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

SAFETY EVALUATION
FORT ST. VRAIN NUCLEAR GENERATING STATION
DOCKET NO. 50-267
DEGRADED GRID VOLTAGE PROTECTION FOR THE CLASS 1E SYSTEM

INTRODUCTION AND SUMMARY

The criteria and staff positions pertaining to degraded grid voltage protection were transmitted to Public Service Company of Colorado (PSC) by NRC Generic Letter dated June 3, 1977. In response to this, by letters dated October 15, 1980, October 20, 1980, December 16, 1981, May 28, 1982, June 7, 1982 and June 23, 1982, the licensee proposed certain design modifications and changes to the Technical Specifications. A detailed review and technical evaluation of these proposed modifications and changes to the Technical Specifications was performed by EG&G, under contract to the NRC, and with general supervision by NRC staff. This work is reported by EG&G in "Degraded Grid Protection for Class 1E Power Systems Fort St. Vrain Nuclear Generating Station"(attached). We have reviewed this technical evaluation report and concur in the conclusion that the proposed electrical design modifications are acceptable.

EVALUATION CRITERIA

The criteria used by EG&G in its technical evaluation of the proposed changes include GDC-17 ("Electric Power Systems") of Appendix A to 10 CFR 50; IEEE Standard 279-1971 ("Criteria for Protection Systems for Nuclear Power Generating Stations"); IEEE Standard 308-1977 ("Voltage Ratings for Electrical Power Systems and Equipment - 60 Hz"); and staff positions defined in NRC Generic Letter to PSC dated June 3, 1977.

PROPOSED CHANGES, MODIFICATIONS AND DISCUSSION

The existing undervoltage protection at Fort St. Vrain consist of the following:

Two non-Class 1E undervoltage relays set a 79.7% of nominal monitor the 4160 volt output of the reserve auxiliary transformer. Actuation of one of these relays, when the unit is being supplied by the reserve auxiliary transformer, will result in shedding of all three 480 volt essential buses, automatic starting of the diesel generators, initiation of load sequencing and actuation of an alarm in the control room. Actuation of both relays will result in disconnection of the 4 kV non-essential buses, through which the offsite power is fed to the 480 volt essential buses. Auxiliary contacts on the circuit breaker for the diesel generator disable the load shed feature when the emergency diesel generators are supplying the 480 volt Class 1E buses. The load shed feature will be reinstated when the diesel generator output breakers are tripped.

The following electrical system design modifications and technical specification changes were proposed by PSC:

1. Installation of three undervoltage relays (ITE-27H) arranged in a two-out-of-three logic per 480 volt Class 1E bus with a setpoint of 416 $\pm$ 20 volts (86.7% of 480 volt nominal). Each relay is connected to a 120 $\pm$ 5 second timer. Actuation of any one relay will provide an alarm in the control room. Actuation of two of the three for longer than 120 seconds will separate the affected bus from the offsite power system.

2. Installation of three undervoltage relays (ITE-27H) arranged in a two-out-of-three logic per 480 volt Class 1E bus. These relays have a setpoint of 288 ± 14.4 volts (60% of 480 volt nominal) with a timer set at 30 ± 1.5 seconds. Actuation of two-out-of-three of these relays on two-out-of-three of the 480 volt Class 1E buses will after a 30 second time delay initiate a reactor scram.

3. Installation of three inverse time (CV-2) undervoltage relays arranged in a two-out-of-three logic per 480 volt Class 1E bus. These relays are set at 93 volts ± 3% time dial 5 (77.5% of 480 volt nominal). Actuation of two of these relays on a bus will restore power to the affected bus by automatic throwover to its adjacent bus. There are three 480 volt Class 1E buses. This automatic throwover will allow connection of bus 1 and bus 2 or bus 2 and bus 3 to the same power source. These relays only affect an automatic throwover for a loss of offsite power to the 480 volt Class 1E buses. Interlocks are provided to prevent connecting more than two Class 1E buses together. In addition interlocks will prevent a second automatic throwover if the first automatic throwover fails to restore power to the affected bus.

4. Installation of three inverse time (CV-2) undervoltage relays arranged in a two-out-of-three logic per 480 volt Class 1E bus. These relays are set at 82 volts, time dial 6 (68.3% of 480 volt nominal). Actuation of two-out-of-three of these relays on two-out-of-three 480 volt Class 1E buses will trip the offsite source breakers to all three 480 volt Class 1E

buses, start both emergency diesel generators, and initiate load shedding on all three 480 volt Class 1E buses. Upon achieving satisfactory voltage and frequency diesel generator 1A breaker will close and loads will be sequenced on 480 volt bus 1 and similarly diesel generator 1B breaker will close and loads will be sequenced on 480 volt bus 3. The 480 volt bus 2, which does not have a connected diesel generator, will be connected by the automatic throwover switch to either 480 volt bus 1 or bus 3. The power source selected for bus 2 is determined by which of the diesel generator buses first achieves satisfactory frequency and voltage. Circuitry which incorporates timers, lock out relays and throwover switch auxiliary contacts is used to provide interlocks that will prevent the closure of more than one throwover attempt, i.e., bus 2 to 1 or bus 2 to 3. Once the selection of power to bus 2 has been made and the applicable throwover switch has been positioned, these interlocks and relays will prevent any additional automatic operation to connect bus 2 to an alternate power source. If power to bus 2 should be subsequently lost, this circuitry will require manual operator action, controlled by plant procedures, to reset the lockout relay prior to transferring bus 2 to an alternate source.

5. The technical specification changes and additions required for the proposed modifications have not been formally submitted by the licensee. However, they have provided preliminary information which will be required in the technical specifications. PSC has committed to formally submit the finalized technical specifications in October, 1982. This will coincide with equipment installation.

We find that the proposed modifications will ensure that the Class 1E equipment is protected from the effects of degraded voltage. However; the existing undervoltage protection uses two non-Class 1E relays to monitor the 4160 volt output of the reserve auxiliary transformer. Spurious actuation or failure of one of these relays will lead to undesired separation of the 480 volt essential buses from the preferred offsite power system, initiation of load shedding on the Class 1E buses and result in unnecessary challenges to the onsite emergency diesel generators. An example, on June 5, 1982, while the reactor was at 15% power, inadvertent actuation of one of these existing non-Class 1E relays resulted in a temporary loss of AC power to all 480 volt Class 1E buses. The proposed protective relay system for the 480 volt Class 1E buses meets staff requirements and provides the necessary undervoltage protection for all Class 1E equipment without reliance on the existing non-Class 1E protective relays.

The above concerns regarding the existing undervoltage protection have been discussed with the licensee. If the existing non-Class 1E undervoltage protective relays are to be retained as protection for the 4160 volt non-Class 1E buses, we require that the Class 1E functions i.e,, diesel generator starting, 480 volt bus breaker tripping and load shedding on the 480 volt Class 1E buses be deleted from these relays. These safety functions shall be carried out only by the proposed Class 1E protective relay system to be installed on the 480 volt Class 1E buses.

CONCLUSIONS

We have reviewed the EG&G technical evaluation report and the licensee's submittals and find that:

1. The proposed degraded grid modifications will protect the Class 1E equipment from sustained degraded voltage of the offsite power system.

2. The existing load shedding circuit will block load shedding once the emergency diesel generators are supplying the safety loads. The load shedding feature will be reinstated if the diesel generator breaker should trip.

3. The preliminary technical specification information supplied by the licensee is acceptable. However; we require that a formal submittal be made of the changes and additions to technical specifications prior to installation of the proposed modification.

4. If the non-Class 1E undervoltage protective relays which presently monitor the 4160 volt output of the reserve auxiliary transformer are to be retained as protection for the non-Class 1E 4160 volt bus and equipment, we require that the Class 1E functions i.e., diesel generator starting, 480 volt bus breaker tripping and load shedding on the 4160 volt Class 1E buses be deleted from these relays.

We therefore find the licensee's proposed modifications acceptable subject to completion of items 3 and 4 above. After resolution of these items with PSC, PSB will issue a supplement to this evaluation report.

Attachment:
EG&G Technical Evaluation
Report

EGG-EA-5926, REV. 1

SEPTEMBER 1982

DEGRADED GRID PROTECTION FOR CLASS 1E POWER SYSTEMS FORT ST. VRAIN NUCLEAR GENERATING STATION

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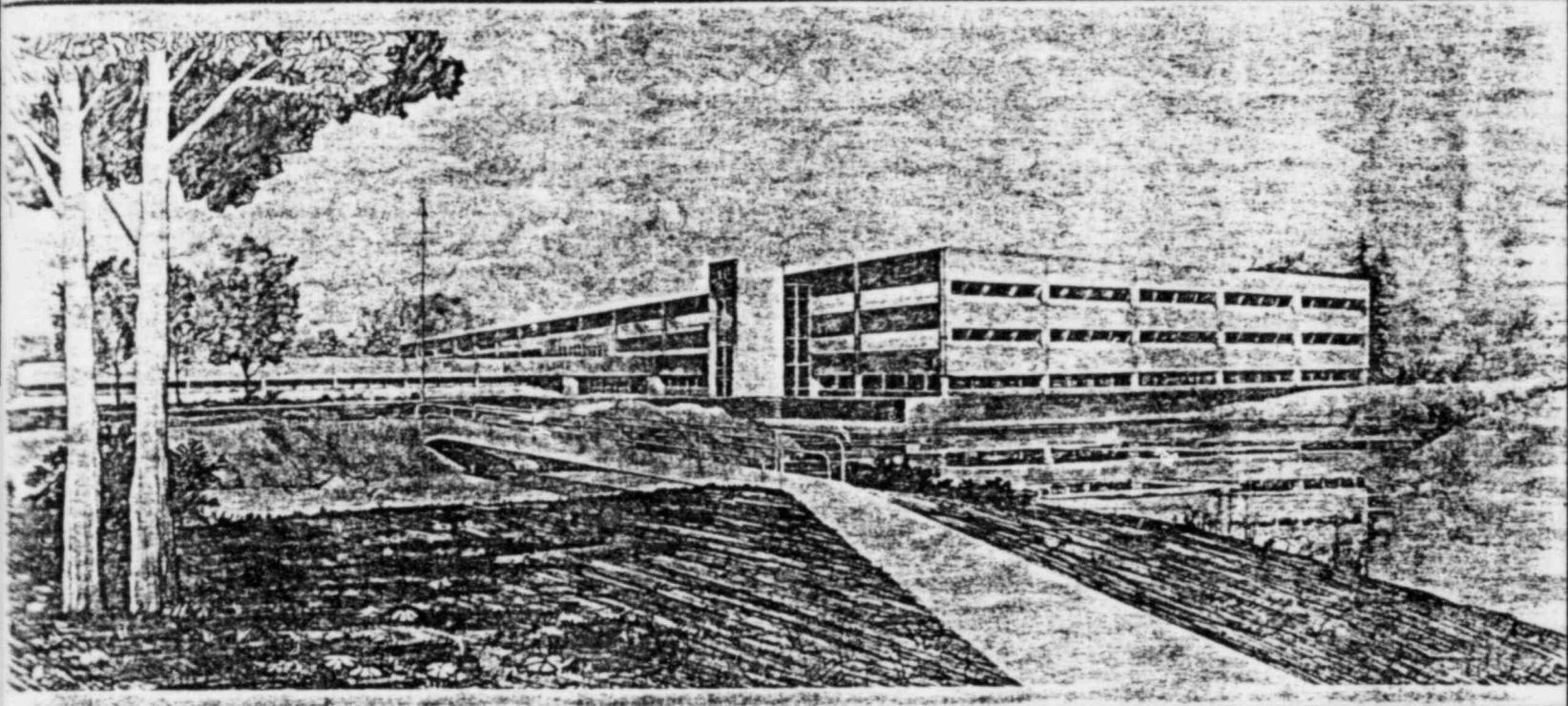
Operated by the U.S. Department of Energy



This is an informal report intended for use as a preliminary or working document

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DEGRADED GRID PROTECTION FOR CLASS 1E POWER SYSTEMS

FORT ST. VRAIN NUCLEAR GENERATING STATION

September 1982

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TAC No. 46504
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ABSTRACT

This EG&G Idaho, Inc. report reviews the susceptibility of the safety-related electrical equipment, at the Fort St. Vrain station, to a sustained degradation of the offsite power sources.

FOREWORD

This report is supplied as part of the "Selected Operating Reactor Issues Program (III)" being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Licensing, by EG&G Idaho, Inc., Reliability and Statistics Branch.

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DEGRADED GRID PROTECTION FOR CLASS 1E POWER SYSTEMS

FORT ST. VRAIN NUCLEAR GENERATING STATION

1.0 INTRODUCTION

On August 25, 1980, the NRC requested the Public Service Company of Colorado (PSC) to assess the susceptibility of the safety-related electrical equipment at the Fort St. Vrain station to a sustained voltage degradation of the offsite source and interaction of the offsite and onsite emergency power systems.[1] The letter contained three positions with which the current design of the plant was to be compared. After comparing the current design to the staff positions, the licensee was required to either propose modifications to satisfy the positions and criteria or furnish an analysis to substantiate that the existing facility design has equivalent capabilities.

PSC initially responded to the NRC letter on October 15, 1980,[2] and on October 20, 1980.[3] PSC provided a summary of activities and a status report on this, and on a related topic on December 16, 1981.[4] PSC consolidated the previous information supplied in a submittal of May 28, 1982.[5] This last submittal proposed to request technical specification changes in October 1982. Portions of this submittal were clarified by telephone conversations in June 1982[6]. A voltage analysis was submitted to the NRC on June 7, 1982.[7] PSC submitted additional information on June 23, 1982.[8]

2.0 DESIGN BASE CRITERIA

The design base criteria that were applied in determining the acceptability of the system modifications to protect the safety-related equipment from a sustained degradation of the offsite grid voltage are:

1. General Design Criterion 17 (GDC 17), Electric Power Systems, of Appendix A, General Design Criteria for Nuclear Power Plants, of 10 CFR 50.[9]

2. IEEE Standard 279-1971, Criteria for Protection Systems for Nuclear Power Generating Stations.[10]

3. IEEE Standard 308-1974, IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.[11]

4. Staff positions as detailed in a letter sent to the licensee, dated August 25, 1980.[1]

5. ANSI Standard C84.1-1977, Voltage Ratings for Electrical Power Systems and Equipment (60 Hz).[12]

3.0 EVALUATION

This section provides, in Subsection 3.1, a brief description of the existing undervoltage protection at the Fort St. Vrain station; in Subsection 3.2, a description of the licensee's proposed scheme for the second-level undervoltage protection; and, in Subsection 3.3, a discussion of how the modified system meets the design base criteria.

3.1 Existing Undervoltage Protection

The present design utilizes undervoltage relays on the secondary side of the reserve auxiliary transformer to sense loss of voltage (setpoint: 45% of 4160V nominal) and to start the diesel generators. The Class 1E buses (480V buses 1, 2, and 3) have separate undervoltage relays (setpoint: 75% of 480V nominal) on buses 1 and 3 (bus 2 does not have its own diesel) that also start their associated diesel generators.

Auxiliary contacts on the circuit breakers of the diesel generators are part of the load shed circuitry. This insures that if a loss of offsite voltage is detected, the 480V Class 1E buses will have their loads

shed to enable the subsequent load sequencing onto diesel supplied power. The diesel generator circuit breakers for buses 1 and 3 must be open, or all four undervoltage relays (2 on 480V bus 1 and 2 on 480V bus 3) de-energized to enable the load shed feature that is initiated from the undervoltage relays at the reserve auxiliary transformer. Once the diesel generator breakers are closed, the loss of voltage relays associated with those buses return to their energized state, preventing any subsequent load shedding.

3.2 Modifications

The licensee has proposed the addition of several sets of undervoltage relays to protect the Class 1E equipment and buses from abnormal voltages. To protect against the effects of degraded voltage, each 480V Class 1E bus will have three undervoltage relays (ITE 27H) arranged in a two-out-of-three logic with a setpoint of 416 $\pm$ 20V (86.7% of 480V nominal). Each relay is individually connected to an alarm and a 120 $\pm$ 5 second timer. Actuation of any individual relay is annunciated in the control room. If two of the three relays of a bus trip, and remain tripped for 120 seconds, the offsite power circuit breaker for that bus is opened. De-energizing a 480V Class 1E bus will actuate Westinghouse CV-2 inverse time delay relays, arranged in a 2/3 logic per bus. This will attempt to restore power by automatic throwover to its neighboring 480V Class 1E bus. Interlocks are installed to prevent connecting more than two Class 1E buses together. These CV-2 relays are set on the 93V tap, time dial 5 (77.5% of 480V nominal). Each 480V Class 1E bus also has three additional 27H relays (setpoint 288 $\pm$ 14.4V, 60% of 480V nominal). These also use a 2/3 logic. The output of this logic initiates a 30 + 1.5 second timer. Should power not be restored before the timer times out on two of the three 480V Class 1E buses, a reactor scram will occur.

On a loss of bus voltage caused by the loss of offsite power or by the operation of the degraded voltage relays, a second set of CV-2 relays will actuate. These CV-2 relays are arranged in a two out of three logic and are set on the 82V tap, time dial 6 (68.3% of 480V nominal). Operation of

two of these three CV-2 relays on two of the three buses or operation of the degraded voltage relays on two of the three buses will trip all three offsite power circuit breakers. Then both diesel-generator sets will be started, loads shed on all three buses, the two diesel generator breakers closed and the loads sequenced onto the diesel generators. The tie breakers between bus 2 and bus 1 and between bus 2 and bus 3 will be tripped as part of the load shedding, regardless of whether the breaker was open or closed. A tie will then be established between bus 2 and either bus 1 or bus 3 (but not both) automatically. The tie is established to the bus that is first energized by the diesel generator. Bus 2 is interlocked so that it can be connected to only one of the other two buses. When used in conjunction with diesel supplied power, the bus tie is effected by one of two redundant motor operated timers. The timers are interlocked so that only one timer is in the control circuit and only that timer operates. Additionally, the control circuit has interlocks provided by tie breaker and generator lockout relay contacts. These interlocks prevent bus numbers 1 and 3 from being tied simultaneously to bus 2, or sequentially, by automatic operation, to bus 2. A fault on bus 2 cannot be automatically propagated to both of the other Class 1E buses. If bus 2, after being powered by one of the diesel supplied buses, subsequently requires connection to the other Class 1E bus, manual operator action following written procedures is required. The operator would have to manually reset the interlocks and lockout relays, and shed the bus 2 loads and the existing tie before the new bus tie can be established.

The existing loss of voltage relays on the secondary side of the reserve auxiliary transformer will be retained as an independent method of starting the diesel generator sets; however, they will not, by themselves, initiate any direct load transfers of the Class 1E buses. They are still an intergral portion of the load shedding circuitry.

Once the diesel generator is supplying its associated Class 1E bus, load-shedding is blocked by interlocks and auxiliary relays in the under-voltage protection logic circuitry. As stated above, this is already incorporated in the existing logic circuits.

The licensee has provided the required technical specification information which covers the surveillance requirements, allowable limits for the setpoint and the time delay, and limiting conditions for operation for the undervoltage monitors. However, a formal technical specification submittal has not been received. Upon receipt of this formal submittal, it will be evaluated.

3.3 Discussion

The first position of the NRC staff letter[1] required that a second level of undervoltage protection for the onsite power system be provided. The letter stipulates other criteria that the undervoltage protection must meet. Each criterion is restated below and followed by a discussion regarding the licensee's compliance with that criterion.

1. "The selection of voltage and time setpoints shall be determined from an analysis of the voltage requirements of the safety-related loads at all onsite system distribution levels."

   The licensee's proposed setpoint of 416V at the 480V buses is 90.4% of the motor nominal voltage rating of 460V. This is greater than the minimum allowable motor voltage (90% of nominal voltage). As the motors are the most limiting equipment in the system, this setpoint is acceptable. The licensee's analysis considered other factors, such as motor control center fuses and contactor pick-up and drop-out voltage.

2. "The voltage protection shall include coincidence logic to preclude spurious trips of the offsite power sources."

   For the proposed modification, all of the relay logic is arranged in two-out-of-three logic, thereby satisfying this criterion.

3. "The time delay selected shall be based on the following conditions:

a. "The allowable time delay, including margin, shall not exceed the maximum time delay that is assumed in the FSAR accident analysis."

The licensee indicates that there is no critical time delay assumed in the FSAR accident analysis.[5] Thus the proposed time delays satisfy this NRC criterion.

b. "The time delay shall minimize the effect of short-duration disturbances from reducing the unavailability of the offsite power source(s)."

The licensee's proposed time delay is long enough to override any short inconsequential grid disturbances. Further, review of the PSC analysis shows that any voltage dip caused by starting large motors will not trip the offsite source.

c. "The allowable time duration of a degraded voltage condition at all distribution system levels shall not result in failure of safety systems or components."

A review of the licensee's voltage analysis[7] indicates that the time delay will not cause any failures of the safety-related equipment since the voltage setpoint is within the allowable tolerance of the equipment voltage rating. Further, all Class 1E motors have a service factor of 1.15, which allows operation at less than normal voltage for short time periods.

4. "The voltage monitors shall automatically initiate the disconnection of offsite power sources whenever the voltage setpoint and time-delay limits have been exceeded."

A review of the licensee's proposal substantiates that this criterion is met.

5. "The voltage monitors shall be designed to satisfy the requirements of IEEE Standard 279-1971."

The licensee has stated that the circuits associated with the undervoltage relays meet the applicable requirements of IEEE Standard 279-1971.

6. "The Technical Specifications shall include limiting conditions for operation, surveillance requirements, trip setpoints with minimum and maximum limits, and allowable values for the second-level voltage protection monitors."

The licensee has not proposed technical specification changes. PSC will request the technical specification changes after they have completed internal reviews. This is expected to be in October 1982.[5]

The licensee has proposed the following to be included in their request for technical specification changes:[8]

1. No change for limiting conditions for operation (LCO) for the 480V buses.

2. A LCO to place an inoperable loss of voltage or degraded voltage relay in the tripped position until repaired or replaced.

3. Channel check will be by observation of the relay alarms in the control room.

4. Functional test will be by verifying relay operation on removal of voltage.

5. Relays and time delays will be calibrated on a refueling basis.

The setpoints and time delays are identified, including nominal setpoint or time delay, ± tolerance and allowable limits (the voltages are expressed in relation to the relays nominal voltage or tap and time dial).

The second NRC staff position requires that the system design automatically prevent load-shedding of the emergency buses once the onsite sources are supplying power to all sequenced loads. The load-shedding must also be reinstated if the onsite breakers are tripped.

The licensee states in his submittal that this feature is already incorporated in the existing circuit design, and will also be incorporated in the modified system. Load shedding is prevented if either diesel generator is supplying its bus. Thus they are not completely independent of each other, and any subsequent load shedding and load sequencing of a single diesel generator is a manual operation.

The third NRC staff position requires that certain test requirements be added to the Technical Specifications. These tests are to demonstrate the full-functional operability and independence of the onsite power sources and are to be performed at least once per 18 months during shutdown. The tests are to simulate loss of offsite power in conjunction with a simulated safety injection actuation signal and to simulate interruption and subsequent reconnection of onsite power sources. These tests verify the proper operation of the load-shed system, the load-shed bypass when the emergency diesel generators are supplying power to their respective buses, and that there is no adverse interaction between the onsite and offsite power sources.

The licensee has indicated that their formal request for technical specification changes will include the loss of offsite power testing on a refueling basis.[8] The following things will be verified as part of the test:

1. Verify de-energization and load shedding of the essential 480V buses

2. Verify the auto start of the diesel generators, closure of the diesel generator breakers, operation of the permanently connected loads and the loads that are sequenced on

3. Verify that, on the trip of both diesel generators, the loads are shed, the diesels restarted on the auto start signal, the permanently connected loads and the sequenced loads (sequenced on by the load sequencer) again operate, and

4. Verify that all undervoltage relays operate as designed.

In both verifications 2 and 3 above, the diesel generators will be loaded with essential loads for greater or equal to five minutes to establish equilibrium conditions in the diesel generators and in the bus loads. Thus, the requirements of the NRC letter will be met.

4.0 CONCLUSIONS

Based on the information provided by the licensee, it has been determined that the proposed changes do comply with NRC staff position 1. All of the staff's requirements and design base criteria have been met. The setpoint and time delay will protect the Class 1E equipment from a sustained degraded voltage condition of the offsite power source. However, a formal request for technical specification changes has not yet been supplied.

The existing load-shed circuitry does comply with staff position 2 and will prevent adverse interaction of the offsite and onsite emergency power systems.

The technical specification changes outlined and equipment arrangement comply with staff position 3.

Therefore, the licensee's proposed changes are acceptable. As the second-level undervoltage protection modifications are to be installed during the third refueling, it is recommended that the licensee proposed technical specification changes, due to be submitted in October 1982, be

approved as a supplement to this report and implemented to coincide with the installation.

5.0 REFERENCES

1. NRC letter, R. L. Tedesco to D. Warembourg, PSC, August 15, 1980.

2. PSC letter, D. Warembourg to R. L. Tedesco, NRC, "Technical Specifications, Electrical Power Systems," October 15, 1980.

3. PSC letter, F. E. Swart to R. L. Tedesco, NRC, "Emergency Power Systems," October 20, 1980.

4. PSC letter, H. L. Brey to G. Kuzmycz, NRC, "Electrical Power Systems," December 16, 1981.

5. PSC letter, H. L. Brey to G. Kuzmycz, NRC, "Electrical Power Systems," May 28, 1982.

6. Telecon, A. Udy, EG&G and M. Niehoff, PSC, June 6, 9, and 21, 1982.

7. PSC letter, H. L. Brey to G. Kuzmycz, NRC, "Electrical Power Systems," June 7, 1982.

8. PSC letter, H. L. Brey to G. Kuzmycz, NRC, "Electrical Power Systems," June 23, 1982.

9. General Design Criterion 17, Electric Power Systems, of Appendix A, General Design Criteria of Nuclear Power Plants, to 10 CFR Part 50, Domestic Licensing of Production and Utilization Facilities.

10. IEEE Standard 279-1971, Criteria for Protection Systems for Nuclear Power Generating Stations.

11. IEEE Standard 308-1974, IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

12. ANSI C84.1-1977, Voltage Ratings for Electric Power Systems and Equipment (60 Hz).