8.3 Transmission System

8.3.1 General

The Browns Ferry Nuclear Plant Units 1, 2, and 3 generators are connected into an existing network supplying large load centers. All three units are tied into TVA's 500-kV transmission system via seven 500-kV transmission lines. The 161-kV switchyard is supplied by two 161-kV transmission lines. The 500- and 161-kV switchyards supply startup, running, and shutdown power through stepdown transformers. The 161-kV switchyard also supplies the cooling tower power. These sources have the capacity and capability to meet the requirements of GDC-17.

The 500-kV connections consist of one line to the Madison 500-kV Substation; two lines to the Trinity 500-kV Substation; one line to the Maury 500-kV substation; one line to the West Point 500-kV Substation; one line to the Union 500-kV Substation; and one line to the Limestone 500-kV Substation.

The 161-kV switchyard is supplied by two 161-kV transmission lines. One of these lines connects to the Trinity 500-161-kV Substation, and the other connects to the Athens, Alabama, 161-kV Substation.

The switchyard layout is shown on Figure 8.3-2. The physical layout of the 500-kV and 161-kV lines is presented in Figure 8.3-2a. The TVA transmission network is shown in Figure 8.3-3 (historical reference only).

8.3.2 Power Generation Objective

1. The objective of the 500-kV switchyard is to receive the output of the station's Units 1, 2, and 3 generators and deliver this output to the 500-kV system network for transmission to system loads. It also serves as an offsite power source from seven 500-kV transmission lines through six unit station service transformers into plant auxiliary power distribution systems.

2. The objective of the 161-kV switchyard is to receive power from the 161-kV system network and deliver this power to station auxiliaries. It also serves as an offsite power source through two common station service transformers for Units 1, 2, and 3.

8.3.3 Power Generation Design Basis

1. The 500-kV switchyard is designed such that the output of the plant's Units 1, 2, and 3 generators may be transmitted to various parts of the 500-kV system network as the system load may require.

2. The 500-kV switchyard is designed to minimize the effects of failure of individual items of equipment so that any such single probable event would not prevent the output of the plant from being transmitted to the 500-kV system network or prevent the 500-kV system from providing power to the offsite power supply.

3. The 161-kV switchyard is designed such that power from two widely separated points of the 161-kV system network is supplied to the common station service and cooling tower transformers.

8.3.4 <u>Safety Design Basis</u>

1. The 500- and 161-kV switchyards are designed to minimize the effects of failures of individual items of equipment so that any such single probable event should not interrupt power from their respective system networks to the station service transformers.

2. The 500- and 161-kV switchyards collectively are designed to provide adequate offsite power to start all three units, carry common plant auxiliary loads and, when necessary, to carry the required emergency loads of equipment in engineered safeguards systems for Units 1, 2, and 3 in a design basis accident while supplying the auxiliary power requirements of the non-accident units stated under Section 8.4.

3. The lines are separated sufficiently to ensure that the failure of any tower in one line will not endanger the integrity of the 500-kV or the 161-kV transmission systems. [redacted] The Browns Ferry-Athens 161-kV Transmission Line crosses under the West Point and Union 500-kV Transmission Lines near the Browns Ferry Nuclear Plant and continues parallel with the Browns Ferry-Madison No. 1 500-kV Transmission Line for 0.96 mile and crosses under each end of this 0.96-mile section. The lines in this section are separated sufficiently to ensure that the failure of any tower in one line could remove from service no more than one 500-kV and one 161-kV circuit. The Browns Ferry-Trinity 161-kV Line crosses under all seven 500-kV lines near the plant.

   TVA's transmission lines are designed to meet or exceed medium loading requirements of the National Electrical Safety Code.

8.3.5 Description

The 500-kV switchyard includes seven line bays and three transformer bays. The 500-kV switchyard arrangement is shown in Figures 8.3-4, 8.3-5, and 8.3-6. The four bus sections can be sectionalized by disconnect switches (see Figures 8.3-4, 8.3-5, and 8.3-6).

Normally the bus sections are tied together through the double breaker bays. This permits the output of each generator to be fed through the unit tie breakers to each bus section. A fault that would require a bus section to be isolated from the system would allow the units to continue to deliver their outputs to the remaining busses uninterrupted. Only those lines that are not served from a double breaker bay and only connected to the faulted bus would trip off. Each line has a capacity of at least 1750 MVA. Any of the 500-kV unit tie breakers may be removed from service without interrupting any unit's output. Any line breaker in a double breaker bay may be removed from service without disturbing the output of any unit. Either of the Trinity 500kV lines, which are in single breaker bays, may be removed from service by removing the affected line from service.

The 161-kV switchyard includes four bays assigned as follows (Figure 8.3-6a):

1. Common station service transformer A, cooling tower transformers 1A and 1B, two 161-kV capacitor banks.

2. Athens 161-kV line,

3. 161-kV bus tie breakers, and

4. Trinity 161-kV line, common station service transformer B, Cooling Tower Transformer 2.

Two physically separated feeders are provided to the two common station service transformers which step down the voltage from 161 to 4.16-kV. Two separate feeders provide power to the cooling tower transformers. Power is received from the 161-kV TVA grid through the Trinity and Athens lines. Normally, the switchyard will be operated with both tie breakers closed and all transformers energized. Disconnect devices are provided to permit isolation of a line or a transformer for maintenance. Both tie breakers can be taken out of service for maintenance without the loss of either common station service transformer.

8.3.5.1 500-kV/Relaying

The 500-kV switchyard is provided with two sets of bus differential and carrier line protective relays. Breaker failure relays are provided for backup protection.

8.3.5.2 161-kV/Relaying

The 161-kV lines are protected by three-zone step distance phase relays augmented with directional comparison carrier blocking and have directional overcurrent carrier ground and backup ground relays. When the line relays operate, the 161-kV breaker, cooling tower transformer circuit switcher, and the secondary breakers of the common station service transformer associated with the faulted line, are tripped. The start buses and cooling tower 4-kV switchgear are transferred to the transformer supplied from the unfaulted line. The 161-kV breakers are equipped with high-speed and standard-speed reclosing.

Each of the 161- to 4.16-kV transformers is protected by variable percentage harmonic restrained differential relays, high set instantaneous overcurrent relays, secondary neutral longtime overcurrent relay, and a transformer sudden pressure device. These relays trip and lock out the 161-kV breaker, and the secondary breakers associated with one transformer. The start buses and cooling tower 4-kV switchgear are transferred to the transformer supplied from the unfaulted line.

In the event that the 161-kV breaker should fail to trip when required, breaker failure relaying is provided to operate within less than zone-2 time. Current supervision is provided from redundant current transformers.

8.3.6 Analysis

The seven transmission lines connected to the 500-kV switchyard and the two transmission lines connected to the 161-kV switchyard have sufficient capacity to supply the total required power to the plant's electrical auxiliary power system under normal, shutdown, and loss of coolant accident (LOCA) conditions for any single transmission contingency. Power reaches each unit's auxiliary loads from the 500-kV system through its main transformer and its unit station service transformers (USSTs) and from the 161-kV system over two physically independent 161-kV transmission lines through the common station service transformers (CSSTs). These sources have sufficient capacity to supply all loads regardless of plant conditions. Separation of the lines, the protection systems, and a strong transmission grid minimize the probability of simultaneous failures of offsite power sources.

Transient stability studies evaluate a LOCA in one unit. Additional stability studies (no design basis event) consider transmission contingencies. They show that the resulting disturbance to the offsite power sources is acceptable, and the transmission system remains stable.

Steady-state and transient stability studies show that the 500- and 161-kV networks are capable of supplying the offsite power requirements for normal, shutdown, and LOCA conditions. Due to the large number of diverse generating units and strong interconnections, the likelihood of an outage of a sufficient part of the transmission system causing the loss of all sources of offsite power is considered to be extremely remote.

8.3.7 Inspection and Testing

The electrical system is to be inspected and tested for:

a. Continuity of circuit,

b. Proper insulation from ground of all ungrounded circuits,

c. Proper grounding of grounded circuits,

d. All wiring checked for correctness,

e. Operational tests on all control and protective circuits,

f. Breaker timing, internal inspection, doble bushings, and bushing inspections,

g. Breaker dielectric-air, gas and oil,

h. Transformers--doble, bridge ratio, megger and oil tests, and

i. Protective relay characteristics and settings.