UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATED TO DEGRADED GRID PROTECTION DUKE POWER COMPANY OCONEE NUCLEAR STATION, UNITS 1, 2 AND 3 DOCKET NOS. 50-269, 50-270 AND 50-287

1.0 INTRODUCTION

By Licensee Event Report (LER) 269/90-04 dated April 30, 1990, the licensee for Oconee Nuclear Station reported a situation where one of the two required onsite emergency electrical paths could be rendered inoperable during a degraded grid condition leaving the station vulnerable to a single failure. Also in LER 269/90-04 and LER 269/90-05 dated May 24, 1990, the licensee reported an additional situation where safety-related equipment could be subjected to low voltages which could render them inoperable or damaged during degraded grid conditions. The root causes for these conditions were determined to be design deficiencies.

In a letter dated May 8, 1990, the licensee provided a description of the conceptual design for a degraded grid protection hardware modification intended as the permanent corrective action. We have reviewed the conceptual design and find it acceptable as discussed below.

2.0 DISCUSSION

During normal operation, electrical power to each of the three Oconee units is supplied through its corresponding auxiliary transformer and N breakers (see attached figure). If a unit's normal path is unavailable, electrical power is then supplied through the E breakers via the unit's startup transformer which is fed from the 230 kV switchyard.

On a loss-of-offsite power condition (230 kV grid voltage below 160 kV), undervoltage relays, which are part of the External Grid Trouble Protection System, start the onsite Keowee hydroelectric units and isolate the 230 kV switchyard from the offsite electrical grid. Emergency electrical power is then available from Keowee to each unit through the underground feeder circuit via transformer CT 4 and the SK breakers or through the overhead path via the

230 kV switchyard and each unit's startup transformer and E breakers. For the overhead path to be established through Keowee breakers, a "Switchyard Isolate Complete" signal must be generated when the necessary breakers in the 230 kV switchyard isolate the switchyard from the offsite grid and align the switchyard to the Keowee overhead path.

For a degraded grid condition (230 kV grid voltage less than 211 kV) undervoltage relays (1 per phase with 2 out-of-three logic) on the secondary side of each unit's auxiliary transformer open the unit's N breakers. Similarly, undervoltage relays on the secondary side of each unit's startup transformer open the unit's E breakers. Upon opening of the N and E breakers, non-safety related undervoltage relays on each unit's 4 kV main feeder buses sense a loss-of-voltage condition and start the Keowee hydroelectric units. Emergency power is available through the Keowee underground path and, if the grid voltage continues to decrease below 160 kV, through the Keowee overhead path by the protective action of the External Grid Trouble Protection System.

2.1 LER 269/90-04

In LER 269/90-04, the licensee reported a design deficiency in the degraded grid protection circuitry. As can be seen from the above discussion, when the grid voltage falls below 211 kV, emergency power is supplied to each unit via the underground path from the Keowee hydroelectric station but the redundant Keowee overhead path for emergency power is not available until the grid voltage falls below 160 kV. If the grid voltage should remain below 211 kV but above 160 kV, only the single underground path is available leaving all three Oconee units vulnerable to a single failure. During degraded grid conditions this could cause the inability of safety systems to mitigate the consequences of a design basis accident/transient unless the operator took action to manually align switchyard breakers for the overhead path.

2.2 LER 269/90-04 AND LER 269/90-05

In LER 269/90-04 and LER 269/90-05, the licensee reported an additional design defect involving the inability of the degraded grid protection circuitry to protect against electrical distribution system voltages falling below minimum values recommended by equipment manufacturers and possibly causing equipment inoperability and/or damage. Between 1979 and 1982, the licensee submitted various analyses and justification to support the selection of 219 kV as the undervoltage relay setpoint for degraded grid protection. The documentation submitted by the licensee established that with a grid voltage as low as 217 kV, corresponding voltages at class 1E equipment input terminals would be sufficient to start and continuously operate the equipment within their voltage ratings for the worst case electrical system loading. With the actual setpoint placed at 211 kV (or as low as 203 kV considering instrument errors), the class 1E equipment performance and/or condition was questionable for design basis scenarios occurring with grid voltages degraded between 217 kV and 203 kV. In LER 269/90-05 the licensee stated that all post-trip equipment except for post-LOCA 208 V MOVs (high and low pressure injection valves, building spray valves) would operate and that the reduction in 4 kV motor life is insignificant. Operator action would be necessary to restore adequate voltage to the valves or to manually operate the MOVs during the degraded grid condition.

3.0 EVALUATION

For immediate corrective action of the design deficiencies, the plant operators will monitor the 230 kV switchyard voltage every two hours. If the voltage drops below 225.2 kV, an attempt to increase the grid voltage will be made, the Keowee underground path will be verified to be operable, electrical power from the Lee gas turbines will be made available to the units' standby buses, and Technical Specification 3.0 will be entered. If grid voltage remains degraded, the units will be in hot shutdown in 12 hours and cold shutdown within the next 24 hours.

In a letter dated May 8, 1990, the licensee provided a conceptual description of the permanent hardware modification intended to eliminate the design deficiencies. New undervoltage relays with setpoints of 222.5kV will be installed utilizing existing potential transformers in one phase on the primary side of each unit's startup transformer. Two-out-of-three logic will be used to generate an undervoltage signal. After a 9 second time delay this signal will then generate alarms in the control rooms and, if an ES signal from any unit's Engineered Safeguards Protective System exists, will then isolate the 230 kV switchyard from the offsite 230 kV electrical grid.

The guidance for the staff's review of the proposed modification is contained in Branch Technical Position (BTP) PSB-1, "Adequacy of Station Electrical Distribution System Voltages." The specific requirements of the BTP for degraded grid undervoltage protection of Class 1E equipment and our evaluation of the proposed design modification against those requirements are as follows:

1. Setpoints and time delays shall be determined from an analysis of Class 1E equipment voltage requirements.

   The licensee has selected a setpoint of 222.5 kV for the new undervoltage relays. This setpoint is based on the value 219 kV, which the staff previously approved, plus 1.6% to account for instrumentation errors. The time delay for the downstream timers has been fixed at 9 seconds to allow for short-duration voltage transients to occur without initiation of undervoltage alarms and equipment protective action.

2. A short time delay shall be provided to allow motor starting transients to occur. Following this delay, a control room alarm should sound to alert the operator to the degraded grid condition. If a subsequent LOCA should occur, the onsite Class 1E electrical distribution system should be separated immediately from the offsite electrical grid.

As stated above, the licensee has selected a 9 second time delay which should be adequate to allow for voltage transients during motor startup. After the 9 seconds have passed, a subsequent LOCA will result in immediate separation of the Class 1E distribution from the offsite grid.

3. A longer time delay, of limited duration such that Class 1E equipment will not be damaged, shall be provided to allow the operator to attempt to restore adequate voltages to the Class 1E equipment. Following this delay, the Class 1E distribution system should be separated from the offsite electrical grid if adequate voltage is unavailable.

   The design modification has only the 9 second fixed delay. A second, longer time delay has not been incorporated into the design. Also, the undervoltage condition in itself does not result in the separation of the Class 1E distribution system from the offsite grid; an ES (LOCA, MSLB) signal must exist coincidentally before undervoltage protective action occurs.

   In response to a staff question, the licensee stated, in a phone conference call, that after a degraded grid alarm is received, steps will be taken to re-establish an adequate voltage level on the grid. For a sustained degraded grid condition, analyses (see licensee's letter dated June 18, 1990) related to LERs 269/90-04 and 269/90-05 have been performed covering equipment and plant performance down to the worst setpoint (203 kV) of the existing degraded grid protection circuitry. This circuitry will remain installed and will provide automatic separation from the grid for scenarios without an ES signal and where voltages drop to levels near where equipment/plant performance is unanalyzed.

4. The voltage sensors of the undervoltage circuitry shall be Class 1E and shall be located at and electrically connected to Class 1E switchgear.

   In response to a staff question, the licensee stated in a phone call that all relays, timers, and auxiliary relays used in the new undervoltage scheme would be Class 1E. Although it is derived from a Class 1E source, the 125 vdc control power will be non-Class 1E utilizing components similar to Class 1E components. The non-Class 1E potential transformers (PTs) are also similar to Class 1E PTs and are seismically mounted.

5. An independent undervoltage scheme shall be provided for each Class 1E division.

   The new degraded grid protection circuitry is not divisionalized and is shared by all three Oconee units. This is consistent with the overall design of the emergency electrical power system at Oconee which has two hydroelectric units shared by all three units with the overhead path from Keowee having some common components with the preferred offsite source. The overall design philosophy at Oconee is to ensure that all the emergency 4 kV buses are fed from the same reliable source selected by a "good voltage" seeking, automatic transfer scheme.

6. Coincident logic on a per bus basis shall be utilized.

   The proposed degraded grid protection circuitry utilizes 2-out-of-3 coincident logic to preclude spurious trips. As stated above, the circuitry and its logic are not divisionalized and are not on a per bus basis. The coincident logic is shared by all three Oconee units.

7. Test and calibration capability during power operation shall be provided for the voltage sensors.

   Since 2-out-of-3 coincident logic is utilized in the new design, it appears that the undervoltage sensors (PTs and relays) should be testable without interfering with normal operation.

8. Bypass annunciation shall be provided in the control room. The staff's review of the proposed design modification indicates that bypasses are not used in the design.

9. Technical specifications shall include limiting conditions for operation, surveillance requirements, and trip setpoints and allowable values for undervoltage relays and time delay devices.

   In response to a staff question, the licensee stated that technical specifications will be proposed but setpoints and time delays will not be specifically identified.

4.0 CONCLUSION

From the discussion above, it can be concluded that the licensee's proposed modification does not fully meet BTP PSB-1 in several areas. Requirements similar to those contained in the BTP were generically applied to every plant (circa 1978). In the northeastern part of the country, low grid quality necessitated the staff to back away somewhat from the BTP requirements, particularly for the requirement to automatically separate the onsite Class 1E electrical distribution system from the degraded grid. For the northeast plants, the staff permitted the use of alarms, procedures and manual operator actions, in lieu of automatic action, to ensure that the safety-related components of the Class 1E systems would not be adversely affected during low voltage conditions. This compromise to the requirements of the BTP was granted due to the known weakness of the New England grid whereby the forced shutdown of one nuclear plant could lead to shutdown of other plants in a cascading manner.

For Oconee, the proposed modification will add another layer of undervoltage protection to the existing, degraded grid protection circuitry. Due to the complexity of the plant's existing undervoltage protection scheme and the onsite electrical distribution system coupled with the speculation that the quality of the grid servicing the Oconee site may have similar weaknesses to what exists in the Northeast, we conclude that it is not prudent to impose the complete requirements of the BTP. Therefore, we find that the licensee's proposed degraded grid protection modification (excluding Technical Specification changes which will be evaluated in a separate SE) is acceptable.

OCONEE NUCLEAR STATION
Power System