8.2 Offsite Power System

8.2.1 System Description

A transmission system to supply offsite ac energy for startup and normal shutdown through a site-specific transmission switchyard is as described in subsection 8.2.5. This offsite ac power system is not required for plant safety.

[[A transformer area containing stepup transformers, unit auxiliary transformers, and the reserve auxiliary transformer is located next to the turbine building.]]

The normal ac power supply to the main ac power system is provided from the main generator. When the main generator is not available, plant auxiliary power is provided from the switchyard by backfeeding through the main stepup and unit auxiliary transformers. This is the preferred power supply. When neither the normal or the preferred power supply is available due to an electrical fault at either the main stepup transformer, unit auxiliary transformer, isophase bus, or 6.9kv nonsegregated bus duct, fast bus transfer will be automatically initiated to transfer the loads to the reserve auxiliary transformers powered by maintenance sources of power. In addition, two non-Class 1E onsite standby diesel generators supply power to selected plant loads in the event of loss of the normal, preferred, and maintenance power sources. The reserve auxiliary transformers also serve as a source of maintenance power.

The maintenance sources are site-specific. Maintenance power is provided at the medium voltage level (6.9 kV) through normally open circuit breakers. Bus transfer to the maintenance source is automatic under fast bus transfer logic or may be initiated manually. Connection of the preferred and maintenance power supplies to the utility grid or other power sources is site-specific.

The main generator is connected to the offsite power system via three single-phase main stepup transformers. The normal power source for the plant auxiliary ac loads is provided from the isophase generator bus through the two unit auxiliary transformers of identical ratings. In the event of a loss of the main generator, the power is maintained without interruption from the preferred power supply by an auto-trip of the main generator breaker. Power then flows from the transformer area to the auxiliary loads through the main and unit auxiliary transformers.

The transmission system is site-specific.

The transmission line structures associated with the plant are designed to withstand standard loading conditions for the specific-site as provided in Reference 1.

Automatic load dispatch is not used at the plant and does not interface with safety-related action required of the reactor protection system.

8.2.1.1 Transmission Switchyard

The transmission switchyard is site-specific, and the responsibility for the transmission system is described in subsection 8.2.5.

8.2.1.2 Transformer Area

The transformer area contains the main stepup transformers, the unit auxiliary transformers, and the reserve auxiliary transformers. Protective relaying and metering required for this equipment is located in the turbine building. The necessary power sources (480 Vac, 120 Vac, and 125 Vdc) to the equipment are supplied from the turbine building. See subsection 9.5.1 for a discussion of fire protection associated with plant transformers.

One feeder connects the transformer area with the switchyard to supply power to/from the main stepup transformers for the unit. An arrangement is shown in Figure 8.3.1-1.

8.2.2 Grid Stability

The AP1000 is designed with passive safety-related systems for core cooling and containment integrity and, therefore, does not depend on the electric power grid for safe operation. This feature of the AP1000 significantly reduces the importance of the grid connection and the requirement for grid stability. The AP1000 safety analyses assume that the reactor coolant pumps can receive power from either the main generator or the grid for a minimum of 3 seconds following a turbine trip.

The AP1000 main generator is connected to the generator bus through the generator circuit breaker. The grid is connected to the generator bus through the main step-up transformers and the grid breakers. The reactor coolant pumps are connected to the generator bus through the reactor coolant pump breakers, the 6.9 kV switchgear, and the unit auxiliary transformers. During normal plant operation the main generator supplies power to the generator bus. Some of this power is used by the plant auxiliary systems (including the reactor coolant pumps); the rest of the power is supplied to the grid.

If, during power operation of the plant, a turbine trip occurs, the motive power (steam) to the turbine will be removed. The generator will attempt to keep the shaft rotating at synchronous speed (governed by the grid frequency) by acting like a synchronous motor. The reverse-power relay monitoring generator power will sense this condition and, after a time delay of at least 15 seconds, open the generator breaker. During this delay time the generator will be able to provide voltage support to the grid if needed. The reactor coolant pumps will receive power from the grid for at least 3 seconds following the turbine trip. A grid stability analysis to show that, with no electrical system failures, the grid will remain stable and the reactor coolant pump bus voltage will remain above the voltage required to maintain the flow assumed in the Chapter 15 analyses for a minimum of 3 seconds following a turbine trip is as addressed in subsection 8.2.5. In the Chapter 15 analyses, if the initiating event is an electrical system failure (such as failure of the isophase bus), the analyses do not assume operation of the reactor coolant pumps following the turbine trip. The responsibility for setting the protective devices controlling the switchyard breakers with consideration given to preserving the plant grid connection following a turbine trip is discussed in subsection 8.2.5.

If the turbine trip occurs when the grid is not connected (generator supplying plant house loads only), the main turbine-generator shaft will begin to slow down as the energy stored in the rotational inertia of the shaft is used to supply the house loads (including reactor coolant pumps).

The system will coast down until the generator exciter can no longer maintain generator terminal voltage and the generator breaker is tripped on either generator under-voltage or exciter over-current. This coast down will last at least 3 seconds before the generator breaker trips.

The sequence of events following a loss-of-offsite-power event is the same as those described for grid-disconnected operation.

8.2.3 Conformance to Criteria

The offsite sources are not Class 1E. Commercial equipment is manufactured to the industrial standards listed in subsection 8.2.6. The design meets General Design Criterion 1. Unit trips occur at the generator breaker and do not cause the loss of the preferred power source to the plant electrical systems. The AP1000 does not require ac power sources for mitigating design basis events; Chapter 15.0 describes the design bases assumptions utilized for analysis of these events.

The AP1000 plant design supports an exemption to the requirement of GDC 17 for two physically independent offsite circuits by providing safety-related passive systems for core cooling and containment integrity, and multiple nonsafety-related onsite and offsite electric power sources for other functions. See Section 6.3 for additional information on the systems for core cooling.

A reliable dc power source supplied by batteries provides power for the safety-related valves and instrumentation during transient and accident conditions.

The Class 1E dc and UPS system is the only safety-related power source required to monitor and actuate the safety-related passive systems. Otherwise, the plant is designed to maintain core cooling and containment integrity, independent of nonsafety-related ac power sources indefinitely. The only electric power source necessary to accomplish these safety-related functions is the Class 1E dc and UPS power system which includes the associated safety-related 120V ac distribution switchgear.

Although the AP1000 is designed with reliable nonsafety-related offsite and onsite ac power that are normally expected to be available for important plant functions, nonsafety-related ac power is not relied upon to maintain the core cooling or containment integrity.

The nonsafety-related ac power system is designed such that plant auxiliaries can be powered from the grid under all modes of operation. During loss of offsite power, the ac power is supplied by the onsite standby diesel-generators. Preassigned loads and equipment are automatically loaded on the diesel-generators in a predetermined sequence. Additional loads can be manually added as required. The onsite standby power system is not required for safe shutdown of the plant.

Conformance with General Design Criterion 18 is provided by the test and inspection capability of the system.

8.2.4 Standards and Guides

In addition to the General Design Criteria, the industry guides and standards listed as Reference 2 through 4 are used as guides in the design and procurement of the offsite power system.

8.2.5 Combined License Information for Offsite Electrical Power

Combined License applicants referencing the AP1000 certified design will address the design of the ac power transmission system and its testing and inspection plan.

The Combined License applicant will address the technical interfaces for this nonsafety-related system listed in Table 1.8-1 and subsection 8.2.2. These technical interfaces include those for ac power requirements from offsite and the analysis of the offsite transmission system and the setting of protective devices.

8.2.6 References

1. ANSI C2-1997, "National Electrical Safety Code."

2. ANSI C37.010-1999, "IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis."

3. ANSI C37.90-1989, "IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus."

4. ANSI C57.12.00-2000, "IEEE Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers."