U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 8.3.1 A-C POWER SYSTEMS (ONSITE)

REVIEW RESPONSIBILITIES

Primary - Power Systems Branch (PSB)

Secondary - None

I. AREAS OF REVIEW

The descriptive information, analyses, and referenced documents, including functional logic diagrams, functional piping and instrument diagrams, electrical single-line diagrams, tables, physical arrangement drawings, and electrical schematics, for the a-c onsite power system presented in the applicant's safety analysis report (SAR) are reviewed. The intent of the review is to determine that the a-c onsite power system satisfies the requirements of General Design Criteria 2, 4, 5, 17, 18 and 50 and will perform its intended functions during all plant operating and accident conditions.

The a-c onsite power system includes those standby power sources, distribution systems, and vital supporting systems provided to supply power to safety-related equipment. Diesel generator sets have been widely used as the standby power source for the a-c onsite power system and will be covered in this SRP section. Other standby power sources such as nearby hydroelectric, nuclear, or fossil units including gas turbine-generator sets will not be addressed herein. These sources, when proposed, will be evaluated on an individual case basis. In addition, those interface areas between the onsite and offsite power systems at the station distribution system level are within the scope of review of this SRP section insofar as they relate to the independence of the onsite power system.

The PSB will review the following features of the a-c onsite power system during both the construction permit (CP) and operating license (OL) stages of the licensing process:

1. System Redundancy Requirements

   The onsite power system is reviewed to determine that the required redundancy of safety-related components and systems is provided. This includes an examination of the a-c power system configuration including the power supplies, power supply feeders, switchgear arrangement, loads supplied from each bus, and power connections to the instrumentation and control devices of the power system.

2. Conformance with the Single Failure Criterion

In establishing the adequacy of this system to meet the single failure criterion, both electrical and physical separation of redundant power sources and associated distribution systems are examined to assess the independence between redundant portions of the system. This will include a review of interconnections between redundant buses, buses and loads, and buses and power supplies; physical arrangement of redundant switchgear and power supplies; criteria and bases governing the installation of electrical cables for redundant power systems; and proposed sharing of the a-c power system between units at the same site.

3. Onsite and Offsite Power System Independence

In evaluating the independence of the onsite power system with respect to the offsite power system, the scope of review extends to the station distribution load centers which are powered from the unit auxiliary transformers and the startup transformers (considered for the purposes of this SRP section as the offsite or preferred power sources). It includes the supply breakers connecting the "low" side of these transformers to the distribution buses. This evaluation includes a review of the electrical protective relaying circuits and power supplies to ensure that in the event of a loss of offsite power, the independence of the onsite power system is established through prompt opening of isolation-feeder breakers.

4. Standby Power Supplies

Design information and analyses demonstrating the suitability of the diesel generators as standby power supplies are reviewed to ensure that the diesel generators have sufficient capacity and capability to perform their intended function. This will include an examination of the characteristics of each load and the length of time each load is required, the combined load demand connected to each diesel generator during the "worst" operating condition, automatic and manual loading and unloading of each diesel generator, voltage and frequency recovery characteristics of the diesel generators, continuous and short-term ratings for the diesel generators, acceptance criteria with regard to the number of successful diesel generator tests and allowable failures to demonstrate acceptability, and starting and load shedding circuits. In addition, where the proposed design provides for the connection of non-safety loads to the diesel generators or sharing of diesel generators between nuclear units at the same site, particular review emphasis is given to the possibility of marginal capacity and degradation of reliability that may result from such design provisions.

5. Identification

The means proposed for identifying the a-c onsite power system components including cables, raceways, and terminal equipment as safety-related equipment in the plant are reviewed. Also, the identification scheme used to distinguish between redundant cables, raceways, and terminal equipment of the power system is reviewed.

6. Vital Supporting Systems

The instrumentation, control circuits, and power connections of vital supporting systems are reviewed to determine that they are designed to the same criteria as those for the safety-related loads and power systems that they support. This will include an examination of the vital supporting system component redundancy; power feed assignment to instrumentation, controls, and loads; initiating circuits; load characteristics; equipment identification scheme, and design criteria and bases for the installation of redundant cables.

7. System Testing and Surveillance

Onsite testing capabilities are reviewed. The means proposed for automatically monitoring the status of system operability are reviewed.

8. Other Review Areas

The a-c power system is reviewed to determine that:

a. The system and its components have the appropriate seismic design classification.

b. The system and its components are housed in a structure with seismic category I classification.

c. The system and its components are designed to withstand environmental conditions associated with normal operation, natural phenomena, and postulated accidents.

d. The system and its components have a "Class 1E" quality assurance classification.

In the review of other areas associated with the a-c onsite power system, the PSB will coordinate other branches evaluations that interface with the overall review of the system as follows: The Auxiliary Systems Branch (ASB), evaluates the adequacy of those auxiliary systems that are vital to the proper operation and/or protection of the a-c power system as part of its primary review responsibility for SRP Section 9.4. This includes such systems as the heating and ventilation systems provided to maintain a controlled environment for safety-related instrumentation and electric equipment. In particular, ASB determines that the piping, ducting, and dampering for these heating and ventilation systems are adequate. In addition, the ASB examines the physical arrangement of components and structures for Class 1E systems and their supporting auxiliary systems, to determine that single events and accidents will not disable redundant features as part of its primary review responsibility for SRP Sections 3.4.1, 3.5.1.1, 3.5.2, and 3.6.1. The ASB determines those system components requiring electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 6.7, 9.1.3, 9.1.4, 9.2, 9.3, 9.4, 9.5.1, 10.4.7, and 10.4.9. The Containment Systems Branch (CSB) evaluates the adequacy of those containment ventilation systems provided for maintaining a controlled environment for safety-related electrical equipment located inside the containment as part of its primary review responsibility for SRP Section 6.2.2. The CSB determines those system components requiring electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 6.2.2, 6.2.4, and 6.2.5. The Equipment Qualification Branch (EQB) determines the environmental qualification of safety-related electrical equipment as part of their primary review responsibility for SRP Section 3.11. In particular, the EQB determines the capability of safety-related electrical equipment to perform their designed safety function when subject to and following (1) the effects of accident environments such as loss of coolant and steam line break accidents, (2) the effects of normal environments that exceed the equipments design parameters such as temperature and humidity, (3) the effects of environments caused by loss of non-Class 1E heating and ventilation systems, (4) the effects of seismic shaking, and (5) the effects of normal design environments on redundant safety-related electrical equipment that do not have diversity of design such as redundant components manufactured and designed by the same supplier. The Reactor Systems Branch (RSB) determines those system components requiring electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 5.4.6, 5.4.7, and 6.3 The Instrumentation and Control Systems Branch (ICSB) determines those system components requiring electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 7.2 through 7.7. In addition, ICSB verifies the adequacy of safety-related display instrumentation and other instrumentation systems required for safety as part of its primary review responsibility for SRP Sections 7.5 and 7.6. The Effluent Treatment Systems Branch (ETSB) determines those system components requiring electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Section 6.5.1. The Procedures and Test Review Branch (PTRB) determines the acceptability of the preoperational and initial startup tests and programs as part of its primary review responsibility for SRP Section 14.0. The Mechanical Engineering Branch (MEB) reviews as part of its review responsibility for SRP Section 3.11 the criteria for seismic qualification and the test and analysis procedures and methods to ensure the mechanical survivability of Category I instrumentation and electrical equipment (including raceways, switchgear, control room boards, and instrument racks and panels) in the event of a seismic occurrence. Electrical operability is reviewed by EQB as described above. The Chemical Engineering Branch (CMEB) examines the fire detection and fire protection systems for the a-c power system and its supporting auxiliary system components to assure that adverse effects of fire are minimized as part of its primary review responsibility for SRP Section 9.5.1. This includes the adequacy of protection provided redundant safe shutdown circuits to determine that a single design basis fire will not disable both redundant circuits. The reviews for technical specifications and quality assurance including periodic testing are coordinated and performed by the Licensing Guidance Branch and Quality Assurance Branch as part of their primary review responsibility for SRP Sections 16.0 and 17.0 respectively.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

In general, the onsite a-c power system is acceptable when it can be concluded that this system has the required redundancy, meets the single failure criterion, is protected from the effects of postulated accidents, is testable, and has the capacity, and capability to supply power to all safety loads and other required equipment in accordance with GDC 2, 4, 5, 17, 18, and 50. Table 8-1 lists General Design Criteria (GDC), regulatory guides, and branch technical positions used as the bases for arriving at this conclusion.

The design of the a-c power system is acceptable if the integrated design is in accordance with the following criteria and guidelines:

1. General Design Criterion 2, as related to structures, systems, and components of the a-c onsite power system being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, as established in Chapter 3 of the SAR, and reviewed by the ASB and the Structural Engineering Branch (SEB) as part of their primary review responsibility.

2. General Design Criterion 4, as related to structures, systems, and components of the a-c power system being capable of withstanding the effects of missiles and environmental conditions associated with normal operation and postulated accidents, as established in Chapter 3 of the SAR and reviewed by ASB, RSB and EQB as part of their primary review responsibility.

3. General Design Criterion 5, as related to the sharing of structures, systems, and components of the a-c power system, and the following guidelines:

   a. Regulatory Guide 1.32 (see also IEEE 308), as related to the sharing of structures, systems, and components of the a-c power system,

   b. Regulatory Guie 1.81, as related to the sharing of structures, systems, and components of the a-c power system, positions C.2 and C.3.

4. General Design Criterion 17, as related to the onsite a-c power system's (a) capacity and capability to permit functioning of structures, systems, and components important to safety, (b) the independence, redundancy, and testability to perform it's safety function assuming a single failure, and (c) provisions 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 or the loss of power from the transmission network. Acceptance is based on meeting the following specific guidelines:

   a. Regulatory Guide 1.6, as related to the independence of the onsite a-c power system, positions D.1, D.2, D.4, and D.5.

   b. Regulatory Guide 1.9 (see also IEEE 387).

   c. Regulatory Guide 1.32 (see also IEEE 308) as related to design criteria for onsite a-c power systems.

   d. Regulatory Guide 1.75 (see also IEEE 304) as related to the onsite a-c power system.

   e. Regulatory Guide 1.108 as related to the testability of the onsite a-c power system.

   f. NUREG/CR 0660, as related to the following recommendations:

      (1) The diesel generator sets shall be capable of operation at less than full load for extended periods of time without degradation of performance or reliability. With offsite power available, no load operation of the diesel generators will occur following a safety injection signal. Extended no load operation of this equipment shall be minimized. Operating procedures shall be provided that limit extended no load operation of the diesel generators. The procedures shall require loading the diesel engine to a minimum of 25% of full load for one hour after eight hours of continuous no load operation or to a load as recommended by the engine manufacturer.

      (2) A complete formal training program shall be provided for all personnel who will be responsible for the maintenance and availability of the diesel generators. The depth and quality of training shall be at least equivalent to that provided by major diesel engine manufacturers training programs.

      (3) A preventive maintenance program shall be provided which encompasses investigative testing of components which have a history of repeated malfunctioning and a plan for the replacement of those components which require constant attention and repair with other products of proven reliability.

      (4) Repair and maintenance procedures shall provide for a final equipment check prior to an actual start-run-load

test to assure that all electrical circuits are functional (i.e. fuses in place, no loose wires, test leads removed etc.) and all valves are in the proper position. The test procedure(s) shall explicitly state that upon satisfactory test completion the diesel generator unit shall be returned to a ready automatic standby service under the control of the control room operator.

(5) Except for sensors and other equipment that must be directly mounted on the engine or associated piping, the controls and monitoring instruments shall be installed on a free standing floor mounted panel located on a vibration free floor area.

<u>NOTE</u>: If the floor is not vibration free the panel shall be equipped with vibration mounts.

5. General Design Criterion 18, as related to the testability of the onsite a-c power system, and the guidelines of Regulatory Guide 1.118 (see also IEEE 338), as related to the capability for testing the onsite a-c power system.

6. The design requirements for an onsite a-c power supply for systems covered by General Design Criteria 33, 34, 38, 41 and 44 are encompassed in General Design Criterion 17.

7. General Design Criterion 50, as related to the design of containment electrical penetrations containing circuits of the a-c power system and the guidelines of Regulatory Guide 1.63 (see also IEEE 317) as related to the capability of the electric penetration assemblies to withstand, without loss of mechanical integrity, the maximum possible fault current versus time condition that could occur given single random failure of circuit overload protective devices located in circuits of the onsite a-c power systems.

Branch Technical Positions and industry standards that provide information, recommendations and guidance and in general describe a basis acceptable to the staff that may be used to implement the requirements of General Design Criteria 2, 4, 5, 17, 18, and 50 are identified in SRP Section 8.1, Table 8.1 and Appendix 8-A. In addition, Task Action Plan items II.E.3.1 and II.G.1 of NUREG's 0737 and 0718 are also implemented to meet these regulations.

III. REVIEW PROCEDURES

The primary objective in the review of the a-c power system is to determine that this system satisfies the acceptance criteria stated in subsection II and will perform its design functions during plant normal operation, anticipated operational occurrences and accident conditions. In the CP review, the descriptive information, including the design bases and their relation to the acceptance criteria, preliminary analyses, electrical single-line diagrams, functional logic diagrams, preliminary functional piping and instrumentation diagrams (P&IDs), and preliminary physical arrangement drawings are examined to determine that there is reasonable assurance that the final design will meet these objectives. At the OL stage, these objectives are verified during the review of final electrical schematics, functional P&IDs, and physical arrangement drawings and are confirmed during a visit to the site. To ensure that acceptance criteria stated in subsection II are satisfied, the review is performed as detailed below.

The primary reviewer will coordinate this review with the other branch areas of review as stated in subsection I. The primary reviewer obtains and uses such input as required to ensure that this review procedure is complete.

1. System Redundancy Requirements

   General Design Criteria 33, 34, 35, 38, 41 and 44 set forth requirements with regard to the safety systems that must be supplied by the a-c onsite power system. Also, these criteria state that safety system redundancy should be such that for onsite power system operation (assuming offsite power is not available), the system safety function can be accomplished assuming a single failure. The acceptability of the onsite power system with regard to redundancy is based on conformance to the same degree of redundancy of safety-related components and systems required by these General Design Criteria. The descriptive information including electrical single-line diagrams (CP and OL stage), functional P&IDs (CP and OL stage), and electrical schematics (OL stage) is reviewed to verify that this redundancy is reflected in the standby power system with regard to both power sources and associated distribution systems. Also, it is verified in coordination with other branches that redundant safety loads are distributed between redundant distribution systems, and that the instrumentation and control devices for the Class 1E loads and power system are supplied from the related redundant distribution systems.

2. Conformance with the Single Failure Criterion

   As required by General Design Criterion 17, the onsite a-c power system must be capable of performing its safety function assuming a single failure.

   In evaluating the adequacy of this system in meeting the single failure criterion both electrical and physical separation of redundant power sources and distribution systems, including their connected loads, are reviewed to assess the independence between redundant portions of the system.

   To ensure electrical independence, the design criteria, analyses, description, and implementation as depicted on functional logic diagrams, electrical single-line diagrams, and electrical schematics are reviewed to determine that the design meets the requirements set forth in IEEE Std 308 and satisfies the positions of Regulatory Guide 1.6. Additional guidance in evaluating this aspect of the design is derived from IEEE Std 379, "Guide for the Application of the Single-Failure Criterion to Nuclear Power Generating Station Protection Systems," as augmented by Regulatory Guide 1.53, "Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems." Other aspects of the design where special review attention is given to ascertain that the electrical independence and physical separation has not been compromised are as follows:

a. Should the proposed design provide for sharing of the a-c onsite power system between units at the same site, the criteria of IEEE Std 308 governing the sharing of this system between units are not specific enough to be used as the basis for assessing the adequacy of the design in meeting the requirements of General Design Criterion 5 and satisfying the single failure criterion. Therefore, the acceptability of such a design is determined by reviewing the proposed system design criteria and electrical schematics and analyses substantiating the adequacy of the design to withstand the consequences of electrical faults and failures in one unit with respect to the others. Generally, the PSB is guided by the requirements set forth in Position 2 of Regulatory Guide 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants," for CP applications docketed before June 1, 1973 and for OL applications. Position 3 of this Regulatory Guide prohibits the sharing of onsite power systems between nuclear units for construction permit applications docketed after June 1, 1973. Further details of the review with regard to Position 2 on sharing of the onsite power system between units are covered in item 4, below.

b. The interconnections between redundant load centers through bus tie breakers and multi-feeder breakers used to connect extra redundant loads to either of the redundant distribution systems are examined to assure that no single failure in the interconnections will cause the paralleling of the standby power supplies. To ensure this, the control circuits of the bus tie breakers or multi-feeder breakers must preclude automatic transferring of load centers or loads from the designated supply to the redundant counterpart upon loss of the designated supply (Position 4 of Regulatory Guide 1.6). Regarding the interconnections through bus tie breakers, an acceptable design will provide for two tie breakers connected in series and physically separated from each other in accordance with the acceptance criteria for separation of the onsite power system, which is discussed below. Further, the interconnection of redundant load centers must be accomplished only manually. With respect to the interconnections through the multi-feeder breakers supplying power to extra redundant loads, the review relates to the use of the extra redundant unit as one of the required operating units (if the substituted-for-normal unit is inoperable). If this is the selected mode of operation prior to an accident concurrent with the loss of offsite power, it is verified by reviewing the breaker arrangement and associated control circuits that no single failure in the feeder breaker which is not connected to the extra redundant unit could cause the closing of this breaker resulting in the paralleling of the power supplies. To ensure against compromising the independence of the redundant power systems under this situation, an acceptable design for connecting extra redundant loads to either distribution system will provide for at least dual means for connecting and isolating each load from each redundant bus. Such a design must also meet the acceptance criteria for electrical and physical separation of the onsite power system.

In addition, the provisions of the design to automatically break all the interconnections (e.g., open tie and multi-feeder breakers) between redundant load centers immediately following an accident condition concurrent with the loss of offsite power are reviewed to ascertain that the independence of the redundant portions of this system is established given a single failure.

c. To assure physical independence, the criteria governing the physical separation of redundant equipment, including cables and raceways, and their implementation as depicted on preliminary (CP stage) or final (OL stage) physical arrangement drawings are reviewed to determine that the design arrangements satisfy the requirements set forth in IEEE Std 384 as augmented by Regulatory Guide 1.75. This standard and regulatory guide set forth acceptance criteria for the separation of circuits and electrical equipment contained in or associated with the Class 1E power system. To determine that the independence of the redundant cable installation is consistent with satisfying the requirements set forth in IEEE Std 384 as augmented by Regulatory Guide 1.75, the proposed design criteria governing the separation of Class 1E cables and raceways are reviewed including such criteria as those for cable derating; raceway filling; cable routing in containment, penetration areas, cable spreading rooms, control rooms and other congested areas; sharing of raceways with nonsafety-related cables or with cables of the same system or other systems; prohibiting cable splices in raceways; control wiring and components associated with Class 1E electric systems in control boards, panels, and relay racks; and fire barriers and separation between redundant raceways.

3. <u>Onsite and Offsite Power System Independence</u>

In ascertaining the independence of the onsite power system with respect to the offsite power system, the electrical ties between these two systems as well as the physical arrangement of the interface equipment are reviewed to assure that no single failure will prevent the separation of the redundant portions of the onsite power system from the offsite power system when required. The scope of the review for independence extends from the supply breakers connected to the low side of the unit auxiliary transformers and startup transformers (referred to as the offsite or preferred power supplies) to the station safety-related distribution system. The number and capability of electrical circuits from the offsite power system to the safety buses are to be consistent with satisfying the requirements of General Design Criterion 17. Then, downstream of the offsite power breakers at the safety buses, the design must satisfy the requirements for redundancy and independence of General Design Criteria 34, 35, 38, 41 and 44; that is, for onsite power system operation (assuming offsite power is not available), the system safety function can be accomplished assuming a single failure.

To determine that the physical independence of the preferred power circuits to the Class 1E buses is consistent with satisfying the requirements of General Design Criterion 17 and IEEE Std 308, the physical arrangement drawings are examined to verify that each circuit is physically separate and independent from its redundant counterparts. In addition, the final feeder-isolation breaker in each circuit through which preferred power is supplied to the safety buses must be designed and physically separated in accordance with the requirements for the onsite power system. Following the loss of preferred power, the safety buses are powered solely from the standby power supplies. Under this situation, the design of the feeder-isolation breaker in each preferred power circuit must preclude the automatic connection of preferred power to the respective safety bus upon the loss of standby power. In this regard, an acceptable design will include the capability for restoring preferred power to the respective safety bus by manual actuation only.

In assessing the adequacy of the electrical ties between the onsite and offsite power systems, and the capability of the preferred power circuits to deliver power to the safety-related buses, both primary and secondary backup protective relaying schemes and their coordination, relay settings, and assigned control power supplies are reviewed by PSB to assure that in the event of an electrical fault, occurring between the preferred power transformer supply breakers and the safety buses, no single failure will result in reducing the number of preferred power circuits to less than the minimum required for safety or prevent the separation of the affected circuit from the respective redundant portion of the onsite power system. In addition, it is verified that no single protective relay or interlock failure will prevent separation of the required redundant portions of the onsite power system from the preferred power system upon loss of the latter.

In reviewing the mode of operation where both power systems are being operated in parallel (such is the case during full load testing of standby power supply diesel-generator sets), the interlock scheme including electrical protective relay coordination and settings are closely examined to verify that the independence of the required redundant portions of the onsite power system is established upon a failure in the offsite power system. The event of concern under this mode of operation is an accident concurrent with a loss of offsite power and a single failure preventing the opening of the feeder-isolation breaker through which the paralleling of the power systems was being accomplished. Because the signal to start the diesel-generator sets is normally derived from undervoltage relays, and under this situation the voltage is maintained above the trip relay settings by the diesel generator under test, the remaining redundant diesel generators will not be commanded to start running. Consequently, the added capacity resulting from the connection of non-safety related loads to the diesel generator under test will cause the tripping of this diesel due to overload. The end result could be the total loss of power to the safety buses. However, this power interruption could be of momentary duration if the remaining redundant diesel generators are commanded automatically to start by undervoltage relay action immediately after total power is lost. The diesel generator under test will be inoperable due to the self-locking feature preventing restarting after an overload trip condition. The reviewer ascertains that the time delay introduced in making power available to the safety buses as a result of this event is within the response time limits assumed in the accident analyses. Included is verification that subsequent failures such as those resulting from improper electrical relaying coordination and self-locking features will not impair the automatic starting of the remaining redundant diesel generators required to meet minimum safety requirements. If the time delay introduced in making power available to the safety buses is not tolerable, it must be demonstrated that either the probability of occurrence of this event is low when compared to the frequency and duration of testing each diesel, or the design must provide diverse automatic signals, other than undervoltage, to ensure the availability of standby power to the safety buses.

As an outcome of reviewing the parallel operation of the offsite and onsite power systems, the use of the standby power supply diesel-generator sets to supply power to the electrical system during peak load demand periods was found by the staff to be unacceptable. The basis for this conclusion is that the required frequent interconnections of the offsite and standby power supplies do not minimize the probability of their coincident loss (General Design Criterion 17) nor can the design be made immune to common failure modes (Section 5.2.1(5) of IEEE Std 308). Further details amplifying the basis for this conclusion are included in Branch Technical Position ICSB 8 (PSB) which sets forth the basis for prohibiting the use of diesel-generator sets for purposes other than emergency standby power supplies.

4. Standby Power Supplies

In ensuring that the requirements of General Design Criterion 17 and IEEE Std 308 have been met with regard to the standby power supply diesel-generator sets having sufficient capacity and capability to supply the required distribution system loads, the design bases, design criteria, analyses, description, and implementation as depicted on electrical drawings and functional P&IDs, the diesel-generator sets are reviewed to verify that the bases for their selection satisfy the positions of Regulatory Guide 1.9. Specifically, the reviewer first becomes familiar with the purpose and operation of each safety system, including system component arrangement as depicted on functional P&IDs, expected system performance as established in the accident analyses, modes of system operation and their interactions during normal and accident conditions, and interactions between systems. Following this, it is verified that the tabulation of all safety-related loads to be connected to each diesel generator is consistent with the information establishing the safety-related systems and loads and their required redundancy. The characteristics of each load (such as motor horsepower, volt-amp rating, in-rush current, starting volt-amps and torque), the length of time each load is required, and the basis used to establish the power required for each safety load (such as motor nameplate rating, pump run-out condition, or estimated load under expected flow and pressure) are used to verify the calculations establishing the combined load demand to be connected to each diesel during the "worst" operating condition. In applying this combined load demand to the selection of each diesel generator capacity, an acceptable design must satisfy Positions 1 and 2 of Regulatory Guide 1.9.

To ensure that each diesel generator is capable of starting and accelerating to rated speed all the connected loads in the required sequence and within the minimum time intervals established by the accident analyses, the PSB reviewer examines for each diesel generator the loading profile curves, voltage and frequency recovering characteristic curves, and the response time of the excitation system to load variations. This examination must verify that the capability of each diesel generator to respond to voltage and frequency variations satisfies Position 5 of Regulatory Guide 1.9. In addition, the adequacy of the circuit design for starting and disconnecting and connecting safety loads from and to each diesel generator is checked. This includes a review of the starting initiating circuits; manual and automatic sequential loading and unloading circuits; interrupting capacity of switchgear, load centers, control centers, and distribution panels; grounding requirements; and electrical protective relaying circuits including their coordination, relay settings, and assigned control power supplies for each load and each diesel generator. In reviewing the criteria governing the design of the thermal overload protection for motors of motor-operated safety-related valves, the reviewer is guided by Regulatory Guide 1.106.

Regarding the review of the electrical protective trip circuits of the diesel generator sets, Positions 8 and 9 of Regulatory Guide 1.9 are used as an evaluation guide. The capability of the automatic sequential loading circuits to reset during a sustained low voltage condition on the diesel generators is reviewed to ensure that upon restoration of normal voltage, the safety-related loads can be connected in the prescribed sequence. Otherwise, the reconnection of all the loads at the same time could result in an overload condition causing the trip of the respective diesel generator. In ensuring that those safety-related loads being powered through latched-type breakers are capable of being reconnected to their respective buses after restoration of power, the design must provide for resetting the breaker anticycle feature when there is an under-voltage condition. The normal function of this feature is to prevent immediate reclosure of a breaker following a trip.

Where the proposed design provides for the sharing of diesel generators between units at the same site, and connection and disconnection of non-Class 1E loads to and from the Class 1E distribution buses, particular attention is given in the review to ensure that the implementation of such design provisions does not compromise the capacity or capability of the standby power supplies.

General Design Criterion 5 prohibits sharing unless it can be shown that the diesel generators are capable of performing all required safety functions in the event of an accident in one unit and an orderly shutdown and cooldown of the remaining units. In ensuring that the proposed design for sharing diesel generators between units meets the requirements of General Design Criteria 5 and 17 as supplemented by General Design Criteria 34, 35, 38, 41 and 44 and satisfies the positions of Regulatory Guide 1.9, the PSB reviewer is guided by Regulatory Guide 1.81. This guide sets forth two principal positions. Position 3 applies to those construction permit applications docketed after June 1, 1973, and prohibits the sharing of onsite power systems between units. Conformance of the design with Position 3 is verified by reviewing the descriptive information including electrical drawings to ensure that the onsite power system of each unit is electrically independent with respect to the onsite power system of other units.

Position 2 of Regulatory Guide 1.81 establishes acceptable bases under which sharing of onsite power systems between units is permitted. Conformance with Position 2 with regard to the adequacy of diesel generator capacity and capability under the sharing mode of operation is verified by following the procedure discussed above for tabulating and summing all loads. In particular, the load tabulation and calculations establishing the diesel generator capacity are examined to ensure that the selected capacity is sufficient to power the minimum ESF loads in any unit and safely shut down the remaining units in the event of an accident in one unit and a single failure or spurious or false accident signal from another unit and loss of preferred power to all the units. In addition, the physical arrangement of instrumentation and control devices on control room panels and consoles in one unit with respect to the other units is examined to ensure that the design minimizes the coordination needed between unit operators to accomplish sharing of the standby power systems.

In the absence of specific criteria in IEEE Std 308 governing the connection and disconnection of non-Class 1E loads to and from the Class 1E distribution buses, the review of the interconnections will consider isolation devices as defined in IEEE Std 384 and augmented by Regulatory Guide 1.75 to determine the adequacy of the design. In ensuring that the interconnections between non-Class 1E loads and Class 1E buses will not result in the degradation of the Class 1E system, the isolation device through which standby power is supplied to the non-Class 1E load, including control circuits and connections to the Class 1E bus, must be designed to meet Class 1E requirements. Should the standby power supplies not have been sized to accommodate the added non-Class 1E loads during emergency conditions, the design must provide for the automatic disconnection of those non-Class 1E loads upon the detection of the emergency condition. This action must be accomplished whether or not the load was already connected to the power supply. Further, the design must also prevent the automatic or manual connection of these loads during the transient stabilization period subsequent to this event.

The description of the qualification test program (CP stage) and the results of such tests (OL stage) for demonstrating the suitability of the diesel generators as standby power supplies are judged to be acceptable if they satisfy the acceptance criteria stated in subsection II. In the event that diesel generators have not been selected for a particular plant, a commitment from the applicant to obtain diesel generators of a design that has been previously qualified for use in nuclear power plant applications, or to perform qualification tests on diesel generators of a new design in accordance with the acceptance criteria, is considered acceptable at the CP stage of review.

The review of the diesel generator auxiliary systems is reviewed in SRP Sections 9.5.4 through 9.5.8.

To assure that diesel generator reliability and operation will not be degraded, the reviewer evaluates the diesel generator descriptive information and the results of failure modes and effects analyses in the SAR and using engineering judgement verifies the following items:

a. Provisions have been made in the facility design and in the design and installation of electrical equipment associated with the starting of the diesel generators to minimize engine failure to start on demand due to accumulation of dust and other deleterious material ingested via the ventilation system or generated in the diesel engine room during normal plant operation on the electrical starting equipment, e.g. Auxiliary Relay contacts, control switches -- etc. panel or individually mounted.

b. The diesel generator sets are capable of operation at less than full load without degradation of performance or reliability and operating procedures limit no load operation.

c. A complete formal training program is provided for all mechanical and electrical maintenance, quality control and operating personnel, including supervisors who are responsible for the maintenance and availability of the diesel generators.

d. A preventive maintenance program is provided which encompasses investigative testing of components and a replacement plan as specified in subsection II.

e. The repair and maintenance procedures provide for a final equipment check and test procedures provide for returning the diesel engine to automatic standby service and under the control of the control room operator.

f. Operating experience at certain nuclear power plants which have two cycle turbocharged diesel engines manufactured by the Electromotive Division (EMD) of General Motors driving emergency generators have experienced a significant number of turbocharger mechanical gear drive failures occurring as the result of running the emergency diesel generators at no load or light load conditions for extended periods. When this equipment is operated under no load conditions insufficient exhaust gas volume is generated to operate the turbocharger; as a result the turbocharger is driven mechanically from a gear drive in order to supply enough combustion air to the engine to maintain rated speed. The turbocharger and mechanical drive gear normally supplied with these engines are not designed for standby service encountered in nuclear power plant application where the equipment may be called upon to operate at no load or light load condition and full rated speed for a prolonged period, where no load speeds for the engine and generator are much lower than full load speeds. The locomotive turbocharger diesel hardly ever runs at full speed except at full load. EMD has developed heavy duty turbo charger mechanical drive gear assemblies for installation on their diesel engines. EMD diesel engines drives proposed for driving emergency generators for nuclear power plants should be provided with heavy duty turbocharger mechanical drive gear assembly as recommended by the manufacturer. The reviewer verifies that the EMD diesel engine is provided a heavy duty turbocharger mechanical gear drive assembly to assure optimum availability of the emergency generators on demand.

g. Except for sensors and other equipment that must be mounted directly on the engine or associated piping, the controls and monitoring instruments are installed on a free standing floor mounted panel located on a vibration free floor area. If the floor is not vibration free, the panel should be equipped with vibration mounts. In the event that the instruments and controls cannot be removed from the engine skid, due to plant design, the controls and instrumentation should be environmentally qualified for vibration service. Until the environmental qualification of the components is completed, the applicant has implemented an augmented inspection, test, and calibration program. Verify that this program has been adequately described in the SAR.

5. Identification of Cables, Raceways, and Terminal Equipment

The identification scheme used for safety-related cables, raceways, and terminal equipment in the plant and internal wiring in the control boards is reviewed to see that it is consistent with IEEE Std 384 as augmented by Regulatory Guide 1.75. This includes the criteria for differentiating between (a) safety-related cables, raceways and terminal equipment of different channels or divisions, (b) nonsafety-related cable which is run in safety raceways, (c) nonsafety-related cable which is not associated physically with any safety division, and (d) safety-related cables, raceways, and terminal equipment of one unit with respect to the other units at a multi-unit site.

6. Vital Supporting Systems

The PSB will review those auxiliary systems identified as being vital to the operation of safety-related loads and systems. The PSB reviews the instrumentation, control, and electrical aspects of the vital supporting systems to ensure that their design conforms to the same criteria as those for the systems that they support. Hence, the review procedure to be followed for ascertaining the adequacy of the vital supporting systems is the same as that discussed herein for the onsite systems. In essence, the reviewer first becomes familiar with the purpose and operation of each vital supporting system, including its components arrangement as depicted on functional P&IDs. Subsequently, the design criteria, analyses, and description and implementation of the instrumentation, control and electrical equipment, as depicted on electrical drawings, are reviewed to verify that the design is consistent with satisfying the acceptance criteria for Class 1E systems. In addition, it is verified that the vital supporting system redundant instrumentation, control devices, and loads are examined to verify that they are powered from the same redundant distribution system as the system that they support. The PSB will also verify that the vital supporting systems which are associated with the emergency diesel engine such as the fuel oil storage and transfer system, cooling water system, starting air system and lubrication system are in accordance with the acceptance criteria.

The ASB reviews the other aspects of the vital supporting systems to verify that the design, capacities, and physical independence of these systems are adequate for their intended functions. Included is a review of the heating and ventilation (H&V) systems identified as necessary to Class 1E systems, such as the H&V systems for the electrical switchgear and diesel generator rooms. The ASB will verify the adequacy of the H&V system design to maintain the temperature and relative humidity in the room required for proper operation of the safety equipment during both normal and accident conditions. It will also verify that redundant H&V systems are located in the same enclosure as the redundant unit they serve, or are separated in accordance with the same criteria as those for the systems they support.

7. System Testing and Surveillance

In ensuring that the proposed periodic onsite testing capabilities of the a-c onsite power system satisfies the requirements of General Design Criterion 18 and the positions of Regulatory Guides 1.108 and 1.118, the descriptive information (CP and OL stages) functional logic diagrams (CP and OL stages), and electrical schematics (OL stage) are reviewed to verify that the design has the built-in capability to permit integral testing of Class 1E systems on a periodic basis when the reactor is in operation.

The descriptive information (CP and OL stages) and the design implementation as depicted on electrical drawings (OL stage) of the means proposed for automatically indicating at the system level a bypassed or deliberately inoperative status of a redundant portion of a safety related system are reviewed to ascertain that the design is consistent with Regulatory Guide 1.47 and Branch Technical Position ICSB 21 (PSB). This position establishes the basis to be considered in arriving at an acceptable design for the inoperable status indication system.

8. Fire Protection for Cable Systems

In ensuring that the requirements of General Design Criterion 3 have been met, CMEB will review the design of the fire stops and seals, including the materials, their characteristics with regard to flammability and fire retardancy, and their fire underwriters rating in accordance with SRP Section 9.5.1. All cable and cable tray penetrations through walls and floors as well as any other types of cable ways or conduits should have fire stops installed. PSB will review cable derating and raceway fill to ensure compliance with accepted industry practices.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that the review supports conclusions of the following type, to be included in the staff's safety evaluation report:

The onsite power system includes the standby power sources, distribution systems, vital auxiliary supporting systems, and instrumentation and controls required to supply power to safety-related components and systems. The review of the a-c power system for the ________ plant covered the descriptive information (CP and OL), functional logic diagrams (CP and OL), functional piping and instrument diagrams (CP and OL), electrical single-line diagrams (CP and OL), preliminary (CP) and final (OL) physical arrangement drawings, and electrical schematics (OL).

The basis for acceptance of the a-c power system in our review was conformance of the design criteria and bases to the Commission's regulations as set forth in the General Design Criteria (GDC) of Appendix A to 10 CFR Part 50. The staff concludes that the plant design is acceptable and meets the requirements of GDC 2, 4, 5, 17, 18 and 50. This conclusion is based on the following:

1. The applicant has met the requirements of GDC 2, "Design Basis for Protection Against Natural Phenomena", with respect to structures, systems, and components of the a-c power systems being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods by locating the a-c power system and components in seismic Category I structures which provides protection from the effects of tornadoes, tornado missiles, and floods. In addition the a-c power system and components have a quality assurance designation of Class 1E.

2. The applicant has met the requirements of GDC 4, "Environmental and Missile Design Bases", with respect to structures, systems, and components of the a-c power system being capable of withstanding the effects of missiles and environmental conditions associated with normal operation and postulated accidents by adequate plant design and equipment qualification program.

3. The applicant has met the requirements of GDC 5, "Sharing of Structures, Systems, and Components", with respect to structures, systems components of the onsite a-c power system. The onsite a-c power system and components associated with the multi-unit facility are housed in physically separate seismic Category I structures, are not shared between units and the applicant has met the positions of Regulatory Guide 1.32, position C.2.a, and Regulatory Guide 1.81, positions C.2 and C.3.

4. The applicant has met the requirements of GDC 17, "Electric Power Systems", with respect to the onsite Class 1E a-c power

system's (a) capacity and capability to permit functioning of structures, systems, and components important to safety, (b) the independence and redundancy to perform their safety function assuming a single failure, and (c) provisions 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 or the loss of power from the transmission network. Acceptability was based on the applicant meeting the positions of Regulatory Guides 1.6, 1.9, 1.32, 1.75, and 1.108, and NUREG/CR 0660.

5. The applicant has met the requirements of GDC 18, "Inspection and Testing of Electric Power Systems", with respect to the onsite Class 1E a-c power system. The a-c power system is designed to be testable during operation of the nuclear power generating station as well as during those intervals when the station is shutdown. This meets the positions of Regulatory Guide 1.118.

6. The applicant has met the requirements of GDC 50, "Containment Design Bases", with respect to penetrations containing circuits of the safety and non-safety a-c power system. Containment electric penetrations have been designed to accommodate, without exceeding their design leakage rate, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident concurrent with the maximum short-circuit current versus time condition that could occur given single random failures of circuit overload protective devices. This meets the positions of Regulatory Guide 1.63.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides and NUREG.

VI. REFERENCES

1. Standard Review Plan Section 8.1, Table 8-1, "Acceptance Criteria and Guidelines for Electric Power Systems".

2. Standard Review Plan Appendix 8-A, "Branch Technical Position (PSB)."

3. Standard Review Plan Appendix 8-B, "General Agenda, Station Site Visits."

4. NUREG-0718, "Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License."

5. NUREG-0737, "Clarifications of TMI Action Plan Requirements."

6. NUREG/CR-0660, "Enchancement of Onsite Emergency Diesel Generators Reliability."

APPENDIX

CRITERIA FOR ALARMS AND INDICATIONS ASSOCIATED WITH DIESEL-GENERATOR UNIT BYPASSED AND INOPERABLE STATUS

[Appendix to SRP Section 8.3.1 has been superseded by Branch Technical Position PSB-2]