third sentence of the second paragraph of 8.3.3.8.2 (formerly 8.3.3.2, page 8.3-23.1) which said "IEEE Std 384 and Regulatory Guide 1.75 are always complied with, however" has been deleted and replaced with the following: "However, separation requirements of 8.3.3.1 are complied with."

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			to the staff.	(Note that 8.3.3.1 was formerly 8.3.1.1.5.1. The reason for this move was to create a more generic section applicable to both ac and dc systemr)
8.3.3.14-1	OPEN	72	8.3.3.14-1 RPS scram and MSIV solenoid valves The staff indicated that the internal protection (EPA) needs to be added to the text discussion to be consistent with the corresponding drawing in the SSAR. GE committed to adding a paragraph to specify the internal protection characteristics. This was acceptable to the staff.	As discussed in the February meetings, the following subsection was added to 8.3.1.1.4.2.2, page 8.3-5 (insert J): "(8) In addition, an external electrical protection assembly (EPA) is provided which performs similar function as the monitor described in (7) above (see Figure 8.3-3, Sheet 1)."
8.3.3.16-1	CONF	73	8.3.3.16-1 Control access to Class 1E power equipment GE committed to adding a statement that Class 1E equipment will have provisions for access control as specified in the DFSER. This is acceptable to the staff.	As agreed in the February meetings, the following subsection was added at the end of 8.3.3.6.1.1 (see page 52 of typed draft) (formerly 8.3.1.4.1.1, page 8.3-15): "(5) Class 1E power system power supplies and distribution equipment (including diesel generators, batteries, battery chargers, CVCF power supplies, 6.9 kV switchgear, 480-volt load centers, and 480-volt motor control centers) are located in areas with access doors that are administratively controlled. In addition, ac and dc distribution panels are located in the same or similar areas as Class 1E power supplies and distribution equipment, or the distribution panels are designed to be locked, so that access to circuit breakers located inside such panels can be administratively controlled. The physical design of the ABWR permits the administrative control of access to Class 1E power equipment areas (see Section 13.6.3)."
8.3.4-1	CONF	74	8.3.4-1 Electrical independence The staff had expected DFSER design commitment bullets to be included in the SSAR markup. Both GE and the staff will review the the SSAR to identify where each bullet is included.	All bullets have been addressed in new additions to roadmap (a. indicated by "***").

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8.3.4-1	COL	74	8.3.4-1 Electrical independence GE indicated that key interlocks to insure that two breakers are always open would be provided along with administrative controls over the use of keys would be a COL action item as specified in the SSAR markup. The staff found this to be acceptable.	The staff agreed, in the February meetings, that the referenced section addition in the draft submittal (sent to the staff previous to the meetings) closed this issue.
8.3.4.1-1	CONF	50a	8.3.4.1-1 Interconnection between redundant divisions GE indicated that the SSAR provides information in the SSAR that addresses the interlocks in 8.3.2.1.3.1, and the staff found it acceptable.	The information provided in the second paragraph of 8.3.2.1.3.1, page 8.3-21, of the February draft SSAR was deemed acceptable by the staff. However, per staff request per phone call 3-25-93, the words "...kept normally open..." were added into the last sentence. (See also, typed draft page 42.)
8.3.4.1-1	COL	50b	8.3.4.1-1 Administrative control of interlock keys This item was resolved in item 8.3.4-1.	This item is resolved, ar indicated by the staff.
8.3.4.4-1	CONF	53	8.3.4.4-1 Transfer of leads between redundant divisions The staff determined that the design implies that the design has one non-1E lead tied to the Class 1E division. This was acceptable to the staff as marked up in the SSAR.	This issue is resolved per the Staff notes.
8.3.4.4-2	CONF	75	8.3.4.4-2 Isolation between safety bus & non-safety lead This item was tentatively closed based on the discussion in 8.3.3.6-1.	This item should be closed contingent on closure of ref 8.3.3.6.1 (69 CONF).
8.3.4.4-1	COL	75	8.3.4.4-1 Periodic calibration of fault interrupt coordination GE agreed to provide a discussion of the periodic testing requirements for protective and/or current limiting devices. This was acceptable to the staff.	The staff agreed this was resolved based on 8.3.4.29, page 8.3-23.4.
8.3.5-1	CONF	54	8.3.5-1 Lighting systems	Item 1:

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			The staff still believed this was unresolved and committed to review the basis for this finding. [UPDATE: The staff faxed a copy of DFSER Section 8.3.5 to GE on March 25, 1993. The following action items were identified therein: 1. The fixture and bulb will be designed and qualified such that they will not fail in a manner that might possibly cause other safety-related systems to fail, and will not become a hazard to personnel or safety equipment during or following a seismic event. 2. The guide lamp units will be supplied ac power from the same power source that supplies the standby lighting system in the area in which they are located. The guide lamp light system will be seismically qualified and will meet Class 1E requirements in plant areas containing Class 1E equipment. 3. Clarify that lighting circuits (including panels, etc.) are "Class 1E associated". The ac and dc lighting sections describe panels as being "Class 1E." 4. Normal, standby, emergency, and guide lamp lighting systems installed in essential areas and in passageways leading to and from these areas will be tested periodically. 5. Light bulbs will be replaced when their expected design life has been exceeded. 6. GE needs to address the adequacy of 50% lighting for all essential areas and not just the control room.	The following commitment has been added to the end of 9.5.3.1.1(3), page 9.5-3 (insert V): "Light fixtures in safety areas are seismically supported, and are designed with appropriate grids or diffusers, such that broken material will be contained and will not become a hazard to personnel or safety equipment during or following a seismic event." Item 2: Per agreement with the staff on a March 25 telephone call, the second-to-last sentence in the first paragraph of 9.5.3.2.4, page 9.5-3.6, has been modified as follows: "The power supply ac source is fed from the standby lighting system in the same area." Also, the last sentence in this subsection has been clarified as follows: "The self-contained emergency lighting sets are Class 1E qualified in safety-related areas." Item 3: Per agreement with the staff on a March 25 telephone call, the last sentence of the second paragraph of 9.5.3.2.2.1, page 9.5-3.5, was deleted; and the first sentence of the next paragraph was modified as follows: "The lighting circuits are Class 1E Associated."

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				Similarly, the third sentence of the second paragraph of 9.5.3.2.3.1, page 9.5-3.6, was deleted; and the next sentence was modified to: "The circuits are classified as Class 1E Associated." Items 4 and 5: (These items are addressed in 8.3.5-1 COL below.) Item 6: The illumination levels for all essential areas of the plant are addressed in Tables 9.5-1 through 9.5-4. These levels correspond with those of the IES Lighting Handbook, and with the Utility Requirments Document (URD) for Advanced Light Water Reactors. SSAR Tables 9.5-1 through 9.5-4 were compared with URD Table 11.8-1. It was noted that both the 100% and 50% lighting levels in the SSAR are within the acceptable ranges given in the URD for all essential areas. This was to be expected since both documents base lighting levels on the IES Standard. The lighting levels are, therefore, adequate even when one of the power sources is lost (i.e., the 50% level).
8.3.5-1	COL	54	8.3.5-1 Periodic testing and replacement of light bulbs The staff indicated that the COL needs to have a program to replace inspect and replace light bulbs. GE disagreed with this requirement. It remained unresolved.	GE objected to a staff proposal to replace light bulbs based on their expected life, and therefore prior to their failure. GE believed this would necessitate some kind of system for tracking individual service hours for each and every light bulb. Per telephone conversation with the staff on March 25, 1993, the staff agreed to an inspection program and GE agreed to add the following sentence just after the first sentence in 9.5.3.3, page 9.5-3.7:

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				"However, periodic inspection and bulb replacement shall be performed (see 8.3.4.25)." GE had added COL License Information item 8.3.4.25 (page 8.3-23.4) in the February draft, which states: "Appropriate plant procedures shall include periodic inspections of all lighting systems installed in safety-related areas, and in passageways leading to and from these areas. In addition, lighting systems installed in such areas which are normally de-energized (e.g., guide lamps) shall be periodically tested."
8.3.5-1	OPEN	76	8.3.5-1 Lighting system under design-basis accident (DBA) The staff indicated that GE needs to address lighting requirements for all essential areas and not just the control room. Further, the staff needs to address the battery pack lighting illumination after a seismic event. GE indicated that the illumination is 7 ft. candles for the battery pack. Other lighting information is included in Table 9.5-1-9.5-4. This item will be evaluated by the staff in the human factors area.	GE considers this closed except for human factors elements to be determined by the staff. At the February meetings, the staff indicated they required "no action at this time" from GE.
8.3.6.2-1	CONF	77	8.3.6.2-1 Control of electrical design bases This will be evaluated by the staff after the final certified SSAR submittal is received.	This issue involves a complete consistency check of Chapter 8. Resolution is pending on the final submittal.
8.3.7-1	OPEN	79	8.3.7-1 Reliability of systems GE indicated that safety equipment will not be taken out of service for testing during operation. GE needs to add a statement to address the reliability of the components when determining testing periodicity similar to the discussion being added to the offsite system testing. This was acceptable to the staff.	In accordance with the February meeting negotiations, the following statements were added to the SSAR as indicated: In 8.2.2.1(3), page 8.2-3.1: "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

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				testing can be performed during plant shutdown (for example, the main generator circuit breaker). See 8.2.4 for COL License Information." In 8.3.3.2 (formerly 8.3.1.1.5.3, page 8.3-7): (A similar statement was added, but the examples in this case were "safety relief valves and certain isolation valves.")
8.3.8.2-1	CONF	81	8.3.8.2-1 Capacity of 1E 125 volt dc battery The staff indicated that the DFSER bullets would need to be added to the SSAR, but GE had not added all of them. The bullets need to be reviewed to determine where they are addressed. The staff indicated that 1-4, 6-10 and 13 had not been addressed. GE indicated that it would review the bullets to determine where they were included and would add the ones which have not been included to the SSAR. - [The bullets identified above are as follows: The staff understands that each of the four Class 1E 125-volt batteries will: 1) be capable of starting and operating its required steady state and transient loads, 2) be immediately available during both normal operations and following loss of power from the alternating current systems, 3) have sufficient stored energy to provide an adequate source of power for starting and operating all required LOCA and/or LOPP loads and circuit breakers for two hours with no ac power, 4) have sufficient stored energy to provide power in excess of the capacity of the battery charger when needed for transients,	The following has been added at the end of 8.3.2.1.1.1, page 8.3-20 (insert O): "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, 2) is immediately available during both normal operations and following loss of power from the alternating current systems, 3) has sufficient stored energy to provide an adequate source of power for starting and operating all required LOCA and/or LOPP loads and circuit breakers for two hours with no ac power, 4) has sufficient stored energy to provide power in excess of the capacity of the battery charger when needed for transients, 6) has a capacity design margin of 5 to 15 percent to allow for less than optimum operating conditions, 7) has a 25-percent capacity design margin to compensate for battery aging, 8) has a 4-percent capacity design margin to allow for the lowest expected electrolyte temperature of 21C (70F),

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			6) have a capacity design margin of 5 to 15 percent to allow for less than optimum operating conditions, 7) have a 25-percent capacity design margin to compensate for battery aging, 8) have a 4-percent capacity design margin to allow for the lowest expected electrolyte temperature of 21C (70F), 9) have a number of battery cells that matches the battery-to-system voltage limitations, 10) base the first minute of the batteries' duty cycle on the sum of all momentary, continuous, and noncontinuous loads that can be expected to operate during the one minute following a LOCA and/or LOPP, 13) be designed so that each battery's capacity can periodically be verified.]	9) has a number of battery cells that correctly matches the battery-to-system voltage limitations, 10) bases the first minute of the batteries' duty cycle on the sum of all momentary, continuous, and noncontinuous loads that can be expected to operate during the one minute following a LOCA and/or LOPP, 13) is designed so that each battery's capacity can periodically be verified."]
8.3.8.4-1	CONF	82	8.3.8.4-1 Class 1E ac standby dc power The staff indicated that local manual start without load sequence capability had not been included in the SSAR. GE indicated that this information would be added to the SSAR. This was acceptable to the staff. Regarding air starts, the staff indicated that the capability for four air starts will be available without recharging the air tanks was not adequately addressed in the SSAR. An agreement was made to the rewording to be included in the SSAR which was acceptable to the staff.	1st Paragraph: The following paragraph was inserted between the two paragraphs of 8.3.1.1.8.6, page 8.3-10 (insert P): "When the diesel is started from the local control station, the engine will attain rated voltage and frequency, then remain on standby without load sequencing (i.e., the generator breaker will remain open)." 2nd Paragraph: This new sentence replaces the first sentence of the third paragraph of 9.5.6.2, page 9.5-6 (insert Q):

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				"To avoid depleting air start capability, following unsuccessful automatic starting of the diesel generator with and without ac external power, each diesel generator's air receiver tanks will have sufficient air remaining for three more successful starts without recharging." Note a difference from the precise sentence agreed at the meetings, which said "...without ac or dc external power...". This change is consistent with a prior understanding with the staff that automatic starts of the diesel are not required without the use of external dc power (i.e., the station Class 1E batteries are always assumed to be available).
8.3.8.4-1	COL	82	8.3.8.4-1 Procedures for testing of DG The staff indicated that all the DFSER bullets for tests had not been included in the SSAR. GE indicated that it would revise the discussion in section 8.3.4.36 to clarify the reference back to section 8.3.1.1.8.2. This was acceptable to the staff.	8.3.4.36, page 8.3-23.5, has been re-written as follows: "Appropriate plant procedures shall include periodic testing and/or analysis of Class 1E diesel generators (see 8.3.1.1.8.2), and to demonstrate their capability to supply the actual full design basis load current for each sequenced load step."
8.3.8.5-1	CONF	83	8.3.8.5-1 Constant voltage/frequency supply capacity The staff indicated that the testability requirement had not been included in the SSAR. GE indicated that it would add the statement about the capability to test the capacity of the CVCF. This was acceptable.	The following sentence was added at the end of the second paragraph of 8.3.1.1.4.2.1, page 8.3-4.1: "The design also provides capability for being tested for adequate capacity (see 8.3.4.34)."
8.3.8.6-1	CONF	84	8.3.8.6-1 Battery charger The staff indicated that GE should indicate the time for return to full charge for minimum charge should be included in the SSAR. GE indicated that they would provide the design basis number for the recharging time. This was acceptable to the staff.	The subject portion of the third paragraph of 8.3.2.1.1, page 8.3-20, has been changed from "...fully charged state within the time stated in the design basis...", to "...fully charged state within 12 hours (per technical specifications)...".
8.3.8.7-1	CONF	85	8.3.8.7-1 Distribution systems	The following sentence was added at the end of 8.3.1.1.5(2)

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			The staff wanted a statement concerning the capacity of each distribution system and the capability to be testable as a design committment. In addition, GE needs to generate a discussion of the distribution design capacity requirements. GE proposed revising section 8.3.1.1.5.2 discussion of the design basis to indicate that the capacity and voltage drop analyses will be performed in accordance with IEEE 141 to assure that power sources and distrubution systems will be capable of transmitting sufficient energy to start and operate all required loads for all plant conditions. GE also indicated that this type of discussion would be considered for addition to several places in the SSAR. This was acceptable to the staff. Regarding the testability of the systems, GE agreed to change the statement in 8.3.1.1.5.3 to replace sensing dev:ses with power supplies. This was acceptable to the staff.	[formerly 8.3.1.1.5.2(2), page 8.3-6, (insert R)]: "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." Also, the words "sensing devices" was changed to "power supplies" in the first sentence of 8.3.3.2 [formerly 8.3.1.1.5.3, page 8.3-7].
8.3.8.7-1	COL	85	8.3.8.7-1 Distribution system GE indicated that a statement in section 8.3.4.30 and 8.3.4.33 indicates that procedures would include periodic testing in accordance with IEEE 308. The staff found tnis acceptable.	Section 8.3.4.30, page 8.3-23.5, is acceptable as is, since it already has a reference to IEEE 308. However, that same reference needed to be added to section 8.3.4.33. The new section reads: "Appropriate plant procedures shall include periodic testing of Class 1E batteries in accordance with Section 7 of IEEE 308, to assure they have sufficient capacity and capability to supply power to their connected loads."
8.3.9.1-1	CONF	80	8.3.9.1-1 Reestablishing ac power The staff expected the DFSER design commitment bullets to be all addressed in the SSAR. GE was asked to clarify how they meet the SBO. They have submitted the CTG and the coping capibility in the design. The staff stated that it believes that the CTG is sufficient to meet the rule and the coping is not required. GE originally was not ready to discard the coping arguement until	Per phone conversation with staff 3/26/93, no GE action is required for this item, in that RG 1.155 assessments and other CTG information will be provided in conjunction with 8.3.9.3-1.

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			the reliability and availability requirements on the CTG in the TS are firmed up by the staff and may want to receive credit for both features. The staff committed to revise its finding to indicate credit for the CTG as an alternative ac source which meets the SBO rule requirements.	
8.3.9.2-1	CONF	86	8.3.9.2-1 Coping capability GE indicated that they may not meet the full requirements of RG 1.155 because the analysis cannot be done without final as-purchased equipment. The staff committed to have the final safety evaluation report (FSER) reflect its revised evaluation.	Per phone conversation with staff 3/26/93, no GE action is required for this item, in that RG 1.155 assessments and other CTG information will be provided in conjunction with 8.3.9.3-1.
8.3.9.3-1	CONF	87	8.3.9.3-1 Combustion turbine generator GE identified where the bullets included in the DFSER are in the SSAR. The staff indicated that the GE discussion needs to be revised to remove all discussions of the coping capability based on the staff approval of the CTG as the alternate ac source. GE needs to clean up the bullets to better meet RG 1.155. Further, the staff indicated that the following sections of RG 1.155: C, 3.3.5, 3.5, and Appendix A & B for the CTG. Specifically, for the CTG Bullet #5 regarding the time to place the CTG on line to feed one train of shutdown loads being less than one hour. GE agreed to provide additional description of the capacity and capibility to do the required functions less than one hour in section 9.5.11. In addition, GE agreed to provide a comprehensive description of how the SBO and RG 1.155 are met to address the electrical and plant systems aspects of the regulatory requirements. This was acceptable to the staff.	A computer word search on "cope" and "coping" was performed for Chapter 8 and Section 9.5.11. All such references were removed, as agreed, and as shown on the attached draft. A review of the bullets originally addressed in the Roadmap submitted in February revealed that changes were needed for the 1st, 5th, 7th, and 9th bullets. Those portions of the Roadmap which underwent changes are separately attached. Appendix 1C (to be added in the near future) specifically addresses the electrical and plant systems aspects of Regulatory Guide 1.155 with credit being taken for the CTG as an alternate ac (AAC) source. For the present time, the assessment of the CTG against section 3.3.5 of the Guide has been provided in the new Roadmap attachments. A new subsection (7) was added to 9.5.11.1, page 9.5-10.2 (insert 5), as follows: "(7) The bus tie arrangment, and the capacity and capability of the CTG, is designed such that the time to place the CTG on line to feed any one train of shutdown loads (i.e., includes manual connection to any one Class 1E bus) shall be within 10 minutes."

ATTACHMENT 2

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DFSER ITEM NUMBER	DFSER BULLET STATEMENT	SSAR REFERENCE	GE COMMENTS
8.2 2.6-1 COL**	Operational restrictions will prohibit the reserve auxiliary transformer from supplying more than one Class 1E load group during normal plant operation, when one of the three unit auxiliary transformers is out of service. (Note: The words of this bullet, as shown above, were modified as agreed by the NRC per the February meetings.)	(See GE Comment)	The following note was added to the end of Section 8.2.3, newly titled "Interface Requirements". (The new markup for the note appears as "insert D" on page 8.2-5.) 8.2.4.2 Plant Procedures when a Reserve or Unit Auxiliary Transformer is Out of Service Appropriate plant operating procedures will be imposed whenever the Reserve 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."
8.2.2.6-1 CONF**	Voltage levels at the low-voltage terminals of the auxiliary and reserve transformers will be analyzed to determine the maximum and minimum load conditions that are expected throughout the anticipated range of voltage variations of the offsite transmission system and the main generator. Separate analyses will be performed for each possible circuit configuration of the offsite power supply system.	8.3.1.1.7(8)	Item 8.3.4.31 was deleted, and the commitment for a load analysis per Chapter 8 of IEEE 141 was added as a footnote to 8.3.1.1.7(8), page 8.3-8.1.
8.2.3.8-1 CONF**	This section addresses, in part, the staff's evaluation of GE's response to DSER (SECY-91-355) Open Item 26 and DFSER (SECY-92-349) Confirmatory Item 8.2.2.6-1 and Open Item	(SEE GE COMMENT)	Switching and lightning surge protection is provided by the station grounding and surge protection systems described in Appendix 8A, and by the redundant feeds (i.e., normal

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	8.2.2.6-1. During their operation, normal and alternate preferred power circuits can be subjected to the transmission system's steady-state and transient conditions (such as switching and lightning surges, maximum and minimum voltage ranges for heavy and light load conditions, frequency variation, or stability limits). Provisions will be included in the design of the offsite system to minimize the probability of losing electric power from any of the remaining sources as a result of these conditions. The Class 1E systems, equipment, and components will be appropriately protected such that Class 1E systems, equipment, and components will not be subject to these conditions if these conditions are beyond the limits for which the Class 1E systems, equipment, and components are designed. This is New Item 8.2.3.8-1. During February 23 to 25, 1993 meeting discussions, the staff indicated that they would reconsider and reevaluate this item.		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. The SSAR therefore supports the criteria indicated by this bullet.
8.3.2.7-1 CONF**	Based on discussions the GE and information subsequently presented in Section 8.3.1.4 of SSAR Amendment 21, the staff understands that the following design commitments apply: I&C and optical cables (including metallic and fiber-optic cables will be treated the same with respect to separation and protection throughout the plant.	(OK) These references refer to typed draft unless otherwise indicated	The staff (John Knox) indicated this bullet was accounted for in the SSAR.
8.3.2.7-1 CONF**	Each division of Class 1E power, instrumentation, and control cable will be routed to the control room complex through a cable chase or other means, so that redundant division areas will be separated by a 3-hour fire-rated barrier.	8.3.3.8.2	Both of these bullets are backed by SSAR subsection 8.3.3.8.2 (last paragraph).

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	Each cable chase will be ventilated.		
8.3.2.7-1 CONF**	Separation between Class 1E and non-Class 1E cab. s within the cable chase will be the same as separation of cables located outside cabinets and panels as described in Section 8.3.2.5 of this report.	8.3.3.6.1.1(3)	The last sentence of 8.3.3.6.1.1(3) was modified as follows: "Class 1E and non-Class 1E cables are separated in accordance with IEEE 384 and R.G. 1.75, as explained in 8.3.3.1. This includes cables within cable chases."
8.3.2.7-1 CONF**	Class 1E, Class 1E associated, or non-Class 1E power circuits routed in a cable chase or the control room area will be limited to those required to operate systems, equipment, or components located in the control room area (power cables will not be permitted to traverse through from one side of the control room area to the other without being terminated in the control room area).	8.3.3.6.2.2.3(6)	The following new paragraph (6) was added to 8.3.3.6.2.2.3: "(6) Class 1E, Class 1E associated, or non-Class 1E power circuits routed in the control room area are limited to those required to operate systems, equipment, or components located in the control room area (power cables are not permitted to traverse through from one side of the control room area to the other without being terminated in the control room area)."
8.3.2.7-1 CONF**	Class 1E, Class 1E associated, or non-Class 1E power circuits routed in a cable chase or the control room area will be routed inside rigid or flexible conduits that will be physically separated horizontally and vertically by a minimum distance of 15.2 cm. (6 in.) or by steel barriers or additional enclosures from any I&C cables.	8.3.3.6.1.1(4)	In conjunction with another similar issue, the following statement was added as the last sentence of 8.3.3.6.1.1(4): "For EMI considerations, power cables are routed in metallic conduit wherever they come in close proximity with low level (V1) cables." The separation of power and I&C cables was considerably discussed at the February meetings, and the above statement was conceived and agreed upon to close this issue.
8.3.2.7-1 CONF**	Power cables may be routed in flexible metallic conduit under the raised floor of the control room.	8.3.3.6.1.1(4)	John Knox indicated this bullet is accounted for in the SSAR.
8.3.2.7-1 CONF**	Separation between redundant Class 1E and between Class 1E and non-Class 1E power, instrumentation, and control cables within the control room area	8.3.3.6.2.2.3	This bullet is backed by SSAR subsection 8.3.3.6.2.2.3.

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	will be separated in the same way as cables located outside cabinets and panels as described in Section 8.3.2.5 of this report.		
8.3.2.7-1 CONF**	Redundant Class 1E power, instrumentation, and control cables will enter cabinets or panels through separate apertures.	8.3.3.6.1.2(6)	The 2nd paragraph of 8.3.3.6.1.2(6) has been clarified as follows: "Redundant Class 1E circuits which m[illegible] enter a common panel, cabinet, et[illegible], enter through separated apertures and terminate on separated terminal blocks. Where redundant circuits unavoidably terminate on the same device, barriers are provided between the device terminations to ensure circuit separation, or approved isolators (generally optical) are used."
8.3.2.7-1 CONF**	Class 1E and non-Class 1E power, instrumentation, and control cables will enter cabinets or panels through separate apertures.	8.3.3.6.1.2(6)	A 3rd paragraph was added to 8.3.3.6.1.2(6) as follows: "Class 1E and non-Class 1E power, instrumentation, and control cables enter cabinets or panels through separate apertures."
8.3.2.7-1 CONF**	Cable chases and the control room area will be non-hazard areas (as defined in Section 6.1.3 of IEEE 384-1981).	8.3.3.6.2.2.3	The following paragraph was added at the beginning of 3.3.3.6.2.2.3: "The control room area and cable chases are considered non-hazard areas (as defined in Section 6.1.3 of IEEE 384). These areas do not contain potential hazards such as high energy switchgear, power distribution panels, transformers, or rotating equipment; nor are they exposed to potential sources of missiles, pipe failure hazards, or fire hazards."
8.3.2.7-1 CONF**	Cable chases and the control room area will not contain potential hazards such as high energy switchgear, power distribution panels, transformers, or rotating equipment; potential sources of missiles; pipe failure hazards, or fire hazards.	8.3.3.6.2.2.3	See response to previous bullet.

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8.3.4-1 CONF**	Based on discussions with GE and information included in SSAR Amendment 21, the staff has the following understandings with respect to electrical independence: 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 will be independent of the protective actions provided by redundant load groups.	8.3.3.1	The following paragraph was added to 8.3.3.1: "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."
8.3.4-1 CONF**	Each onsite Class 1E power supply (for example, the diesel generator or the constant voltage constant frequency power suppies) will have provisions for automatic connection to one Class 1E load group, but will have no automatic connection to any other redundant Class 1E or non-Class 1E (non-divisional) load group. If nonautomatic (manual) interconnecting means are furnished, provisions that prevent paralleling of the redundant onsite Class 1E power supplies will be included. - The ABWR electrical system design will not include provisions for the manual connection of the onsite Class 1E power supply of one Class 1E divisional load group to any other redundant Class 1E divisional or non-Class 1E non-divisional load group (except for the manual transfer of spare battery chargers between redundant divisions, the manual transfer of the fine motion control rod drive motors from a non-divisional to a divisional supply, and the manual connection of any one of the Class 1E diesel generators to any one of the Class 1E divisional load groups by backfeeding	(SEE GE COMMENT)	The "no automatic interconnection" provision of the diesels is stated in 8.3.1.1.8.1. Administrative controls to prevent paralleling Class 1E sources have been added per the following: "8.3.4.15 Administrative Controls for Manual Interconnections As indicated in 8.3.1.2(4)(b), the ABWR has capability for manually connecting any plant loads to receive power from any of the six sources. Appropriate plant operating procedures shall prevent paralleling of the redundant onsite Class 1E power supplies." The sub-bullets relating to the spare battery charger and associated key interlocks is backed by SSAR section 8.3.2.1.3. The following was added as the last paragraph of 8.3.1.1.1: "Non-Class 1E loads being supplied from a Class 1E bus exists only in Division 1, as described above for the FMCRD's. Non-Class 1E loads are not permitted on Divisions II or III.

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	power from the diesel generator through the combustion turbine bus). + The ABWR design will include provisions to allow one spare battery charger to be connected to either of two divisions and another spare battery charger to be connected to either of two other divisions. + The spare chargers for the dc power supply may be manually connected to either of two designated divisions, but only when their loads are switched to the same division. Key interlocks will mechanically ensure that these standby chargers can only be used in one division at a time. + The design for the manual transfer of load between the non-divisional power supply and the divisional power supply will be through interlocked breakers. - The ABWR electrical system design will not have interconnections between redundant Class 1E divisions except as noted in Sections 8.2.2.3 and 8.3.4.1 of this report. - The divisional battery charger will normally be fed from its assigned Class 1E divisional 480-volt motor control center bus.		This prevents any possibility of interconnection between Class 1E divisions." Subsection 8.3.2.1.3.1 supports the sub-bullet on battery chargers being fed from their assigned divisional 480-volt MCC bus.
8.3.4-1 CONF**	Each standby power system division includes the diesel generator, its auxiliary systems, and the distribution of power to various Class 1E loads through the 6.9 kV and 480 volt systems. Each of these divisions will be segregated and separated from the other divisions. No automatic interconnection will be provided between the Class 1E divisions. Each diesel generator set will operate independently of the other sets.	8.3.1.1.8.1	This bullet is backed by SSAR subsection 8.3.1.1.8.1.
8.3.4-1 CONF**	Control power (for the Class 1E	8.3.1.1.2.1	See last paragraph of 8.3.1.1.2.1.

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	480-volt auxiliaries) will be from the Class 1E 125-volt dc power system of the same division.		
8.3.4-1 CONF**	Each Class 1E dc system load group will have its own battery charger with no provision for automatic interconnection with other redundant Class 1E load groups.	8.3.2.1.3.1	This bullet is backed by SSAR subsection 8.3.2.1.3.1.
8.3.4-1 CONF**	There will be no provision for automatically interconecting redundant Class 1E dc system load groups.	8.3.2.1.3.1	This bullet is backed by SSAR subsection 8.3.2.1.3.1.
8.3.4-1 CONF**	No provision will be made for automatically transferring loads between Class 1E dc power sources.	8.3.2.1.3.1	This bullet is backed by SSAR subsection 8.3.2.1.3.1.
8.3.4-1 CONF**	The ABWR design will not have manual interconnections between redundant Class 1E divisions of the dc system except those that involve the battery chargers.	8.3.2.1.3.1	The following sentence was added at the end of the first paragraph in 8.3.2.1.3.1: "Also, there are no manual interconnections between dc divisions except those involving the standby battery chargers, as described below."
8.3.4-1 CONF**	Each Class 1E battery will be independent of the other redundant battery.	(SEE GE COMMENT)	This bullet is backed by SSAR subsections 8.1.2.2 (11th paragraph), 8.3.2.1.3, and 8.3.2.1.3.1. (Note the word "independent" was added in the first sentence of 8.3.2.1.3.)
8.3.4-1 CONF**	Each Class 1E battery charger will be independent of the other redundant battery chargers.	83213 & 832131	This bullet is backed by SSAR subsections 8.3.2.1.3 and 8.3.2.1.3.1.
8.3.4-1 CONF**	The ac and dc switchgear power circuit breakers in each division will receive control power from their respective divisional load groups to provide the following assurances: - Loss of one Class 1E 125-volt dc system division will not jeopardize the Class 1E power supply to the Class 1E busses of the other redundant load groups.	8.3.2.2.1	This bullet is backed by SSAR subsection 8.3.2.2.1 (2nd paragraph).

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	- The differential relays in one division and all the interlocks affiliated with these relays will be from one 125-volt Class 1E dc system division. There will be no cross connections between the redundant dc system divisions through protective relaying.		
8.3.9.3-1 CONF**	The staff understands that the ABWR design will include an alternative ac power source. The staff understands that this alternate ac power source will: be a combustion turbine generator,	8.1.3.1.1.1, 9.5.11	First paragraph of referenced subsection identifies the CTG, as does numerous other places in Chapter 8. The main description and purpose for the CTG is presented in 9.5.11.
8.3.9.3-1 CONF**	be designed to power all the normal and/or Class 1E shutdown loads necessary within 1 hour or less of the onset of the station blackout, such that the plant is capable of maintaining core cooling and containment integrity,	8.2.1.3 (9th para.)	The referenced subsection supports this bullet statement in that the CTG is 80% larger than each diesel generator which, of itself, is capable of "maintaining core cooling and containment integrity." See also 8.3.1.0.1, 3rd paragraph. Subsection 9.5.11.1(1) states the capability of the CTG to assume its PIP load automatically within two minutes. Should it be necessary for the CTG to assume an emergency bus load, the operator must act manually. For Division II, a circuit breaker is immediately available for manual closure. For Divisions I and III, circuit breakers are normally racked out and must be racked in before they can be closed (see Figure 8.3-1, Sheet 1). However, these operations can easily be accomplished in less than an hour. A commitment statement to this effect was added as subsection (7) of 9.5.11.1.
8.3.9.3-1 CONF**	be subject to quality assurance guidelines commensurate with importance to the equipment's function.	APPENDIX 1C	The quality assurance guidelines of Section 3.5 of Regulatory Guide 1.115 are met (as appropriate for non-Class 1E Station Blackout Equipment), as described in Appendix 1C [to be provided in the near future].
8.3.9.3-1 CONF**	have sufficient capacity and	8.2.1.3 (9th para.)	The referenced subsection supports

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	capability to supply the normal non-Class 1E loads used for safe shutdown,		this bullet statement in that the CTG is sized to provide sufficient power for all three plant investment protection (PIP) buses, which it assumes automatically on loss of offsite power. Also, see Sheet 1 of Figure 8.3-1.
RG 1.155,SEC.3.3.5**	If an AAC power source is selected specifically for satisfying the requirements for station blackout, the design should meet the following criteria: 1. The AAC power source should not normally be directly connected to the preferred or blacked-out unit's onsite emergency ac power system.	APPENDIX 1C	See Figure 8.3-1, Sheet 1. In event of offsite power loss, the CTG is design to automatically assume the loads on three non-Class 1E power buses, which are designated for plant investment protection (PIP). Manual capability for assuming any one of the three Class 1E diesel generator buses is also provided. However, the breakers which accomplish this function are normally racked out for Divisions I and III. Division II is normally racked in since this division is the most heavy loaded, and has the most protection equipment channels fed from it. Under normal circumstances, this breaker is always open and the CTG would not be connected to the emergency ac power system (Also, see 9.5.11.3).
RG 1.155,SEC.3.3.5**	2. There should be a minimum potential for common cause failure with the preferred or the blacked-out unit's onsite emergency ac power sources. No single-point vulnerability should exist whereby a weather-related event or single active failure could disable any portion of the blacked-out unit's onsite emergency ac power sources or the preferred power sources and simultaneously fail the AAC power source.	APPENDIX 1C	SSAR Section 9.5.11.2 references Figure 8.3-1 which shows that there is "minimum potential for common cause failure with the ...onsite emergency ac power sources" from the electrical perspective. Protection from "single-point vulnerability" due to "weather-related event or single active failure" is also inherent in the physical separation of the CTG (located in the Turbine Building [Figure 9A.4-20]) and the diesel generators (located in the Reactor Building [Figure 9A.4-4]).
RG 1.155,SEC.3.3.5**	3. The AAC power source should be available in a timely manner after the onset of station blackout and have provisions to be manually connected to one or all of the redundant safety buses as required. The time required for making this	APPENDIX 1C	SSAR Section 9.5.11.2 states "Manually controlled breakers also provide the capability of connecting the combustion turbine generator to any one of the emergency buses if all other power sources are lost." Thus, the CTG has "...provisions to be

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	equipment available should not be more than 1 hour as demonstrated by test. If the AAC power source can be demonstrated by test to be available to power the shutdown buses within 10 minutes of the onset of station blackout, no coping analysis is required.		manually connected to one or all of the redundant safety buses as required." The configuration and capability described in the response for criterion 1 shows that manual connections to any one of the Class 1E buses should be easily accomplished within the 10-minute period. It is assumed this can be successfully demonstrated by test; therefore, no coping analysis is required.
RG 1.155,SEC.3.3.5**	4. The AAC power source should have sufficient capacity to operate the systems necessary for coping with a station blackout for the time required to bring and maintain the plant in safe shutdown.	APPENDIX 1C	Figure 8.3-1, Sheet 1 indicates the CTG's rating at 9 mW. This considerably exceeds that of each diesel generator, which is rated at 5 mW, and which is capable of bringing the unit to shutdown. Therefore, the CTG has more than "...sufficient capacity to operate the systems...to bring and maintain the plant in safe shutdown.".
RG 1.155,SEC.3.3.5**	5. The AAC power system should be inspected, maintained, and tested periodically to demonstrate operability and reliability. The reliability of the AAC power system should meet or exceed 95 percent as determined in accordance with NSAC-108 (Ref. 11) or equivalent methodology. (The remainder of criteria in 3.3.5 pertains to multiple-unit sites and does not apply to the single-unit ABWR plant design.)	APPENDIX 1C	SSAR Section 9.5.11.4 states that "Site acceptance testing, periodic surveillance testing and preventive maintenance, inspections, etc., shall be performed..."Also, per that same section, the CTG must undergo factory testing similar to the diesel generator (i.e., per IEEE 387) unless its reliability maintains 99% over a five-year period. The reliablity requirement of "...meet or exceed 95 percent as determined in accordance with NSAC-108..." was added at the end of the first paragraph of 9.5.11.4, page 9.5-10.3.

ATTACHMENT 3

MARK-UP TEXT INSERTS

INSERT A

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.

MARK-UP TEXT INSERTS

The Class 1E 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 8.3.3.6.2.2.3.

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 Class 1E circuits remain with or are physically separated in the same manner as those Class 1E circuits with which they are associated; <u>or</u> associated Class 1E circuits remain with or are physically separated in the same manner as those Class 1E circuits with which they are associated, from the Class 1E equipment to and including an isolation device. Associated Class 1E circuits (including their isolation devices or their connected safety or non-safety system loads without isolation devices) are subject to all requirments placed on Class 1E circuits.

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.

8.3.3.2 Testing

The design provides for periodically testing the chain of power system elements from power supplies 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 power divisions. For equipment which cannot be tested during plant operation, the reliability is such that testing can be performed during plant shutdown (for example, safety relief valves and certain isolation valves). The requirements of IEEE Std 379 Regulatory Guide 1.118 and IEEE 338 are met.

8.3.3.3 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 pro- curement specifications incorporating quality 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 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.

8.3.3.4 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 as discussed in Section 3.11.

8.3.3.5 Physical Identification of Safety-Related Equipment

8.3.3.5.1 Power, Instrumentation and Control Systems

Electrical and control equipment, assemblies, devices, and cables grouped into separate divisions shall be identified so that their electrical divisional assignment is apparent and so that an observer can visually differentiate between Class 1E equipment and wiring of different divisions, and between Class 1E 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 treated as Class 1E (see Note 1) , there shall be an "A" appended to the divisional designation (e.g., "A1"). The latter "A" stands for associated. "N" shall be used for nondivisional cables. 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 elementary diagrams. Identification of raceways, cables, etc., shall be compatible with the identification of the Class 1E equipment with which it interfaces. Loca- tion of identification shall be such that points of change of circuit classification (at isolation devices, etc.) are readily identifiable.

Note 1 The emergency lighting circuits are the only Class 1E associated circuits in the pre-certified ABWR design. 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.

8.3.3.5.1.1 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 name-plate 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- 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 name-plates have color coded background with black engraving.

8.3.3.5.1.2 Cable Identification

All cables for Class 1E systems and 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 number (cable number), in addition to the marking characteristics shown below.

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 30.5 cm (1 ft.)) 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. Any non-divisional cable within such cabinets shall be appropriately marked to distinguish it from the divisional cables.

8.3.3.5.1.3 Raceway Identifcation

All conduit is similarly tagged with a unique conduit number, in addition to the marking cha- racteristics shown below, at 4.57 meters (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 Class 1E cable raceways are marked with the division color, and with their proper raceway identification at 4.57 meters (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 and markings are used:

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

The VN or VS markings are superimposed on the divisional color markings, and placed at the same intervals.

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 separate conduit for each rod scram group.

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,name-plates, cables and raceways, as described above.

8.3.3.5.1.4 Sensory Equipment Grouping and Designation Letters

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

8.3.3.6 Independence of Redundant Systems

8.3.3.6.1 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 as described in Subsection 8.3.3.6.2. Any exceptions are justified in Appendix 9A, Subsection 9A.5.5.5.

MARK-UP TEXT INSERTS

The physical independence of electric power systems complies with the requirements of IEEE Standard 384, General Design Criteria 17, 18 and 21 and NRC Regulatory Guides 1.6 and 1.75.

8.3.3.6.1.1 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 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 requirements are applied to control power and motive power for all systems involved.

(2) Equipment arrangement and/or protective bar- riers are provided such that no locally ge- nerated force or missile can destroy any re- dundant 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. 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 of current and 250 VDC or ac for relay contactor control.

   (d) V1 = Low level signal and control, including fiber-optic cables and metallic cables with analog signals up to 55 VDC and digital signal up to 12 VDC.

   Power cables (V3) are routed in flexible metallic conduit under the raised floor of the control room. For EMI considerations, power cables are routed in metallic conduit wherever they come in close proximity with low level (V1) cables.

(5) Class 1E power system power supplies and distribution equipment (including diesel generators, batteries, battery chargers, CVCF power supplies, 6.9 kV switchgear, 480-volt load centers, and 480-volt motor control centers) are

located in areas with access doors that are administratively controlled. In addition, ac and dc distribution panels are located in the same or similar areas as Class 1E power supplies and distribution equipment, or the distribution panels are designed to be locked, so that access to circuit breakers located inside such panels can be administratively controlled. The physical design of the ABWR permits the administrative control of access to Class 1E power equipment areas (see Section 13.6.3).

8.3.3.6.1.2 Electric Cable Installation

(1) **Cable Derating and cable tray fill**--Base ampacity rating of cables is established as described in Subsection 8.3.3.8.1. 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 8.3.3.6.1.1(4). Tray fill is as established in Subsection 8.3.3.8.

(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. Cable routing in the drywell is discussed in association with the equipment it serves in the "Special Cases" Section 9A.5.

(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 8.3.3.8 and 9.5.1.

(5) **Cable and raceway markings**--All cables (except lighting and nonvital communications) are tagged at their terminations with a unique identifying number. Colors used for identification of cables and raceways are covered in Subsection 8.3.3.5.

(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 8.3.3.6.2.

In this case, redundant circuits which serve the same Class 1E 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.

MARK-UP TEXT INSERTS

(7) **Electric penetration assembly**--The separation of electric penetration assemblies exceeds the requirements for cables and raceways given in Section 6.1.5 of IEEE 384. Separation by distance (without barriers) is allowed only within the inerted containment. Here the minimum allowable distances of .9 meters (3 feet) and 1.5 meters (5 feet) apply, as delineated in Section 6.1.5 of IEEE 384. However, the lesser distances allowed by IEEE 384 for enclosed raceways does not apply to the containment penetrations themselves. Grouping of circuits in penetration assemblies follows the same raceway voltage groupings as described in 8.3.3.6.1.1(4).

For the other ends of the penetrations, which are outside the containment in the non-inerted areas, separation by distance alone is not allowed. These are separated by separate rooms, or barriers, or different floor levels. Such walls, barriers or floors are 3-hour fire-rated.

Such separation criteria applies to the following:

1. Between redundant penetrations,

2. Between penetrations containing non-Class 1E and penetrations containing Class 1E or associated Class 1E circuits, and

3. Between penetrations containing Class 1E circuits and other divisional or non-divisional cables.

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. This avoids penetration damage in the event of failure of any single overcurrent device to clear a fault within the penetration or beyond it. See Subsection 8.3.4.4 for COL license information.

8.3.3.6.1.3 Control of Compliance with Separation Criteria During Design and Installation

Compliance with the criteria which insures independence of redundant systems is a supervisory 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 assure compliance with approved and issued drawings and specifications.

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The equipment nomenclature used on the ABWR standard design is one of the primary mechanisms 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 driven). Based on these identification numbers, each item can be identified as Class 1E or non-Class 1E, and each Class 1E 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 de- sired to enhance power generation reliability, although such separation is not a safety consid- eration.

Once the safety-related equipment has been identified with a Class 1E safety division, the divisional assignment dictates a characteristic color (Subsection 8.3.3.5) for positive visual identification. Likewise, the divisional identification of all ancillary equipment, cable and raceways match the divisional assignment of the system it supports.

8.3.3.6.2 Independence of Redundant Class 1E Instrumentation and Control Systems

This subsection defines independence criteria applied to Class 1E 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.

8.3.3.6.2.1 General

Separation of the equipment for the systems referred to in Subsections 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 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 di- verse Class 1E equipment, devices, and cables is achieved by three-hour fire-rated barriers and elec- trical isolation. This protection is provided to maintain the independence of nuclear Class 1E circuits and equipment so that the protective function re- quired 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. The exceptional cases where it is not possible to install such barriers have been analyzed and justified in Appendix 9A.5.

8.3.3.6.2.2 Separation Techniques

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The methods used to protect redundant safety systems from results of single failures or events are utilization of safety class structures, three-hour fire-rated protective barriers, and isolation devices.

8.3.3.6.2.2.1 **Safety Class Structure**

The basic design consideration of plant layout is such that redundant circuits and equipment are located in separate safety class areas (i.e., separate fire zones) insofar as possible. The separation of Class 1E circuits and equipment is such that the required independence will not be compromised by the failure of mechanical systems served by the Class 1E electrical system. For example, Class 1E circuits are routed or protected so that failure of related 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 floors.

8.3.3.6.2.2.2 **Three-Hour Fire Rated Protective Barriers**

Three-hour fire rated protective barriers shall be such that no locally generated fire, or missile resulting from a design basis event (DBE) or from random failure of Seismic Category I equipment can disable a safety-related function. The electrical equipment from the Class 1E power supplies to the distribution centers are separated by 3-hour-rated fire barriers. Beyond the distribution centers, the exceptional cases where it is not possible to install such barriers have been analyzed and justified in Appendix 9A.5.

Separation in all safety equipment or cable areas shall equal or exceed the requirements of IEEE 384.

8.3.3.6.2.2.3 **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 following general criteria to preclude 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. Single panels orinstrument racks will not contain circuits or devices of the redundant protection system or ESF systems except:

(1) Certain operator interfac[illegible]ntrol 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 15.24 cm (6 inches) or by steel barriers or enclosures. Solid or flexible metalic conduit is considered an acceptable barrier, providing 2.54 cm (1

inch) separation is maincained between the outside wall of the conduit and other wiring not of the same division.

(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 5 inches or by steel barriers or enclosures. Solid or flexible metalic conduit is considered an acceptable barrier, providing 2.54 cm (1 inch) separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(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 8.3.3.6.2.2.4). Solid or flexible metalic conduit is considered an acceptable barrier, providing 2.54 cm (1 inch) separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(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 2.54 cm (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.

8.3.3.6.2.2.4 Isolation Devices

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 will be used. AC isolation (the FMCRD drives on Division 1 is the only case) is provided by interlocked circuit breaker coordination and an isolation transformer as described in Subsection 8.3.1.1.1.

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

8.3.3.6.2.3 System Separation Requirements

Specific divisional assignment of safety-related systems and equipment is given in Table 8.3-1. (Note that in Table 8.3-1, diesel generator "A" corresponds with Class 1E electrical division "I", "B" with "II", and "C" with "III".) Other separation requirements pertaining to the RPS and other ESF systems are given in the following subsections.

8.3.3.6.2.3.1 Reactor Protection (Trip) System (RPS)

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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 separate 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 separated 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 (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 ident- ification 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).

MARK-UP TEXT INSERTS

(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-Clas 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.

(9) The startup range monitoring (SRNM) subsystem cabling of the NMS cabling under the vessel is treated as divisional. The SRNM cables will be assigned to Division I, II, III and IV. Under the vessel, cables will be enclosed and separated as defined in Appendix 9A.5.5.5.

8.3.3.6.2.3.2 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.

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

Class 1E 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 sources 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. (Note that in Table 8.3-1, diesel generator "A" corresponds with Class 1E electrical division "I", "B" with "II", and "C" with "III".) The wiring to the ADS

solenoid valves within the drywell shall run in rigid conduit. ADS conduit for solenoid A shall be divisionally separated from solenoid B conduit. Short pieces (less than .6 m [2 ft.]) 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 leak.

(6) Class 1E electrical equipment located in the suppression pool level swell zone is limited to suppression pool temperature monitors and their feeder cables. The terminations are 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.

(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 nondivisional.

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 (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.

Current-limiting devices designed to protect the penetrations shall be periodically tested (see 8.3.4.4).

INSERT B (19 CONF)

IEEE Std 141	Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book)
IEEE Std 242	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)

INSERT C (19 CONF)

IEEE Std 399	Recommended Practice for Industrial and Commercial Power Systems Analysis (IEEE Brown Book)

INSERT D (19 COL)

8.2.4.2 Plant Procedures when a Reserve or Unit Auxiliary Transformer is Out of Service

Appropriate plant operating procedures will be imposed whenever the Reserve 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.

MARK-UP TEXT INSERTS

INSERT E (35 CONF)

(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.

INSERT F (35 CONF)

(5) Other Criteria

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

The ABWR fully meets the requirements of this standard.

INSERT G (65 CONF)

This equipment is designed and qualified to survive the combined effects of temperature, humidity, radiation, and other conditions related with a LOCA or other design-basis event environment at the end of their qualified and/or design life.

INSERT H (43 CONF)

These overload bypasses meet the requirements of IEEE 603, and are capable of being periodically tested (see 8.3.4.24).

INSERT I (71 CONF)

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 Class1E 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 criteria as defined in IEEE 603 for: operating bypass, maintenance bypass, and bypass indication."

INSERT J (72 OPEN/CONF)

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(8) In addition, an external elec :ical protection assembly (EPA) is provided which performs similar function as the monitor described in (7) abov (see Figure 8.3-3, Sheet 1).

INSERT K (33 CONF) & (69 CONF)

These transfer switches are classified as Class 1E associated, and are treated as Class 1E.

INSERT L (33 CONF)

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).

INSERT M (69 CONF) [Note: this insert is placed within Insert A above]

Associated Class 1E circuits remain with or are physically separated in the same manner as those Class 1E circuits with which they are associated; or associated Class 1E circuits remain with or are physically separated in the same manner as those Class 1E circuits with which they are associated, from the Class 1E equipment to and including an isolation device. Associated Class 1E circuits (including their isolation devices or their connected safety or non-safety system loads without isolation devices) are subject to all requirments placed on Class 1E circuits.

INSERT N (69 CONF)

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. 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.

INSERT O (81 CONF)

MARK-UP TEXT INSERTS

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,

2) is immediately available during both normal operations and following loss of power from the alternating current systems,

3) has sufficient stored energy to provide an adequate source of power for starting and operating all required LOCA and/or LOPP loads and circuit breakers for two hours with no ac power,

4) has sufficient stored energy to provide power in excess of the capacity of the battery charger when needed for transients,

5) has a capacity design margin of 5 to 15 percent to allow for less than optimum operating conditions,

6) has a 25-percent capacity design margin to compensate for battery aging,

7) has a 4-percent capacity design margin to allow for the lowest expected electrolyte temperature of 21C (70F),

8) has a number of battery cells that correctly matches the battery-to-system voltage limitations,

9) bases the first minute of the batteries' duty cycle on the sum of all momentary, continuous, and noncontinuous loads that can be expected to operate during the one minute following a LOCA and/orLOPP,

10) is designed so that each battery's capacity can periodically be verified.

<u>INSERT P</u> (82 CONF)

When the diesel is started from the local control station, the engine will attain rated voltage and frequency, then remain on standby without load sequencing (i.e., the generator breaker will remain open).

<u>INSERT Q</u> (82 CONF)

To avoid depleting air start capability, following unsuccessful automatic starting of the diesel generator with and without ac external power, each diesel generator's air receiver tanks will have sufficient air remaining for three more successful starts without recharging.

<u>INSERT R</u> (85 CONF)

MARK-UP TEXT INSERTS

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.

INSERT S (87 CONF)

(7) The bus tie arrangment, and the capacity and capability of the CTG, is designed such that the time to place the CTG on line to feed any one train of shutdown loads (i.e., includes manual connection to any one Class 1E bus) shall be within 10 minutes.

INSERT T (87 CONF - RG 1.155, Sect. 3.3.5 assessment)

The reliability of the CTG should meet or exceed 95 percent as determined in accordance with NSAC-108 or equivalent methodology.

INSERT U (87 CONF - RG 1.155, Sect. 3.3.5 assessment)

6. Electric Power Research Institute, "Reliability of Emergency Diesel Generators at U.S. Nuclear Power Plants," NSAC-108, September 1986.

INSERT V (66 CONF)

Light fixtures in safety areas are seismically supported, and are designed with appropriate grids or diffusers, such that broken material will be contained and will not become a hazard to personnel or safety equipment during or following a seismic event.

(7) Radiation shielding is provided and access control patterns are established to allow a properly trained operating staff to control radiation doses within the limits of applicable regulations in any mode of normal plant operations.

(8) Those portions of the nuclear system that form part of the reactor coolant pressure boundary are designed to retain integrity as a radioactive material containment barrier following abnormal operational transients and accidents.

(9) Nuclear safety systems and engineered safety features function to assure that no damage to the reactor coolant pressure boundary results from internal pressures caused by abnormal operational transients and accidents.

(10) Where positive, precise action is immediately required in response to abnormal operational transients and accidents, such action is automatic and requires no decision or manipulation of controls by plant operations personnel.

(11) Safety related actions are provided by equipment of sufficient redundance and independence so that no single failure of active components, or of passive components in certain cases in the long term, will prevent the required actions.

(12) Provisions are made for control of active components of safety related systems from the control room.

(13) Safety related systems are designed to permit demonstration of their functional performance requirements.

(14) The design of safety related systems, components and structures includes allowances for natural environmental disturbances such as earthquakes, floods, and storms at the station site.

(15) Standby electrical power sources have sufficient capacity to power all safety related systems requiring electrical power concurrently.

(16) Standby electrical power sources are provided to allow prompt reactor shutdown and removal of decay heat under circumstances where normal auxiliary power is not available.

(17) A containment is provided that completely encloses the reactor systems, drywell, and suppression chambers. The containment employs the pressure suppression concept.

(18) It is possible to test primary containment integrity and leak tightness at periodic intervals.

(19) A secondary containment is provided that completely encloses the primary containment above the reactor building basemat. This secondary containment provides for a controlled, monitored release of any potential radioactive leakage from the primary containment.

(20) The primary containment and secondary containment in conjunction with other safety related features limit radiological effects of accidents resulting in the release of radioactive material to the containment volumes to less than the prescribed acceptable limits.

(21) Provisions are made for removing energy from the primary containment as necessary to maintain the integrity of the containment system following accidents that release energy to the containment.

(22) Piping that penetrates the primary containment and could serve as a path for the uncontrolled release of radioactive material to the environs is automatically isolated when necessary to limit the

TABLE 1.8-21 (Continued)

INDUSTRIAL CODES AND STANDARDS
APPLICABLE TO ABWR

Code or Standard Number	Year	Title
IEEE		
279	1971	Criteria for Protection Systems for NGPS
308	1980	Criteria for Class 1E Power Systems for NPGS
317	1983	Electrical Penetration Assemblies in Containment Structures for NPGS
323	~~1974~~ 1983	Qualifying Class 1E Equipment for NPGS
334	1974	Motors for NPGS, Type Tests of Continuous Duty class 1E
338	1977	Criteria for the Periodic Testing of NPGS Safety Systems
344	1987	Recommended Practices for Seismic Qualifications of Class 1E Equipment for NPGS
379	1977	Standard Application of the Single Failure Criterion to NPGS Safety Systems
382	1985	Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for NPP
383	1974	Type Test of Class 1E Cables; Field Splices and Connections for NPGS
384	1981	Criteria for Independence of Class 1E Equipment and Circuits
387	1984	Criteria for Diesel-Generator Units Applied as Standby Power Supplies for NPGS
450	1987	Practice for Maintenance, Testing, and Replacement of Large lead Storage Batteries for Generating Stations and Substations
484	1987	Recommended Practice for the Installation Design and Installation of Large Lead Storage Batteries for NPGS

(1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences, and

(2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

The onsite electric power supplies including the batteries, and the onsite electric distribution system shall have sufficient independence, redundancy, and testability to perform their safety functions assuming a single failure.

Electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located to minimize to the extent practical the likelihood of simultaneous failure under operating and postulated accident and environmental conditions. A switchyard common to both circuits is acceptable. Each of these circuits shall be designed to be available in sufficient time following a loss of all onsite alternating current power supplies and the other offsite electric power circuit to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded. One of these circuits shall be designed to be available within a few seconds following a loss-of-coolant accident to assure that the core cooling, containment integrity, and other vital safety functions are maintained.

Provisions shall be included to minimize the probability of losing electric power from any of the remaining supplies as a result of or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies.

3.1.2.2.8.2 Evaluation Against Criterion 17

3.1.2.2.8.2.1 Onsite Electric Power System

There are three independent AC load groups provided to assure independence and redundancy of equipment function. These meet the safety requirements, assuming a single failure, since:

(1) each load group is independently capable of isolation from the offsite power sources, and

(2) each load group has separate circuits to independent power sources.

For each of the three AC load groups there are independent batteries which furnish DC load and control power for the corresponding divisions. An additional battery furnishes DC load and control power for the safety system logic and control (SSLC) Division IV bus.

The reactor protection instrumentation is powered from four independent AC/DC power sources.

The onsite electric power systems are designed to meet the requirements of Criterion 17. For further discussion, see the following sections:

	Chapter/ Section	Title
(1)	1.2	General Plant Description
(2)	3.10	Seismic Qualification of Seismic Category I Instrumentation and Electrical Equipment
(3)	3.11	Environmental Qualification of Safety-Related Mechanical and Electrical Equipment
(4)	8.3	Onsite Power Systems

3.1.2.2.8.2.2 Offsite Electric Power System

A part of the design of the offsite power systems is out of the scope of the ABWR design. A description of the offsite power system and the scope split between the ABWR Standard Plant design and the COL applicant design is defined in Subsection 8.2.1.1 and 8.2.1.2. The ABWR Standard Plant interfaces requirements are addressed in Subsection 8.2.3 and 8.2.4.

applicable, these parameters are given in terms of a time-based profile.

The magnitude and 60-year frequency of occurrence of significant deviations from normal plant environments in the zones have insignif- icant effects on equipment total thermal normal aging or accident aging. Abnormal conditions are overshadowed by the normal or accident conditions in the Appendix 3I tables.

Margin is defined as the difference between the most severe specified service conditions of the plant and the conditions used for qualification. Margins shall be included in the qualification parameters to account for normal variations in commercial production of equipment and reasonable errors in defining satisfactory performance. The environmental conditions shown in the Appendix 3I tables do not include margins.

Some mechanical and electrical equipment may be required by the design to perform an intended safety function between munutes of the occurrence of the event but less than 10 hours into the event. Such equipement shall be shown to remain functional in the accident environment for a period of at least 1 houre in excess of the time assumed in the accident anylysis unless a time margin of less than 1 hour can be justified. Such justification will include for each piece of equipment: (1) consideration of a spectrum of breaks; (2) the potential need for the equipment later in the event or during recovery operations; (3) detemination that failure of the equipment after performance of its safety function will not be detrimental to plant safety or mislead the operator; and (5) determination that the margin applied to the minimum operability time, when combined with other test margins, will account for the uncertainties accociated with the use of analytical techniques in the derivation of environmental parameters, the number of units tested, production tolerances, and test equipment inaccuracies

The environmental conditions shown in the Appendix 3I tables are upper-bound envelopes used to establish the environmental design and qualification bases of safety-related equipment. The upper bound envelopes indicate that the zone data reflects the worse case expected environment produced by a compendium of accident conditions. Estimated chemical environmental conditions are also reported is Appendix 3I.

3.11.2 Qualification Tests and Analyses

All Safety-related electrical equipment ~~that is located in a harsh environment~~ is qualified by test or other methods as described in IEEE 323 (65) and permitted by 10CFR50.49(f) (Reference 1). Equipment type test is the preferred method of qualification.

Insert G (65)

Safety-related mechanical equipment that is located in a harsh environment is qualified by analysis of materials data which are generally based on test and operating experience.

The qualification methodology is described in detail in the NRC approved licensing Topical Report on GE's environmental qualification program (Reference 2). This report also addresses compliance with the applicable portions of the General Design Criteria of 10CFR50, Appendix A, and the Quality Assurance Criteria of 10CFR50, Appendix B. Additionally, the report describes conformance to NUREG-0588 (Reference 3), and Regulatory Guides and IEEE Standards referenced in Section 3.11 of NUREG-0800 (Standard Review Plan).

Mild environment is that which, during or after a design basis event (DBE, as defined in Reference 2), would at no time be significantly more severe than that which exists during normal, test and abnormal events.

The COL applicant will require vendors of equipment located in a mild environment to submit a certificate of compliance certifying that the equipment has been qualified to assure its required safety- related function in its applicable environment. This equipment is qualified for dynamic loads as addressed in Sections 3.9 and 3.10. Further, a surveillance and maintenance program will be developed to ensure equipment operability during its designed life. (See Subsection 3.11.6).

3.11.3 Qualification Test Results

The results of qualification tests for safety-related equipment will be documented, maintained, and reported as mentioned in Subsection 3.11.6.

3.11.4 Loss of Heating, Ventilating, and Air Conditioning

To ensure that loss of heating, ventilating, and air conditioning (HVAC) system does not adversely affect the operability of safety-related controls and electrical equipment in buildings and areas served by safety-related HVAC systems, the HVAC systems serving these areas meet the single-failure criterion. Section 9.4 describes the safety-related HVAC systems including the detailed safety evaluations. The loss of ventilation calculations are based on maximum heat loads and consider operation of all operable equipment regardless of safety classification.

3.11.5 Estimated Chemical and Radiation Environment

3.11.5.1 Chemical Environment

Equipment located in the containment drywell and wetwell is potentially subject to water spray modes of the RHR system. In addition, equipment in the lower portions of the containment is potentially subject to submergence. The chemical composition and resulting pH to which safety-related equipment is exposed during normal operation and design basis accident conditions is reported in Appendix 3I.

Sampling stations are provided for periodic analysis of reactor water, refueling and fuel storage pool water, and suppression pool water to assure compliance with operational limits of the plant technical specifications.

3.11.5.2 Radiation Environment

Safety-related systems and components are designed to perform their safety-related function when exposed to the normal operational radiation levels and accident radiation levels.

Electronic equipment subject to radiation exposure in excess of 1000 R and mechanical equipment in excess of 10,000 R will be qualified in accordance with Reference 1.

7.2.2.2.3.2 Conformance to Other IEEE Standards

(1) IEEE 323, Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations

The general guide for qualifying Class 1E equipment is presented in Section 3.11. Records covering all essential components are maintained.

(2) IEEE 344, Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations

Seismic qualification of Class 1E equipment requirements are satisfied by all Class 1E RPS equipment as described in Section 3.10.

7.2.2.2.4 Conformance to Branch Technical Positions

(1) BTP-ICSB-12: Protection System Trip Point Changes for Operation with Reactor Coolant Pumps out of Service.

The RPS design conforms with this position in that setpoint changes to more restrictive values are accomplished automatically in conjunction with the mode switch position. See Subsection 7.2.2.2.3.1(15)

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

The RPS design conforms with this position as discussed in Subsection 7.2.2.2.4(2)

(3) BTP-ICSB 22: Guidance for Application of Regulatory Guide 1.22.

The RPS design conforms with this position as discussed in Subsection 7.2.2.2.1(1)

(4) BTP-ICSB-26: Requirements for Reactor Protection System Anticipatory Trips

All hardware used to provide trip signals to the RPS is designed in accordance with IEEE 279 and is considered safety grade. This includes the sensors for turbine stop valve closure and turbine control valve fast closure even though these are located in the non-seismic turbine building. Since reactor high pressure and power trips are diverse to the turbine scram variables, locating the sensors in the turbine enclosure does not compromise the ability of the RPS to provide protection action when required in addition, the "high seismic activity" trip provides a direct scram for seismic events of sufficient magnitude to damage the turbine building. For further justification, see 9A.5.5.1. (62

7.2.2.3 Additional Design Considerations Analyses (RPS)

(1) Spurious Rod Withdrawals

Spurious control rod withdrawal will not normally cause a scram but may cause control rod withdrawal block rod block is discussed in Section 7.7 and is not part of the RPS. A scram will occur, however, if the spurious control rod withdrawal causes the average flux to exceed the trip setpoint, or causes SRNM short period.

(2) Loss of Plant Instrument Air System

Loss of plant instrument air will cause gradual opening of the scram valves on the hydraulic control units which will insert all control rods. Full insertion will result as air pressure is lost at the scram valves.

(3) Loss of Cooling Water to Vital Equipment

There is no loss of cooling water which will directly affect the RPS.

(4) Plant Load Rejection

Electrical grid disturbances could cause a significant loss of load which would initiate a turbine generator overspeed trip and control valves fast closure which may result in a reactor scram. The reactor scram occurs to anticipate an increase in reactor vessel pressure due to shutting off the path of steam flow to the turbine. Any additional increase in pressure will be prevented by the safety/relief valves which will open to relieve reactor pressure and close as pressure is reduced. The reactor core isolation cooling (RCIC) or high pressure core flooder (HPCF) systems will automatically actuate and provide vessel makeup water if required.

7.3.2.2.2 Specific Regulatory Requirements Conformance

Table 7.1-2 identifies the leak detection and isolation system and the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.

(1) 10CFR50.55a (IEEE 279):

The leak detection and isolation system is a four-division system which is redundantly designed so that failure of any single element will not interfere with a required detection of leakage or isolation.

All components used for the safety isolation functions are qualified for the environments in which they are located (Sections 3.10 and 3.11). Most initiation parameters are represented by all four divisions which actuate the isolation functions via two-out-of-four logic permissives. Most of the sensors are provided by the nuclear boiler system. These instruments are shared by the ECCS as well as the RPS and other systems which require actuation signals from these essential variables. However, each system receives all four signals as input to its own unique voting logic incorporated in the safety system logic and control (SSLC) network. If individual channels are bypassed for service or testing, the voting logic reverts to two-out-of-three.

The containment is divided into four quadrants, each housing the electrical equipment which, in general, corresponds to the mechanically separated divisions assigned to each section (i.e., mechanical divisions A, B, C, and D correspond with electrical divisions I, II, III and IV, respectively). Some exceptions are necessary where a given mechanical division has more than one electrical division within the quadrant. For example, the MSIVs have redundant solenoid operators which require separate divisional power interfaces. However, electrical separation is maintained between the redundant divisions.

All of these signals are multiplexed and passed through fiber optic medium before entering the voting logic of the redundant divisions involved in the isolation valve logic. Separation and isolation are thus preserved both mechanically and electrically in accordance with IEEE 279 and Regulatory Guide 1.75. For further information, see 9A.5.5.7. (62)

Other requirements of IEEE 279 such as testing, bypasses, manual initiation, logic seal-in, etc., are described in Subsection 7.3.1.1.2.

(2) General Design Criteria (GDC):

In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, the following GDCs are addressed for the LDS:

(a) <u>Criteria</u>: GDCs 2, 4, 13, 16, 19, 20, 21, 22, 23, 24, 29, 34, 35, 38, 41, and 44.

(b) <u>Conformance</u>: The LDS is in full compliance with all GDCs identified in (a) as discussed in Subsection 3.1.2.

The following clarification should be made with respect to GDC 23: The RPS is designed to fail in a safe state (i.e., de-energize to actuate). This is also true for most isolation valves including the MSIVs. However, the RHR and RCIC isolation valves are designed to "fail as is" in that these are motor-operated valves and require power to both open and close. In addition, should the RHR or RCIC be in operation when valve power is lost, it essential these valves remain open so the systems can continue their safety functions.

(3) Regulatory Guides (RGs):

In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, the following RGs are addressed for the LDS:

to the remote shutdown system. All necessary power supply circuits are also transferred to other sources. Remote shutdown control is not possible without actuation of the transfer devices. Operation of the transfer devices causes an alarm in the main control room. The remote shutdown control panels are located outside the main control room. Access to this point is administratively and procedurally controlled.

Control of all necessary power supply circuits is also transferred to the remote shutdown system.

(6.8 OPEN)

Instrumentation and controls located on the remote shutdown control panels are shown in instrument and electrical diagram Figure 7.4-2.

Editor: Please replace all VAC & VDC with Vac & Vdc respectively. The same goes for "AC" and "DC" to "ac" and "dc" unless at start of sentence.

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

8.1.2.0 Definitions

The definitions used throughout Chapter 8 are consistent with Section 3 of IEEE 308 with the following important clarifications for the ABWR:

division. The designation applied to a given safety related system or set of components that enables the establishment and maintenance of physical, electrical, and functional independence from other redundant sets of components. (The term "safety related" is added to the IEEE 308 definition.)

load group. An arrangement of buses, transformers, switching equipment, and loads fed from a common power supply. (The last three words "...within a division" are deleted with respect to the IEEE 308 definition.) A load group may be safety-related or non-safety-related depending on its common power supply.

safety related. Any Class 1E power or protection system device included in the scope of IEEE 279 or IEEE 308. (This term is explicitly defined in IEEE 100, though not in IEEE 308.) Note that "safety related" includes both electrical and non-electrical equipment, whereas "Class 1E" pertains only to electrical equipment (i.e., any equipment which has an electrical interface).

8.1.2.1 Description of Offsite Electrical Power System

The scope of the offsite electrical power system includes the entire transmission line system and the transmission lines coming into the switchyards to the termination of the bus duct and power cables at the input terminals of the circuit breakers for the 6.9KV 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 main generator circuit breaker capable of interrupting the maximum available fault current is provided. This allows the generator to be taken off line and the main power transmission system 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 secondary winding for the Class 1E buses as an alternate to the "Normal Preferred" power. The other secondary winding supplies reserve power to the non Class 1E buses. This is truly a reserve transformer because unit startup is accomplished from the normal preferred power, which is backfed from the offsite power transmission system 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.

8.1.2.2 Description of Onsite AC Power Distribution System

Three non Class 1E buses and one Class 1E 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 the non-Class 1E buses either directly or indirectly through bus tie breakers. The three Class 1E buses may be supplied power from the other winding of the reserve auxiliary transformer.

A combustion turbine generator supplies standby power to permanent non-Class 1E loads. These loads are grouped on one of the 6.9KV buses per load group. Power is also provided from the combustion turbine generator to the three Class 1E medium voltage buses 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 (M/C) bus. Motors 300KW or smaller but larger than 100KW are supplied power from 480V power center (P/C) switchgear. Motors 100KW or smaller are supplied power from 480V motor control centers (MCC). The 6.9KV and 480V 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 main turbine generator through the unit auxiliary transformers. The remaining Class 1E bus is supplied from the reserve auxiliary transformer. This 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 division 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 circuit breaker located in the switchgear.

The standby ac power system is capable of providing the required power to safely shut down the reactor after loss of preferred power (LOPP) and/or loss of coolant accident (LOCA) and to maintain the safe shutdown condition and operate the Class 1E auxiliaries necessary for plant safety after shutdown.

The plant 480 VAC power system distributes sufficient power for normal auxiliary and Class 1E 480 volt plant loads. All Class 1E elements of the 480 V 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 8.3-2, provides power for non-Class 1E control and instrumentation loads.

The Class 1E 120 VAC instrument power system, Figure 8.3-2, provides 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 battery 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. A separate non-Class 1E 250V battery is provided to supply uninterruptible power to the plant computers and non-Class 1E dc motors (See Figure 8.3-4).

The safety system and logic control (SSLC) for RPS and MSIV derives its power from four uninterruptible 120 VAC divisional buses (See Figure 8.3-3). 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.

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) Safety-Related 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 Class 1E load is divided into three divisions. Each division is fed by an independent 6.9Kv Class 1E bus, and each division has access to one onsite and two offsite power sources. An additional offsite power source is provided by the combustion turbine generator (CTG). A description of the CTG is provided in Section 9.5.11.

Each of the two normally energized offsite power feeders (i.e., normal preferred and alternate preferred power) are provided for the Divisions I, II and III Class 1E systems. Normally two divisions are fed from the normal preferred power source and the third division 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 other preferred feeder is manual. During the interim, power is automatically supplied by the diesel generators.

The redundant Class 1E electrical divisions (Divisions I, II, and III) are provided with separate onsite standby ac power supplies, electrical buses, distribution cables, controls, relays and other electrical devices. Redundant parts of the system are physically separated and electrically independent to the extent that in any design basis event with any resulting loss of equipment, the plant can still be shut down with the remaining two divisions. Independent raceway systems are provided to meet 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 safely shut down the reactor or limit the consequences of a design basis accident (DBA) to acceptable limits and maintain the reactor in a safe condition. The standby power supplies are capable of being started and stopped manually and are not 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), level 1 signal (RHR initiate) and high drywell pressure.

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. (See Section 3.10)

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, abnormal 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 respective 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 uninter- ruptible power supply complies with IEEE Std. 944.

8.1.3.1.1.3 Controls and Indication

The ABWR electrical system design provides controls and indicators in accordance with IEEE 308 guidelines. The specific design bases are described as follows:

1. The ABWR electrical system provides controls and indicators in the main control room.
2. The design provides for control and indication outside the main control room for;
   a. Circuit breakers that switch Class 1E buses between the preferred and standby power supply,
   b. The standby power supply, and
   c. Circuit breakers and other equipment as required for safety systems that must function to bring the plant to a safe shutdown condition.
3. Operational status information is provided for Class 1E power systems.
4. Class 1E power systems required to be controlled from outside the main control room also have operational status information provided outside the central control room at the equipment itself, or at its power supply, or at an alternate central location.
5. The operator is provided with accurate, complete, and timely information pertinent to the status of the execute features in the control room.
6. Indication is provided in the control room of protective actions and execute features unavailability.
7. Electric power systems and equipment has the capability of being periodically tested.
8. Testability of electrical systems and equipment is not so burdensome operationally that required testing intervals cannot be included.

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 Dynamic Effects 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;

Functional operation of ~~Fuses~~ fuses cannot be periodically tested and ~~are~~ is exempt from such requirements per Section 4.1.7 of IEEE 741. However, periodic inspection for continuity, correct size, etc., shall be performed.

(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 1.128- 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;

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

(14) RG 1.155- Station Blackout (See Appendix 1C)

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.

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

(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 COL license information. (See Subsection 8.1.4.1).

(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 COL License Information

8.1.4.1 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 COL applicant (see Subsection 8.1.3.1.2.4(1)).

8.1.5 References

IEEE Std 944, Recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations.

8.2 OFFSITE POWER SYSTEMS

8.2.1. Description

8.2.1.1 Scope

This section provides a description of the design and performance requirements for the offsite power system. The offsite power system, as defined in the USNRC Standard Review Plan Section 8.2, consists of the following:

(Applicant Scope)

a) The offsite transmission system **[including the tie lines to the switchyard(s)]**

b) The plant switchyard(s),

c) The separated switching stations,

d) The high voltage tie lines from the switching stations to the main power transformers, and to the reserve auxiliary transformer,

e) The main step-up power transformers,

(ABWR Standard Plant Scope)

f) The reserve auxiliary transformer,

g) The three unit auxiliary transformers,

h) The plant main generator,

i) The combustion turbine generator,

j) The isolated phase buses from the main power transformer to the main generator circuit breaker, and to the unit auxiliary transformers,

k) The main generator circuit breaker,

l) The non-segregated phase buses from the unit auxiliary transformers to the input terminals of the medium voltage (6.9 kV) switchgear,

m) The non-segregated phase bus and power cables from the reserve auxiliary transformer to the input terminals of the non-safety related and safety-related medium voltage (6.9 kV) switchgear, and

n) The power cables from the combustion turbine generator to medium voltage (6.9 kV) switchgear, including the disconnect and interconnecting bus.

The design scope for the standard plant ends at the low voltage terminals of the main power transformer and the high voltage terminals of the reserve auxiliary transformer. Although the remainder of the offsite power system is not in the scope of the standard plant design, the standard plant design is based on a power system which meets certain design concepts. Design bases (10CFR Part 52 interface requirements) consistent with these concepts are included in Section 8.2.3 for COL applicant. Meeting the stated design bases will ensure that the total power system design is consistent and meets all regulatory requirements.

The portions of the offsite power system which fall under the design responsibility of the COL applicant will be unique to each COL application. 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. See Section 8.2.3 for a detailed listing and description of the COL license information.

8.2.1.2 Description of Offsite Power System

The offsite electrical power system components within the scope of the applicant include items a) through e) identified in Subsection 8.2.1.1. The remaining items f) through n) are within the scope of the ABWR standard plant design.

When used for normal operation, each preferred power supply will be sized to supply the maximum expected coincident Class 1E and non-Class 1E loads.

The normal and alternate preferred power circuits are designed in accordance with industry-recommended practice in order to minimize the likelihood that they will fail while operating under the environmental conditions (such as, wind, ice, snow, lightning, temperature variations, or flood), to which they are subject.

Air cooled isolated phase bus duct rated 36kA is provided for a power feed to the main power transformer and unit auxiliary transformers from the main generator.

A generator circuit breaker is provided in the isolated phase bus duct at an intermediate location between the main generator and the main power transformer. The generator circuit 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 main generator circuit 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 source for the unit.

Unit sychronization will normally be through the main generator circuit 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 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 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 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 and reserve transformers are designed and constructed to withstand the mechanical and thermal stresses produced by external short circuits. In addition, these transformers meet the corresponding requirements of the latest revisions of ANSI Standard C57.12.00. [See 8.2.3(8) for COL requirements on the main step-up transformers. See 8.2.3(10) for COL requirements on the high-voltage circuit breakers and disconnect switches.]

Offsite system circuits derive their control, protection, and instrument DC power from non-Class 1E DC sources in the same non-Class 1E load group, and are independent of the Class 1E DC sources.

8.2.1.3 Separation

The location of the main power transformer, unit auxiliary transformers, and reserve auxiliary transformer are shown on Figure 8.2-1. The reserve auxiliary transformer is separated from the main power and unit auxiliary transformers by a minimum distance of 15.24 meters (50 feet). It is a requirement that the 15.24 meters (50 foot) minimum separation be maintained between the switching stations and the incoming tie lines. 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. The circuits associated with the alternate offsite circuit from the reserve auxiliary transformer to the Class 1E busses are separated by walls or floors, or by at least 15.24 meters (50 feet), from the main and unit auxiliary transformers. The circuits associated with the normal preferred offsite circuit from the unit auxiliary transformers to the Class 1E busses are separated by walls or floors, or by at least 15.24 meters (50 feet), from the reserve auxiliary transformer. 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 are routed to opposite ends of the same switchgear lineups.

The normal preferred feeds from the unit auxiliary transformers 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

The operational configurations are such that the FOA ratings of the reserve auxiliary transformer, or any unit auxiliary transformers, will not be exceeded under any operating mode.

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 I and III side of the control building (Figure 8.2-1, Sheet 3). 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 I and III side of the reactor building to the respective Class 1E 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 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 interlock circuitry required to prevent paralleling of the two offsite sources. Separation of I&C cable for unit auxiliary transformers is equivalent to that provided for the power feeder cables. The reserve auxiliary transformer power, instrument and control cables do not share raceways with any other cables.

(15) & (16)

circuits in the control room, and the

However, these circuits are electrically isolated and separated to the extent practical.

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 ~~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. 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 ~~is~~ 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 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.

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

The main generator circuit breaker opens on a turbine trip to maintain the normal preferred power supply to the Class 1E buses. This breaker cannot be tested during normal operation of the plant. Generator breakers are extremely reliable and can be tested during plant shutdown. See 8.2.3.

All other equipment can either be tested during normal plant operation or is continually tested by virtue of its operation during normal plant operation and its remaining in the same state to supply normal preferred power to the Class 1E buses following a turbine trip.

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 ~~facilitate the~~ provide capability of testing and/or verification described above, including the items identified in ~~8.2.3(17).~~ 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.

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

(6) RG 1.155--Station Blackout (See Appendix 1C)

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

(8) Appendix A to SRP Section 8.2

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

(9) IEEE Std 765, IEEE Standard for Preferred Power Supply for Nuclear Powered Generating Stations

It is a requirement that the total design provided by GE and the applicant meet the requirements of this IEEE standard as modified by the ~~following~~ specific additional requirements and explanatory statements in Table 8.2-1. The additional requirements are more restrictive than the requirements which they replace or modify from the IEEE standard. Any stated requirements in the SSAR which are in conflict with the requirements stated in this standard take precedence over the requirements of the standard.

8.2.3 Interface Requirements ~~COL License Information~~

(NI) * (Insert guts of 8.2.4 here.)

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

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

(2) Voltage variations of the transmission system shall be no more than plus or minus 10 percent of their nominal value during normal steady state operation.

(3) The normal steady state frequency of the transmission system shall be within plus or minus 2 cycles per second of 60 cycles per second during recoverable periods of system instability.

(4) The site specific configuration of the incoming transmission lines shall be analyzed to assure that the expected availability of the offsite power is as good as the assumptions made in performing the plant probability risk analysis (see item 5.1.2 of Table 8.2-1, and Chapter 19).

(5) The main and reserve offsite power circuits shall be connected to switching stations which are independent and separate. They shall be connected to different transmission lines. The offsite transmission line to the main power switching station, the main power switching station, the tie lines from the main power switching station to the main power transformer and the main power transformer shall be separated by a minimum of 15.24 meters (50 feet) from the offsite transmission line to the reserve power switching station, the reserve power switching station, the tie lines from the reserve power switching station to the reserve auxiliary transformer, and the reserve ~~power~~ auxiliary transformer. The output feeders of the reserve auxiliary transformer to the medium voltage (6.9 kV) switchgear shall be separated from the output of the main power and unit auxiliary transformers by a minimum of 15.24 meters (50 feet) outside the turbine building or as described in Section 8.2.1.3. Instrument and control circuits of the main and reserve power systems shall be separated in the same manner as the power feeders. The switching stations may be in the same switchyard or separate switchyards provided the required minimum separation is maintained.

(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) Transformers shall be provided with separate oil collection pits and drains to a safe disposal area, and shall be provided with fire protection deluge systems as specified in Section 9A.4.6. Transformers shall also be provided with lightning protection systems and grounded to the plant grounding grid.

(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 main generator circuit breaker, provisions shall be made to synchronize the unit through the switching station's circuit breakers. This makes it possible to re-synchronize with the system following a load rejection within the steam bypass capability of the generating unit.

(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 switching station 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. Each charger shall be capable of supplying the required loads while recharging its battery.

(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.

(16) The requirements of IEEE Std 765, Preferred Power Supply for Nuclear Generating Stations, as modified by Section 8.2.2.1(9) of this SSAR shall be met.

(17) Appropriate plant procedures shall include periodic testing and/or verification to ensure the following:

(a) The normal and alternate offsite power circuits are energized and connected to the appropriate Class 1E distribution system division at least once every 12 hours.

(b) The instrumentation, control, and protection systems, equipment, and components associated with the normal and alternate offsite preferred circuits are properly calibrated and perform their required functions.

(c) The required Class 1E and non-Class 1E loads can be powered from their designated preferred power supply within the capacity and capability margins specified in the SSAR for the offsite system circuits.

(d) The loss of the offsite preferred power supply can be detected.

(e) Switching between preferred power supplies can be accomplished.

(f) The batteries and chargers associated with the preferred power system can meet the requirements of their design loads.

(g) The generator breaker can open on demand. (Note: The breaker's actual opening and closing mechanisms are inherently confirmed during the shutdown and synchronizing processes. However, testing/verification of the trip circuits shall be periodically verified during shutdown periods while the breaker is open.)

(h) Isolated and non-segregated phase bus ducts are inspected and maintained such that they are clear of debris, fluids, and other undesirable materials.

The test and inspection intervals will be established and maintained according to the guidelines of IEEE 338-1977, Section 6.5, as appropriate for non-Class 1E systems [i.e., Items (4) and (7) of Section 6.5.1 are not applicable].

8.2.4 Scope Split (Interface Requirements)

The interface point between the ABWR design and the COL applicant 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 COL applicant 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 COL applicants. 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 shall be made to determine the optimal impedance for the main transformer.

(move to 8.2.3) (Insert at *)

The second power scope split interface occurs at the ~~high~~ low 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 COL applicants standard with the actual values to be determined at contract award. Tolerances on the transmission lines 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 recoverable system instability.

When coordinated with the design of the reserve auxiliary transformer the transmission line shall support a maximum allowable voltage dip of 20% during the starting of large motors.

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

(N1)

8.2.5 ~~COL License Information~~ Conceptual Design

(move to 8.2.4 at "**")

8.2.~~5.1~~ 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.

(N2)

8.2.~~5.2~~ 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.

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.

Table 8.2-1
ADDITIONAL REQUIREMENTS
IEEE STD 765

IEEE STD765 Reference	Requirement or Explanatory Note
4.1 General	SSAR Figure 8.3-1 should be used as the reference single line instead of the IEEE Std example, Figures 2, (a), (b) and (c).
4.2 Safety Classification	The separation criteria called for in Subsection 8.2.1.3 must be met.
4.5 Availibility	The ABWR design utilizes direct connection of the two preferred power circuits to the Class 1E buses.
5.1.2 Transmission System Reliability	Additional analysis is required per Section 8.2.3.4. (4)
5.1.3 Transmission System Independence	
5.1.3.2	Specific requirements for tolerance to equipment failures are stated in the SSAR and must be met.
5.1.3.3	Since a separation of at least 50 feet is required for the exposed circuits, a common takeoff structure cannot be used.
5.3.2 Class 1E Power System Interface Independence	See 5.1.3.3 comments.
5.3.3 Connections with Class 1E Systems	
5.3.3.2	Automatic dead-bus transfers are used to transfer from the preferred power supply to the onsite AC source. Manual dead-bus transfers are used between preferred power supplies, and to transfer from the onsite source back to the preferred power supply. Automatic live-bus transfers are not required and are not used.
5.3.3.3	Only standby power sources may be paralleled with the preferred power sources for load testing. The available fault current must be less than the rating of the breakers. It is not required and not allowed for the normal and alternate preferred power supply breakers for a bus to be closed simultaneously so there is no 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.

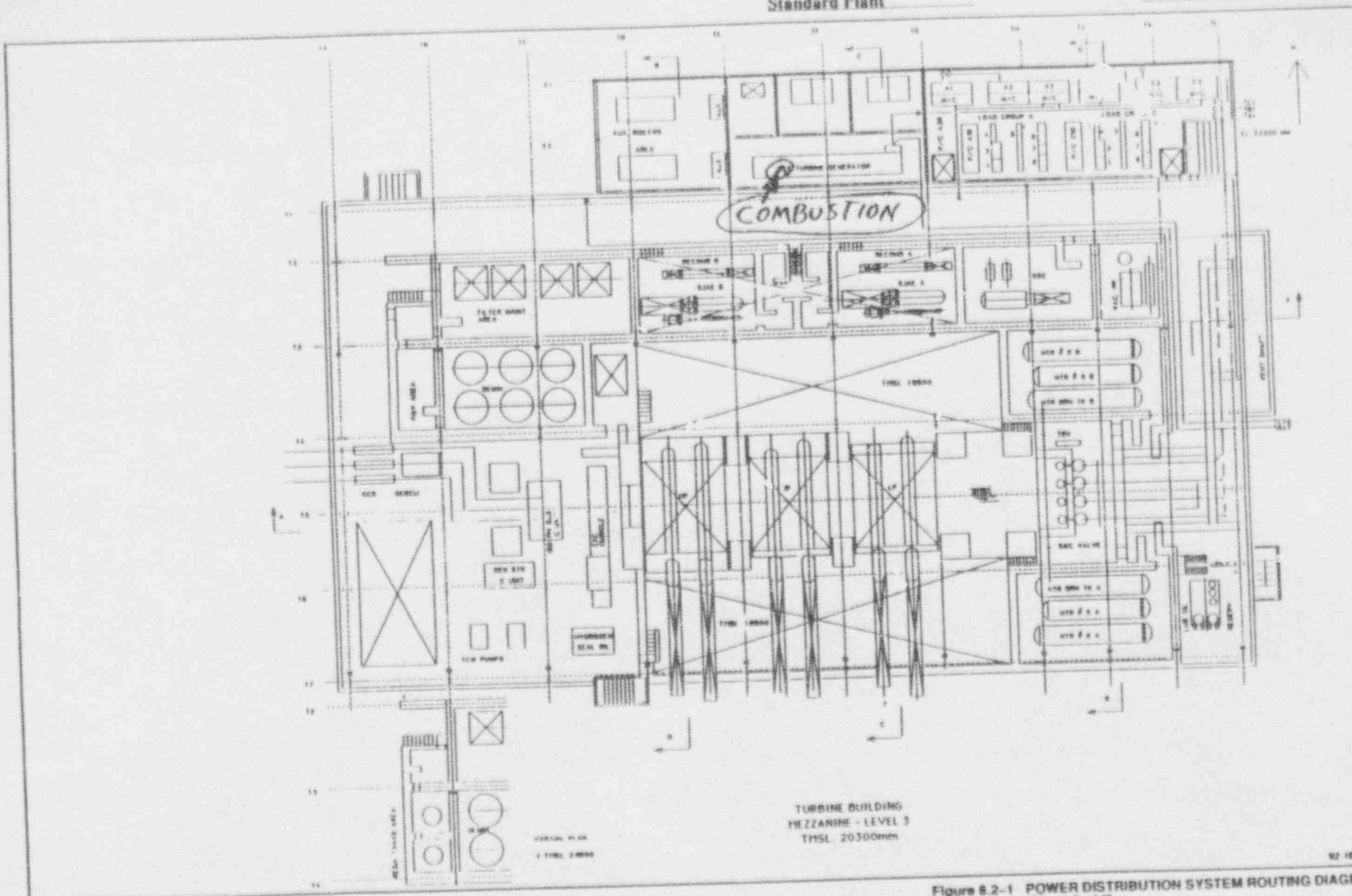

Figure 8.2-1 POWER DISTRIBUTION SYSTEM ROUTING DIAGRAM (Sheet 2 of 7)

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.

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 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 between preferred power sources 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 of 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 Class 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-Class 1E 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 metal clad switchgear rated for 7.2KV 500MVA 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-Class 1E 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-Class 1E, 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-Class 1E 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 8.3-3). 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 frequency 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 the 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-Class 1E)

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 8.3-3). 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 Subsection 8.3.1.0.3).

8.3.1.1 Class 1E AC Power Distribution System

8.3.1.1.1 Medium Voltage Class 1E 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 preferred 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 interlocked 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 Class 1E bus supplies power to three separate groups of non-Class 1E fine motion control rod drive (FMCRD) motors (see Figure 8.3-1, Sheet 3). Although these motors are not Class 1E, 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 supplied pip bus as the second backup source. Division I was chosen because it was the most lightly loaded diesel generator. See Subsection 8.3.4.13 for COL license information.

The load breakers in the Division I switchgear are part of the isolation scheme between the Class 1E power and the non-Class 1E load. In addition to the normal overcurrent tripping of these Class 1E load breakers, 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. (33) (69)

Insert K

Switchover 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.

(33) Insert L

The Class 1E load breakers in conjunction with the zone selective interlocking feature provides the needed isolation between the Class 1E bus and the non-Class 1E loads. Therefore, the FMCRD circuits are entirely non-Class 1E on the load side of the Class 1E load breaker and are identified accordingly. The feeder circuits on the upstream side of the Class 1E load breakers are Class 1E.

Insert N (69)

In order to prevent any possibility of interconnection between Class 1E divisions through the FMCRD circuits, the FMCRD circuits will not be routed with any Class 1E or Class 1E associated circuits.

8.3.1.1.2 Low Voltage Class 1E 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 transformers and associated metal clad switchgear, Figure 8.3-1.

Class 1E 480V power centers supplying Class 1E loads are arranged as independent radial systems, with each 480V bus fed by its own power transformer. Each 480V Class 1E bus in a division 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 480V MCCs feed motors 100kW or 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 100kW or smaller are MCC-mounted, across-the-line magnetically operated, air break type. Power 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 Class 1E 120/240V power. This power is used for emergency lighting, and other 120V Class 1E loads.

8.3.1.1.4 Instrument Power Supply Systems

8.3.1.1.4.1 120V AC Class 1E Instrument Power System

Individual transformers supply 120V ac instrument power (Figure 8.3-2). 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 Class 1E 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 8.3-3, 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.

The capacity of each of the four redundant Class 1E CVCF power supplies is based on the largest combined demands of the various continuous loads, plus the largest combination of non-continuous loads that would likely be connected to the power supply simultaneously during normal or accident plant operation, whichever is higher, (see 8.3.4.34).

(83) {The design also provides capability for being tested for adequate capacity}

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 II 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 8.3-4)]. The ac buses also supply power to the 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.

8.3.1.1.4.2.2 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.

(7) an output power monitor (external to the CVCF power supply) 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.

Insert J (72 open)

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 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.

move to 8.3.3.1

8.3.1.1.5.1 Physical Separation and Independence

All cables outside panels and cabinets are supported in raceways (i.e., tray or conduit). 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 Class 1E 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.

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 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. 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.

(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 accordance with ANSI Standards. See Subsection 8.3.4.1 for COL license information.

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 devices 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. 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

Station grounding and surge protection is discussed in Appendix 8A.1. The medium voltage (6900V) system is low resistance grounded except that each diesel generator is high resistance grounded to maximize availability.

See Subsection 8.3.4.14 for COL license information pertaining to administrative control for bus grounding circuit breakers.

8.3.1.1.6.3 Bus Protection

Bus protection is as follows:

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

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

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

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

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

8.3.1.1.6.4 Protection Requirements

Protective devices of the diesel generators meet all requirements of IEEE 603. 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 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 8.3.4.15 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 shall be periodically tested (see Subsection 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 are used to trip the loads. However, the presence of a LOCA during
(24) LOPP reduces the time delay for initiation of bus transfer from 3 seconds to 0.4 seconds. The Class 1E equipment is qualified 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

(1) 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 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 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 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, 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. 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 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 (see 8.3.4.31). 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 undervoltage will be tripped instantly. Subsequent bus transfer will be as described above. These bus voltage monitoring schemes are designed in accordance with Section 5.1.2 of IEEE 741.

(Ed: wherever the erroneous þ symbol appears please replace it with "±".)

Equipment is qualified for continuous operation with voltage þ10% of nominal and for degraded voltages below 90% for the time period established in the load analysis* for the degraded voltage protective time delay relay (see 8.3.[illegible]).

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 LOPP. Figure 8.3-1 shows the interconnections between

… IEEE 242 and 399

{Editor: … add footnote … shown}

* A complete load analysis shall be performed in accordance with Chapter 3 of IEEE 141 for the power distribution system to demonstrate proper sizing of power source and distribution equipment. Such analysis shall provide the basis for the degraded voltage protective relay timer settings and other protective relay settings.

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the preferred power supplies and the Divisions I, II and III diesel-generator standby power supplies.

See Subsection 9.5.13.8 for COL license information.

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 or a 5% frequency drop measured at the bus.

(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 criteria is for each diesel generator to be capable of reaching full speed and voltage within 20 seconds after receiving a signal to start, and capable 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.

See Subsection 8.3.4.2 for COL license information.

(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.

(6) Each diesel generator has stored energy (fuel) at the site in its own storage tank with the capacity to operate the standby diesel generator power supply, while suppying post-accident power requirements to a unit for seven days (see 9.5.4.1.1).

(7) Each diesel generator has stored energy (fuel) at the site in its own day tank with the capacity to operate the standby diesel generator power supply while supplying post accident power requirements for 8 hours. The fuel transfer system automatically maintains the capacity of the day tank (see 9.5.4.2).

(8) Each diesel generator is capable of operating in its service environment during and after any design basis event, without support from the preferred power supply. It can start up and run, with no cooling available, for the time required to bring the cooling equipment into service as it sequences onto the bus (see 20.3 RAI-16, Question/Answer 430.282).

(9) Each diesel generator is capable of restarting with an initial engine temperature equal to the continuous rating full load engine temperature.

(10) Each diesel generator is capable of accepting design load following operation at light or no load for a period of 4 hours. This capability shall be demonstrated by the supplier prior to shipment, but is exempt from periodic testing to avoid undue stress to the diesel engine.

(11) Each diesel generator is capable of carrying its continuous load rating of 22 hours followed by 2 hours of operation at its short time rating.

(12) The maximum loads expected to occur for each division (according to nameplate ratings) do

not exceed 90 percent of the continuous power output rating of the diesel generator.

(13) Each diesel generator's air receiver tanks have sufficient capacity for ~~five~~ starts without recharging ~~(see 9.5.6.2)~~.

(14) During diesel generator load sequencing, the frequency will be restored to within 2% of nominal, and voltage will be restored to within 10% of nominal within 60% of each load sequence time interval (see C.4 of Regulatory Guide 1.9).

(15) During recovery from transients caused by step load increases or resulting from the disconnection of the largest single load, the speed of the diesel generator unit will not exceed the nominal speed plus 75% of the difference between nominal speed and the overspeed trip setpoint or 115% of nominal, whichever is lower (see C.4 of Regulatory Guide 1.9).

(16) The transient following the complete loss of load will not cause the speed of the diesel generator unit to attain the overspeed trip setpoint (see C.4 of Regulatory Guide 1.9).

(17) Bus voltage and frequency will recover to 6.9 kV ±10% at 60 ±2% Hz within 10 seconds following trip and restart of the largest load.

(18) Each of the above design criteria has the capability of being periodically verified (see 8.3.4.36). However, note exception for Item (10).

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 is also provided. The Class 1E batteries provide power for the diesel control and protection circuits. The transfer of the Class 1E buses to standby power supply is automatic should this become necessary on loss of 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 8.3-5. 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.

8.3.1.1.8.6 Local and Remote Control and Indication

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. (82)

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Control room indications are provided for system output, i.e., volts, amps, watts, vars, frequency, synchronization, field volts, field amps, engine speed, and watt-hours. Diesel generator status (i.e., "RUN", "STOP") indication is provided for the Remote Shutdown System.

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. These interlocks are designed to be testable and are periodically tested (see 8.3.4.21). A lockout or maintenance mode removes the diesel generator from service. The inoperable status is indicated in the control room. (25)

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

~~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

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

Section 5.2 of IEEE 308 requires that Class 1E equipment which has no direct safety function (such as overload devices, protective relaying, etc.), be analyzed to assure consequences of any operation or failure is acceptable to the Class 1E power system. Such devices may potentially fail in such a way that a pump or motor within a safety group is prematurely tripped and cannot perform its function. However, such devices cannot cause inadvertent actuation of the safety function. (For example, a motor cannot inadvertently start as a result of a failed overload protection device.) Therefore, this analysis need only be concerned with one of two possible failure modes.

The ABWR has three independent divisions, any one of which can safety shut down the plant (8.3.1.1.5.3). The failure of one complete division is acceptable because the remaining divisions will automatically assure adequate reactivity control, core cooling, containment of radioactivity release, and integrity of the reactor coolant system and containment. A detailed failure analysis is presented in Chapter 15. The assumption of a complete divisional failure is conservative in that it envelopes the severity of any individual component failures within the division.

The probability of common-mode failures attributed to set point drift is not credible for two reasons:

1) Set points are determined on the basis of an NRC-approved methodology (NEDC-31336 "General Electric Instrument Setpoint Methodology"), which incorporates allowance for set point drift based on historical data accumulated from approximately 9 reactor-years of experience.

2) Loads, such as motors, are designed with sufficient current carrying capability or overload margins so that set points of protective devices are set sufficiently above the operating current point of the loads to allow for setpoint drift.

This analysis has shown that postulated failure of Class 1E components which have no direct safety function is acceptable to the Class 1E power system.

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(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

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 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

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

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

(k) RG 1.155 - Station Blackout

Regarding Position C-1 of Regulatory Guide 1.75 (see Section 8.3.1.1.1), the non-Class 1E FMCRD motors and brakes are supplied power from the Division 1 Class 1E 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-Class 1E 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-Class 1E 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.

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

Each standby power supply for each of the three divisions is composed of a single generator driven by a diesel engine having faststart 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 Divisions 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 8.1.4.1)

(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 ~~last paragraph of Section~~ 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.

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8.3.1.2.2 Deleted

~~8.3.1.2.3~~ Quality Assurance Requirements (move to 8.3.3.3)

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 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 as discussed in Section 3.11. See Subsection 8.3.4.3 for COL license information.

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 identified so that their electrical divisional assignment is apparent and so that an observer can visually differentiate between Class 1E equipment and wiring of different divisions, and between Class 1E 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 treated as Class 1E (see Note 1), there shall be an "A" appended to the divisional designation (e.g., "A1"). The latter "A" stands for associated. "N" shall be used for nondivisional cables. 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 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.

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 name-plate 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, transformers, 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 name-plates have color coded background with black engraving.

8.3.1.3.1.2 Cable Identification

All cables for Class 1E systems and 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 number (cable number), in addition to the marking characteristics shown below.

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 30.5 cm (1 ft.)) 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. Any non-divisional cable within such cabinets shall be appropriately marked to distinguish it from the divisional cables.

8.3.1.3.1.3 Raceway Identifcation

All conduit is similarly tagged with a unique conduit number, in addition to the marking characteristics shown below, at 4.57 meters (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 Class 1E cable raceways are marked with the division color, and with their proper raceway identification at 4.57 meters (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 and markings are used:

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

The VN or VS markings are superimposed on the divisional color markings, and placed at the same intervals.

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 separate conduit for each rod scram group.

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, name-plates, cables and raceways, as described above.

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. 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 as decribed in Subsection 8.3.1.4.2. Any exceptions are justified in Appendix 9A, Subsection 9A.5.5.5.

The physical independence of electric power systems complies with the requirements of IEEE Standard 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 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 requirements are applied to control power and motive power for all systems involved. Access to Class 1E equipment is administratively controlled (see Section 13.6.3).

(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. 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 of current and 250 VDC or ac for relay contactor control.

(d) V1 = Low level signal and control, including fiber-optic cables and metallic cables with analog signals up to 55 VDC and digital signal up to 12 VDC.

Power cables (V3) are routed in flexible metallic conduit under the raised floor of the control room. For EMI considerations, power cables are routed in metallic conduit wherever they come in close proximity with low level (V1) cables.

(73) 8.3.1.4.1.2 Electric Cable Installation (8.3.3.6.1.2)

(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 8.3.3.1.

(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. Cable routing in the drywell is discussed in association with the equipment it serves in the "Special Cases" Section 9A.5.

(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 communications) are tagged at their terminations with a unique identifying number. Colors used for identification of cables and raceways 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 Class 1E 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**--The separation of electric penetration assemblies exceeds the requirements for cables and raceways given in Section 6.1.5 of IEEE 384. Separation by distance (without barriers) is allowed only within the inerted containment. Here, the minimum allowable distances of .9 meters (3 feet) and 1.5 meters (5 feet) apply, as delineated in Section 6.1.5 of IEEE 384. However, the lesser distances allowed by IEEE 384 for enclosed raceways does not apply to the containment penetrations themselves. Groupings of circuits in penetration assemblies follows the same raceway voltage groupings as described in 8.3.3.6.1. For the other ends of the penetrations, which are outside the containment in the non-inerted areas, separation by distance alone is not allowed. These ~~will be~~ are separated by separate

rooms, or barriers, or different floor levels. Such walls, barriers or floors are 3-hour fire-rated.

Such separation criteria applies to the following:

1. Between redundant penetrations,

2. Between penetrations containing non-Class 1E and penetrations containing Class 1E or associated Class 1E circuits, and

3. Between penetrations containing Class 1E circuits and other divisional or non-divisional cables.

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. This avoids penetration damage in the event of failure of any single overcurrent device to clear a fault within the penetration or beyond it. See Subsection 8.3.4.4 for COL license information.

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 supervisory 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 assure compliance with approved and issued drawings and specifications.

The equipment nomenclature used on the ABWR standard design is one of the primary mechanisms 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 driven). Based on these identification numbers, each item can be identified as Class 1E or non-Class 1E, and each Class 1E 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 raceways match the divisional assignment of the system it supports.

8.3.1.4.2 Independence of Redundant Class 1E Instrumentation and Control Systems

This subsection defines independence criteria applied to Class 1E 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 Subsections 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 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 three-hour fire-rated barriers and electrical isolation. This protection is provided to maintain the independence of nuclear Class 1E 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. 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, 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 (i.e., separate fire zones) insofar as possible. The separation of Class 1E circuits and equipment is such that the required independence will not be compromised by the failure of mechanical systems served by the Class 1E electrical system. For example, Class 1E circuits are routed or protected so that failure of related 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 floors.

8.3.1.4.2.2.2 Three-Hour Fire Rated Protective Barriers

Three-hour fire rated protective barriers shall be such that no locally generated fire, or missile resulting from a design basis event (DBE) or from random failure of Seismic Category I equipment can disable a safety-related function. The exceptional cases where it is not possible to install such barriers have been analzed and justified in Appendix 9A.5.

Separation in all safety equipment or cable areas shall equal or exceed the requirements of IEEE 384.

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 following general criteria to preclude 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. 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 15.24 cm (6 inches) or by steel barriers or enclosures. Solid or flexible metalic conduit is considered an acceptable barrier, providing 2.54 cm (1 inch) separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(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. Solid or flexible metalic conduit is considered an acceptable barrier, providing 2.54 cm (1 inch) separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(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). Solid or flexible metalic conduit is considered an acceptable barrier, providing 2.54 cm (1 inch) separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(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 2.54 cm (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.

The electrical equipment from the Class 1E power supplies to the distribution centers are separated by 3-hour fire barriers. Beyond the distribution centers,

8.3.1.4.2.2.4 Isolation Devices

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 will be used. AC isolation (the FMCRD drives on Division 1 is the only case) is provided by interlocked circuit breaker coordination and an isolation transformer as described in Subsection 8.3.1.1.1.

Wiring from Class 1E equipment or circuits which interface with non-Class 1E equipment circuits (i.e., annunciators or data loggers) is treated as Class 1E and retain its divisional identification up to and including its isolation device. The output circuits from this isolation device are classified as non-divisional and shall be physically separated from the divisional 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. (Note that in Table 8.3-1, diesel generator "A" corresponds with Class 1E electrical division "I", "B" with "II", and "C" with "III".) 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 separate 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 separated 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 (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~~, 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) 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 ~~in accordance with IEEE 384 and Regulatory Guide 1.75 i.e.~~ by .9 m (3 ft) horizontal, or 1.5 m (5 ft) vertical, or ~~a barrier.~~ with an additional barrier separated by 2.5 cm (1 inch).

(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-Clas 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.

(9) The startup range monitoring (SRNM) subsystem cabling of the NMS cabling under the vessel is treated as divisional. ... SRNM cables will be assigned to Division I, II, III and IV. Under the vessel, cables will be enclosed and separated as defined in Appendix 9A.5.5.5.

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.

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

Class 1E 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 sources 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. (Note that in Table 8.3-1, diesel generator "A" corresponds with Class 1E electrical division "I", "B" with "II", and "C" with "III".) The wiring to the ADS solenoid valves within the drywell shall run in rigid conduit. ADS conduit for solenoid A shall be divisionally separated from solenoid B conduit. Short pieces (less than .6 m [2 ft.]) 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 leak.

(6) Class 1E electrical equipment located in the suppression pool level swell zone is limited to suppression 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.

(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 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

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 125VDC divisions, three independent non-Class 1E 125VDC load groups and one non-Class 1E 250VDC 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.

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 the time stated in the design basis, regardless of the status of the plant during which these demands occur (see 8.3.4.35).

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

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).

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, 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 Class 1E 125 VDC buses.

8.3.2.1.3 Station Batteries and Battery Chargers, General Considerations

The four ESF divisions are supplied from the four Class 1E 125 VDC systems (See Figure 8.3-4). Each of the Class 1E 125 VDC systems has a 125 VDC battery, a battery charger and a distribution panel. One standby battery charger can be connected to either of two divisions and another standby battery charger can be connected to either of two other divisions. Kirk key interlocks prevent cross connection between divisions. The main dc distribution buses include distribution panels, drawout-type breakers and molded case circuit breakers.

The Class 1E 125 VDC systems supply dc power to Divisions 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 single failure in any 125 VDC system will result in conditions that prevent safe shutdown of the plant with the remaining ac 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.

Each division of the system is located in an area separated physically from other divisions. All the components of Class 1E 125 VDC systems are housed in Seismic Category I structures.

8.3.2.1.3.1 125 VDC Systems Configuration

Figure 8.3-4 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 battery charger is normally fed from its divisional 480V MCC bus, with no automatic transfer between buses.

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 discharged state to a fully charged state while handling the normal, steady-state dc load. Cross connection between two divisions through a standby charger is prevented by at least two interlocked breakers in series in each potential cross-connect path. (See Figure 8.3-4 and Subsection 8.3.4.18.)

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.

As a general requirement, the batteries have sufficient stored energy to operate connected ~~safety-related~~ loads continuously for at least two hours without recharging. 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 Divisions II, III, and IV also extend the times these batteries are available (See 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.

A load capacity analysis has been performed, based on IEEE 485-1978, for estimated Class 1E dc battery loads as of September, 1989.

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 satisfy a safety load demand profile under the conditions of a LOCA and loss of preferred power.

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

See Subsection 8.3.4.6 for COL license informations.

8.3.2.1.3.2 Non-Class 1E 125V DC Power Supply

A non-class 1E 125VDC power supply, Figure 8.3-4, is provided for non-Class 1E switchgear, valves, converters, transducers, controls and instrumentation. The system has three load groups with one battery, charger and bus per load group. There are bus tie breakers between buses. Normal operation is with bus tie breakers open and interlocks prevent paralleling batteries. Each load group's battery and charger may be removed from service as a unit for maintenance or 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 load 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 Groups A or B or C ac power via the backup 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 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 as the charger is load limiting and therefore protects itself. 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.

See Subsection 8.3.4.6 for COL license information.

8.3.2.1.3.3 Non-Class 1E 250V DC Power Supply

A non-class 1E 250VDC power supply, Figure

8.3-4, is provided for the computers and the turbine turning gear motor. The power supply consists of one 250VDC battery and two chargers. The normal charger is fed by 480VAC from either the load Group A or load Group C turbine building load centers. Selection of the desired AC supply is by a mechanically interlocked transfer switch. The standby charger is fed from a load Group 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.

8.3.2.1.3.4 Ventilation

Battery rooms are ventilated to remove the minor amounts of gas produced during the charging of batteries.

8.3.2.1.3.5 Station Blackout

Station blackout performance is discussed in Subsection 19E.2.1.2.2. An assessment of Regulatory Guide 1.155 is provided in Appendix 1C. See Subsection 8.3.4.16 for COL license information.

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 8.3-4). 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 sources. The DC system is so arranged that the probability 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 conditions of important system parameters such as charger failure or low bus voltage are annunciated 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 grouips ensuring the following:

(1) The unlikely loss of one 125 VDC system does not jeopardize the Class 1E feed supply to the Class 1E buses.

(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 NRC General Design Criteria, NRC Regulatory Guides and other criteria consistent with the standard review plan. The analyses establish the ability of the system to sustain credible single failures 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 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 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. 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.

Associated circuits added beyond the certified design must be specifically identified and justified per Subsection 8.3.4.15. 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 Postion 1.(b) of the guide.

(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 and are exempt from such requirements per Section 4.1.7 of IEEE 741.

(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, 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.

(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):

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 as listed in Table 9.5.1-1.

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 and qualified to survive the LOCA ambient condition at the end of the 60-yr life span. The cable installation (i.e., redundant divisions separated by fire barriers) is such that direct impingement of fire suppressant will not prevent safe reactor shutdown, even if failure of the cable occurs. Cables are specified to be submersible, however (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 8.3.3.6. Floors and walls are effectively used to provide vertical and horizontal fire-resistive separations between redundant cable divisions.

In any given fire area an attempt is made to insure that there is equipment from only one Class 1E 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.

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.

8.3.3.3 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 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 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 8.3.1.2.4 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 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). The COL applicant will 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.

The COL applicant will provide specific identification and location of power supplies used to provide external control power for tripping primary and backup electrical penetration breakers (if utilized).

The COL applicant will provide an analysis demonstrating the thermal capability of all electrical conductors within penetrations is perserved and protected by one of the following:

(1) The maximum available fault current (including failure of upstream devices) is less than the maximum continuous current capacity (based on no damage to the penetration) of the conductor within the penetration; or

(2) 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.

(3) 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.

8.3.4.5 (deleted)

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 8.3.2.1.3.12).

8.3.4.7 (deleted

8.3.4.8 (deleted)

8.3.4.9 Offsite Power Supply Arrangement

The COL applicant 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. The selection of that division should be based on the Class 1E bus loads, the reliability/stability of the offsite circuits, and on the separation of the offsite feeds as they pass through the divisional areas.

Continued plant operation will be appropriately limited (per technical specifications), when the reserve auxiliary transformer is inoperable [see 8.2.3(10) for COL information].

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 by the COL applicant. The tests shall be in accordance with IEEE 387 and Regulatory Guide 1.9. (See Subsection 8.3.1.1.8.9).

8.3.4.11 (deleted)

8.3.4.12 Minimum Starting Voltages for Class 1E Motors

The COL applicant will provide the minimum required starting voltages for Class 1E motors. A comparision will be made of 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 diesel generators. (See Subsection 8.3.1.1.5(1)).

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 for the FMCRD drive power feed taken from the Division I 6.9Kv safety-related bus (see Subsection 8.3.1.1.1) and the emergency lighting circuits (see Section 9.5.3). In the implementation design, the COL applicant will provide 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. (See Subsection 8.3.1.1.1).

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 by the COL applicant 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. (See Subsection 8.3.1.1.6.2).

8.3.4.15 Testing of Thermal Overload Bypass Contacts for MOVs

Thermal overload protection for Class 1E MOVs is bypassed only during LOCA events. A means for testing the bypass function shall be implemented by the COL applicant, in accordance with the requirements of Regulatory Guide 1.106. [See Subsection 8.3.1.1.6.4)

8.3.4.16 Emergency Operating Procedures for Station Blackout

COL applicants will provide instructions in their plant Emergency Operating Procedures for operator actions during a postulated station blackout event. Specifically, if Division I 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. (See Subsection 8.3.2.1.3.5).

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 industrial standards, as appropriate, for the assurance of quality manufacturing of both Class 1E and non-Class 1E equipment. Such standards would include ANSI, ASTM, IEEE, NEMA, UL, etc. (See Subsection 8.3.5).

8.3.4.18 Administrative Controls for Switching 125 VDC Standby Charger

Administrative controls shall be provided to assure all input and output circuit breakers are normally open when standby battery chargers are not in use (See Figure 8.3-4, Note 1). Administrative controls shall also be provided to assure at least two circuit breakers (in series) are open between redundant divisions when placing the standby charger into service. This includes controls for the keys associated with the switching interlocks. The only exception is an emergency condition requiring one division's loads be assumed by a redundant division by manual connection via the standby charger interface.

8.3.4.19 Control of Access to Class 1E Power Equipment

Administrative control of access to Class 1E power equipment areas and/or distribution panels shall be provided (see Section 13.6.3).

8.3.4.20 Periodic Testing of Voltage Protection Equipment

Appropriate plant procedures shall include periodic testing of instruments, timers, and other electrical equipment designed to protect the distribution system from: 1) loss of offsite voltage, and 2) degradation of offsite voltage. These protection features are described in Subsection 8.3.1.1.7.

8.3.4.21 Diesel Generator Parallel Test Mode

The technical specifications require periodic testing of the diesel generator loading capabilities by operating the diesel generators in parallel with the offsite power source. Interlocks which restore the units to emergency standby on event of a LOCA or LOPP shall also be tested. Appropriate procedures shall require that the duration of the connection between the preferred power supply and the standby power supply shall be minimized in accordance with Section 6.1.3 of IEEE 308.

8.3.4.22 Periodic Testing of Diesel Generator Protective Relaying

Appropriate plant procedures shall include periodic testing of all diesel generator protective relaying, bypass circuitry and annunciation.

8.3.4.23 Periodic Testing of Diesel Generator Synchronizing Interlocks

Appropriate plant procedures shall include periodic testing of diesel generator synchronizing interlocks (see 8.3.1.1.6.4).

8.3.4.24 Periodic Testing of Thermal Overloads and Bypass Circuitry

Appropriate plant procedures shall include periodic testing of thermal overloads and associated bypass circuitry for Class 1E MOVs. The testing shall be performed in accordance with the requirements of Regulatory Guide 1.106 [see 8.3.1.2(2)(g) and 8.3.2.2.2(2)].

8.3.4.25 Periodic Inspection/Testing of Lighting Systems

Appropriate plant procedures shall include periodic inspections of all lighting systems installed in safety-related areas, and in passageways leading to and from these areas. In addition, lighting systems installed in such areas which are normally de-energized (e.g., guide lamps) shall be periodically tested.

8.3.4.26 Controls for Limiting Potential Hazards into Cable Chases

Appropriate plant procedures shall provide administrative control of operations and maintenance activities to control and limit introduction of potential hazards into cable chases and the control room area.

8.3.4.27 Periodic Testing of Class 1E Equipment Protective Relaying

Appropriate plant procedures shall include periodic testing of all protective relaying and/or thermal overloads associated with Class 1E motors and switchgear.

8.3.4.28 Periodic Testing of CVCF Power Supplies and EPA's

Appropriate plant procedures shall include periodic testing of the CVCF power supplies and associated electrical protection assemblies (EPA's) which provide power to the Reactor Protection System.

8.3.4.29 Periodic Testing of Class 1E Circuit Breakers

Appropriate plant procedures shall include periodic calibration and functional testing of the fault interrupt capability of all Class 1E breakers, fault interrupt coordination between the supply and load breakers for each Class 1E load and the Division I non-Class 1E load, and the zone selective interlock feature of the breaker for the non-Class 1E load.

8.3.4.30 Periodic Testing of Electrical Systems & Equipment

Appropriate plant procedures shall include periodic testing of all Class 1E electrical systems and equipment in accordance with Section 7 of IEEE 308.

(Deleted)

8.3.4.31 Power Distribution System Load Analysis

A complete load analysis shall be performed for the Power Distribution System to demonstrate proper sizing of power source and distribution equipment. Such analysis shall provide the basis for the degraded voltage protective relay timer settings [see 8.3.1.1.7 (8)] and other protective relay settings.

8.3.4.32 Class 1E Battery Installation and Maintenance Requirements

The installation, maintenance, testing, and replacement of the Class 1E station batteries shall meet the requirements of IEEE 484 and Section 5 of IEEE 946.

8.3.4.33 Periodic Testing of Class 1E Batteries

in accordance with Section 7 of IEEE 308

(85 COL)

Appropriate plant procedures shall include periodic testing of Class 1E batteries to assure they have sufficient capacity and capability to supply power to their connected loads.

8.3.4.34 Periodic Testing of Class 1E CVCF Power Supplies

Appropriate plant procedures shall include periodic testing of Class 1E constant voltage constant frequency (CVCF) power supplies to assure they have sufficient capacity to supply power to their connected loads (see 8.3.1.1.4.2.1).

8.3.4.35 Periodic Testing of Class 1E Battery Chargers

Appropriate plant procedures shall include periodic testing of Class 1E battery chargers to assure they have sufficient capacity to supply power to their connected loads (see 8.3.2.1.1). Such periodic tests shall be in conformance with Section 7.5.1 of IEEE 308 (i.e., IEEE 338).

8.3.4.36 Periodic Testing of Class 1E Diesel Generators

Appropriate plant procedures ~~and/or technical specifications~~ shall include periodic testing and/or analysis of Class 1E diesel generators and to demonstrate their capability to supply the actual full design basis load current for each sequenced load step (see 8.3.1.1.8.2).

(82 COL)

8.3.5 References

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

Insert B

IEEE Std 323	Qualifying Class 1E Equipment for Nuclear Power Generating Stations
IEEE Std 334	Type Test of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations
IEEE Std 379	Applications of the Single-Failure Criterion to Nuclear Power Generating Stations Class 1E Systems
IEEE Std 382	Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants.
IEEE Std 383	Type Test of Class 1E Electrical Cables, Field Splices, and Connections fro Nuclear Power Generating Stations
IEEE Std 387	Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations

Insert C

IEEE Std 450	Recommended Practice for Large Lead Storage Batteries for Generating Stations and Substations

IEEE Std 484	Recommended Practice for Installation Design and Installation of 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
IEEE Std 519	Guide for Harmonic Control and Reactive Compensation of Static Power Converters
IEEE Std 741	Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations.
IEEE Std 946	Recommended Practice for the Design of Safety-Related DC Auxiliary Power Systems for Nuclear Power Generating Stations
IPCEA-46-426/ IEEE S-135	Power Cable Ampacities
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 Polyethlene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
SECY-89-013	Stello, Victor, Jr., *Design Requirements Related To The Evolutionary Advanced Light Water Reactors (ALWRS)*, Policy Issue, SECY-89-013, The Commissioners, Uni- ted State Nuclear Regula- tory Commission, January 19, 1989.

Topical Report NEDC-31336 "General Electric Instrument Setpoint Methodology"

UL-44	UL Standard for Safety Rubber-Insulated Wires and Cabies

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 below:

Motor Control Centers

NEMA ICS-2	Standards for Industrial Control Devices, Con- trollers 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-rated 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 Switchgear
ANSI C37.20	Switchgear Assemblies and Metal-Enclosed Bus
ANSI C37.100	Definitions for Power Switchgear

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

See Subsection 8.3.4.17 for COL license information pertaining to common industrial standards referenced in purchase specifications.

TABLE 8.3-1

D/G LOAD TABLE -LOCA + LOPP

SYS. NO.	LOAD DESCRIPTION	RATING (kW)	GENERATOR CONNECTED LOADS (kW) A	B	C	NOTE*
--	MOTOR ope VALVES	231x3	X	X	X	(2)
C12	FMCRD (@ 0.25pf)	210x1 (840 KVA)	X	--	--	(4)
C41	SLC PUMP	45x2	X	X	--	(5) add
E11	RHR PUMP	540x3	540	540	540	
	Fill Pump*	3.7x3	X	X	X	add
E22	HPCF PUMP	1400x2	--	1400	1400	
P21	RCW PUMP	370x4	740	740	--	
		280x2	--	--	560	
P25	HECW PUMP	22x5	22	44	44	
	HECW REFRIGERATOR	135x5	135	270	270	
P41	RSW PUMP**	270x6	540	540	540	
R23	P/C TRANSF. LOSS	421x6 (42.1)	84.2	84.2	84.2	
R42	DC 125V CHGR div. I	70x1	70.0	--	--	
	div. II, III, IV	34x3	--	268	34	(11)
	125V DC stby charger		70	--	34	

* *See Table 8.3-3 for Notes*
** *Part of Turbine Island*

TABLE 8.3-1

D/G LOAD TABLE -LOCA + LOPP (Continued)

SYS. NO.	LOAD DESCRIPTION	RATING (kW)	GENERATOR ~~OUTPUT~~ CONNECTED LOADS (kW) A	B	C	NOTE*
R46	VITAL CVCF		--	--	--	
	(Div. 1,2,3)	20x3	20	20	20	
	(Div. 4)	20		20		
R47	TRANSF. C/R INST	20x6	40	40	40	
R52	LIGHTING	100x3	100	100	100	
T22	SGTS FAN	18.5x2	18.5	18.5	--	
	SGTS HEATER	10x6	30	30	--	
T49	FCS HEATER	130x2		130	130	
	FCS BLOWER	12x2		120	120	
U41	MCR HVAC FANS B-C	74.5X4	--	149	149	(13)
	MCR RECIRC FANS B-C	14X4	--	28	28	(13)
	C/B ELEC EQUIP AREA HVAC FANS A-C	14X6	28	28	28	(13)
	R/B DG/ELEC EQUIP AREA HVAC FANS A-C	84X6	168	168	168	(13)
	R/B DG ROOM EMERGENCY SUPPLY FANS A-C	46.5X6	93	93	93	(13)
	R/B EQUIP AREA ROOM COOLERS A-C		89	107	84	(13)
	OTHER LOADS		62.5	62.5	60.5	
	TOTAL CONNECTED LOADS		3339.9	4971.9	4653.4	
	TOTAL STANDBY LOADS AND SHORT TIME LOADS		678.7*	566.2*	509.7*	
	TOTAL OPERATING LOADS		2661.2	4405.7	4143.7	

* *See Table 8.3-3 for Notes*

TABLE 8.3-3

NOTES FOR TABLES 8.3-1 AND 8.3-2

(1) --: shows that the load is not connected to the switchgear of this division.
X: shows that the load is not counted for D/G continuous output claculation by the reasons shown on other notes.

(2) "Motor operated valves" are operated only 30-60 seconds. Therefore they are not counted for the DG continuous output calculation.

(3) Deleted

(4) FMCRD operating time (about 2 minutes) is not counted for the DG continuous output calculation.

(5) Sufficient boron concentration is achieved in about 40 minutes. Since the diesels can operate at least 2 hours at 110% rated load, the SLC pumps are not counted for the DG continous output calculation.

(6) Deleted

(7) Deleted

(8) Deleted

(9) Deleted

(10) Deleted

(11) Div. IV battery charger is fed from Div. II motor control center.

(12) Load description acronyms are interpeted as follws:

C/B	- Control Building	HX	- Heat Exchanger
COMP	- Computer	IA	- Instrument Air
CRD	- Control Rod Drive	MCR	- Main Control Room
CUW	- Clean Up Water	MUWC	- Make Up Water System (condensed)
CVCF	- Constant Voltage Constant Frequency	NPSS	- Nuclear Protection Safety System
DG	- Diesel Generator	R/B	- Reactor Building
FCS	- Flammability Control System	RCW	- Reactor Cooling Water (building)
FPC	- Fuel Pool Cooling	RHR	- Residual Heat Removal
FMCRD	- Fine Motion Cotrol Rod Drive	RSW	- Reactor Service Water
HECW	- Emergency Cooling Water	SBGT	- Standby Gas Treatment
HPCF	- High Pressure Core Flooder	SLC	- Standby Liquid Control

(13) Redundant units, one unit of a division operates and one unit is in standby in case the operating unit shuts down. Total connected load is shown on the table, but operating loads are half these amounts.

Table 8.3-4

D/G LOAD SEQUENCE DIAGRAM
MAJOR LOADS
(Response to Questions 435.14 & 435.15)

Mode	Block Time Div.	BLOCK 1 (20 SEC)	BLOCK 2 (30 SEC)	BLOCK 3 (35 SEC)	BLOCK 4 (40 SEC)	BLOCK 5 (45 SEC)	BLOCK 6 (50 SEC)	BLOCK 7 (55 SEC)	BLOCK 8 (60 SEC) Auto	BLOCK 9 AFTER 65 SEC Manual	
LOPP	I	MOV Inst. Tr Lighting FMCRD	DG HVAC	RCW Pump HECW Pump	RCW Pump	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump	SGTS	Chargers CVCFs	SLC Pump HECW Refrig	RHR Pump
LOPP	II	MOV Inst. Tr Lighting	DG HVAC	RCW Pump HECW Pump	RCW Pump MCR HVAC	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump	SGTS	Chargers CVCFs	SLC Pump HECW Refrig	RHR Pump
LOPP	III	MOV Inst. Tr Lighting	DG HVAC	RCW Pump HECW Pump	RCW Pump MCR HVAC	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump		Chargers CVCFs	HECW Refrig	RHR Pump
LOCA & LOPP	I	MOV Inst. Tr Lighting FMCRD*	RHR Pump DG HVAC	RCW Pump HECW Pump	RCW Pump	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump	SGTS	Chargers CVCFs	SLC Pump HECW refrig	FCS
LOCA & LOPP	II	MOV HPCF Pump Inst. Tr Lighting	RHR Pump DG HVAC	RCW Pump HECW Pump	RCW Pump MCR HVAC	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump	SGTS	Chargers CVCFs	SLC Pump HECW Refrig	FCS
LOCA & LOPP	III	MOV HPCF Pump Inst. Tr Lighting	RHR Pump DG HVAC	RCW Pump HECW Pump	RCW Pump MCR HVAC	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump		Chargers CVCFs	HECW Refrig	

Note* FMCRDs are the only Non Class 1E loads on the DG buses.

TABLE 8.3-5

DIESEL GENERATOR ALARMS*

Annunciation	DOS	DTS	DTT	GDT	GCB	GTT	LBP
Engine Overspeed Trip	X	X	X		X		
Generator Differential Relay Trip		X		X	X	X	
Generator Ground Overcurrent					X	X	X
Generator Voltage Restraint Overcurrent					X	X	X
Generator Bus Underfrequency					X	X	X
Generator Reverse Power		X			X	X	X
Generator Loss of Field		X			X	X	X
Generator Bus Differential Relay Trip					X		
High-High Jacket Water Temperature		X	X		X		X
D/G Bearing High Temperature		X	X		X	X	X
Low-Low Lube Oil Temperature		X	X		X		X
D/G Bearings High Vibration		X	X		X	X	X
High-High Lube Oil Temperature		X	X		X		X
Low-Low Lube Oil Pressure		X	X		X		X
High Crankcase Pressure		X	X		X		X
Low-Low Jacket Water Pressure		X	X		X		X
Low Level -- Jacket Water			X				
Low Pressure -- Jacket Water			X				
Low Temperature -- Jacket Water In			X				
High Temperature -- Jacket Water Out			X				
Low Level -- Lube Oil Mark			X				
Low Temperature -- Lube Oil In			X				
High Temperature -- Lube Oil Out			X				
High Diff. Pressure -- Lube Oil Filter			X				
Low Pressure -- Turbo Oil Right/Left Bank			X				
Low Pressure -- Lube Oil			X				
Control Circuit Fuse Failure			X				
Diesel Generator Overvoltage						X	
Low Pressure -- Starting Air			X				
In Maintenance Mode			X			X	
D/G Unit Fails to Start			X				
Generator Phase Overcurrent						X	
Out of Service		X			X		
Lockout Relay Operated		X			X	X	
Low-High Level -- Fuel Day Tank			X				
Low Level -- Fuel Storage Tank			X				
Low Pressure -- Fuel Oil			X				
High Diff. Pressure -- Fuel Filter			X				
In Local control Only			X				

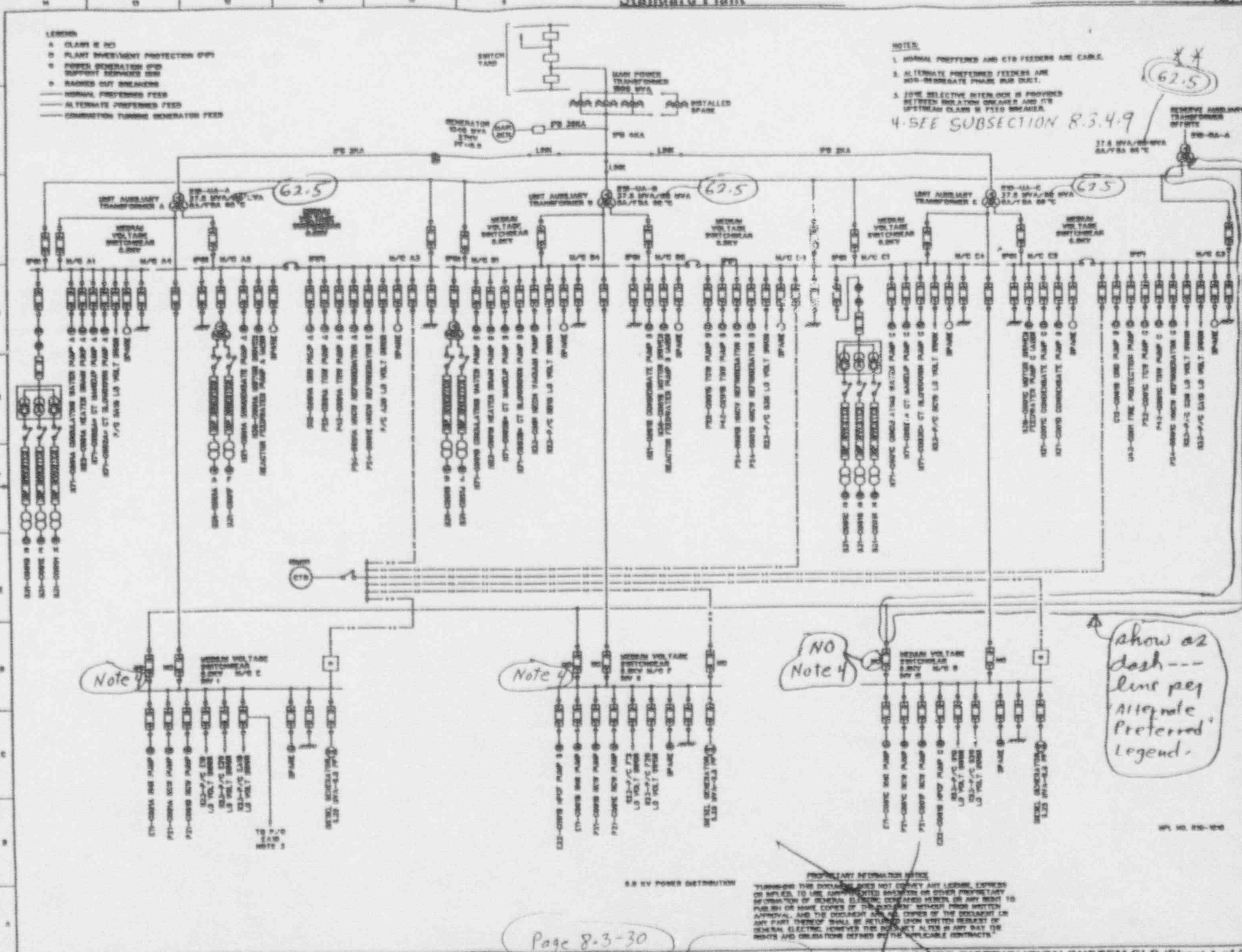
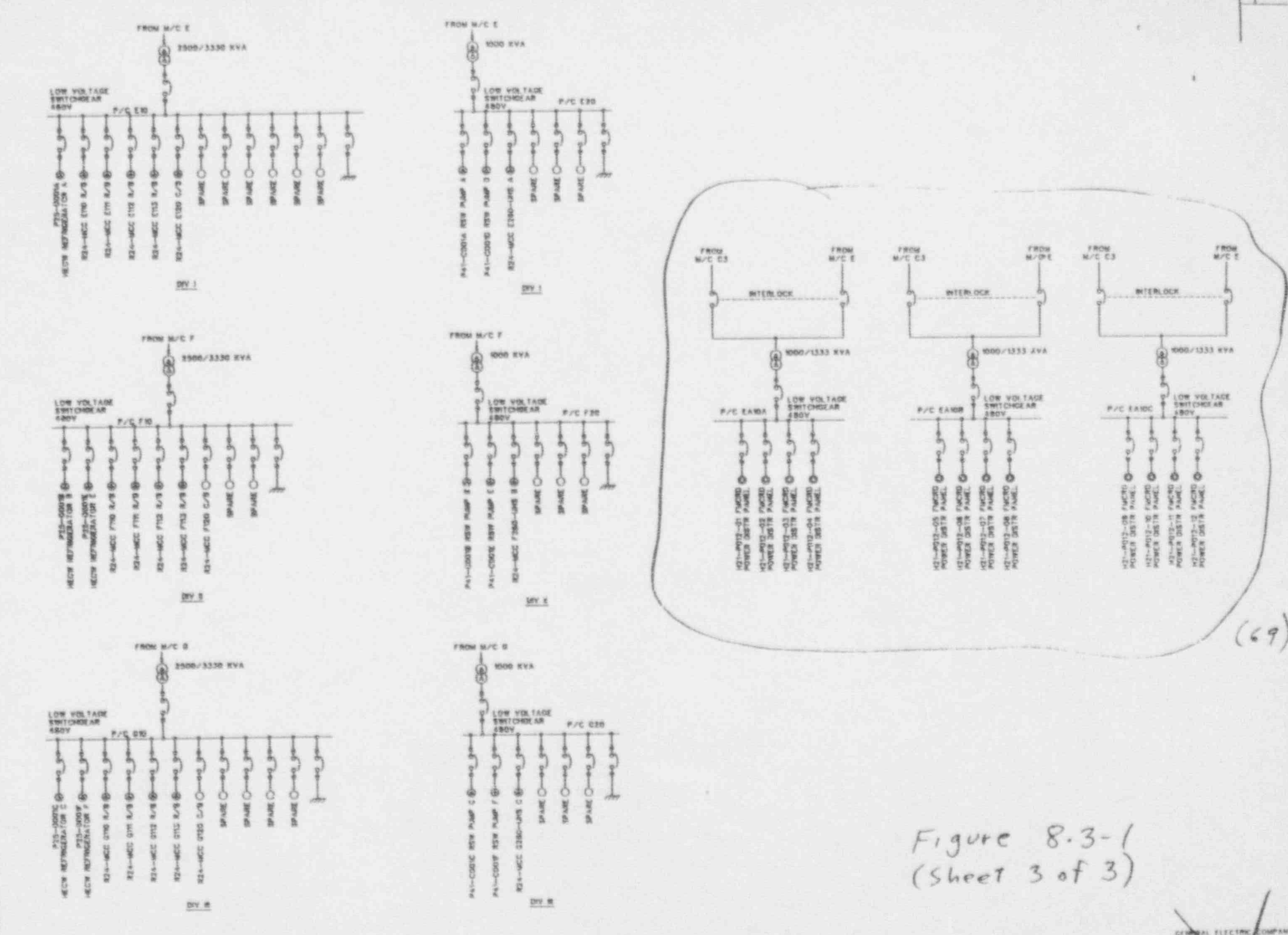
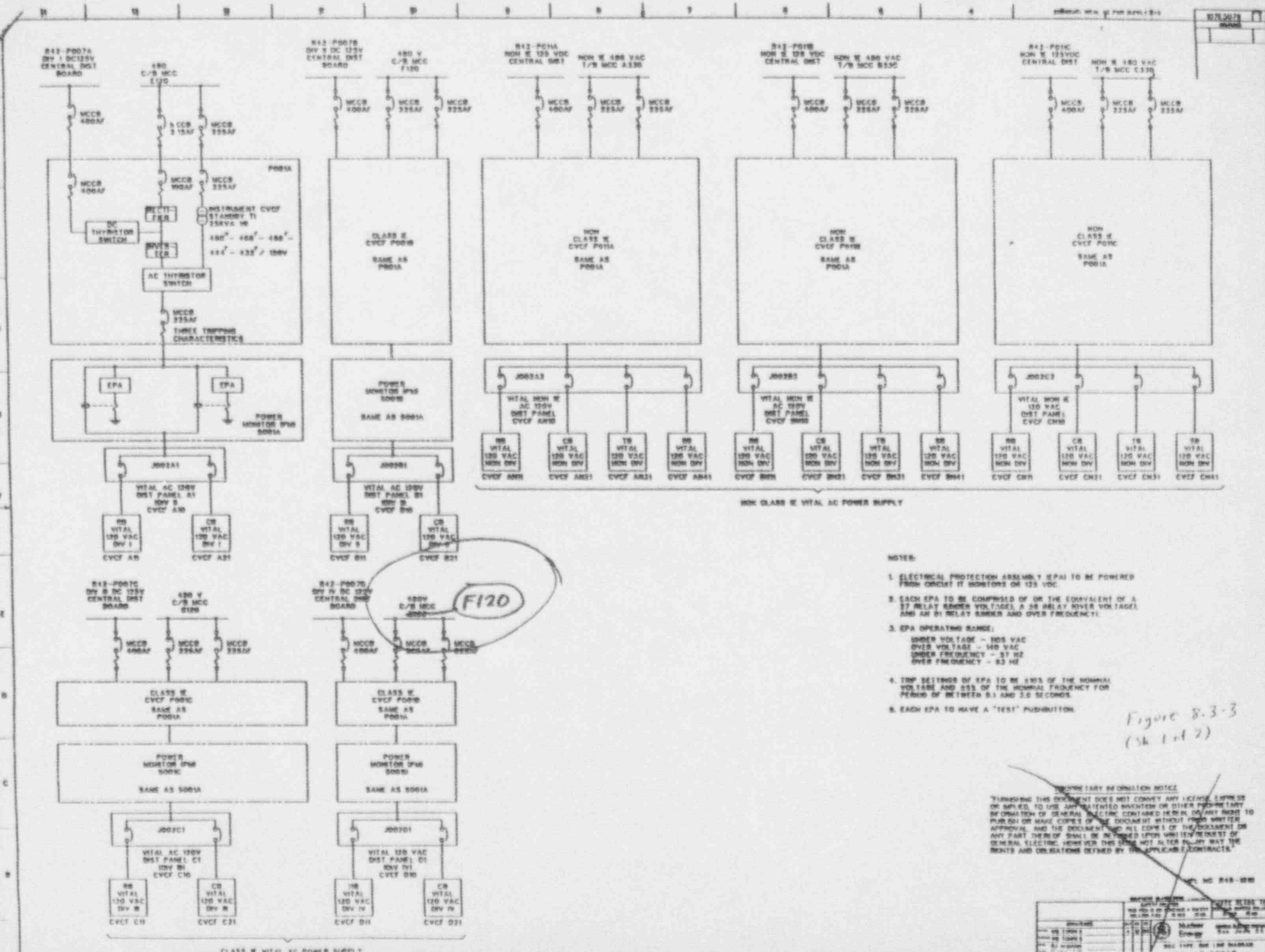


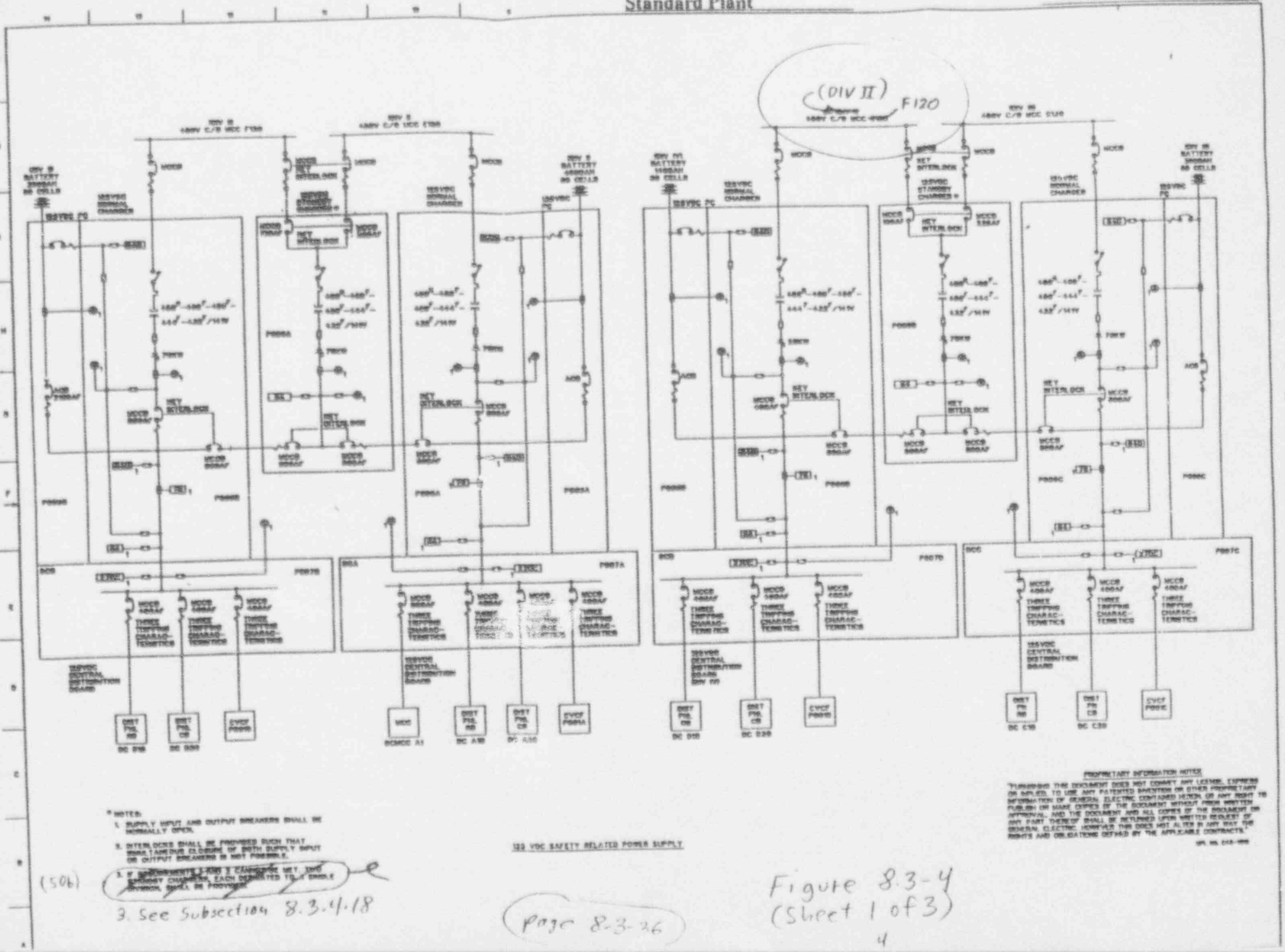
Figure 8.3-1 ELECTRICAL POWER DISTRIBUTION SYSTEM SLD (Sheet 1 of 3)



480V IE POWER DISTRIBUTION

Figure 8.3-1
(Sheet 3 of 3)


R42-P007A DIV I DC125V CENTRAL DIST BOARD
480 C/B MCC E120
R42-P007B DIV II DC 125V CENTRAL DIST BOARD
480 V C/B MCC F120
R42-PO11A NON IE 125 VDC CENTRAL DIST
NON IE 480 VAC T/B MCC A330
R42-PO11B NON IE 125 VDC CENTRAL DIST
NON IE 480 VAC T/B MCC B330
R42-PO11C NON IE 125VDC CENTRAL DIST
NON IE 480 VAC T/B MCC C330
MCCB 400AF
MCCB 225AF
P001A
DC THYRISTOR SWITCH
AC THYRISTOR SWITCH
THREE TRIPPING CHARACTERISTICS
EPA
POWER MONITOR S001A
CLASS IE CVCF P001B SAME AS P001A
NON CLASS IE CVCF P011A SAME AS P001A
NON CLASS IE CVCF P011B SAME AS P001A
NON CLASS IE CVCF P011C SAME AS P001A
SAME AS S001A
J002A1
VITAL AC 120V DIST PANEL A1
J002B1
VITAL AC 120V DIST PANEL B1
J003A2
J003B2
J003C2
VITAL NON IE AC 120V DIST PANEL
VITAL 120 VAC NON DIV
NON CLASS IE VITAL AC POWER SUPPLY
R42-P007C DIV III DC 125V CENTRAL DIST BOARD
480 V C/B MCC E120
R42-P007D DIV IV DC 125V CENTRAL DIST BOARD
480V C/B MCC
F120
CLASS IE CVCF P001C SAME AS P001A
CLASS IE CVCF P001D SAME AS P001A
J002C1
VITAL AC 120V DIST PANEL C1
J002D1
VITAL 120 VAC DIST PANEL D1
CLASS IE VITAL AC POWER SUPPLY
NOTES:
1. ELECTRICAL PROTECTION ASSEMBLY (EPA) TO BE POWERED FROM CIRCUIT IT MONITORS OR 125 VDC.
2. EACH EPA TO BE COMPRISED OF OR THE EQUIVALENT OF A 27 RELAY (UNDER VOLTAGE), A 59 RELAY (OVER VOLTAGE) AND AN 81 RELAY (UNDER AND OVER FREQUENCY).
3. EPA OPERATING RANGE:
UNDER VOLTAGE - 105 VAC
OVER VOLTAGE - 140 VAC
UNDER FREQUENCY - 57 HZ
OVER FREQUENCY - 63 HZ
4. TRIP SETTINGS OF EPA TO BE ±10% OF THE NOMINAL VOLTAGE AND ±5% OF THE NOMINAL FREQUENCY FOR PERIOD OF BETWEEN 0.1 AND 3.0 SECONDS.
5. EACH EPA TO HAVE A "TEST" PUSHBUTTON.
Figure 8.3-3
(Sh 1 of 2)
PROPRIETARY INFORMATION NOTICE



* NOTES:

1. SUPPLY INPUT AND OUTPUT BREAKERS SHALL BE NORMALLY OPEN.
2. INTERLOCKS SHALL BE PROVIDED SUCH THAT SIMULTANEOUS CLOSURE OF BOTH SUPPLY INPUT OR OUTPUT BREAKERS IS NOT POSSIBLE.
3. ~~IF COMPONENTS 1 AND 2 CANNOT BE MET, TWO STANDBY CHARGERS, EACH DEDICATED TO A SINGLE DIVISION, SHALL BE PROVIDED.~~ (50b)

3. See Subsection 8.3.4.18

Figure 8.3-4 (Sheet 1 of 3)

4

8A MISCELLANEOUS ELECTRICAL SYSTEMS

8A.1 Station Grounding and Surge Protection

8A.1.1 Description

The electrical grounding system is comprised of:

(1) an instrument grounding network,

(2) an equipment grounding network for grounding electrical equipment (e.g. switchgear, motors, distribution panels, cables, etc.) and selected mechanical components (e.g. fuel tanks, chemical tanks, etc.),

(3) a plant grounding grid, and

(4) a lightning protection network for protection of structures, transformers and equipment located outside buildings.

The plant instrumentation is grounded through a separate insulated radial grounding system comprised of buses and insulated cables. The instrumentation grounding systems are connected to the station grounding grid at only one point and are insulated from all other grounding circuits. Separate instrumentation grounding systems are provided for plant analog (i.e. relays, solenoids, etc.) and digital instrumentation systems.

The equipment grounding network is such that all major equipment, structures and tanks are grounded with two diagonally opposite ground connections. The ground bus of all switchgear assemblies, motor control centers and control cabinets are connected to the station ground grid through at least two parallel paths. Bare copper risers are furnished for all underground electrical ducts and equipment, and for connections to the grounding systems within buildings. One bare copper cable is installed with each underground electrical duct run, and all metallic hardware in each manhole is connected to the cable.

A plant grounding grid consisting of bare copper cables is provided to limit step and touch potentials to safe values under all fault conditions. The buried grid is located at the switchyard and connected to systems within the buildings by a 500 MCM bare copper loop which encircles all buildings (See Figure 8A.1-1)

Each building is equipped with grounding systems connected to the station grounding grid. As a minimum, every other steel column of the building perimeter will connect directly to the grounding grid.

The plant's main generator is grounded with a neutral grounding device. The impedance of that device will limit the maximum phase current under short-circuit conditions to a value not greater than that for a three-phase fault at its terminals. Provisions are included to ensure proper grounding of the isophase buses when the generator is disconnected.

The onsite, medium-voltage ac distribution system is resistance grounded at the neutral point of the low-voltage windings of the unit auxiliary and reserve transformers.

The neutral point of the generator windings of the onsite, standby power supply units (i.e., the diesel generators and the combustion turbine generator), is through distribution-type transformers and loading resistors, sized for continuous operation in the event of a ground fault.

The neutral point of the low-voltage ac distribution systems are either solidly or impedance grounded, as necessary, to ensure proper coordination of ground fault protection. The dc systems are ungrounded.

The target value of ground resistance is 0.05 ohms or less for the reactor, turbine, control, service and radwaste buildings. If the target grounding resistance is not achieved by the ground grid, auxiliary ground grids, shallow buried ground rods or deep buried ground rods will be used in combination as necessary to meet the target ground resistance value.

The lightning protection system covers all major plant structures and is designed to prevent direct lightning strikes to the buildings, electric power equipment and instruments. It consists of air terminals, bare downcomers and buried grounding electrodes which are separate from the normal grounding system. Lightning arresters are provided for each phase of all tie lines connecting the plant electrical systems to the switchyard and offsite line. These arresters are connected to the high-voltage terminals of the main step-up and reserve transformers. Plant instrumentation located outdoors or connected to cabling running outdoors is provided with surge suppression devices to protect the equipment from lightning induced surges.

8A.1.2 Analysis

No SRP or regulatory guidance provided for the grounding and lightning protection system. It is designed and required to ~~be~~ installed to the applicable sections of the following codes and standards.

(1) IEEE Std 80, Guide for Safety in AC Substation Grounding

(2) IEEE Std 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

(3) IEEE Std 665, Guide for Generation Station Grounding

(4) NFPA-78, National Fire Protection Association's Lightning Protection Code

This code is utilized as recommended practices only. It does not apply to electrical generating plants.

(5) Nuclear Energy Property Insurance Association (NEPIA) document titled: "Basic Fire Protection for Nuclear Power Plants"

8A.1.3 COL License Information

It is the responsibility of the COL applicant to perform ground resistance measurements to determine that the required value of 0.05 ohms or less has been met and to make additions to the system if necessary to meet the target resistance.

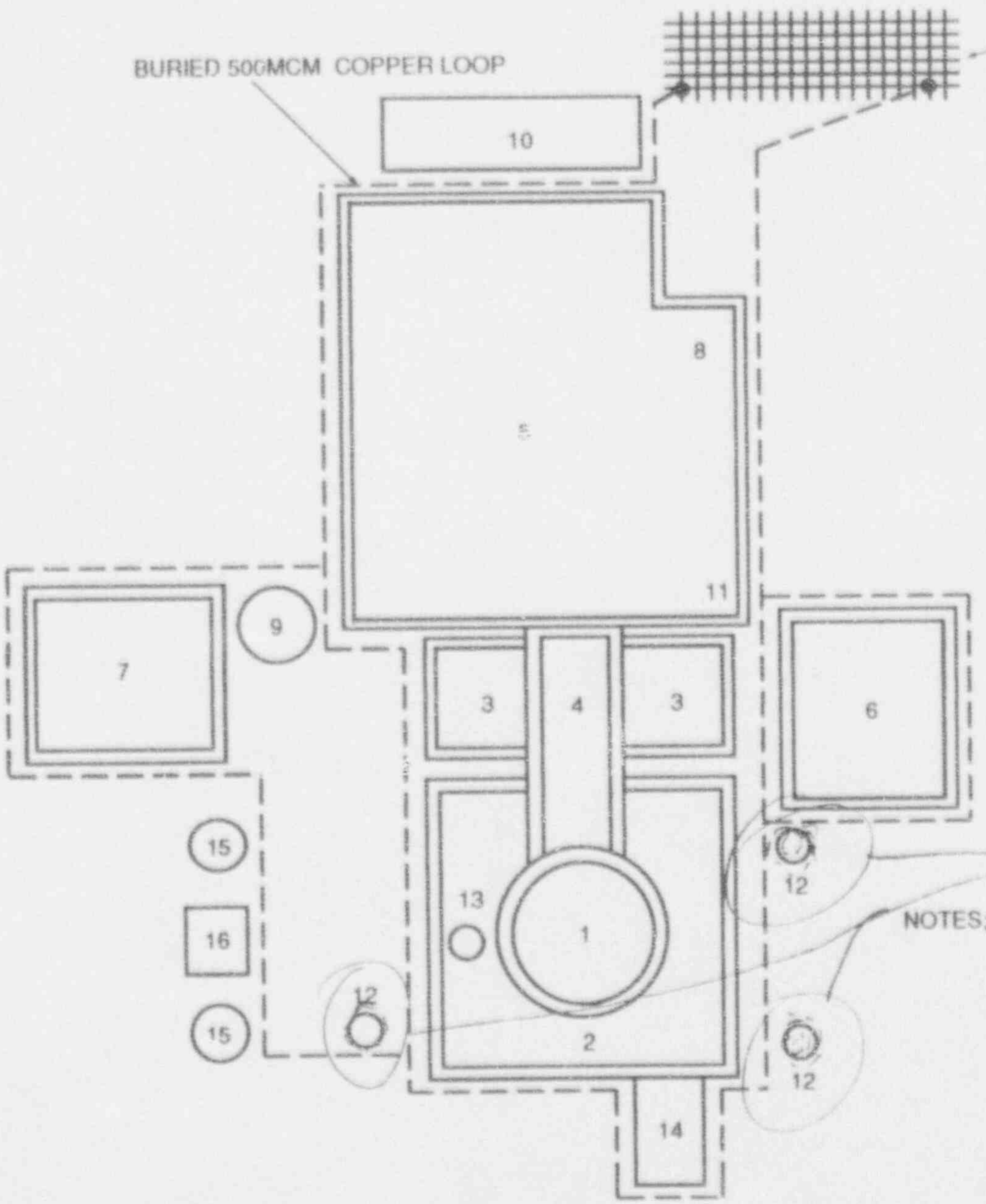
8A.1.4 References

(1) IEEE Std 80, Guide for Safety in AC Substation Grounding

(2) IEEE Std 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

(3) IEEE Std 665, Guide for Generation Station Grounding

(4) NFPA-78, National Fire Protection Association's Lightning Protection Code



NO.	FACILITY
1	REACTOR CONTAINMENT
2	REACTOR BUILDING
3	CONTROL BUILDING
4	MAIN STEAM/FEEDWATER TUNNEL
5	TURBINE BUILDING
6	SERVICE BUILDING
7	RADWASTE BUILDING
8	HOUSE BOILER
9	CONDENSATE STORAGE TANK
10	MAIN TRANSFORMER
11	NORMAL SWITCHGEAR
12	DIESEL OIL STORAGE TANK ~~(3), buried~~ (3-buried)
13	STACK
14	EQUIPMENT ENTRY LOCK
15	FIRE PROTECTION WATER STORAGE TANK (2)
16	FIRE PROTECTION PUMPHOUSE

NOTES;

STRUCTURES AND BUILDINGS TO BE GROUNDED TO THE YARD LOOP PER THE FOLLOWING SPECIFICATIONS:

A. ELECTRICAL GROUNDING REQUIREMENTS SPECIFICATIONS

B. LIGHTING PROTECTION SPECIFICATION

FIGURE 8A.1-1 SITE PLAN (GROUNDING)

8A.3 Electric Heat Tracing

8A.3.1 Description

The electric heat tracing system provides freeze protection where required for outdoor service components and fluid warming of process fluids if required, either in or out doors. If the operation of the heat tracing is required for proper operation of a safety-related system, the heat tracing for the safety-related system is required to be Class 1E, ~~also.~~ Power for heat tracing is supplied from buses backed by the onsite standby generators. Non-Class 1E heat tracing has access to the combustion turbine generator through the same load group as the components protected. Class 1E heat tracing is assigned to the appropriate division for a source of Class 1E power.

8A.3.2 Analysis

There are no SRP or regulatory [guidance provided] ~~requirements~~ for cathodic protection systems. They are required to be designed and installed to the applicable sections of the following codes and standards.

(1) IEEE Std 622, Recommended Practice for the Design and Installation of Electric Heat Tracing Systems in Nuclear Power Generating Stations

(2) IEEE Std 622A, Recommended Practice for the Design and Installation of Electric Pipe Heating Control and Alarm Systems in Nuclear Power Generating Stations

8A.3.3 COL License Information

No COL applicant information is required.

8A.3.4 References

The following codes and standards have been referenced in this section of the SSAR.

(1) IEEE Std 622, Recommended Practice for the Design and Installation of Electric Heat Tracing Systems in Nuclear Power Generating Stations

(2) IEEE Std 622A, Recommended Practice for the Design and Installation of Electric Pipe Heating Control and Alarm Systems in Nuclear Power Generating Stations

9.5.3 Lighting and Servicing Power Supply System

The plant lighting is comprised of four independent lighting systems. They are the normal lighting system, the standby lighting system, the emergency lighting system, and the guide lamp lighting system. The normal lighting system is non-Class 1E. The other three lighting systems are comprised of Class 1E (guide lamps only), Class 1E associated, and non-Class 1E subsystems.

All lighting systems are designed to provide intensities consistent with the lighting needs of the areas in which they are located, and with their intended purpose. The lighting design considers the effects of glare and shadows on control panels, video display devices, and other equipment, and the mirror effects on glass and pools. Lighting and other equipment maintenance, in addition to the safety of personnel, plant equipment, and plant operation is considered in the design. Areas containing flammable materials (e.g. battery rooms, fuel tanks) have explosion proof lighting systems. Areas subject to high moisture have water proof installations (e.g. drywell, washdown areas). Plant AC lighting systems are generally of the fluorescent type, with mercury lamps provided for high ceiling and yard lighting, except where breakage could introduce mercury into the reactor coolant system. Incandescent lamps are used for DC lighting systems and above the reactor, fuel pools, and other areas where lamp breakage could introduce mercury into the reactor coolant.

Lighting systems and their distribution panels and cables are identified according to their essentiality and type. Class 1E and Class 1E associated lighting systems are located in Seismic Category 1 structures, and are electrically independent and physically separated in accordance with assigned divisions. Cables are routed in their respective divisional raceways. Normal lighting is separated from standby lighting. DC lighting cables are not routed with any other cables and are distinguished by "DCL" markings superimposed on the color markings at the same intervals.

Plant service buses supply power and heavy duty service outlets to equipment not generally used during normal plant power operation (e.g. turbine building and refueling floor cranes, welding equipment). Service outlets have grounded connections and the outlets in wet or moist areas are supplied from breakers with ground current detection.

9.5.3.1 Design Bases

9.5.3.1.1 General Design Bases

The general design bases for the Nuclear Island portion of the lighting systems are as follows:

(1) The lighting guidelines shall be based on Illuminating Engineering Society (IES) recommended intensities. These shall be in-service values as shown on Table 9.5-1 Illumination Levels. Reflected glare will be minimized.

(2) Control room lighting is designed with respect to reduction of glare and shadows on the control boards.

(3) Lighting systems and components are in conformity with the electrical standards of NFPA and OSHA as applicable for safety of personnel, plant and equipment. (66) Insert V

(4) Each of the normal, standby or emergency lighting systems has the following arrangement criteria:

(a) Areas without doors and hatches (where access is impossible) have no lighting.

(b) Normal (non-essential) lighting shall have on/off switches if the rooms are also used as passage (e.g. patrol routes).

(c) For high radiation areas, the on/off switches shall be arranged to facilitate maintenance and to obtain maximum service life from the lamps.

(d) The switches shall be located at the entrance to the rooms, or the side of the passage.

(e) Normal lighting power for the small rooms with on/off switches shall be supplied from one power bus.

Note: A small room means a room with three or less lighting fixtures, except for instrument rack rooms and electrical panel rooms.

(f) DC emergency lighting and Class 1E Associated lighting have no switch on their power supply lines.

(g) Standby lighting shall have no switch on power supply lines, as a rule. However, lighting for conference rooms etc., will have on/off switches.

(h) Power of inner panel lighting and outlets are supplied from one power bus.

(i) Each part of the 120V, 240V and 120/240V buses in lighting distribution panels shall have two or three spare circuits.

(j) Installation of fixtures on a high ceiling shall be avoided as far as possible to minimize lamp replacement work.

(k) The fixtures shall be located with due consideration of maintenance and inspection for the equipment in the rooms (such as tank rooms) where a well balanced arrangement is difficult.

(l) For mercury lamps, ballasts can be installed separately for life extension under the defined environment.

(m) The standard installation interval of service power supply boxes should be 150-200 ft.

(n) The standard installation interval of outlets should be 50-100 ft, however outlets shall be arranged around instrument racks. The outlet installation level in hazard control areas shall be above the top of dikes.

(o) As a rule, normal lighting power shall be supplied with two power buses. However, a power supply with one power bus can be used for areas with high illumination lighting by standby lighting and in small rooms.

(p) Lighting shall be designed with due consideration of reflection on the CRT screens where CRTs are installed.

(q) Lighting fixtures in rooms with glass windows shall be arranged with due consideration of the mirror effect to keep the window clear.

(r) Power for staircase and passage lighting is from the standby system and shall be supplied from two power buses in the staircases and passages to prevent a total lighting loss. Each bus supplies power to 50% of the standby lighting of the passages and staircases. The two power buses for safety-related area passages and staircases shall consist of the following: One Class 1E bus (the same division as the safety-related equipment in the area), which is backed by the associated divisional diesel generator; and a non-Class 1E bus, which is backed by the combustion turbine generator. Under annual inspection of the power supplies, 50% lighting is secured with one lighting power supply. The 50% lighting level shall be sufficient for access and egress of personnel to and from the areas.

(5) Lighting fixtures shall be selected in accordance with the following criteria:

(a) Lighting fixtures inside the plant shall be the following type of fixtures:

(i) Fluorescent lamps: As a rule, fluorescent lamps shall be selected as fixtures for the general area.

(ii) Mercury lamps: Mercury lamps shall be selected as fixtures for high ceiling areas and the yard area (except in reactor building or other areas where lamp breakage could introduce mercury into the reactor coolant).

(iii) Incandescent lamps: Incandescent lamps shall be selected as fixtures for dc emergency lighting and as fixtures above the reactors and fuel pool in R/B operating floor.

(b) Standby lighting shall be the rapid start type.

(c) Incandescent lamps shall have water proof guards inside drywell.

(d) The fixtures can be a general industry type, however the fixtures for the part of service area in S/B and control rooms shall match the interior finish of the area.

(e) Lighting fixtures above operator consoles, bench boards and RW operator consoles shall be dark green embedded louver lighting to reduce the reflection of fixtures on CRT screens. Illumination levels around the operator console and bench boards shall be adjustable.

(f) Non-Class 1E battery pack lamps shall be self contained units suitable for the environment in which they are located.

(g) The light fixtures for Class 1E battery packs may be located remote from the battery if the environment at the lamp is not within the qualified range of the battery. Alternatively, lamps powered from the station batteries may be provided.

(h) Outlets shall have grounded connections and should be 120V-15A type or 240V-15A type.

(i) Standard service power boxes shall be 3 phase 480V-100A type.

(j) Lighting around the reactor and fuel pool on the R/B operating floor shall be designed with due consideration of the reflection on the water surface to keep from impeding pool work. Lamps in a location where the lamps may drop in the reactor or fuel pool, shall have guards.

(k) Outdoor lamps shall have automatic on/off switches.

(l) Class 1E Associated lighting equipment shall be selected for the following areas. Wiring shall be an explosion proof type.

(i) Batch oil tank room such as turbine oil tank room and lubrication oil tank room.

(ii) EHC equipments room.

(iii) Battery rooms.

(iv) Diesel generator rooms.

(v) Day tank rooms.

(vi) Hydrogen related panels and seal oil equipment area.

(m) Lighting inside the cask cleaning pit shall be an embedded water proof type fixture.

(n) Feeder circuits for the lighting fixtures and outlets in the following areas shall have circuit breakers with ground current detection.

(i) Decontamination pans

(ii) Decontamination rooms

(iii) Inside Drywell (Outlets)

(iv) R/B operating floor (Service power supply boxes)

(v) Yard (Damp area)

(vi) Service power supply boxes.

(6) Fixture installation levels shall be as follows with consideration for the arrangement of trays. HVAC ducts and equipment lifting space:

Equipment	Installation eight (from floor surface)

Distribution panels	6.5 ft to the top of the panels
Suspended fixture	8 ft to bottom of the fixtures
Wall mounted fixtures	8 ft to bottom of the fixtures
Switches* boxes	4 ft to center of the switch
Outlets*	(1) 1 ft to center of the switch boxes
	(2) 8 ft to center of the switch boxes

(7) Wiring Criteria

(a) Wiring from power buses to distribution panels shall be done with conduit or cable trays. Wiring from the distribution panels shall be done with conduits.

(b) Normal non-Class 1E lighting power supply lines from the distribution panels with dual power bus configuration can share the same conduit.

(c) Standby lighting circuits shall not share raceways with normal lighting circuits.

(39) To enhance lighting reliability,

(d) Emergency dc lighting circuits shall not share raceways with any other circuits.

* *In the yard, the height from the ground to the center of the boxes shall be 5 ft.*

(1) Bottom of outlets in the area with dikes shall be installed higher than the top of the dikes.

(2) Outlets in laboratories and analysis rooms shall be installed at an appropriate level with consideration of the work in the area.

Detailed installation levels will be coordinated at the construction site.

(e) Physical identification of the Class 1E and Class 1E Associated equipment and cables is addressed in Subsection 8.3.1.3.

(8) Wires and Cables

(a) Wire size shall be 12 AWG, or larger as required.

(b) The size of the neutral line shall be the same as the branched circuits.

(9) Conduits

(a) Generally, embedded conduits shall be thick wall type, and exposed conduits may be thin wall type.

Exposed conduits in drywell, the yard and the area where safety type fixtures or pressure resistant explosion proof fixtures are required shall be thick wall type.

9.5.3.1.2 Safety-Related Design Bases

Nuclear safety-related design bases for ABWR Standard Plant lighting systems are as follows:

(1) Mercury vapor fixtures and mercury switches are not used where a broken fixture or switch may result in introduction mercury into the reactor coolant system.

(2) Adequate lighting for any safety-related areas, such as areas used during emergencies or reactor safe shutdown, including those along the appropriate access or exit routes, are provided from 4 different lighting circuits (normal ac; standby ac; 125Vdc or self-contained battery fixtures). See Subsection 9.5.13.4 for COL license information.

See Table 9.5-2 for the lighting subsystems and their normal and backup power sources and the switching sequence. This table shows that the lighting is provided with normal standby and emergency dc lighting during normal operation. On the loss of normal power, the lighting is provided from standby and emergency power. On the loss of all ac power the lighting is provided by dc emergency lighting facilities or self-contained battery fixtures.

9.5.3.2 System Description

Plant lighting is divided into four subsystems:

(1) normal lighting (ac);

(2) standby lighting (ac);

- (a) Class 1E Associated
- (b) Non-Class 1E

(3) emergency lighting (dc);

- (a) Class 1E Associated
- (b) Non-Class 1E

(4) Guide lamps

- (a) Class 1E
- (b) Non-Class 1E

Lighting fixtures that contain mercury are not used inside the reactor building or in any other location where broken fixtures may introduce mercury into the reactor coolant system.

9.5.3.2.1 Normal (Non-Class 1E) Lighting

The normal lighting system is ac and non-Class 1E and provides up to 50% of the lighting needed for operation, inspection, and repairs during normal plant operation and is installed throughout the plant in nonessential equipment areas, except for the passageways and stairwells. Normal lighting is generally supplied from the nonessential power generation (PG) buses. In the nonessential equipment areas, the normal lighting is supplemented (a minimum of 50%) by the non-Class 1E lighting system. Lighting from a single load group is acceptable for localized high intensity lighting and lighting in small rooms where only a limited number of fixtures are needed. Non-Class 1E service outlets and internal lighting for non-Class 1E panels is provided by the normal lighting system. In passageways and stairwells leading to non-Class 1E equipment areas, the lighting is supplied from two different load groups of the non-Class 1E lighting system. With this configuration, non-Class 1E equipment areas receive 100% of their lighting from two different power sources.

9.5.3.2.2 Standby Lighting

Standby lighting is provided for the operation and maintenance of equipment during the loss of normal power and is installed over the entire plant area. The ac lighting configuration permits retaining approximately 50% of the lighting illumination in all passageways, stairwells and essential equipment areas during lighting maintenance or loss of a load group. Illumination from 50% of the lighting is adequate to observe equipment and support personnel movement.

The standby lighting system is made of two subsystems: Class 1E Associated and non-Class 1E. The Class 1E standby lighting subsystem - serves the safety related areas, and their associated passageways. The non-Class 1E lighting subsystem serves the non-safety-related areas and their associated passageways.

9.5.3.2.2.1 Class 1E Associated Standby Lighting Subsystem (SSLS)

The Class 1E Associated ac standby lighting system is comprised of lighting from three Class 1E safety divisions. Each of the three Class 1E divisions is supplied power from the Class 1E divisional bus, which is connectable to the Class 1E standby power supply (emergency diesel generator (DG)) in its respective division. Each Class 1E standby lighting system supplies a minimum of 50% of the lighting needs of the safety-related equipment areas in its respective division and of the passageways and stairwells leading to its respective equipment areas. The Class 1E lighting in the battery room and other instrument and control areas of Division IV is supplied from the Division II Class 1E standby lighting system. The main control room lighting is supplied from Divisions II and III Class 1E standby lighting systems. The remainder of the lighting (up to 50%) in the Class 1E equipment areas and the passageways and stairwells leading to them is supplied from non-Class 1E standby lighting system in the same load group as the Class 1E Associated lighting system. With this configuration, safety-related equipment areas receive 100% of their lighting needs from two different standby lighting power supplies.

The Class 1E Associated standby lighting subsystem is fed from Class 1E buses through separate lighting panels. Fixtures are provided for all safety-related areas, areas where Divisions I, II, III and IV systems equipment is located, and their associated access areas. The fixtures provide a reduced lighting level adequate to support personnel movement and observation of equipment after interruption of the normal lighting system. In the event of a LOPP, the SSLS is automatically fed from the diesel generator sets. The transformers for this lighting subsystem and their associated panels are Class 1E and Seismic Category I.

(54) This is acceptable to the Class 1E power supply because of overcurrent protective device coordination.

(66)

The ~~cables up to the lighting fixtures~~ lighting circuits are classified as Class 1E Associated~~, and are routed in Seismic Category I raceways~~. The lighting fixtures themselves are not seismically qualified, but are seismically supported. The bulbs cannot be seismically qualified. This is why the subsystem is considered Class 1E Associated. The bulbs can only fail open and therefore do not represent a hazard to the Class 1E power sources.

9.5.3.2.2.2 Non-Class 1E Standby Lighting Subsystems

The non-Class 1E ac standby lighting system is comprised of lighting from three non-Class 1E load groups. Each load group is supplied from a different plant investment protection (PIP) bus which is connectable to the non-Class 1E standby power supply (combustion turbine generator (CTG)). The non-Class 1E standby lighting system supplies a minimum of 50% of the lighting needs of the non-safety-related equipment areas and 100% of the lighting in passageways and stairwells leading to ~~non-Class 1E~~ non-safety-related equipment areas (as described above). In addition, the non-Class 1E standby lighting system supplies up to 50% of the lighting needs in safety-related equipment areas and in passageways and stairwells leading to ~~essential~~ safety related equipment areas. The remainder of the lighting (a minimum of 50%) in the safety-related equipment areas and in passageways and stairwells leading to them is supplied from the Class 1E standby lighting system.

The non-Class 1E standby lighting subsystem is fed from non-Class 1E buses through separate lighting panels. Fixtures are provided for all non-safety-related areas (areas where non-divisional equipment is located), and their associated passageways. The fixtures provide a reduced lighting level adequate to support personnel movement and observation of equipment after interruption of the normal lighting system. In the event of a LOPP, the NSLS is automatically fed from the combustion turbine generator. The NSLS transformers and their associated panels are non-Class 1E and are routed in non-Class 1E raceways. The illumination levels and power sources are shown on Table 9.5-3.

9.5.3.2.3 DC Emergency Lighting

The DC emergency lighting system consists of two subsystems, Class 1E Associated and non-Class 1E. The Class 1E Associated subsystem serves the following safety-related areas:

Main control room
Safety-related electric equipment rooms
Diesel generator areas and associated control rooms
DC electric equipment rooms (battery rooms are included)
Remote shutdown control rooms

The non-Class 1E subsystem serves the non-safety-related radwaste control room.

The dc emergency lighting system provides backup illumination for periods after the loss of preferred power, until the combustion turbine generator energizes the standby lighting system, as well as in the event of loss of all the ac lighting sources.

The illumination levels and power sources of the dc emergency lighting system is shown in Table 9.5-4.

9.5.3.2.3.1 Class 1E Associated Emergency Lighting Subsystem

The Class 1E Associated emergency lighting system provides the emergency lighting needs to the main control room, the remote shutdown panel room, the emergency diesel generator areas and control rooms, and the safety-related electrical equipment rooms (both ac and dc). Lighting power for the identified safety-related areas is supplied from the 125 VDC battery in the same divisions as the area. The lighting power to the main control room is supplied from Divisions II and III 125 VDC batteries.

The power for the Class 1E Associated emergency lighting subsystem is fed from the Class 1E station dc power supply system (R42) through Class 1E distribution panels for the above safety-related areas. Fixtures are provided for all safety-related areas. ~~The dc emergency lighting panels are Class 1E and seismic Category I.~~ The ~~cables up to the lighting fixtures~~ are classified as Class 1E Associated. All Class 1E Associated emergency lighting fixtures are seismically supported. The bulbs are not seismically qualified. This is why the subsystem is considered Class 1E Associated. The bulbs can only fail open and therefore do not represent a hazard to the Class 1E power sources.

9.5.3.2.3.2 Non-Class 1E Emergency Lighting Subsystem

The non-Class 1E emergency lighting system provides the emergency lighting needs to the radwaste building (RWB) control room, the combustion turbine generator (CTG) area and control room, and the non-safety-related electrical equipment areas (both ac and dc). Lighting power for the RWB control room is supplied from the non-Class 1E 250 VDC battery. Lighting power for the non-safety-related electrical equipment rooms is supplied from the 125 VDC battery in the same non-safety-related load group as the equipment in the room. Lighting power for the non-Class 1E CTG is supplied from one of the non-Class 1E 125 VDC batteries.

The power for the non-Class 1E emergency lighting subsystem is fed from the non-Class 1E station dc power supply system (R42) through the non-Class 1E distribution panel for the radwaste control room. The lighting panel and wiring are non-Class 1E and non-siesmic. The circuits are classified as non-Class 1E and are routed in non-siesmic raceways.

9.5.3.2.4 Guide Lamps With Self-Contained Battery Packs

DC emergency lighting fixtures are installed for stairways, exit routes and major control areas such as the main control room and remote shutdown panel areas. Each of the emergency lighting fixtures has two incandescent sealed-beam lamps, with an 8 hr minimum self-contained battery, charger and an initiating switch which energizes the fixture from the battery in the event of loss of the ac power supply, and de-energizes the fixture upon return of ac power to the standby light, following a time delay of 15 minutes (see Table 9.5-2). The power supply ac source is fed from the standby lighting system. The passageways are illuminated to a level of 1 foot candle on the floor per the Life Safety Code.

The self contained emergency lighting sets are ~~seismically~~ qualified in safety-related areas.

9.5.3.2.5 Emergency Operation Failure Analysis

Because of the redundancy provided by the systems described above, the complete loss of lighting in any of the critical areas is not credible. The standby lighting system, on loss of the normal lighting system, and the emergency lighting systems, provide totally independent low level illumination in areas vital to safe shutdown of the reactor and evacuation or access by personnel should the need occur. This is specifically demonstrated by Tables 9.5-1 and 9.5-2. Also, the safety-related control systems will automatically bring the plant to safe shutdown if lighting is not available.

9.5.3.3 Inspection and Testing Requirements

Since the normal standby and emergency lighting circuits are energized and maintained continuously, they require no periodic testing. ~~However, periodic inspection and bulb replacement shall be performed~~ The guide lamps will be inspected and tested periodically to ensure operability of lights and switching circuits.

(54COL)

However, periodic inspection and bulb replacement shall be performed (see 8.3.4.25).

9.5.6 Diesel-Generator Starting Air System

9.5.6.1 Design Bases

The diesel-generator starting air system provides a supply of compressed air for starting the emergency generator diesel engines without external power. In order to meet the single-failure criterion, each diesel-generator set is provided with two complete, redundant starting air systems. Each starting air system has enough air storage capacity for five consecutive starts of the engine, and performs its starting function in such a way that the time interval between signal to start and "ready to load" status will not exceed 20 sec. The air storage tanks, valves and piping between tank and up to first connection on the engine skid are designed to Seismic Category I requirements, and in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Class 3. The system is located in a Seismic Category I structure, protected against tornado, external missiles and flood waters.

9.5.6.2 System Description

Although specific suppliers may differ in the final design, a typical P&ID is provided as Figure 9.5-8. See Subsection 9.5.13.5 for COL license information.

The diesel-generator starting air system provides a separate and independent starting facility for each of the diesel-generating units. Each facility includes two 100% capacity sections, each section consisting of an air compressor, after cooler, air dryer and air receiver. Two redundant starting air admission valves in each of two engine starting air manifolds are provided for each engine. Failure of an one starting system in no way affects the ability of any other system to perform its required safety related function. Normally, the compressors are fully automatic in operation, controlled by pressure switches located on their respective air receivers. The pressure switches signal the start and stop of the compressors, as necessary to maintain the required system pressure. Manual override of the automatic sequence is provided for emergency situations.

Each independent air starting system section has sufficient capacity for cranking the engine for five automatic or manual starts without recharging the tanks. Each motor-driven compressor has sufficient capacity to recharge the storage system in 30 min, after five starts of the diesel engine. The compressors are electric motor-driven.

Each air receiver is also provided with a blowdown connection. A connection at the receiver bottom will be used to blow down any water accumulated in the tank. The starting air admission valves are operated by solenoids supplied with uninterruptible dc power from 125 Vdc. Solenoids and power feeds are in the same division.

Diesel generator air start system is provided with an air dryer to ensure clean dry air to engine starting. The dryer will be capable of controlling the dew point as recommended by the diesel engine manufacturer. The dryer will be equiped with pre and after filters to remove oil, waste, dust and any pipe scale from the air stream.

9.5.6.3 Safety Evaluation

The standby diesel-generator starting air system air compressors and tanks are designed in accordance with the requirements of Section III of the ASME Boiler and Pressure Vessel Code. The system is classified Safety Class 3 and Seismic Category I. Starting air facilities for each of the diesel engines are completely redundant, with each redundant section capable of supplying enough air for a minimum of five normal engine starts. Because of the redundancy incorporated in the system design, the diesel-generator starting system provides its minimum required safety function under the following conditions.

(1) design basis loss of coolant condition with loss-of-offsite power, by putting into operation the standby diesel generator; and

(2) maintenance, outage or failure of one of the two air starting systems associated with the diesel engine.

Components of the diesel-generator starting system are designed to Seismic Category I requirements. Procurement of components is

(2) The target reliability of the CTG unit, based on successful starts and successful load runs, shall be > 0.98, as calculated by methods defined in NSAC 108, The Reliability of Emergency Diesel Generators at US Nuclear Power Plants.

(3) The gas turbine shall have an ISO rating (continuous rating at 59°F and at sea level) of at least 6 mW, with nominal output voltage of 6.9 kV at 60 Hz.

(4) The generator output shall have a steady-state voltage regulation within 0.5% of rated voltage when the load is varied from no load to rated kVA and all transients have decayed to zero.

(5) The transient response of the generator shall be capable of assuming sudden application of up to 20% of the generator NEMA rating when the generator, exciter, and regulator are operating at no load, and rated voltage and frequency results in less than 25% excursion from rated voltage. Recovery shall be within 5% of rated voltage, with no more than one undershoot or one overshoot within one second.

(6) With the generator initially operating at rated voltage, and with a constant load between 0 and 100% at rated power factor, the change in the regulated output shall not exceed 1% of rated voltage for any 30-minute period at a constant ambient temperature.

Insert S (87)

9.5.11.2 System Description

The interconnections for the CTG are shown on the power distribution system single line diagram (SLD), Figure 8.3-1.

The CTG is designed to supply standby power to one of the two turbine building (non-Class 1E) 6.9kV buses which carry the plant investment protection loads. (The other investment protection bus receives back-up power from the auxiliary transformer fed from the alternate off-site power source.) The CTG automatically starts on detection of a voltage drop of less than 70% on its downstream bus. When the CTG is ready to synchronize, if the voltage level is still deficient, power is automatically transferred from the unit auxiliary transformer to the CTG.

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

The CTG consists of a completely-packaged, fully-assembled and tested, skid-mounted unit with the following components:

(1) A gas turbine with diesel hydraulic start system (i.e., capable of black start). The unit shall be operated with liquid fuel.

(2) A generator with brushless excitation system and terminal box.

(3) A reduction drive gear system between the turbine and generator.

(4) Lubrication system.

(5) An air cooling system with radiator and AC motor-driven fans for oil cooling.

(6) Accessory gearbox.

(7) Air intake and exhaust equipment.

(8) Microprocessor-based control system with control and protective circuits.

(9) Panels, junction boxes and other accessories as required.

9.5.11.3 Safety Evaluations

The CTG is non-Class 1E and its failure will not affect safe shutdown of the plant. The unit is not required for safety, but is provided to assist in mitigating the consequences of a station blackout event. However, the plant can cope with a station blackout without the CTG. e (87) The CTG does not supply power to nuclear safety related equipment except on condition of complete failure of the emergency diesel generators and all off-site power. Under this condition, the CTG can provide emergency back-up power through manually-actuated Class-1E breakers in the same interface manner as the off-site power sources. This provides a diverse power in accordance with RG 1.155. Adequate protection of the CTG against sabotage is provided by locating the unit inside the security protected area.

9.5.11.4 Tests and Inspections

The initial test qualification requirements described in IEEE 387, IEEE Standard Criteria for Diesel Units Applied as Standby Power Supplies for Nuclear Power Generating Stations, shall also be applied to the CTG in order to ensure adequate system reliability. However, the factory-test portion of this requirement may be waived if the identically designed unit has been shown capable of maintaining a reliability of 0.99 over a five-year period. (87) Insert T

Site acceptance testing, periodic surveillance testing and preventive maintenance, inspections, etc., shall be performed in accordance with the manufacture's recommendations, including time intervals for parts replacement.

9.5.11.5 Instrumentation Requirements

The CTG is provided with local instrumentation and control systems suitable for manual start-up and shutdown, and for monitoring and control during operation. Automatic start-up and load sequencing is controlled via the control console located in the main control room.

Mechanical and electrical instrumentation linked to control room displays are provided to monitor starting, lubricating and fuel supply systems, the combustion air in-take and exhaust system, and the excitation, voltage regulation and synchronization systems.

Generator output voltage, current, kVA, power factor, Hz, etc., are also displayed in the control room. Annunciators and computer logs provide early detection of abnormal behavior.

9.5.12 Lower Drywell Flooder

9.5.12.1 Design Basis

The function of the lower drywell flooder (LDF) is to flood the lower drywell with water from the suppression pool in the unlikely event of a severe accident where the core melts and causes a subsequent vessel failure to occur.

The equipment shall meet the following performance criteria:

(1) The LDF shall provide a flow path from the suppression pool to the lower drywell when the drywell air space temperature reaches 260°C.

(2) The LDF shall pass sufficient flow from the suppression pool to the lower drywell to quench all of the postulated corium, cover the corium, and remove the corium decay heat, as confirmed by severe accident analysis (Appendix 19E).

(3) The LDF shall operate automatically in a passive manner.

(4) The LDF outlet shall be at least one meter above the lower drywell floor.

(5) The LDF inlet shall be located as far below the bottom of the first horizontal drywell-to-wetwell vent as possible while still meeting the requirements for the location of the LDF outlet.

(6) The LDF shall not become a flow path from the suppression pool to the lower drywell during design basis accidents (DBAs) such as loss-of-coolant accidents (LOCAs) or during normal plant operation.

(7) The LDF shall distribute flow evenly around the circumference of the lower drywell.

9.5.12.2 System Description

The LDF is shown schematically in Figure 9.5-3.

The LDF provides a flow path for suppression pool water into the lower drywell area during a severe accident scenario that leads to core meltdown, vessel failure, and deposition of molten corium on the lower drywell floor. Molten corium is a molten mixture of fuel, reactor internals, the vessel bottom head and control rod drive components. The flow path is opened when the lower drywell airspace temperature reaches 260°C.

The flow of suppression pool water to the lower drywell through the LDF quenches the

9.5.13.16 NUREG/CR-0660 Diesel Generator Reliability Recommendations

Programs shall be developed to address NUREG/CR-0660 recommendations regarding training, preventive maintenance, and root-cause analysis of component and system failures.

9.5.14 References

1. Stello, Victor, Jr., *Design Requirements Related To The Evolutionary Advanced Light Water Reactors (ALWRS)*, Policy Issue, SECY-89-013, The Commissioners, United States Nuclear Regulatory Commission, January 19, 1989.

2. Cote, Authur E., *NFPA Fire Protection Handbook*, National Fire Protection Association, Sixteenth Edition.

3. *Design of Smoke Control Systems for Buildings*, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., September 1983.

4. *Recommended Practice for Smoke Control Systems*, NFPA 92A, National Fire Protection Association, 1988.

5. Life Safety Code, NFPA 101, National Fire Protection Association.

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9A.5 SPECIAL CASES

9A.5.1 Piping Penetrations, Reactor Building

Piping penetrations through the drywell shell have unique design considerations. The stress and containment requirements along with the temperature inputs to the concrete walls leave little design latitude. Experience has shown that some of these penetrations for high energy piping may not contain a 3-hr fire-resistive barrier such as have provided throughout the other ABWR buildings. Penetration details are not available at this stage of the plant design. It is an COL license information requirement (see Subsection 9.5.13.7) that the detailed design provide completely equivalent construction to tested wall assemblies or testing will be required.

9A.5.2 Fire Door Deviations

The design of the nuclear facility must meet many criteria, including fire resistivity. Fire doors are an example of compromise with other overriding design criteria that must also be met. Some, such as the airlock doors between the lock and the Reactor Building, form part of a pressure vessel and are of special construction. Such doors generally have a backup fire door.

9A.5.3 Charcoal Filters for Process Tanks and Drain Sumps

Several tanks and sumps are fitted with small charcoal canister-type filters to adsorb radioactive halogens and particulates that may be in the gases vented from the tank during filling or draining operations. Vents from the individual filters and tanks with low level radioactivity are ducted to the HVAC exhaust system.

Temperature monitoring and automatic or manually actuated fixed fire suppression systems have not been provided for these filters. Valves cannot be installed in the lines to isolate the filters as valve closure would result in pressure gradients that could cause tank or sump failure. Manual fire suppression systems are available at or nearby each filter.

9A.5.4 Pipe Break Analyses

Per the criteria in Section 3.6, the high pressure fire water systems require analysis for high energy and moderate lines, respectively.

9A.5.5 Fire Separation for Divisional Electrical Systems

There are some cases where cables of more than one division are in relatively close proximity and require special justification. These areas are listed below and justification of each is evaluated in the discussion.

9A.5.5.1 RPS Scram Circuits

Wiring to each of the four groups of scram solenoids is run in separate rigid steel conduits for the purpose of preventing any possibility of the scram solenoid circuits being exposed to a "hot" short (i.e., two energized switch legs of different group circuits shorted together that could negate the scram command to more than one group of control rods). The conduits do not require other special separation. Overheating of the conductors, as by fire, cannot cause an unsafe failure because solenoids can be de-energized by shorts to ground or between conductors without creating an unsafe condition.

The AO Scram Solenoid valves are part of the HCU assemblies (two solenoids per valve). They are safety related and recieve their divisional power (Division 2 or 3) from RPS via the Scram Solenoid Fuse Panels (H22-P055 A-H). The fuse panels are located in rooms 111, and 118 (Div. I), 125, and 129 (Div. II). Fire in any of these rooms could cause a short on the cables feeding power to the scram solenoids and cause the associated fuse in the scram solenoid fuse panel to blow. The fault will be limited to the loss of power to the associated solenoid and will not propagate upstream.

The Div. I rooms are located in separate fire zones from the Div. II rooms, which zones are separated by 3-hour fire barriers. (62)

Divisions I & IV pressure transmitters which monitor control rod drive charging header pressure are located in the HCU unit room which contains the HCUs for Divisions I & IV. Corresponding Divisions II & III transmitters are located in the Divisions II & III HCU unit room. Each divisional cable is individually contained in steel conduit. Shorts or grounds postulated to occur on these cable will not affect the upstream power division because of the current limiting capability inherent in the low voltage power supplies which feed the transmitters. Therefore, postulated multi-divisional shorts or grounds on these cables, due to fire in one of the HCU rooms, will not cause an unsafe condition.

ATTACHMENT 4

The following attachment is a "clean" copy of the marked-up draft submittal of Chapter 8. A significant number of sections were re-numbered in order to provide a general section applicable to both ac and dc equipment and systems. Any references to these sections will need to be converted to the new section numbers. For this purpose, the following conversion table is provided:

ORIGINAL SECTION NUMBER	NEW SECTION NUMBER
8.3.1.1.5.1	8.3.3.1
8.3.1.1.5.2	8.3.1.1.5
8.3.1.1.5.3	8.3.3.2
8.3.1.2.3	8.3.3.3
8.3.1.2.4	8.3.3.4
8.3.1.3	8.3.3.5
8.3.1.3.1	8.3.3.5.1
8.3.1.3.1.1	8.3.3.5.1.1
8.3.1.3.1.2	8.3.3.5.1.2
8.3.1.3.1.3	8.3.3.5.1.3
8.3.1.3.1.4	8.3.3.5.1.4
8.3.1.4	8.3.3.6
8.3.1.4.1	8.3.3.6.1
8.3.1.4.1.1	8.3.3.6.1.1
8.3.1.4.1.2	8.3.3.6.1.2
8.3.1.4.1.3	8.3.3.6.1.3
8.3.1.4.2	8.3.3.6.2
8.3.1.4.2.1	8.3.3.6.2.1
8.3.1.4.2.2	8.3.3.6.2.2
8.3.1.4.2.2.1	8.3.3.6.2.2.1
8.3.1.4.2.2.2	8.3.3.6.2.2.2
8.3.1.4.2.2.3	8.3.3.6.2.2.3
8.3.1.4.2.2.4	8.3.3.6.2.2.4
8.3.1.4.2.3	8.3.3.6.2.3
8.3.1.4.2.3.1	8.3.3.6.2.3.1
8.3.1.4.2.3.2	8.3.3.6.2.3.2
8.3.4.4	8.3.3.7 (Note some info. remained in 8.3.4.4)
8.3.3	8.3.3.8
8.3.3.1	8.3.3.8.1
8.3.3.2	8.3.3.8.2
8.3.3.3	8.3.3.8.3

Contents

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

8.1.2.0 Definitions

The definitions used throughout Chapter 8 are consistent with Section 3 of IEEE 308 with the following important clarifications for the ABWR:

Division. The designation applied to a given safety-related system or set of components that enables the establishment and maintenance of physical, electrical, and functional independence from other redundant sets of components. (The term "safety-related" is added to the IEEE 308 definition.)

Load group. An arrangement of buses, transformers, switching equipment, and loads fed from a common power supply. (The last three words "...within a division" are deleted with respect to the IEEE 308 definition.) A load group may be safety-related or non-safety-related depending on its common power supply.

Safety-related. Any Class 1E power or protection system device included in the scope of IEEE 279 or IEEE 308. (This term is explicitly defined in IEEE 100, though not in IEEE 308.) Note that "safety-related" includes both electrical and non-electrical equipment, whereas "Class 1E" pertains only to electrical equipment (i.e., any equipment which has an electrical interface).

8.1.2.1 Description of Offsite Electrical Power System

The scope of the offsite electrical power system includes the entire transmission line system and the transmission lines coming into the switchyards to the termination of the bus duct and power cables at the input terminals of the circuit breakers for the Class 1E 6.9KV 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 main generator circuit breaker capable of interrupting the maximum available fault current is provided. This allows the generator to be taken off line and the main power transmission system 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 (RAT) provides power via one secondary winding for the Class 1E buses as an alternate to the "Normal Preferred" power. The other secondary winding supplies reserve power to the non Class 1E buses. This is truly a reserve transformer because unit startup is accomplished from the normal preferred power, which is backfed from the offsite power transmission system 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.

8.1.2.2 Description of Onsite AC Power Distribution System

Three non Class 1E buses and one Class 1E 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 the non-Class 1E buses either directly or indirectly through bus tie breakers. The three Class 1E buses may be supplied power from the other winding of the reserve auxiliary transformer.

A combustion turbine generator supplies standby power to permanent non-Class 1E loads. These loads are grouped on one of the 6.9KV buses per load group. Power is also provided from the combustion turbine generator to the three Class 1E medium voltage buses 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 (M/C) bus. Motors 300KW or smaller but larger than 100KW are supplied power from 480V power center (P/C) switchgear. Motors 100KW or smaller are supplied power from 480V motor control centers (MCC). The 6.9KV and 480V 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 main turbine generator through the unit auxiliary transformers. The remaining Class 1E bus is supplied from the reserve auxiliary transformer. This 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 division 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 circuit breaker located in the switchgear.

The standby ac power system is capable of providing the required power to safely shut down the reactor after loss of preferred power (LOPP) and/or loss of coolant accident (LOCA) and to maintain the safe shutdown condition and operate the Class 1E auxiliaries necessary for plant safety after shutdown.

The plant 480 Vac power system distributes sufficient power for normal auxiliary and Class 1E 480 volt plant loads. All Class 1E elements of the 480 V 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 8.3-2, provides power for non-Class 1E control and instrumentation loads.

The Class 1E 120 Vac instrument power system, Figure 8.3-2, provides 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 battery 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. A separate non-Class 1E 250V battery is provided to supply uninterruptible power to the plant computers and non-Class 1E dc motors (See Figure 8.3-4).

The safety system and logic control (SSLC) for RPS and MSIV derives its power from four uninterruptible 120 Vac divisional buses (See Figure 8.3-3). 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.

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) Safety-Related 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 Class 1E load is divided into three divisions. Each division is fed by an independent 6.9Kv Class 1E bus, and each division has access to one onsite and two offsite power sources. An additional offsite power source is provided by the combustion turbine generator (CTG). A description of the CTC is provided in Section 9.5.11.

Each of the two normally energized offsite power feeders (i.e., normal preferred and alternate preferred power) are provided for the Divisions I, II and III Class 1E systems. Normally two divisions are fed from the normal preferred power source and the remaining division is fed from the alternate preferred power source. Both feeders are used during normal plant operation to prevent simultaneous de-energization of all divisional buses on the loss of only one of the offsite power supplies. The transfer to the other preferred feeder is manual. During the interim, power is automatically supplied by the diesel generators.

The redundant Class 1E electrical divisions (Divisions I, II, and III) are provided with separate onsite standby ac power supplies, electrical buses, distribution cables, controls, relays and other electrical devices. Redundant parts of the system are physically separated and electrically independent to the extent that in any design basis event with any resulting loss of equipment, the plant can still be shut down with the remaining two divisions. Independent raceway systems are provided to meet 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 safely shut down the reactor or limit the consequences of a design basis accident (DBA) to acceptable limits and maintain the reactor in a safe condition. The standby power supplies are capable of being started and stopped manually and are not 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), level 1 signal (RHR initiate) and high drywell pressure.

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. This equipment is housed in Seismic Category I structures except for some control sensors associated with the Reactor Protection System [see 9A.5.5.1], and the Leak Detection System [see 9A.5.5.7]. Seismic Qualification is in accordance with IEEE Standard 344. (See Section 3.10)

8.1.3.1.1.2 **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, abnormal 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 respective 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.

8.1.3.1.1.3 Controls and Indication

The ABWR electrical system design provides controls and indicators in accordance with IEEE 308 guidelines. The specific design bases are described as follows:

1. The ABWR electrical system provides controls and indicators in the main control room.

2. The design provides for control and indication outside the main control room for;

   a. Circuit breakers that switch Class 1E buses between the preferred and standby power supply,

   b. The standby power supply, and

   c. Circuit breakers and other equipment as required for safety systems that must function to bring the plant to a safe shutdown condition.

3. Operational status information is provided for Class 1E power systems.

4. Class 1E power systems required to be controlled from outside the main control room also have operational status information provided outside the central control room at the equipment itself, or at its power supply, or at an alternate central location.

5. The operator is provided with accurate, complete, and timely information pertinent to the status of the execute features in the control room.

6. Indication is provided in the control room of protective actions and execute features unavailability.

7. Electric power systems and equipment has the capability of being periodically tested.

8. Testability of electrical systems and equipment is not so burdensome operationally that required testing intervals cannot be included.

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 Dynamic Effects 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;

Functional operation of fuses cannot be periodically tested and is exempt from such requirements per Section 4.1.7 of IEEE 741. However, periodic inspection for continuity, correct size, etc., shall be performed.

(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 1.128- 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;

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

Functional operation of fuses cannot be periodically tested and is exempt from such requirements per Section 4.1.7 of IEEE 741. However, periodic inspection for continuity, correct size, etc., shall be performed.

(14) RG 1.155- Station Blackout

(See Appendix 1C)

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.

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

(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 COL license information. (See Subsection 8.1.4.1).

(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 COL License Information

8.1.4.1 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 COL applicant (see Subsection 8.1.3.1.2.4(1)).

8.1.5 References

IEEE Std 944, Recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations.

8.2 OFFSITE POWER SYSTEMS

8.2.1 Description

8.2.1.1 Scope

This section provides a description of the design and performance requirements for the offsite power system. The offsite power system, as defined in the USNRC Standard Review Plan Section 8.2, consists of the following:

(Applicant Scope)

a) The offsite transmission system [including the tie lines to the switchyard(s)]
b) The plant switchyard(s),
c) The separated switching stations,
d) The high voltage tie lines from the switching stations to the main power transformers, and to the reserve auxiliary transformer,
e) The main step-up power transformers,
f) The reserve auxiliary transformer,

(ABWR Standard Plant Scope)

g) The three unit auxiliary transformers,
h) The plant main generator,
i) The combustion turbine generator,
j) The isolated phase buses from the main power transformer to the main generator circuit breaker, and to the unit auxiliary transformers,
k) The main generator circuit breaker,
l) The non-segregated phase buses from the unit auxiliary transformers to the input terminals of the medium voltage (6.9 kV) switchgear,

m) The non-segregated phase bus and power cables from the reserve auxiliary transformer to the input terminals of the non-safety related and safety-related medium voltage (6.9 kV) switchgear, and

n) The power cables from the combustion turbine generator to medium voltage (6.9 kV) switchgear, including the disconnect and interconnecting bus.

The design scope for the standard plant ends at the low voltage terminals of the main power transformer and the low voltage terminals of the reserve auxiliary transformer. Although the remainder of the offsite power system is not in the scope of the standard plant design, the standard plant design is based on a power system which meets certain design concepts. Design bases (10CFR Part52 interface requirements) consistent with these concepts are included in Section 8.2.3. Meeting the stated design bases will ensure that the total power system design is consistent and meets all regulatory requirements.

The portions of the offsite power system which fall under the design responsibility of the COL applicant will be unique to each COL application. 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. See Section 8.2.4 for a detailed listing and description of the COL license information.

8.2.1.2 Description of Offsite Power System

The offsite electrical power system components within the scope of the applicant include items a) through f) identified in Subsection 8.2.1.1. The remaining items g) through n) are within the scope of the ABWR standard plant design.

When used for normal operation, each preferred power supply will be sized to supply the maximum expected coincident Class 1E and non-Class 1E loads.

The normal and alternate preferred power circuits are designed in accordance with industry-recommended practice in order to minimize the likelihood that they will fail while operating under the environmental conditions (such as, wind, ice, snow, lightning, temperature variations, or flood), to which they are subject.

Air cooled isolated phase bus duct rated 36kA is provided for a power feed to the main power transformer and unit auxiliary transformers from the main generator.

A generator circuit breaker is provided in the isolated phase bus duct at an intermediate location between the main generator and the main power transformer. The generator circuit 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 main generator circuit 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 source for the unit.

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.

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 addition, these transformers meet the corresponding requirements of the latest revisions of ANSI Standard C57.12.00. [See 8.2.3(8) for COL requirements on the main step-up transformers and the reserve auxiliary transformer.] See 8.2.3(10) for COL requirements on the high-voltage circuit breakers and disconnect switches.]

Offsite system circuits derive their control, protection, and instrument DC power from non-Class 1E DC sources in the same non-Class 1E load group, and are independent of the Class 1E DC sources.

8.2.1.3 Separation

The location of the main power transformer, unit auxiliary transformers, and reserve auxiliary transformer are shown on Figure 8.2-1. The reserve auxiliary transformer is separated from the main power and unit auxiliary transformers by a minimum distance of 15.24 meters (50 feet). It is a requirement that the 15.24 meters (50 foot) minimum separation be maintained between the switching stations and the incoming tie lines. 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. The circuits associated with the alternate offsite circuit from the reserve auxiliary transformer to the Class 1E busses are separated by walls or floors, or by at least 15.24 meters (50 feet), from the main and unit auxiliary transformers. The circuits associated with the normal preferred offsite circuit from the unit auxiliary transformers to the Class 1E busses are separated by walls or floors, or by at least 15.24 meters (50 feet), from the reserve auxiliary transformer. 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 are routed to opposite ends of the same switchgear lineups.

The normal preferred feeds from the unit auxiliary transformers 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 I and III side of the control building (Figure 8.2-1, Sheet 3). 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 I and III side of the reactor building to the respective Class 1E 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 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.

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 [illegible] a safe disposal area. Separation of offsite equipment is discussed in [illegible].2.1.3. The plant fire protection system is discussed in 9.5.1.

(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.

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

(6) RG 1.155--Station Blackout

(See Appendix 1C)

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

(8) Appendix A to SRP Section 8.2

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

(9) IEEE Std 765, IEEE Standard for Preferred Power Supply for Nuclear Powered Generating Stations

It is a requirement that the total design provided by GE and the applicant meet the requirements of this IEEE standard as modified by the specific additional requirements and explanatory statements in Table 8.2-1. The additional requirements are more restrictive than the requirements which they replace or modify from the IEEE standard. Any stated requirements in the SSAR which are in conflict with the requirements stated in this standard take precedence over the requirements of the standard.

8.2.3 Interface Requirements

The interface point between the ABWR design and the COL applicant 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 COL applicant 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 COL applicants. 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 shall be made to determine the optimal impedance for the main transformer.

The second power scope split interface occurs at the low 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 COL applicants standard with the actual values to be determined at contract award. Tolerances on the transmission lines 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 recoverable system instability. When coordinated with the design of the reserve auxiliary transformer, the transmission line shall support a maximum allowable voltage dip of 20 percent during the starting of large motors.

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

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

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

(2) Voltage variations of the transmission system shall be no more than plus or minus 10 percent of their nominal value during normal steady state operation.

(3) The normal steady state frequency of the transmission system shall be within plus or minus 2 cycles per second of 60 cycles per second during recoverable periods of system instability.

(4) The site specific configuration of the incoming transmission lines shall be analyzed to assure that the expected availability of the offsite power is as good as the assumptions made in performing the plant probability risk analysis (see item 5.1.2 of Table 8.2-1, and Chapter 19).

(5) The main and reserve offsite power circuits shall be connected to switching stations which are independent and separate. They shall be connected to different transmission lines. The offsite transmission line to the main power switching station, the main power switching station, the tie lines from the main power switching station to the main power transformer and the main power transformer shall be separated by a minimum of 15.24 meters (50 feet) from the offsite transmission line to the reserve power switching station, the reserve power switching station, the tie lines from the reserve power switching station to the reserve auxiliary transformer, and the reserve auxiliary transformer. The output feeders of the reserve auxiliary transformer to the medium voltage (6.9 kV) switchgear shall be separated from the output of the main power and unit auxiliary transformers by a minimum of 15.24 meters (50 feet) outside the turbine building or as described in Section 8.2.1.3. Instrument and control circuits of the main and reserve power systems shall be separated in the same manner as the power feeders. The switching stations may be in the same switchyard or separate switchyards provided the required minimum separation is maintained.

(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 transformers and the reserve auxiliary 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) Transformers shall be provided with separate oil collection pits and drains to a safe disposal area, and shall be provided with fire protection deluge systems as specified in Section 9A.4.6. Transformers shall also be provided with lightning protection systems and grounded to the plant grounding grid.

(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 main generator circuit breaker, provisions shall be made to synchronize the unit through the switching station's circuit breakers. This makes it possible to re-synchronize with the system following a load rejection within the steam bypass capability of the generating unit.

(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 switching station 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. Each charger shall be capable of supplying the required loads while recharging its battery.

(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.

(16) The requirements of IEEE Std 765, Preferred Power Supply for Nuclear Generating Stations, as modified by Section 8.2.2.1(9) of this SSAR shall be met.

8.2.4 COL License Information

8.2.4.1 Periodic Testing of Offsite Equipment

Appropriate plant procedures shall include periodic testing and/or verification to ensure the following:

(1) The normal and alternate offsite power circuits are energized and connected to the appropriate Class 1E distribution system division at least once every 12 hours.

(2) The instrumentation, control, and protection systems, equipment, and components associated with the normal and alternate offsite preferred circuits are properly calibrated and perform their required functions.

(3) The required Class 1E and non-Class 1E loads can be powered from their designated preferred power supply within the capacity and capability margins specified in the SSAR for the offsite system circuits.

(4) The loss of the offsite preferred power supply can be detected.

(5) Switching between preferred power supplies can be accomplished.

(6) The batteries and chargers associated with the preferred power system can meet the requirements of their design loads.

(7) The generator breaker can open on demand. (Note: The breaker's actual opening and closing mechanisms are inherently confirmed during the shutdown and synchronizing processes. Trip circuits shall be periodically verified during shutdown periods while the breaker is open.)

(8) Isolated and non-segregated phase bus ducts are inspected and maintained such that they are clear of debris, fluids, and other undesirable materials. Also, terminals and insulators are inspected, cleaned and tightened, as necessary.

The test and inspection intervals will be established and maintained according to the guidelines of IEEE 338-1977, Section 6.5, as appropriate for non-Class 1E systems [i.e., Items (4) and (7) of Section 6.5.1 are not applicable].

8.2.4.2 Procedures when a Reserve or Unit Aux. Transformer is Out of Service

Appropriate plant operating procedures will be imposed whenever the Reserve 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 <u>unless</u> 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.

8.2.5 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.

Table 8.2-1
ADDITIONAL REQUIREMENTS
IEEE STD 765

IEEE STD765 Reference	Requirement or Explanatory Note
4.1 General	SSAR Figure 8.3-1 should be used as the reference single line instead of the IEEE Std example, Figures 2, (a), (b) and (c).
4.2 Safety Classification	The separation criteria called for in Subsection 8.2.1.3 must be met.
4.5 Availability	The ABWR design utilizes direct connection of the two preferred power circuits to the Class 1E buses.
5.1.2 Transmission System Reliability	Additional analysis is required per Section 8.2.3(4)
5.1.3 Transmission System Independence	
5.1.3.2	Specific requirements for tolerance to equipment failures are stated in the SSAR and must be met.
5.1.3.3	Since a separation of at least 50 feet is required for the exposed circuits, a common takeoff structure cannot be used.
5.3.2 Class 1E Power System Interface Independence	(See comments above for 5.1.3.3)
5.3.3 Connections with Class 1E Systems	
5.3.3.2	Automatic dead-bus transfers are used to transfer from the preferred power supply to the onsite AC source. Manual dead-bus transfers are used between preferred power supplies, and to transfer from the onsite source back to the preferred power supply. Automatic live-bus transfers are not required and are not used.
5.3.3.3	Only standby power sources may be paralleled with the preferred power sources for load testing. The available fault current must be less than the rating of the breakers. It is not required and not allowed for the normal and alternate preferred power supply breakers for a bus to be closed simultaneously so there is no

		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.

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 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 between preferred power sources is manual dead bus transfer and not automatic.

Another bus within each load group supplies power to pumps which a: 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 re-closed 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 of 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 Class 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-Class 1E 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 metal clad switchgear rated for 7.2KV 500MVA 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-Class 1E Low Voltage Power Distribution System

Power for the 480V auxiliaries is supplied from power centers consisting of 6.9KV/480 volt transformers and associated metal-clad switchgear (see Figure 8.3-1). There are six non-Class 1E, 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-Class 1E 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 step-down transformer (as an alternate ac power supply), and a distribution panel (Figure 8.3-3). 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 frequency 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 the 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) Over-current 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-Class 1E)

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 8.3-3, sheet 2). 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 250 Vdc 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 Subsection 8.3.1.0.3).

8.3.1.1 Class 1E AC Power Distribution System

8.3.1.1.1 Medium Voltage Class 1E 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, re-fueling, 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 preferred 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) Under-voltage 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 interlocked 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 Class 1E bus supplies power to three separate groups of non-Class 1E fine motion control rod drive (FMCRD) motors (see Figure 8.3-1, sheet 3). Although these motors are not Class 1E, 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 supplied PIP bus as the second backup source. Division I was chosen because it was the most lightly loaded diesel generator.

The load breakers in the Division I switchgear are part of the isolation scheme between the Class 1E power and the non-Class 1E load. In addition to 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. 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

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

Class 1E 480V power centers supplying Class 1E loads are arranged as independent radial systems, with each 480V bus fed by its own power transformer. Each 480V Class 1E bus in a division 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 draw-out 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 480V MCCs feed motors 100kW or 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 100kW or smaller are MCC-mounted, across-the-line magnetically operated, air break type. Power 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 over-current 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 Class 1E 120/240V power. This power is used for emergency lighting, and other 120V Class 1E loads.

8.3.1.1.4 Instrument Power Supply Systems

8.3.1.1.4.1 120V AC Class 1E Instrument Power System

Individual transformers supply 120V ac instrument power (Figure 8.3-2). 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 Class 1E Vital AC Power Supply System

8.3.1.1.4.2.1 CVCF Power Supply for the Safety System Logic and Control

The power supply for the SSLC is shown in Figure 8.3-3, 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.

The capacity of each of the four redundant Class 1E CVCF power supplies is based on the largest combined demands of the various continuous loads, plus the largest combination of non-continuous loads that would likely be connected to the power supply simultaneously during normal or accident plant operation, whichever is higher. The design also provides capability for being tested for adequate capacity (see 8.3.4.34).

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 125 Vdc 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 II 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 8.3-4)]. The ac buses also supply power to the 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.

8.3.1.1.4.2.2 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.

(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.

(8) In addition, an external electrical protection assembly (EPA) is provided 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 accordance with ANSI Standards. See Subsection 8.3.4.1 for COL license information.

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 over-current devices. Impedance of connecting upstream cable is factored in for a specific physical layout.

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

Station grounding and surge protection is discussed in Appendix 8A.1. The medium voltage (6900V) system is low resistance grounded except that each diesel generator is high resistance grounded to maximize availability.

See Subsection 8.3.4.14 for COL license information pertaining to administrative control for bus grounding circuit breakers.

8.3.1.1.6.3 Bus Protection

Bus protection is as follows:

(1) 6.9kV bus incoming circuits have inverse time over-current, ground fault, bus differential and under-voltage protection.

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

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

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

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

8.3.1.1.6.4 Protection Requirements

Protective devices of the diesel generators meet all requirements of IEEE 603. 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 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, 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 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. 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.

Subsequent bus transfer will be as described above. These bus voltage monitoring schemes are designed in accordance with Section 5.1.2 of IEEE 741.

Equipment is qualified for continuous operation with voltage ±10% of nominal and for degraded voltages below 90% for the time period established in the load analysis* for the degraded voltage protective time delay relay. (See 8.3.4.20 for COL license information.)

FOOTNOTE

* A complete load analysis shall be performed in accordance with Chapter 3 of IEEE 141, and IEEE's 242 and 399, for the power distribution system to demonstrate proper sizing of power source and distribution equipment. Such analysis shall provide the basis for the degraded voltage protective relay timer settings and other protective relay settings.

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 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.

See Subsection 9.5.13.8 for COL license information.

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 or a 5% frequency drop measured at the bus.

(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 criteria is for each diesel generator to be capable of reaching full speed and voltage within 20 seconds after receiving a signal to start, and capable 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.

See Subsection 8.3.4.2 for COL license information.

(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.

(6) Each diesel generator has stored energy (fuel) at the site in its own storage tank with the capacity to operate the standby diesel generator power supply, while supplying post-accident power requirements to a unit for seven days (see 9.5.4.1.1).

(7) Each diesel generator has stored energy (fuel) at the site in its own day tank with the capacity to operate the standby diesel generator power supply while supplying post accident power requirements for 8 hours. The fuel transfer system automatically maintains the capacity of the day tank (see 9.5.4.2).

(8) Each diesel generator is capable of operating in its service environment during and after any design basis event, without support from the preferred power supply. It can start up and run, with no cooling available, for the time required to bring the cooling equipment into service as it sequences onto the bus (see 20.3 RAI-16, Question/Answer 430.282).

(9) Each diesel generator is capable of restarting with an initial engine temperature equal to the continuous rating full load engine temperature.

(10) Each diesel generator is capable of accepting design load following operation at light or no load for a period of 4 hours. This capability shall be demonstrated by the supplier prior to shipment, but is exempt from periodic testing to avoid undue stress to the diesel engine.

(11) Each diesel generator is capable of carrying its continuous load rating of 22 hours followed by 2 hours of operation at its short time rating.

(12) The maximum loads expected to occur for each division (according to nameplate ratings) do not exceed 90 percent of the continuous power output rating of the diesel generator.

(13) Each diesel generator's air receiver tanks have capacity for sufficient starts without recharging as defined in 9.5.6.2.

(14) During diesel generator load sequencing, the frequency will be restored to within 2% of nominal, and voltage will be restored to within 10% of nominal within 60% of each load sequence time interval (see C.4 of Regulatory Guide 1.9).

(15) During recovery from transients caused by step load increases or resulting from the disconnection of the largest single load, the speed of the diesel generator unit will not exceed the nominal speed plus 75% of the difference between nominal speed and the over-speed trip setpoint or 115% of nominal, whichever is lower (see C.4 of Regulatory Guide 1.9).

(16) The transient following the complete loss of load will not cause the speed of the diesel generator unit to attain the over-speed trip setpoint (see C.4 of Regulatory Guide 1.9).

(17) Bus voltage and frequency will recover to 6.9 kv±10% at 60±2% Hz within 10 seconds following trip and restart of the largest load.

(18) Each of the above design criteria has the capability of being periodically verified (see 8.3.4.36). However, note exception for Item (10).

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 is also provided. The Class 1E batteries provide power for the diesel control and protection circuits. The transfer of the Class 1E buses to standby power supply is automatic should this become necessary on loss of 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 re-applied 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 over-speed 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 8.3-5. 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 inoperative are so indicated in accordance with Regulatory Guide 1.47 and BTP PSB-2.

8.3.1.1.8.6 Local and Remote Control and Indication

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. When the diesel is started from the local control station, the engine will attain rated voltage and frequency, then remain on standby without load sequencing (i.e., the generator breaker will remain open).

Control room indications are provided for system output, i.e., volts, amps, watts, vars, frequency, synchronization, field volts, field amps, engine speed, and watt-hours. Diesel generator status (i.e., "RUN", "STOP") indication is provided for the Remote Shutdown System.

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. These interlocks are designed to be testable, and are periodically tested per 8.3.4.21. 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 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 Systems for Nuclear Power Plants

Fuses cannot be periodically tested 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 criteria as defined in IEEE 603 for: operating bypass, maintenance bypass, and bypass indication.

(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

Regarding Position C-1 of Regulatory Guide 1.75 (see Section 8.3.1.1.1), the non-Class 1E FMCRD motors and brakes are supplied power from the Division 1 Class 1E bus through three dedicated power center transformers. The Class 1E load breaker for the bus is tripped by fault current for faults in the non-Class 1E 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 delayed from tripping while fault current is flowing in the non-Class 1E 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. The transfer switch downstream of the load feeder is Class 1E associated, and meets Class 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.

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

Each standby power supply for each of the three divisions 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 Divisions I, II and III diesel generators, respectively, and the maximum coincidental load for each.

(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 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).

(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

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

Fuses cannot be periodically tested 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.

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,

2) is immediately available during both normal operations and following loss of power from the alternating current systems,

3) has sufficient stored energy to provide an adequate source of power for starting and operating all required LOCA and/or LOPP loads and circuit breakers for two hours with no ac power,

4) has sufficient stored energy to provide power in excess of the capacity of the battery charger when needed for transients,

5) has a capacity design margin of 5 to 15 percent to allow for less than optimum operating conditions,

6) has a 25-percent capacity design margin to compensate for battery aging,

7) has a 4-percent capacity design margin to allow for the lowest expected electrolyte temperature of 21C (70F),

8) has a number of battery cells that correctly matches the battery-to-system voltage limitations,

9) bases the first minute of the batteries' duty cycle on the sum of all momentary, continuous, and non-continuous loads that can be expected to operate during the one minute following a LOCA and/or LOPP,

10) is designed so that each battery's capacity can periodically be verified.

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, 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 Class 1E 125 Vdc buses.

8.3.2.1.3 **Station Batteries and Battery Chargers, General Considerations**

The four ESF divisions are supplied from four independent Class 1E 125 Vdc systems (See Figure 8.3-4). Each of the Class 1E 125 Vdc systems has a 125 Vdc battery, a battery charger and a distribution panel. One standby battery charger can be connected to either of two divisions and another standby battery charger can be connected to either of two other divisions. Kirk key interlocks prevent cross connection between divisions. The main dc distribution buses include distribution panels, drawout-type breakers and molded case circuit breakers.

The Class 1E 125 Vdc systems supply dc power to Divisions 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 single failure in any 125 Vdc system will result in conditions that prevent safe shutdown of the plant with the remaining ac 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.

Each division of the system is located in an area separated physically from other divisions. All the components of Class 1E 125 Vdc systems are housed in Seismic Category I structures.

8.3.2.1.3.1 125 Vdc Systems Configuration

Figure 8.3-4 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 battery charger is normally fed from its divisional 480V MCC bus, with no automatic interconnection or transfer between buses. Also, there are no manual interconnections between dc divisions except those involving the standby battery chargers, as described below.

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 discharged state to a fully charged state while handling the normal, steady-state dc load. Cross connection between two divisions through a standby charger is prevented by at least two interlocked breakers, kept normally open, in series in each potential cross-connect path. (See Figure 8.3-4 and Subsection 8.3.4.18.)

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.

As a general requirement, the batteries have sufficient stored energy to operate connected Class 1E loads continuously for at least two hours without recharging. The Division I battery, which controls the RCIC system, is sufficient for eight hours during station blackout. During this event scenario, the load reductions on Divisions II, III, and IV also extend the times these batteries are available (see 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.

A load capacity analysis has been performed based on IEEE 485-1978, and submitted on the docket for estimated Class 1E dc battery loads as of September, 1989. A final analysis will be performed when specific battery parameters are known (see 8.3.4.6).

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 satisfy a safety load demand profile under the conditions of a LOCA and loss of preferred power.

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

See Subsection 8.3.4.6 for COL license informations.

8.3.2.1.3.2 **Non-Class 1E 125V DC Power Supply**

A non-class 1E 125 Vdc power supply, Figure 8.3-4, is provided for non-Class 1E switchgear, valves, converters, transducers, controls and instrumentation. The system has three load groups with one battery, charger and bus per load group. There are bus tie breakers between buses. Normal operation is with bus tie breakers open and interlocks prevent paralleling batteries. Each load group's battery and charger may be removed from service as a unit for maintenance or 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 load 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 Groups A or B or C ac power via the backup 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 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 over-current 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 over-current trips as the charger is load limiting and therefore protects itself. They are used as disconnect switches only. Bus load breakers have over-current trips coordinated with the battery output breaker. Tripping current for the load breakers is supplied by the battery.

See Subsection 8.3.4.6 for COL license information.

8.3.2.1.3.3 **Non-Class 1E 250V DC Power Supply**

A non-class 1E 250 Vdc power supply, Figure 8.3-4, is provided for the computers and the turbine turning gear motor. The power supply consists of one 250 Vdc battery and two chargers. The normal charger is fed by 480 Vac from either the load Group A or load Group C turbine building load centers. Selection of the desired AC supply is by a mechanically interlocked transfer switch. The standby charger is fed from a load Group A control building motor control center. Selection of the normal or the standby charger is controlled by key interlocked breakers. A 250 Vdc central distribution board is provided for connection of the loads, all of which are non-class 1E.

8.3.2.1.3.4 **Ventilation**

Battery rooms are ventilated to remove the minor amounts of gas produced during the charging of batteries.

8.3.2.1.3.5 **Station Blackout**

Station blackout performance is discussed in Subsection 19E.2.1.2.2. An assessment of Regulatory Guide 1.155 is provided in Appendix 1C See Subsection 8.3.4.16 for COL license information.

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 8.3-4). 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 sources. The DC system is so arranged that the probability 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 conditions of important system parameters such as charger failure or low bus voltage are annunciated 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 Class 1E feed supply to the Class 1E buses.

(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 NRC General Design Criteria, NRC Regulatory Guides and other criteria consistent with the standard review plan. The analyses establish the ability of the system to sustain credible single failures 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 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 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 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"

The ABWR fully meets the requirements of this standard.

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 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 8.3.3.6.2.2.3.

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 Class 1E circuits remain with or are physically separated in the same manner as those Class 1E circuits with which they are associated; or associated Class 1E circuits remain with or are physically separated in the same manner as those Class 1E circuits with which they are associated, from the Class 1E equipment to and including an isolation device. Associated Class 1E circuits (including their isolation devices or their connected safety or non-safety system loads without isolation devices) are subject to all requirements placed on Class 1E circuits.

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.

8.3.3.2 Testing

The design provides for periodically testing the chain of power system elements from power supplies 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 power divisions. For equipment which cannot be tested during plant operation, the reliability is such that testing can be performed during plant shutdown (for example, safety relief valves and certain isolation valves). The requirements of IEEE Std 379 Regulatory Guide 1.118 and IEEE 338 are met.

8.3.3.3 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.

8.3.3.4 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 as discussed in Section 3.11.

8.3.3.5 Physical Identification of Safety-Related Equipment

8.3.3.5.1 Power, Instrumentation and Control Systems

Electrical and control equipment, assemblies, devices, and cables grouped into separate divisions shall be identified so that their electrical divisional assignment is apparent and so that an observer can visually differentiate between Class 1E equipment and wiring of different divisions, and between Class 1E 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 treated as Class 1E (see Note 1) , there shall be an "A" appended to the divisional designation (e.g., "A1"). The latter "A" stands for associated. "N" shall be used for non-divisional cables. 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 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.

Note 1 The emergency lighting circuits are the only Class 1E associated circuits in the pre-certified ABWR design. 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.

8.3.3.5.1.1 **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 name-plate 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, transformers, 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 name-plates have color coded background with black engraving.

8.3.3.5.1.2 **Cable Identification**

All cables for Class 1E systems and 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 number (cable number), in addition to the marking characteristics shown below.

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 30.5 cm (1 ft.)) such that their division is still discernible. Exceptions are permitted for individual conductors within cabinets or panels where all wiring is unique to a single division. Any non-divisional cable within such cabinets shall be appropriately marked to distinguish it from the divisional cables.

8.3.3.5.1.3 **Raceway Identification**

All conduit is similarly tagged with a unique conduit number, in addition to the marking characteristics shown below, at 4.57 meters (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 Class 1E cable raceways are marked with the division color, and with their proper raceway identification at 4.57 meters (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 and markings are used:

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

The VN or VS markings are superimposed on the divisional color markings, and placed at the same intervals.

For EMI protection, neutron-monitoring cables are run in their own dedicated divisional conduits and cable trays. Scram solenoid cables are run in a separate conduit for each rod scram group.

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, name-plates, cables and raceways, as described above.

8.3.3.5.1.4 Sensory Equipment Grouping and Designation Letters

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

8.3.3.6 Independence of Redundant Systems

8.3.3.6.1 Power Svstems

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 as described in Subsection 8.3.3.6.2. Any exceptions are justified in Appendix 9A, Subsection 9A.5.5.5.

The physical independence f electric power systems complies with the requirements of IEEE Standard 384, General Design Criteria 17, 18 and 21 and NRC Regulatory Guides 1.6 and 1.75.

8.3.3.6.1.1 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 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 requirements 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. Class 1E and non-Class 1E cables are separated in accordance with IEEE 384 and R.G. 1.75, as explained in 8.3.3.1. This includes cables within cable chases. (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 of current and 250 VDC or ac for relay contactor control.

   (d) V1 = Low level signal and control, including fiber-optic cables and metallic cables with analog signals up to 55 VDC and digital signal up to 12 VDC.

   Power cables (V3) are routed in flexible metallic conduit under the raised floor of the control room. For EMI considerations, power cables are routed in metallic conduit wherever they come in close proximity with low level (V1) cables.

(5) Class 1E power system power supplies and distribution equipment (including diesel generators, batteries, battery chargers, CVCF power supplies, 6.9 kv switchgear, 480-volt load centers, and 480-volt motor control centers) are located in areas with access doors that are administratively controlled. In addition, ac and dc distribution panels are located in the same or similar areas as Class 1E power supplies and distribution equipment, or the distribution panels are designed to be locked, so that access to circuit breakers located inside such panels can be administratively controlled. The physical design of the ABWR permits the administrative control of access to Class 1E power equipment areas (see 13.6.3).

8.3.3.6.1.2 Electric Cable Installation

(1) **Cable De-rating and cable tray fill**--Base ampacity rating of cables is established as described in Subsection 8.3.3.8.1. 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 8.3.3.6.1.1(4). Tray fill is as established in Subsection 8.3.3.8.

(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. Cable routing in the drywell is discussed in association with the equipment it serves in the "Special Cases" Section 9A.5.

(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 8.3.3.8 and 9.5.1.

(5) **Cable and raceway markings**--All cables (except lighting and non-vital communications) are tagged at their terminations with a unique identifying number. Colors used for identification of cables and raceways are covered in Subsection 8.3.3.5.

(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 8.3.3.6.2.

Redundant Class 1E circuits which must enter a common panel, cabinet, etc., enter through separated apertures and terminate on separated terminal blocks. Where redundant circuits unavoidably terminate on the same device, barriers are provided between the device terminations to ensure circuit separation, or approved isolators (generally optical) are used.

Class 1E and non-Class 1E power, instrumentation, and control cables enter cabinets or panels through separate apertures.

(7) **Electric penetration assembly**--The separation of electric penetration assemblies exceeds the requirements for cables and raceways given in Section 6.1.5 of IEEE 384. Separation by distance (without barriers) is allowed only within the inerted containment. Here, the minimum allowable distances of .9 meters (3 feet) and 1.5 meters (5 feet) apply, as delineated in Section 6.1.5 of IEEE 384. However, the lesser distances allowed by IEEE 384 for enclosed raceways does not apply to the containment penetrations themselves. Grouping of circuits in penetration assemblies follows the same raceway voltage groupings as described in 8.3.3.6.1.1(4).

For the other ends of the penetrations, which are outside the containment in the non-inerted areas, separation by distance alone is not allowed. These are separated by separate rooms, or barriers, or different floor levels. Such walls, barriers or floors are 3-hour fire-rated.

Such separation criteria applies to the following:

1. Between redundant penetrations,

2. Between penetrations containing non-Class 1E and penetrations containing Class 1E or associated Class 1E circuits, and

3. Between penetrations containing Class 1E circuits and other divisional or non-divisional cables.

Redundant over-current 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. This avoids 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 COL license information.

8.3.3.6.1.3 Compliance with Separation During Design and Installation

Compliance with the criteria which insures independence of redundant systems is a supervisory 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 assure compliance with approved and issued drawings and specifications.

The equipment nomenclature used on the ABWR standard design is one of the primary mechanisms 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 driven). Based on these identification numbers, each item can be identified as Class 1E or non-Class 1E, and each Class 1E 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 8.3.3.5) for positive visual identification. Likewise, the divisional identification of all ancillary equipment, cable and raceways match the divisional assignment of the system it supports.

8.3.3.6.2 Independence of Redundant Class 1E I & C Systems

This subsection defines independence criteria applied to Class 1E 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.

8.3.3.6.2.1 General

Separation of the equipment for the systems referred to in Subsections 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 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 three-hour fire-rated barriers and electrical isolation. This protection is provided to maintain the independence of nuclear Class 1E 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. The exceptional cases where it is not possible to install such barriers have been analyzed and justified in Appendix 9A.5.

8.3.3.6.2.2 Separation Techniques

The methods used to protect redundant safety systems from results of single failures or events are utilization of safety class structures, three-hour fire-rated protective barriers, and isolation devices.

8.3.3.6.2.2.1 Safety Class Structure

The basic design consideration of plant layout is such that redundant circuits and equipment are located in separate safety class areas (i.e., separate fire zones) insofar as possible. The separation of Class 1E circuits and equipment is such that the required independence will not be compromised by the failure of mechanical systems served by the Class 1E electrical system. For example, Class 1E circuits are routed or protected so that failure of related 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 floors.

8.3.3.6.2.2.2 Three-Hour Fire Rated Protective Barriers

Three-hour fire rated protective barriers shall be such that no locally generated fire, or missile resulting from a design basis event (DBE) or from random failure of Seismic Category I equipment can disable a safety-related function. The electrical equipment from the Class 1E power supplies to the distribution centers are separated by 3-hour-rated fire barriers. Beyond the distribution centers, the exceptional cases where it is not possible to install such barriers have been analyzed and justified in Appendix 9A.5.

Separation in all safety equipment or cable areas shall equal or exceed the requirements of IEEE 384.

8.3.3.6.2.2.3 Main Control Room and Relay Room Panels

The control room area and cable chases are considered non-hazard areas (as defined in Section 6.1.3 of IEEE 384). These areas do not contain potential hazards such as high energy switchgear, power distribution panels, transformers, or rotating equipment; nor are they exposed to potential sources of missiles, pipe failure hazards, or fire hazards.

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 following general criteria to preclude 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. 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 15.24 cm (6 inches) or by steel barriers or enclosures. Solid or flexible metallic conduit is considered an acceptable barrier, providing 2.54 cm (1 inch) separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(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. Solid or flexible metallic conduit is considered an acceptable barrier, providing 2.54 cm (1 inch) separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(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 8.3.3.6.2.2.4). Solid or flexible metallic conduit is considered an acceptable barrier, providing 2.54 cm (1 inch) separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(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 2.54 cm (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.

(6) Class 1E, Class 1E associated, or non-Class 1E power circuits routed in the control room area are limited to those required to operate systems, equipment, or components located in the control room area (power cables are not permitted to traverse through from one side of the control room area to the other without being terminated in the control room area).

8.3.3.6.2.2.4 Isolation Devices

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 will be used. AC isolation (the FMCRD drives on Division 1 is the only case) is provided by interlocked circuit breaker coordination and an isolation transformer as described in Subsection 8.3.1.1.1.

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

8.3.3.6.2.3 System Separation Requirements

Specific divisional assignment of safety-related systems and equipment is given in Table 8.3-1. (Note that in Table 8.3-1, diesel generator "A" corresponds with Class 1E electrical division "I", "B" with "II", and "C" with "III".) Other separation requirements pertaining to the RPS and other ESF systems are given in the following subsections.

8.3.3.6.2.3.1 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 separate groups designated Divisions I, II, III 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 separated 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 di·isions, Class 1E

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).

(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.

(9) The start-up range monitoring (SRNM) subsystem cabling of the NMS cabling under the vessel is treated as divisional. The SRNM cables will be assigned to Division I, II, III and IV. Under the vessel, cables will be enclosed and separated as defined in Appendix 9A.5.5.5.

8.3.3.6.2.3.2 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.

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

Class 1E 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 sources 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. (Note that in Table 8.3-1, diesel generator "A" corresponds with Class 1E electrical division "I", "B" with "II", and "C" with "III".) The wiring to the ADS solenoid valves within the drywell shall run in rigid conduit. ADS conduit for solenoid A shall be divisionally separated from solenoid B conduit. Short pieces (less than .6 m [2 ft.]) 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 leak.

(6) Class 1E electrical equipment located in the suppression pool level swell zone is limited to suppression pool temperature monitors and their feeder cables. The terminations are 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.

(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 (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.

Current-limiting devices designed to protect the penetrations shall be periodically tested (see 8.3.4.4).

8.3.3.8 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 non-propagating 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 as listed in Table 9.5.1-1.

8.3.3.8.1 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 (See 8.3.4.3). Also, Class 1E cables are designed and qualified to survive the LOCA ambient condition at the end of the 60-yr. life span. The cable installation (i.e., redundant divisions separated by fire barriers) is such that direct impingement of fire suppressant will not prevent safe reactor shutdown, even if failure of the cable occurs. Cables are specified to be submersible, however (See the fourth requirement/compliance in Subsection 9.5.1.0).

8.3.3.8.2 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 8.3.3.6. Floors and walls are effectively used to provide vertical and horizontal fire-resistive separations between redundant cable divisions.

In any given fire area an attempt is made to insure that there is equipment from only one Class 1E division. This design objective is not always met due to other over-riding design requirements; however, separation requirements of 8.3.3.1 are complied with. 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.

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

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.

8.3.4.5 (Deleted)

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 8.3.2.1.3.1)

Provide the manufacturer'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 8.3.2.1.3.1).

8.3.4.7 (Deleted)

8.3.4.8 (Deleted)

8.3.4.9 Offsite Power Supply Arrangement

The COL applicant 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 de-energization of all divisional buses on the loss of only one of the offsite power supplies. The selection of that division should be based on the Class 1E bus loads, the reliability/stability of the offsite circuits, and on the separation of the offsite feeds as they pass through the divisional areas.

Continued plant operation will be appropriately limited when the reserve auxiliary transformer is inoperable [see 8.2.4 for COL information].

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 by the COL applicant. The tests shall be in accordance with IEEE 387 and Regulatory Guide 1.9. (See Subsection 8.3.1.1.8.9).

8.3.4.11 (Deleted)

8.3.4.12 Minimum Starting Voltages for Class 1E Motors

The COL applicant will provide the minimum required starting voltages for Class 1E motors. A comparison will be made of 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 diesel generators. [See Subsection 8.3.1.1.5(1)].

8.3.4.13 (Deleted)

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 by the COL applicant 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. (See Subsection 8.3.1.1.6.2).

8.3.4.15 **Administrative Controls for Manual Interconnections**

As indicated in 8.3.1.2(4)(b), the ABWR has capability for manually connecting any plant loads to receive power from any of the six sources. Appropriate plant operating procedures shall prevent paralleling of the redundant onsite Class 1E power supplies.

8.3.4.16 **Emergency Operating Procedures for Station Blackout**

COL applicants will provide instructions in their plant Emergency Operating Procedures for operator actions during a postulated station blackout event. Specifically, if Division I 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. (See Subsection 8.3.2.1.3.5).

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 industrial standards, as appropriate, for the assurance of quality manufacturing of both Class 1E and non-Class 1E equipment. Such standards would include ANSI, ASTM, IEEE, NEMA, UL, etc. (See Subsection 8.3.5).

8.3.4.18 **Administrative Controls for Switching 125 Vdc Standby Charger**

Administrative controls shall be provided to assure all input and output circuit breakers are normally open when standby battery chargers are not in use (See Figure 8.3-4, Note 1). Administrative controls shall also be provided to assure at least two circuit breakers (in series) are open between redundant divisions when placing the standby charger into service. This includes controls for the keys associated with the switching interlocks. The only exception is an emergency condition requiring one division's loads be assumed by a redundant division by manual connection via the standby charger interface.

8.3.4.19 **Control of Access to Class 1E Power Equipment**

Administrative control of access to Class 1E power equipment areas and/or distribution panels shall be provided (see Section 13.6.3).

8.3.4.20 **Periodic Testing of Voltage Protection Equipment**

Appropriate plant procedures shall include periodic testing of instruments, timers, and other electrical equipment designed to protect the distribution system from: 1) loss of offsite voltage, and 2) degradation of offsite voltage. These protection features are described in Subsection 8.3.1.1.7.

8.3.4.21 **Diesel Generator Parallel Test Mode**

The technical specifications require periodic testing of the diesel generator loading capabilities by operating the diesel generators in parallel with the offsite power source. Interlocks which restore the units to emergency standby on event of a LOCA or LOPP shall also be tested.

Appropriate procedures shall require that the duration of the connection between the preferred power supply and the standby power supply shall be minimized in accordance with Section 6.1.3 of IEEE 308.

8.3.4.22 Periodic Testing of Diesel Generator Protective Relaying

Appropriate plant procedures shall include periodic testing of all diesel generator protective relaying, bypass circuitry and annunciation.

8.3.4.23 Periodic Testing of Diesel Generator Synchronizing Interlocks

Appropriate plant procedures shall include periodic testing of diesel generator synchronizing interlocks (see 8.3.1.1.6.4).

8.3.4.24 Periodic Testing of Thermal Overloads and Bypass Circuitry

Appropriate plant procedures shall include periodic testing of thermal overloads and associated bypass circuitry for Class 1E MOVs. The testing shall be performed in accordance with the requirements of Regulatory Guide 1.106 [see 8.3.1.2(2)(g) and 8.3.2.2.2(2)(f)].

8.3.4.25 Periodic Inspection/Testing of Lighting Systems

Appropriate plant procedures shall include periodic inspections of all lighting systems installed in safety-related areas, and in passageways leading to and from these areas. In addition, lighting systems installed in such areas which are normally de-energized (e.g., guide lamps) shall be periodically tested.

8.3.4.26 Controls for Limiting Potential Hazards into Cable Chases

Appropriate plant procedures shall provide administrative control of operations and maintenance activities to control and limit introduction of potential hazards into cable chases and the control room area.

8.3.4.27 Periodic Testing of Class 1E Equipment Protective Relaying

Appropriate plant procedures shall include periodic testing of all protective relaying and/or thermal overloads associated with Class 1E motors and switchgear.

8.3.4.28 Periodic Testing of CVCF Power Supplies and EPA's

Appropriate plant procedures shall include periodic testing of the CVCF power supplies and associated electrical protection assemblies (EPA's) which provide power to the Reactor Protection System.

8.3.4.29 Periodic Testing of Class 1E Circuit Breakers

Appropriate plant procedures shall include periodic calibration and functional testing of the fault interrupt capability of all Class 1E breakers, fault interrupt coordination between the supply and load breakers for each Class 1E load and the Division I non-Class 1E load, and the zone selective interlock feature of the breaker for the non-Class 1E load.

8.3.4.30 Periodic Testing of Electrical Systems & Equipment

Appropriate plant procedures shall include periodic testing of all Class 1E electrical systems and equipment in accordance with Section 7 of IEEE 308.

8.3.4.31 (Deleted)

8.3.4.32 Class 1E Battery Installation and Maintenance Requirements

The installation, maintenance, testing, and replacement of the Class 1E station batteries shall meet the requirements of IEEE 484 and Section 5 of IEEE 946.

8.3.4.33 Periodic Testing of Class 1E Batteries

Appropriate plant procedures shall include periodic testing of Class 1E batteries, in accordance with Section 7 of IEEE 308, to assure they have sufficient capacity and capability to supply power to their connected loads.

8.3.4.34 Periodic Testing of Class 1E CVCF Power Supplies

Appropriate plant procedures shall include periodic testing of Class 1E constant voltage constant frequency (CVCF) power supplies to assure they have sufficient capacity to supply power to their connected loads (see 8.3.1.1.4.2.1).

8.3.4.35 Periodic Testing of Class 1E Battery Chargers

Appropriate plant procedures shall include periodic testing of Class 1E battery chargers to assure they have sufficient capacity to supply power to their connected loads (see 8.3.2.1.1). Such periodic tests shall be in conformance with Section 7.5.1 of IEEE 308 (i.e., IEEE 338).

8.3.4.36 Periodic Testing of Class 1E Diesel Generators

Appropriate plant procedures shall include periodic testing and/or analysis of Class 1E diesel generators (see 8.3.1.1.8.2), including demonstration of their capability to supply the actual full design basis load current for each sequenced load step.

8.3.5 References

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

IEEE Std 141   Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book)

IEEE Std 242 Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)

IEEE Std 323 Qualifying Class 1E Equipment for Nuclear Power Generating Stations

IEEE Std 334 Type Test of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations

IEEE Std 379 Applications of the Single-Failure Criterion to Nuclear Power Generating Stations Class 1E Systems

IEEE Std 382 Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants.

IEEE Std 383 Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations

IEEE Std 387 Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations

IEEE Std 399 Recommended Practice for Industrial and Commercial Power Systems Analysis (IEEE Brown Book)

IEEE Std 450 Recommended Practice for Large Lead Storage Batteries for Generating Stations and Substations

IEEE Std 484 Recommended Practice for Installation Design and Installation of 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

IEEE Std 519 Guide for Harmonic Control and Reactive Compensation of Static Power Converters

IEEE Std 741 Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations.

IEEE Std 946 Recommended Practice for the Design of Safety-Related DC Auxiliary Power Systems for Nuclear Power Generating Stations

IPCEA S-66-402 Thermoplastic Insulated Wire & Cable for the Transmission and Distribution of Electrical Energy

IPCEA-46-426/ IEEE S-135 Power Cable Ampacities

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
SECY-89-013	Stello, Victor, Jr., Design Requirements Related To The Evolutionary Advanced Light Water Reactors (ALWRS), Policy Issue, SECY-89-013, The Commissioners, United State Nuclear Regulatory Commission, January 19, 1989.

Topical Report NEDC-31336 "General Electric Instrument Setpoint Methodology"

UL-44	UL Standard for Safety Rubber-Insulated Wires and Cables

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 below:

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-rated metal-clad 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.C9	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 Switchgear
ANSI C37.20	Switchgear Assemblies and Metal-Enclosed Bus
ANSI C37.100	Definitions for Power Switchgear 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

See Subsection 8.3.4.17 for COL license information pertaining to common industrial standards referenced in purchase specifications.