Enclosure 2

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TECHNICAL EVALUATION REPORT (REVISION 1) ON THE PROPOSED DESIGN MODIFICATIONS AND TECHNICAL SPECIFICATION CHANGES ON GRID VOLTAGE DEGRADATION FOR THE PILGRIM NUCLEAR POWER STATION, UNIT 1

(Docket No. 50-293)

James C. Selan

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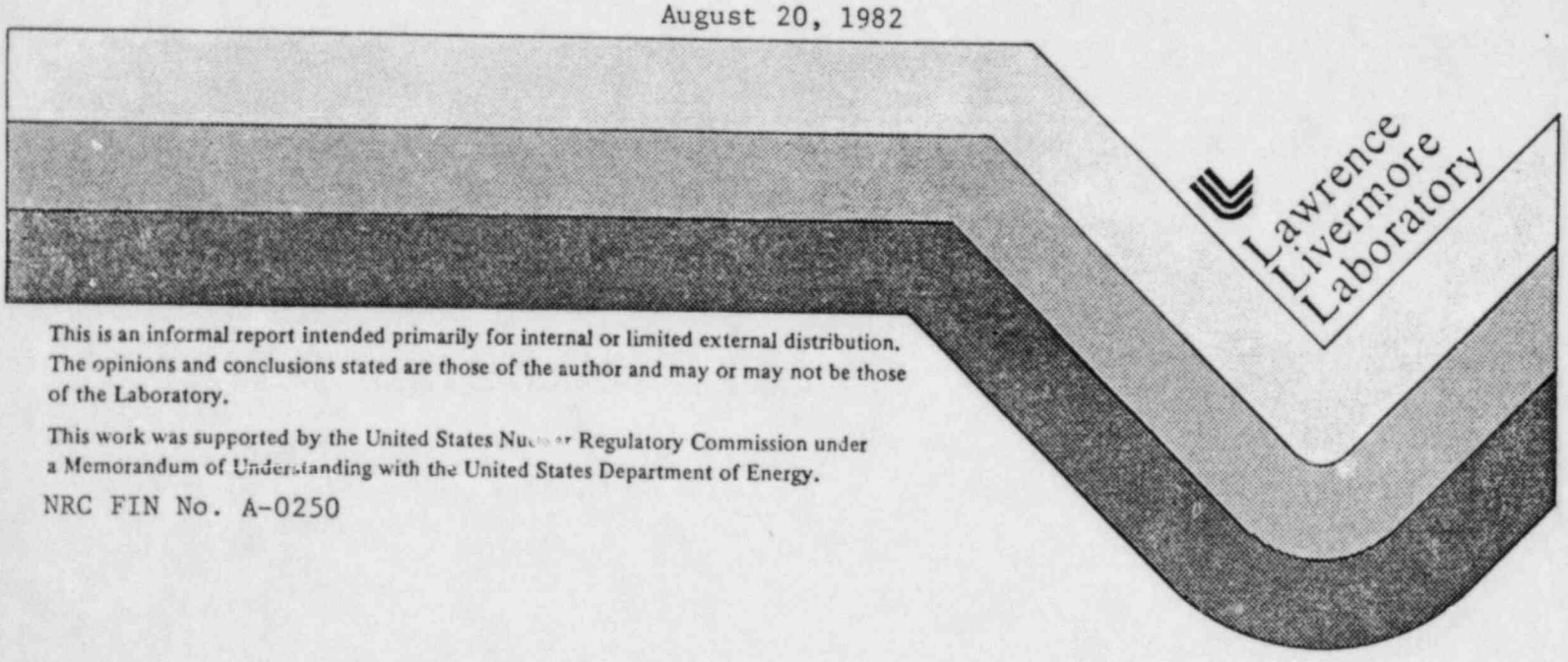

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ABSTRACT

This report documents the technical evaluation of the proposed design modifications and Technical Specification changes for the protection of Class 1E equipment from grid voltage degradation for the Pilgrim Nuclear Power Station. The review criteria are based on several IEEE standards and the Code of Federal Regulations. The evaluation finds that the proposed design modifications and Technical Specification changes ensure that the Class 1E equipment will be protected from sustained voltage degradation.

FOREWORD

This report is supplied as part of the Selected Electrical, Instrumentation, and Control Systems Issues (SEICSI) Program being conducted for the U. S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Licensing by Lawrence Livermore National Laboratory.

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1. INTRODUCTION

By letter dated June 3, 1977 [Ref. 1], the U.S. Nuclear Regulatory Commission (NRC) requested the Boston Edison Company (BECO), the licensee, to assess the susceptibility of the Pilgrim Nuclear Power Station, Unit 1, Class 1E electrical equipment both to sustained degraded voltage conditions at the offsite power sources and to the interaction between the offsite and onsite emergency power systems. In addition, the NRC requested that the licensee compare the current design of the emergency power systems at the plant facilities with the NRC staff positions as stated in the June 3, 1977 letter [Ref. 1], and propose plant plant modifications, as necessary, to meet the NRC staff positions, or that they provide a detailed analysis to show that the facility design has equivalent capabilities and protective features. Further, the NRC required incorporation of certain Technical Specifications into all facility operating licenses.

By letters dated August 8, 1977 [Ref. 2], August 24, 1977 [Ref. 3], September 27, 1979 [Ref. 4], March 28, 1980 [Ref. 5], October 26, 1981 [Ref. 6], and June 17, 1982 [Ref. 7], the licensee proposed certain design modifications and additions to the licensee's Technical Specifications. These design modifications include the installation of a degraded voltage protection system for the Class 1E equipment. The licensee proposed additions to the Technical Specifications regarding relay setpoints, calibrations, surveillance requirements, and test requirements associated with the proposed voltage protection system.

The purpose of this report is to evaluate the licensee's proposed design modifications and Technical Specification changes and to determine that they meet the criteria established by the NRC to protect Class 1E equipment from grid voltage degradation.

2. DESIGN BASIS CRITERIA

The design basis criteria that were applied to determine the acceptability of the system modification for protection of Class 1E equipment from degradation of grid voltages are as follows:

(1) General Design Criterion 17 (GDC 17), "Electric Power Systems," of Appendix A, "General Design Criteria for Nuclear Power Plants," in the Code of Federal Regulations, Title 10, Part 50 (10 CFR 50), [Ref. 8].

(2) IEEE Standard 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations" [Ref. 9].

(3) IEEE Standard 308-1974, "Class 1E Power Systems for Nuclear Power Generating Stations" [Ref. 10].

(4) NRC staff positions as stated in a letter dated June 3, 1977 [Ref. 1].

3. EVALUATION

3.1 EXISTING UNDERVOLTAGE PROTECTION

The present design consists of three sets of relays on each of the two 4160-volt Class 1E buses. The function of each set of relays is as follows:

(a) Two inverse time-delay voltage relays monitor the voltage from the startup transformer (preferred offsite source) at the source side of the breaker between the startup transformer and the Class 1E bus. These relays are set to function at 3094 volts (74% of 4160 volts) with a time delay of 18 seconds. At 0 volts the relay will trip in 1.1 seconds. The function of this set of relays is to trip the startup transformer breakers, start the diesel generator, and, in conjunction with a LOCA signal, initiate the load-shedding feature.

(b) Four instantaneous relays with a setting of 840 volts (20% of 4160 volts) monitor the voltage on the 4160-volt Class 1E buses. The function of this set of relays is to trip the unit auxiliary transformer breakers and initiate load shedding of all motors on the emergency bus.

(c) Two inverse time-delay voltage relays monitor the voltage from the shutdown transformer at the source side of the breaker between the shutdown transformer and the Class 1E bus. These relays are set at 3094 volts (74% of 4160 volts) with a time delay of 1.8 seconds. At 0 volts the relay will trip in 1.1 seconds. The function of this set of relays is to initiate the trip of the shutdown transformer breaker.

The shutdown transformer is utilized by the plant as a secondary offsite source of power. Should the diesels fail to come on line within 12 seconds, or if they are tripped off line, the Class 1E buses are automatically transferred to the shutdown transformer.

The automatic load-shedding feature is blocked out after the diesel generator breakers are closed. The load-shedding feature is reinstated if the diesel generator breakers are tripped.

3.2 MODIFICATIONS

The licensee has proposed a design change which includes automatic degraded voltage protection of the two Class 1E buses when they are energized by the startup transformer (preferred offsite source). This design change uses four inverse time-delay relays for each Class 1E bus. These relays are connected in parallel with the existing loss-of-voltage relays that monitor the voltage at the source side of the breaker between the startup transformer and the Class 1E bus. The voltage setting for the relays will be 3745 volts $\pm$ 2% (90% of 4160 volts) with a time delay of 9.2 seconds $\pm$ 0.5 seconds. The coincident logic used with this undervoltage protection is "1-out-of-2, taken twice."

The licensee is also proposing a second modification for the installation of two additional undervoltage relays on each of the the two 4160-volt Class 1E buses. The function of these relays will be to activate an alarm for a low-voltage condition on the emergency bus. The setpoint for this alarm will be 3850 volts (92.5% of 4160 volts) with a time delay of 9.2 seconds $\pm$ 0.1%. The purpose of the alarm is to alert the operator that there is voltage degradation on the Class 1E buses.

Upon alarm actuation, if the unit auxiliary transformer is energizing the Class 1E buses, the operator through established plant procedures will attempt to increase the voltage. Should the voltage drop to or below 3745 volts (90% of 4160 volts), the operator will tranfer the Class 1E buses to the diesel generators and be in hot shutdown within 4 hours [Ref. 11, item 6, page 197]. If the startup transformer is energizing the Class 1E buses, the operator should expect a trip of the Class 1E buses if the voltage degradation reaches the setpoint of the second-level undervoltage setpoint (90% of 4160 volts).

The final design change, which is presently installed, will immediately trip the unit auxiliary transformer (with the unit on-line) for any reactor scram. The trip will automatically fast transfer the Class 1E buses to the startup transformer (preferred offsite source) which has both first and second levels of undervoltage protection.

No modifications are necessary for meeting the NRC staff position on blocking the load-shedding feature when the Class 1E buses are energized by the emergency generators, as this circuitry already exists.

The licensee has proposed Technical Specifications changes including relay surveillance requirements, diesel generator test procedures, degraded voltage setpoints for relays and alarms, as well as limiting conditions for operations.

3.3 DISCUSSION

This section presents a statement on the NRC staff position from their June 3, 1977 letter [Ref. 1] and is followed by an evaluation of the licensee's design.

3.3.1 NRC Staff Position 1: Second Level Undervoltage or Overvoltage Protection with a Time Delay.

This position is to be met by the licensee meeting certain criteria. Each criterion has been evaluated against the licensee's proposal and is addressed below.

(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 degraded undervoltage setpoint is 3745 volts $\pm$ 2% (90% of 4160 volts) with a time-delay of 9.2 seconds $\pm$ 0.5 seconds. The licensee's analysis shows that this setpoint and time delay will protect all Class 1E loads including relays, contactors, and other components whose functional performance would be inadequate because of undervoltage supplied from the startup transformer.

When the Class 1E buses are being supplied from the unit auxiliary transformer (unit on-line), an undervoltage alarm with a setpoint of 3850 volts $\pm$ 2% (92.5% of 4160 volts) and a time delay of 9.2 seconds $\pm$ 0.1% will alert the operator of undervoltage conditions. This setpoint was determined from an analysis to be below the normal voltage range but above a voltage which is considered degraded to the operation of the Class 1E equipment.

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

The proposed modification incorporates a "1-out-of-2, taken twice" coincidence logic scheme. There will be two undervoltage relays monitoring the voltage between phases A and B. The contacts of these two undervoltage relays will be in parallel and then in series with the parallel contacts from two undervoltage relays monitoring the voltage between phases B and C. This logic scheme will be used on both 4160-volt Class 1E buses.

(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 proposed time delay of 9.2 seconds $\pm$ 0.5 seconds does not exceed the maximum time delay that is assumed in the FSAR accident analysis.

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

The licensee's proposed time delay of 9.2 seconds $\pm$ 0.5 seconds is long enough to override any grid disturbances of short duration. This has been confirmed by testing.

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

A review of the licensee's voltage analysis indicates that the time delay will not cause the failure of any equipment connected to and associated with the Class 1E emergency power system.

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

The undervoltage protection scheme with a setpoint of 3745 volts $\pm$ 2% and a time delay of 9.2 seconds $\pm$ 0.5 seconds will automatically initiate the disconnection of the startup transformer (preferred offsite source) whenever the setpoints are exceeded. Automatic disconnection from the unit auxiliary transformer (normal source supply) will also occur for any reactor scram. Upon disconnection, the Class 1E buses will

fast transfer to the startup transformer unless a degraded voltage is sensed prior to the transfer which will result in transferring to the diesel generators.

For undervoltage conditions with the unit on-line and the Class 1E buses being supplied from the unit auxiliary transformer, undervoltage alarms will alert the operator of undervoltage conditions. These alarms are set to annunciate when the voltage degrades to a voltage below the normal voltage range but above a voltage considered degraded to the operation of the Class 1E equipment. Upon receiving the alarm, the operator through established plant procedures will attempt to restore voltage within the normal range. Should the restoration fail, plant procedures require manual disconnection and the initiation of the voltage restoring scheme.

The licensee's bases for not providing this auto-disconnection when on the unit auxiliary transformer are as follows:

(a) Load flow studies indicate that with the unit on-line and the grid voltage within the normal range (328 kV to 362 kV), the voltage on the Class 1E buses will be adequate to ensure operation of the equipment with their voltage design ratings.

(b) Operator action in conjunction with the system dispatcher (REMVEC) will be able to assess whether the voltage degradation is long-term or short-term with recovery imminent, localized or widespread, and what actions have been taken or will be taken by the system dispatcher.

(c) Load flow studies also indicate that degraded voltages (outside the normal range) at the switchyard are highly unlikely even with the loss of several units on the grid system.

(d) Existence of plant procedures and a strict voltage schedule for maintaining optimum voltage levels at the switchyard and onsite buses.

(e) Operating experience with no noted degraded incidents with the exception of the July 30, 1979 event in which Pilgrim was off-line. This worst-case event nearly caused a system collapse. The switchyard voltage at Pilgrim did not go below the 321 kV level but may have had an instantaneous dip to 319 kV before final corrective actions were taken to restore adequate voltage. Calculations have shown that the probability of the events of this incident occuring in the same hour is 10^{-8} to 10^{-10}. If Pilgrim were to be on-line, the probability would be 10^{-11} to 10^{-13} for low voltage conditions at Pilgrim.

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

The licensee states that the relays and the relaying scheme will be in compliance with the requirements of IEEE Standard 279-1971.

(6) "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 monitors."

The licensee has submitted proposed Technical Specifications covering limiting conditions for operations, surveillance requirements, voltage and time delay setpoints with tolerances and test procedures for the emergency diesel generators. These Technical Specifications are detailed in Amendment No. 42 to Facility Operating License No. DPR-35 for the Pilgrim Nuclear Power Station Unit 1 [Ref. 11].

3.3.2 NRC Staff Position 2: Interaction of Onsite Power Sources with Load-Shed Feature

The second position requires the system to be designed to prevent automatic load shedding of the emergency buses once the onsite sources are energizing all sequenced loads. If an adequate basis can be provided for retaining the load-shed feature, the licensee must assign maximum and minimum values to the setpoint of the load-shed feature. These setpoints must be documented in the Technical Specifications. The load-shedding feature must also be reinstated if the onsite source supply breakers are tripped.

The present design of Pilgrim Nuclear Power Station, Unit 1 meets this position. When the generators are put on line as the emergency source, the load-shedding feature is blocked out. Should there be an emergency generator breaker trip, the load-shedding feature would be reinstated.

3.3.3 NRC Staff Position 3: Onsite Power Source Testing.

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

The licensee will verify the requirements of the NRC by testing the system by initiating loss of offsite power in conjunction with a simulated safety injection signal. The tests sequence will be bus de-energization, load

shedding, voltage restoration, and load sequencing. The operating time on emergency onsite power will be at least 5 minutes. The licensee will also verify that upon interruption of the diesel generators, the loads will be shed, the secondary (offsite) power source will be automatically connected to the emergency buses, and the loads will be re-energized through the load sequencer.

3.4 TECHNICAL SPECIFICATIONS

Amendment No. 42 to Facility Operating License No. DPR-35 for the Pilgrim Nuclear Power Station Unit #1 reflects the proposed design modifications. Specifically, these Technical Specifications changes:

(1) Include the trip setpoint of 3745 volts $\pm$ 2% (90% of 4160 volts) with a time delay of 9.2 seconds $\pm$ 0.5 seconds for the degraded voltage protection scheme for the startup transformer.

(2) Include the setpoint of 3850 volts $\pm$ 2% (92.5% of 4160 volts) with a time delay of 9.2 seconds $\pm$ 0.1 second for the degraded voltage alarm relays on the 4160-volt Class 1E buses. If the alarm is inoperable the Class 1E bus voltage must be logged every 30 minutes until the alarm is restored to operable status.

(3) Provide the required coincidence logic ("1-out-of-2, taken twice").

(4) Incorporate action statements regarding limiting conditions for operation when the number of operable channels for degraded voltage protection is reduced.

(5) Provide the surveillance requirements for channel calibration and channel functional test.

(6) Provide the surveillance requirements to demonstrate at least once per 18 months that the loss of offsite power, in conjunction with a safety injection actuation signal, will provide the sequence of Class 1E bus de-energization, load shedding, voltage restoration, and load sequencing. Further, to demonstrate that on diesel generator trip the load is shed and the secondary offsite power source is automatically connected to the emergency service buses within 12 to 14 seconds and that emergency loads are sequenced back on.

(7) Incorporate action statements regarding limiting conditions for operation. If the Class 1E bus voltage drops below 3745 volts (90% of 4160 volts) during normal operation these buses will be transferred to the emergency diesel generators. If the voltage cannot be restored in 4 hours the plant must be brought to the hot shutdown mode.

4. CONCLUSION

Based on the information provided by Boston Edison Company, it has been determined that the proposed modifications to Pilgrim Nuclear Power Station, Unit 1 comply with NRC Staff Position 1 when the Class 1E buses are being supplied by the startup transformer. The voltage trip setting and time delay will automatically protect the Class 1E equipment from a sustained degraded voltage condition of the offsite power source (startup transformer).

For operating conditions (Pilgrim on line) when the Class 1E buses are being supplied by the unit auxiliary transformer, low-voltage conditions will be alarmed by undervoltage relays located on the 4160-volt Class 1E buses. These relays are set to actuate at 3850 volts $\pm$ 2% (92.5% of 4160 volts) with a time delay of 9.2 seconds $\pm$ 0.1%. Upon receiving an alarm, the operator will through established plant procedures attempt to restore the voltage to acceptable levels. Should the voltage restoration fail, the operator is required to disconnect and transfer to the diesel generators. The licensee provided load flow studies for numerous plant operating scenarios, outline of plant procedures, and a voltage maintaining schedule which demonstrates that the Class 1E equipment would not be exposed to degraded voltage conditions which could damage the Class 1E equipment. In addition to the above, the licensee provided a plant operating history of low voltage events and the probability calculations of experiencing such low voltage conditions at Pilgrim. Therefore, based on this information, I recommend that the NRC accept the licensee's position of not providing automatic undervoltage protection of the Class 1E equipment when supplied by the unit auxiliary transformer. The licensee has demonstrated that through strict plant procedures, operating restrictions, and voltage schedules, the Class 1E equipment will not be exposed to degraded voltage conditions from the unit auxiliary transformer.

The existing design of Pilgrim Nuclear Power Station, Unit 1 complies with NRC Staff Position 2 and will prevent adverse interaction of the offsite and onsite emergency power systems.

The proposed Technical Specifications changes concerning surveillance requirements and the method of testing the emergency diesel generators have been reviewed and found to meet NRC Staff Positon 3.

REFERENCES

1. NRC letter (D. K. Davis) to Boston Edison Company (G. C. Andognini), dated June 3, 1977.

2. Boston Edison Company letter (G. C. Andognini) to NRC (D. K. Davis), dated August 8, 1977.

3. Boston Edison Company letter (J. E. Howard) to NRC (D. K. Davis), dated August 24, 1977.

4. Boston Edison Company letter (C. G. Andognini) to NRC (T. A. Ippolito), dated September 27, 1980.

5. Boston Edison Company letter (C. G. Andognini) to NRC (T. A. Ippolito), dated March 28, 1980.

6. Boston Edison Company letter (A. V. Morisi) to NRC (T. A. Ippolito), dated October 26, 1981.

7. Boston Edison Company letter (A. V. Morisi) to NRC (D. B. Vasallo), dated June 17, 1982.

8. Code of Federal Regulations, Title 10, Part 50 (10 CFR 50), General Design Criterion 17 (GDC 17), "Electric Power Systems" of Appendix A "General Design Criteria for Nuclear Power Plants."

9. IEEE Std. 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations."

10. IEEE Std. 308-1974, "Criteria for Class 1E Power Systems for Nuclear Power Generating Stations."

11. NRC letter (T. A. Ippolito) to Boston Edison Company (G. Carl Andognini), dated May 12, 1980.