U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 8.2 OFFSITE POWER SYSTEM

REVIEW RESPONSIBILITIES

Primary - Electrical, Instrumentation and Control Systems Branch (EICSB)

Secondary - Auxiliary and Power Conversion Systems Branch (APCSB)
Reactor Systems Branch (RSB)
Quality Assurance Branch (QAB)

I. AREAS OF REVIEW

The descriptive information, analyses, and referenced documents, including electrical single line diagrams, electrical schematics, logic diagrams, tables, and physical arrangement drawings for the offsite power systems, presented in the applicant's safety analysis report (SAR), are reviewed. The intent of the review is to determine that this system satisfies applicable acceptance criteria and will perform its design functions during plant normal operation, anticipated operational occurrences, and in accident conditions. The information provided at the construction permit (CP) stage should show that the design will be in conformance with the acceptance criteria and should support a statement to this effect to be included in the staff's construction permit safety evaluation report. At the operating license (OL) stage, review of the final design information and a site visit should establish that the design criteria have been correctly implemented, that the design meets the requirements of the safety analyses and conforms to the acceptance criteria, and should support a statement to this effect to be included in the staff's operating license safety evaluation report.

The offsite power system is referred to in industry standards and regulatory guides as the "preferred power system." It includes two or more identified power sources capable of operating independently of the onsite or standby power sources and encompasses the grid, transmission lines (overhead or underground), transmission line towers, transformers, switchyard components and control systems, switchyard battery systems, the main generator, and disconnect switches, provided to supply electric power to safety-related and other equipment.

The EICSB will pursue the following phases in review of the preferred power system.

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1. The preferred power system arrangement is reviewed to determine that the required minimum of two separate circuits from the transmission network to the standby-power distribution system is provided. In determining the adequacy of this system, the independence of the two (or more) circuits is examined to see that both electrical and physical separation exists so as to minimize the chance of simultaneous failure. This includes a review of the assignment of power sources from the grid, location of rights-of-way, transmission lines and towers, transformers, switchyard interconnections (breakers and bus arrangements), switchyard control systems and power supplies, location of switchgear (in plant), interconnections between switchgear, cable routings, main generator disconnect, and the disconnect control system and power supply.

   The independence of the preferred power system with respect to the standby power system is evaluated. The scope of review extends to the safety-related distribution system buses that are capable of being powered by standby power sources. It does not include the supply breakers of the safety-related distribution system buses. This evaluation will include a review of the electrical protective relaying and breaker control circuits and power supplies to assure that loss of one preferred system circuit will not cause or result in loss of the redundant counterpart, nor any standby power system sources.

3. Design information and analyses demonstrating the suitability of the power sources, transmission lines, breakers, and transformers used for supplying preferred power from a distant source are reviewed to assure that each path has sufficient capacity, capability, and reliability to perform its intended function. This will require examination of loads required to be powered for each plant operating condition; continuous and fault ratings of breakers, transformers, and transmission lines; loading, unloading, and transfer effects on equipment; and power capacity available from each source.

4. The instrumentation required for monitoring and indicating the status of the preferred power system is reviewed to assure that any change in the preferred power system which would prevent it from performing its intended function will be immediately identified by the control room operator. Also, all instrumentation for initiating safety actions associated with the preferred power system is reviewed.

5. Preoperational and initial startup tests and programs and periodic testing capabilities are reviewed.

6. The EICSB will also review the following:
   a. Environmental conditions such as those resulting from floods, hurricanes, high and low atmospheric temperatures, rain, and snow are considered in the review of the preferred power system to determine any effects on function.
   b. Quality group classifications of equipment of the preferred power system are reviewed.

c. The equipment and functions of the preferred power systems that are used as a basis for assumptions in the accident analyses are reviewed to assure that they conform to the requirements of those assumptions.

7. Other areas of review associated with this system are covered elsewhere as follows:
   a. Environmental design and qualification testing of electrical equipment are addressed in Standard Review Plan (SRP) 3.11.
   b. Technical specification requirements imposed upon the operation of the preferred power system are discussed in Chapter 16 of the applicant's safety analysis report (SAR). The review of technical specifications for the preferred power systems is covered in SRP 8.1.
   c. The APCSB will evaluate the adequacy of those auxiliary systems required for the proper operation of the preferred power system in connection with the review of SAR Chapters 9 and 10. These include such systems as heating and ventilation systems for switchgear in the circuits from the preferred power sources to the standby power distribution system buses and main generator auxiliaryy systems such as the cooling water system, hydrogen cooling system, electrohydraulic system, air supply system, and fire detection system.
   d. The APCSB will examine the physical arrangements of components and structures of the preferred power system to assure that the paths from the preferred power sources to the standby power distribution system buses will not experience simultaneous failure under operating or postulated accident environmental conditions.
   e. The RSB and APCSB will be consulted as required to assure proper identification of the electrical equipment and systems required as a function of time for each mode of reactor operation and accident condition.

II. ACCEPTANCE CRITERIA

In general, the preferred power system is acceptable when it can be concluded that two separate paths from the transmission network to the standby power distribution system are provided; adequate physical and electrical separation exists; and the system has the capacity, capability, and reliability to supply power to all safety loads and other required equipment.

Table 8-1 lists general design criteria (GDC), standards of the Institute of Electrical and Electronic Engineers (IEEE), regulatory guides, and staff technical positions utilized as the bases for arriving at this conclusion. In addition, the references include documents used by the reviewer as aids in ascertaining that the criteria have been met. Section III of this plan discusses the application of these documents to the review.

Details of the application of the acceptance criteria to the areas of review described in Section I of this plan are as follows:

1. System Design Requirements.

   a. GDC 33, 34, 35, 41, and 44 set forth requirements for the safety systems that must be supplied by the preferred power system. Also, these criteria state that safety system redundancy shall be such that, for preferred power system operation (assuming standby power is not available), the system safety function can be accomplished assuming a single failure. The acceptability of the preferred power system design in this regard is based on its capability to supply the redundant safety components and systems required by these GDC.

   b. GDC 17 requires two physically independent circuits from the offsite grid.

   c. The preferred power system must be independent of the standby power system. The basis for acceptance is that no single event, including a single protective relay, interlock, or switchgear failure, in the event of loss of standby power, will prevent the separation of the preferred power system from the standby power system or prevent the preferred power system from accomplishing its intended functions. The design must satisfy the requirements of GDC 17 in this regard. In addition, the preferred and standby power supplies should not have common failure modes, as required by Section 5.2-1(5) of IEEE Std 308. To assure that the preferred power system satisfies the requirements of GDC 17, as supplemented by GDC 34, 35, 38, 41 and 44, an acceptable design must be capable of restoring the preferred power supply after the loss of either circuit in a time period such that the plant can be safely shutdown, taking into account the effects of a single failure in the safety-related distribution system.

2. Testing, Quality Assurance, and System Operability Surveillance.

   a. To assure that the requirements of GDC 1 are met in the preferred power system, the quality assurance program must satisfy the requirements of IEEE Std. 336, as augmented by Regulatory Guide 1.30.

   b. Preoperational and initial startup test programs should be in accordance with Regulatory Guide 1.68, as augmented by Regulatory Guide 1.41. To assure that the periodic onsite testing capabilities satisfy the requirements of GDC 18 and 21, an acceptable testing program must satisfy Regulatory Guide 1.22.

   c. With regard to the surveillance of system operability status, an acceptable design must satisfy the positions of Regulatory Guide 1.47, as augmented by Branch Technical Position EICSB 21.

3. Secondary Review Branch Areas.

   For those areas of review identified in Section I of this plan as being the responsibility of other branches, the acceptance criteria are included in the applicable standard review plans. Some areas of review require close coordination between primary and secondary review branches in determining that a certain aspect of the design conforms with the criteria.

III. REVIEW PROCEDURES

The general objectives in the review of the preferred power system are to determine that this system satisfies the acceptance criteria and can reliably and adequately perform the functions that are assumed and used as a bases in the accident analyses for normal

and abnormal plant 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, and preliminary physical arrangement and layout drawings are examined to determine that the final design will meet this objective if properly implemented. During the OL review, this objective is verified by examination of final electrical schematics, physical arrangement and layout drawings, and equipment ratings identified in the SAR and confirmed during a visit to the site (SRP Appendix 7-A). To assure that the applicable criteria of Table 8-1 are satisfied, the review of the proposed design is performed as follows:

1. An understanding of the design bases, normal and abnormal operation modes, accident analyses, and plant equipment is required to evaluate the design and acceptability of the preferred power system. This information is gained by reading the SAR and in discussions with the applicant.

2. To assure that the requirements of GDC 17 are satisfied, the following review steps should be taken (as applicable for a CP or OL review):
   a. The electrical schematics should be examined to assure that at least two separate circuits from the transmission network to the standby power distribution system buses are provided (a switchyard may be common to these paths).
   b. The routing of transmission lines should be examined on the station layout drawings and verified during the site visit to assure that at least two independent circuits from the offsite grid to the safety-related distribution buses are physically separate and independent. Preferably these lines should enter the station on separate rights-of-way, ideally on opposite sides of the switchyard, should leave the switchyard on opposite sides, and should terminate at transformers located on opposite sides of the reactor or turbine building. No other line should cross these two circuits. As physical separation becomes less than the ideal, attention should be directed towards assuring that no single event such as a tower falling or a line breaking can simultaneously affect both circuits in such a way that neither can be returned to service in time to prevent fuel design limits or design conditions of the reactor coolant pressure boundary from being exceeded.
   c. As the switchyard may be common to both circuits from the offsite grid to the safety-related distribution buses, the electrical schematics of the switch-yard breaker control system and power supply and the breaker arrangement itself should be examined for the possibility of simultaneous failure of both circuits from single events such as a breaker not operating during fault conditions, loss of a control circuit power supply, etc.
   d. The design is examined to determine that one of the two circuits can immediately provide power to safety-related equipment following a loss-of-coolant accident. GDC 17 does not require this circuit in itself to be single failure-proof for this accident. However, it is required that each circuit be available in sufficient time to prevent fuel design limits and design conditions of the reactor collant pressure boundary from being exceeded. Therefore, the

switchyard control system design and implementation should be such that any incoming line, switchyard bus, or any path to the safety-related distribution bus can be isolated. This is generally achieved by separated and redundant breaker tripping and closing devices, with each circuit independent of its redundant counterpart including control circuit power supplies. Designs that do not provide redundant control circuits must be justified by an analysis which shows the period of time that the station can remain in a safe condition assuming no a-c power is available. The time established in this analysis must be greater than the time required to re-establish a-c power from the offsite grid to the safety-related distribution bus for each single failure event. These designs sometimes depend on manual operation of the switchyard breakers, which involves an operator going to the yard and manually actuating valves controlling high pressure air stored in accumulators to open the breakers. It has been found in past reviews that several designs were such that the breakers could not be manually released by this action or by other means. Other items to be evaluated concern the consequences of shorting of switchyard buses, battery failures, status of breaker air accumulators, breaker failures, routing of control circuits and power supplies, shorting of transmission lines, and the design of a back-feed path through the main generator transformer if provided in the design.

e. Each of the circuits from the offsite grid to the safety-related distribution buses should have the capacity and capability to supply the loads assigned to the bus or buses it is connected to during normal or abnormal operating conditions, accident conditions, or plant shutdown conditions. Therefore, the loads to be supplied during these conditions should be determined from information provided by the RSB as to the equipment required to be operable for each condition. The capacity and electrical characteristics of transformers, breakers, buses, transmission lines, and the offsite grid power source for each path should be evaluated to assure that there is adequate capability to supply the maximum connected load during all plant conditions. The design should be examined to assure that during transfer from one power source to another the design limits of equipment are not exceeded.

f. The results of the grid stability analysis must show that loss of the largest single supply to the grid does not result in the complete loss of preferred power. The analysis should consider the loss, through a single event, of the largest capacity being supplied to the grid or removal of the largest load from the grid. This could be the total output of the station, the largest station on the grid, or possibly several large stations if these use a common transmission tower, transformer, or a breaker in a remote switchyard or substation. The station layout and the grid system layout drawings are reviewed to determine that all events were included in the analysis.

The applicant should include in the grid stability analysis the consideration of failure modes that could result in frequency variations exceeding the maximum rate of change determined in the accident analysis for loss of reactor coolant flow.

g. During the review of the electrical schematics, it should be determined that loss of standby power will not result in loss of preferred power, loss of one preferred power circuit will not result in loss of the other circuit, and loss of the main generator will not result in loss of either preferred power circuit.

3. To assure that the requirements of GDC 18 and 21, and Regulatory Guide 1.22 are satisfied, the electrical schematics should be examined to determine that the design includes provisions for testing the transfer of power to the safety-related distribution system from the main generator supply to the preferred power system, or to any other supply. It should also be established that the circuitry required to perform these transfer functions has the capability of being tested during plant operation.

4. To assure that the requirements of GDC 33, 34, 35, 38, 41 and 44 are satisfied, the electrical schematics of the systems required for reactor coolant makeup, residual heat removal, emergency core cooling, containment heat removal, containment atmosphere cleanup, and cooling water should be examined to assure that the circuits from the preferred power system can supply these systems assuming a single failure in these systems. Each of the circuits should be physically separate and independent of the other. If the minimum design required by GDC 17 is provided, the immediately available preferred circuit must be made available to the redundant portions of these systems.

5. To assure that the requirements of GDC 1 are satisfied, it should be determined that the design criteria and quality group classifications for all equipment conform to current codes and standards. The QAB will determine the adequacy of the quality assurance program.

6. To assure that the requirements (excluding seismic) of GDC 2 are satisfied, the QAB will provide information on the maximum probable flood, wave runup, hurricanes, high and low atmospheric temperatures, and rain and snow conditions. This information will be considered during the review to assure that the design minimizes the effects of these conditions. Items such as switchyard and transformer location could be affected by the maximum probable flood, wave runup, or hurricane conditions. Transmission lines and the ability to restore a preferred circuit could be affected by hurricanes, high or low temperatures, or rain and snow conditions.

7. To assure that the requirements of GDC 3 are satisfied, it should be determined that the equipment of the preferred power system is designed and located to minimize, consistent with other safety requirements, the probability and effects of fires and explosions. The review of the design criteria for the equipment should ascertain this. The APCSB will review the fire detection and fire fighting systems in the preferred power system areas to assure that adverse effects of fire are minimized. They will also examine ruptures of the fire fighting system to assure that they do not degrade the safety capability of structures, systems, and components to a condition where essential functions are lost.

8. To assure that the requirements of GDC 4 are satisfied, the APCSB will review the location of structures, systems, and components of the preferred power system to determine the protection provided against dynamic effects, including effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the station. This information will be used to determine the possibility of simultaneous loss of both paths of preferred power.

9. To assure that the requirements of GDC 5 are satisfied, the structures, systems, and components of the preferred power systems will be examined to identify any that are shared between units of a multi-unit station. These will be reviewed to ascertain that they are capable of performing all required safety functions in the event of an accident in one unit, with a simultaneous orderly shutdown and cooldown of the remaining units. Review of the design criteria should establish that the capacity and capability of incoming lines, power sources, and transformers for each required circuit have margin to achieve this. Spurious or false accident signals should not overload these circuits. SRP 8.3 further discusses spurious or false accident signal considerations.

10. To assure that the requirements of GDC 13 are satisfied, the preferred power system instrumentation provided to monitor variables and systems over anticipated ranges for normal operation, anticipated abnormal occurrences, and accident conditions should be identified during the electrical schematic and system description review. It should be ascertained that these instruments present status information that can be used to determine the condition of the preferred power system at all times. Review of the electrical schematics should determine that controls (automatic and manual) are provided to maintain these variables and systems within prescribed operating ranges. It should also be determined during the review of the electrical schematics that single failures of these controls and instruments will not violate the requirements of GDC 17.

11. The review of the electrical schematics of the automatic load dispatch system should ascertain that the reactor protection system is designed to prevent any load dispatch system actions that could interfere with safety actions during periods when safety actions are required. The results of analyses of this system should be reviewed to assure that no failure mode of the load dispatch system will cause an incident at the generating station or interfere with any protective action required.

In certain instances, it will be the reviewer's judgement that, for a specific case under review, emphasis should be placed on specific aspects of the design, while other aspects of the design need not receive the same emphasis and in-depth review. Typical reasons for such a non-uniform placement of emphasis are the introduction of new design features or the utilization in the design of design features previously reviewed and found acceptable.

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 offsite power system includes two or more identified power sources from the grid, transmission lines (overhead and underground), transmission line towers, transformers, switchyards and switchyard component control systems, switchyard battery systems, the main generator, and disconnect switches used to supply electric power to safety-related and other equipment. The review of the offsite power system for the _____ plant covered single line diagrams (CP and OL), station layout drawings (CP and OL) and schematic diagrams (OL), and descriptive information. The review included the applicant's proposed design criteria and design bases for the offsite power system and his analyses of the adequacy of those criteria and bases. The review also included the applicant's analyses of the manner in which the design of the offsite power system conforms to the proposed design criteria.

"The basis for acceptance in the staff review has been conformance of the applicant's designs, design criteria, and design bases for the offsite power system to the Commission's regulations as set forth in the general design criteria, and to applicable regulatory guides, staff technical positions, and industry standards. These are listed in Table 8-1. (Table 8-1 should be included in the safety evaluation report, either at this point in 8.2 or in section 8.1.)

"The staff concludes that the design of the offsite power system conforms to applicable regulations, guides, technical positions, and industry standards and is acceptable."

V. REFERENCES

1. Standard Review Plan Table 8-1, "Acceptance Criteria for Electric Power."

2. Standard Review Plan Appendix 7-B, "General Agenda, Station Site Visits."

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SRP 8.3.1