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Chapter 8. Electric Power

The AC and DC electric power systems are the source of power for station auxiliaries during normal operation, and for the protection system and engineered safety features during abnormal and accident conditions. Non-passive designs rely on offsite AC power, onsite AC power, and onsite DC power for safe shutdown while passive designs do not depend on either onsite or offsite AC systems for safe shutdown. Passive designs will rely solely on onsite DC systems for safe shutdown. Thus, the COL applicant should provide information in establishing the functional adequacy of the safety-related AC and DC electric power systems as applicable to either a passive design or non-passive design reactor (and electrical systems important to safety) and ensuring that these systems have adequate redundancy, independence, and testability in conformance with the current criteria established by the U.S Nuclear Regulatory Commission (NRC).

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8.1 *Introduction*

Provide a brief description of the utility grid and its interconnection to the nuclear unit and other grid interconnections. The applicant should list electrical systems as well as supporting systems that are safety-related. In the case of non-passive designs, these electrical systems will encompass both safety related AC and DC systems. For passive designs that do not rely on offsite AC power, the onsite Class 1E DC systems will be the only safety related electrical systems.

The application document should provide a regulatory requirements applicability matrix that lists all design bases, criteria, regulatory guides, standards, and other documents that will be implemented in the design of the electrical systems that are beyond the scope of the design certification. The specific information identified in Section C.I.8.1 of this guide should be included in the application document.

8.2 *Offsite Power System*

8.2.1 Description

For non-passive designs, the offsite power system is the preferred source of power for the reactor protection system and engineered safety features during abnormal and accident conditions. It includes two or more physically independent circuits from the transmission network. It encompasses the grid, transmission lines (overhead or underground), transmission line towers, transformers, switchyard components and control systems, switchyard battery systems, the main generator, and so forth.

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Provide information concerning offsite power lines coming from the transmission network to the plant switchyard. For non-passive designs where the circuits from the transmission network that are designated as two offsite power circuits and are relied upon for accident mitigation should be identified and described in sufficient detail to demonstrate conformance with General Design Criteria (GDCs) 5, 17, and 18, as set forth in Appendix A to Title 10, Part 50, of the Code of Federal Regulations (10 CFR Part 50). The discussion should include the independence between these two offsite power sources to ensure that both electrical and physical separation exists, in order to minimize the chance of simultaneous failure.

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For non-passive designs, perform a failure mode and effects analysis of the switchyard components to assess the possibility of simultaneous failure of both circuits as a result of single events, such as a breaker not operating during fault conditions, a spurious relay trip, a loss of a control circuit power supply, or a fault in a switchyard bus or transformer. The capacity and electrical characteristics of transformers, breakers, buses, transmission lines, and the preferred power source for each path should also be provided to demonstrate that there is adequate capability to supply the maximum connected load during all plant conditions.

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For non-passive designs, identify the equipment that must be considered in the specification of offsite power supplies, the acceptance testing performed to demonstrate compliance, the effects that must be considered, the margins that are applied, and how the design incorporates these requirements for offsite power

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supplies, including high-voltage transmission networks, medium-voltage distribution networks, switchyard equipment (bus work, transformers, circuit breakers, disconnect switches, surge protective devices, control, communication, grounding, and lightning systems), switching capacitors, and offsite power supplies.

Provide information on location of rights-of-ways, transmission towers, voltage level, and length of each transmission line from the site to the first major substation that connects the line to the grid. All unusual features of these transmission lines should be described. For non-passive designs, such features might include (but are not limited to) crossovers or proximity of other lines (to ensure that no single event such as a tower falling or a line breaking can simultaneously affect both circuits), rugged terrain, vibration or galloping conductor problems, icing or other heavy loading conditions, and high thunderstorm occurrence rate in the geographical area.

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Indicate if generator breakers are used as a means of providing immediate access from the offsite power system to the onsite ac distribution system by isolating the unit generator from the main step-up and unit auxiliary transformers and allowing backfeeding of power through these circuits to the onsite ac distribution system. If so, provide sufficient information for the staff to evaluate the generator circuit breakers and load break switches.

Compliance with GDC 5 requires that structures, systems, and components important to safety shall not be shared among nuclear power units, unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units. Toward that end, describe how the design satisfies the requirements of GDC 5.

Discuss the stability of the local area grid network. This should identify the equipment that must be considered for review and approval by the appropriate grid reliability planning and coordination organization(s). For non-passive designs, discuss the maximum and minimum switchyard voltage that must be maintained by the transmission system provider/operator (TSP/TSO) without any reactive power support from the nuclear power plant. In addition for non-passive designs, describe the formal agreement or protocol between the nuclear power plant and the TSP/TSO of the preferred offsite power capable of supporting plant startup, and to shut down the plant under normal and emergency conditions.

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Non-passive designs should include a description of the capability of the TSP to analyze contingencies on the grid involving the largest generation unit outage, critical transmission line outage, and other contingencies under varying power flows in response to market conditions and system demands.

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Furthermore, non-passive designs should include a description of the analysis tool used by the TSO to determine, in real time, the impact of the loss or unavailability of various transmission system elements on the condition of the transmission system. In addition, the applicant should provide information on the protocols in place for the nuclear power plant to remain cognizant of grid vulnerabilities, in order to make informed decisions regarding maintenance activities that are critical to the plant's electrical system (Maintenance Rule, 10 CFR 50.65).

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8.2.2 Analysis

Provide an analysis of the stability of the utility grid. This analysis should include the worst case disturbances for which the grid has been analyzed and considered to remain stable and to describe how the stability of the grid is continuously studied as the loads grow and additional transmission lines and generators are added. Also to provide the assumptions and conclusions that demonstrate that the acceptance criteria required for the continued safe operation of the nuclear unit and the stability of the grid have been addressed. Identify the approving grid organization for the reliability studies, and identify any potential limits that may be imposed on the operation of the nuclear plant. Provide a discussion of grid availability, including the frequency, duration and causes of outages over the past 20 years for both the transmission system accepting the unit's output and the transmission system providing the preferred power for the unit's loads.

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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 (or complete loss of the transmission system connected to the station for passive designs). The analysis should also consider the loss, as a result of a single event, of the largest capacity being supplied to the grid, removal of the largest load from the grid, or loss of the most critical transmission line. In determining the most critical transmission line, consider lines that use a common tower to be a single line. 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 breaker in a remote switchyard or substation.

8.3 *Onsite Power Systems*

8.3.1 AC Power Systems

8.3.1.1 *Description*

Describe how independence is established between the onsite and offsite power systems. Two aspects of independence should be addressed in each case:

physical independence
electrical independence

In ascertaining the independence of the onsite power system with respect to the offsite power system, the applicant should describe the electrical ties between these two systems, and should provide the physical arrangement of the interface equipment. It should also demonstrate that no single failure will prevent separation of the redundant portions of the onsite power systems from the offsite power systems. For non-passive designs, following a loss of offsite power, the safety buses are solely fed from the standby power systems. Under this situation, describe the design of the feeder-isolation breaker in each offsite power circuit that must preclude the automatic connection of preferred power to the respective safety buses upon the loss of standby power.

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If non-Class 1E loads are connected to the Class 1E buses, the COL applicant should demonstrate that the design will not result in degradation of the Class 1E system. Describe the design of 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. To ensure physical separation between the Class1E equipment and the non-1E equipment, including cables and raceways, describe how the recommendations of Regulatory Guide 1.75 are followed.

Describe the means of identifying the non-1E components, including cables, raceways, and terminal equipment. Provide information on the identifying scheme used to distinguish between redundant Class 1E systems and non-Class 1E systems and their associated cables, raceways without the need to consult reference material.

The COL applicant should also describe how the diesel generators are sized to accommodate the added non-Class 1E loads.

8.3.1.2 *Analysis*

For non-passive designs, provide analyses to demonstrate compliance with GDCs 17 and 18, and to indicate the extent to which the recommendations of Regulatory Guides 1.6, 1.9, and 1.32 and other appropriate criteria and standards are followed. The discussion should identify all aspects of the onsite power system that do not conform to Regulatory Guides 1.6, 1.9, and 1.32, and should explain why such deviations are not in conflict with applicable GDCs.

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8.3.1.3 ***Electrical Power System Calculations, and Distribution System Studies for AC Systems***

COL applicants that reference a certified design do not need to include this information unless design changes are made.

8.3.2 **DC Power Systems**

8.3.2.1 ***Description***

For passive designs, the onsite DC Class 1E system is the preferred source of power for the reactor protection system and engineered safety features during abnormal and accident conditions. It includes two or more physically independent circuits from separate station batteries and associated battery chargers. Non-passive designs will also include some onsite DC Class 1E systems.

Provide information concerning the onsite Class 1E DC power system. For passive designs where the onsite DC Class 1E system is the preferred means for accident mitigation, description in sufficient detail to demonstrate conformance with General Design Criteria (GDCs) 5, 17, and 18, as set forth in Appendix A to Title 10, Part 50, of the Code of Federal Regulations (10 CFR Part 50) should be provided. The discussion should include the independence between these two DC power sources to ensure that both electrical and physical separation exists, in order to minimize the chance of simultaneous failure.

For passive designs, identify the equipment that must be considered in the specification of the onsite Class 1E DC power supplies, the acceptance testing performed to demonstrate compliance, the effects that must be considered, the margins that are applied, and how the design incorporates these requirements for the onsite DC power supplies.

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Discuss the maximum and minimum DC voltages that must be maintained in order to satisfactorily perform their safety functions.

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If non-Class 1E loads are connected to the Class 1E batteries, the COL applicant should demonstrate that the design will not result in degradation of the Class 1E batteries. Describe the design of the isolation device through which dc power is supplied to the non-Class 1E loads. To ensure physical separation between the Class1E equipment and the non-1E equipment, including cables and raceways, describe how the recommendations of Regulatory Guide 1.75 are followed.

Describe the means of identifying the non-1E components, including cables, raceways, and terminal equipment. Provide information on the identifying scheme used to distinguish between redundant Class 1E systems and non-Class 1E systems and their associated cables, raceways without the need to consult reference material.

The COL applicant should also describe how the batteries are sized to accommodate the added non-Class 1E loads.

8.3.2.2 ***Analysis***

The COL applicant should provide analyses to demonstrate compliance with GDCs 17 and 18, and indicate the extent to which the recommendations of Regulatory Guides 1.6, and 1.32 are followed. The discussion should identify all aspects of the dc power system that do not conform to Regulatory Guides 1.6, and 1.32, and should explain why such deviations are not in conflict with applicable GDCs.

8.3.2.3 ***Electrical Power System Calculations, and Distribution System Studies for DC Systems***

COL applicants that reference a certified design do not need to include this information unless design changes are made.

8.4 *Station Blackout (SBO)*

8.4.1 Description

For non-passive designs, the applicant should describe how the alternate alternating current (AAC) power source provided to mitigate station blackout is independent from the offsite power system. Describe the physical arrangement of circuits and incoming source breakers [to the affected Class 1E bus(es)], separation and isolation provisions (control and main power), permissive and interlock schemes proposed for source breakers, source initiation/transfer logic, that could affect the ability of the AAC power source to power safe shutdown loads, source lockout schemes, and bus lockout schemes in arriving at the determination that the independence of the AAC power source is maintained.

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For non-passive designs, describe how the AAC power source components are physically separated and electrically isolated from offsite power components or equipment, as specified in the separation and isolation criteria applicable to the unit's licensing basis and the criteria of Appendix B to Regulatory Guide 1.155.

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Identify local power sources and transmission paths that could be made available to resupply power to the plant following a loss of a grid or SBO.

Describe the procedures and training provided for the plant operators for an SBO event of the specified duration and recovery therefrom.

8.4.2 Analysis

For non-passive designs, provide an analysis to demonstrate that no single-point vulnerability exists whereby a single active failure or weather-related event could simultaneously fail the AAC power source and offsite power sources. The power sources should have minimum potential for common failure modes.

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