April 17, 1981

NOTE TO: PSB Members

FROM: F. Rosa, Acting Chief, PSB

SUBJECT: BRANCH TECHNICAL POSITION PSB 1 "ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES"

REFERENCE: Memorandum to PSB Members from R. Fitzpatrick, dated March 11, 1981

Enclosed is the finalized branch technical position (BTP) on the above subject. Thank you for your input in response to the above reference in enabling us to finalize the position in a timely fashion.

This BTP is effective immediately. It is a preferred method over the old PSB Review Reminder #3 but it in no way detracts from the acceptability of designs in accordance with Review Reminder #3.

The guidance of part 4 concerning an acceptable verification testing program should be applied across-the-board to all plants [ORs, OLs & CPs] that have not already either provided or proposed on accepted verification testing program.

You should bring the revised criteria of part 1 to the attention of those licensees/applicants that have designs now under review simply for their information and inform them that they may opt for the revised design criteria if they so choose. However, this should not become a mechanism to substantially delay implementation of a final design.

This BTP will be part of our Chapter 8 submittal of revised SRPs scheduled for completion by May 1, 1981.

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BRANCH TECHNICAL POSITION PSB 1

ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

A. BACKGROUND

Events at the Millstone station have shown that adverse effects on the Class 1E loads can be caused by sustained low grid voltage conditions when the Class 1E buses are connected to offsite power. These low voltage conditions will not be detected by the loss of voltage relays (loss of offsite power) whose low voltage pickup setting is generally in the range of .7 per unit voltage or less.

The above events also demonstrated that improper voltage protection logic can itself cause adverse effects on the Class 1E systems and equipment such as spurious load shedding of Class 1E loads from the standby diesel generators and spurious separation of Class 1E systems from offsite power due to normal motor starting transients.

A more recent event at Arkansas Nuclear One (ANO) station and the subsequent analysis performed disclosed the possibility of degraded voltage conditions existing on the Class 1E buses even with normal grid voltages, due to deficiencies in equipment between the grid and the Class 1E buses or by the starting transients experienced during certain accident events not originally considered in the sizing of these circuits.

B. BRANCH TECHNICAL POSITION

1. In addition to the undervoltage scheme provided to detect loss of offsite power at the Class 1E buses, a second level of undervoltage protection with time delay should also be provided to protect the Class 1E equipment; this second level of undervoltage protection shall satisfy the following criteria:

a) The selection of undervoltage and time delay setpoints shall be determined from an analysis of the voltage requirements of the Class 1E loads at all onsite system distribution levels;

b) Two separate time delays shall be selected for the second level of undervoltage protection based on the following conditions:

1) The first time delay should be of a duration that establishes the existance of a sustained degraded voltage condition (i.e., something longer than a motor starting transient). Following this delay, an alarm in the control room should alert the operator to the degraded condition. The subsequent occurrence of a safety injection actuation signal (SIAS) should immediately separate the Class 1E distribution system from the offsite power system.

2) The second time delay should be of a limited duration such that the permanently connected Class 1E loads will not be damaged. Following this delay, if the operator has failed to restore adequate voltages, the Class 1E distribution system should be

automatically separated from the offsite power system. Bases and justification must be provided in support of the actual delay chosen.

c) **The voltage sensors shall be designed to satisfy the following applicable requirements derived from IEEE Std. 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations":**

1) **Class 1E equipment shall be utilized and shall be physically located at and electrically connected to the Class 1E switchgear.**

2) **An independent scheme shall be provided for each division of the Class 1E power system.**

3) The undervoltage protection shall include coincidence logic on a per bus basis to preclude spurious trips of the offsite power source;

4) **The voltage sensors shall automatically initiate the disconnection of offsite power sources whenever the voltage set point and time delay limits** (cited in item 1.b.2 above) have been exceeded;

5) **Capability for test and calibration during power operation shall be provided.**

6) **Annunciation must be provided in the control room for any bypasses incorporated in the design.**

d) The Technical Specifications shall include limiting conditions for operations, surveillance requirements, trip setpoints with minimum and maximum limits, and allowable values for the second-level voltage protection sensors and associated time delay devices.

2. The Class 1E bus load shedding scheme should automatically prevent shedding during sequencing of the emergency loads to the bus. The load shedding feature should, however, be reinstated upon completion of the load sequencing action. The technical specifications must include a test requirement to demonstrate the operability of the automatic bypass and reinstatement features at least once per 18 months during shutdown.

In the event an adequate basis can be provided for retaining the load shed feature during the above transient conditions, the setpoint value in the Technical Specifications for the first level of undervoltage protection (loss of offsite power) must specify a value having maximum and minimum limits. The basis for the setpoints and limits selected must be documented.

3. The voltage levels at the safety-related buses should be optimized for the maximum and minimum load conditions that are expected throughout the anticipated range of voltage variations of the offsite power sources by appropriate adjustment of the voltage tap settings of the intervening transformers. The tap settings selected should be based on an analysis

of the voltage at the terminals of the Class 1E loads. The analyses performed to determine minimum operating voltages should typically consider maximum unit steady state and transient loads for events such as a unit trip, loss of coolant accident, startup or shutdown; with the offsite power supply (grid) at minimum anticipated voltage and only the offsite source being considered available. Maximum voltages should be analyzed with the offsite power supply (grid) at maximum expected voltage concurrent with minimum unit loads (e.g. cold shutdown, refueling). A separate set of the above analyses should be performed for each available connection to the offsite power supply.

4. The analytical techniques and assumptions used in the voltage analyses cited in item 3 above must be verified by actual measurement. The verification and test should be performed prior to initial full power reactor operation on all sources of offsite power by:

   a) loading the station distribution buses, including all Class 1E buses down to the 120/208 v level, to at least 30%;

   b) recording the existing grid and Class 1E bus voltages and bus loading down to the 120/208 volt level at steady state conditions and during the starting of both a large Class 1E and non-Class 1E motor (not concurrently);

      Note: To minimize the number of instrumented locations, (recorders) during the motor starting transient tests, the bus voltages and loading need only be recorded on that string of buses which previously showed the lowest analyzed voltages from item 3 above.

c) using the analytical techniques and assumptions of the previous voltage analyses cited in item 3 above, and the measured existing grid voltage and bus loading conditions recorded during conduct of the test, calculate a new set of voltages for all the Class 1E buses down to the 120/208 volt level;

d) compare the analytically derived voltage values against the test results.

With good correlation between the analytical results and the test results, the test verification requirement will be met. That is, the validity of the mathematical model used in performance of the analyses of item 3 will have been established; therefore, the validity of the results of the analyses is also established. In general the test results should not be more than 3% lower than the analytical results; however, the difference between the two when subtracted from the voltage levels determined in the original analyses should never be less than the Class 1E equipment rated voltages.

C. REFERENCES

1. General Design Criterion 17

2. IEEE Std. 279, "Criteria for Protection Systems for Nuclear Power Stations"

3. Millstone Unit No. 2, Safety Evaluation Supporting Amendment No. 16 to license No. DPR-65

4. NRC Summary of Meeting for Arkansas Nuclear One Incident of September 16, 1978, dated February 9, 1979.