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NRC Research and/or Technical Assistance Report

DEGRADED GRID PROTECTION FOR CLASS 1E POWER SYSTEMS, QUAD CITIES STATION, UNIT NOS. 1 AND 2

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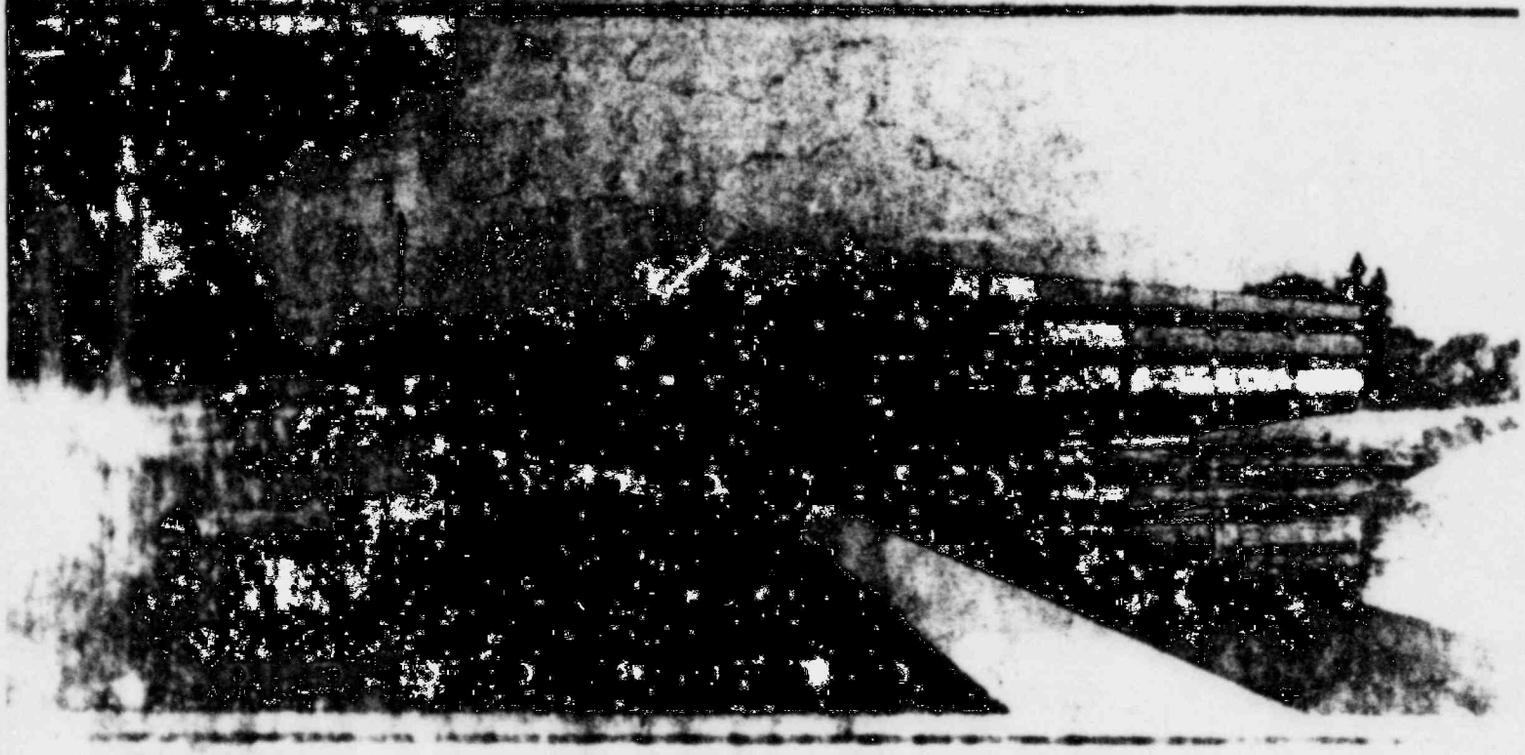

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INTERIM REPORT

DEGRADED GRID PROTECTION FOR CLASS 1E POWER SYSTEMS

QUAD CITIES STATION, UNIT NOS. 1 AND 2

Docket No. 50-254 and 50-265

March 1982

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ABSTRACT

This EGSG Idaho, Inc. report reviews the susceptibility of the safety-related electrical equipment, at the Quad Cities 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 EGSG Idaho, Inc., Reliability and Statistics Branch.

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DEGRADED GRID PROTECTION FOR CLASS 1E POWER SYSTEMS

QUAD CITIES STATION, UNIT NOS. 1 AND 2

1.0 INTRODUCTION

On June 3, 1977, the NRC requested Commonwealth Edison (CE) to assess the susceptibility of the safety-related electrical equipment at the Quad Cities 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, CE 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.

CE responded to the NRC letter on July 27, 1977.[2] CE proposed design modifications on June 26, 1980[3] and provided additional details on the modifications on October 1, 1980.[4] Draft technical specifications were submitted on October 22, 1981.[5] These were modified by a submittal of January 6, 1982,[6] and replaced by a submittal of March 4, 1982.[7]

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), "Electrical Power Systems," of Appendix A, "General Design Criteria for Nuclear Power Plants," of 10 CFR 50.[8]

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

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

4. Staff positions as detailed in a letter sent to the licensee, dated June 3, 1977.[1]

5. ANSI Standard C84.1-1977, "Voltage Ratings for Electrical Power Systems and Equipment (60 HZ)."[11]

3.0 EVALUATION

This section provides, in Subsection 3.1, a brief description of the existing undervoltage protection at the Quad Cities 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 system meets the design base criteria.

3.1 Existing Undervoltage Protection. The present design utilizes two undervoltage relays on each 4160V Class 1E bus. They are arranged in a two-out-of-two logic scheme that senses complete loss of voltage. The relays and their logic circuitry start the diesel generator, initiate load-shedding, and trip the incoming line breaker.

The existing logic circuitry of the undervoltage protection system does not disable the load-shed feature once the diesel generators are supplying power to the Class 1E buses.

3.2 Modifications. To protect the Class 1E safety-related equipment from the effects of a degraded grid condition, the licensee has proposed adding another set of undervoltage relays to each of the 4160V Class 1E buses. Each set will be comprised of two solid-state undervoltage relays that have an inherent time delay of seven seconds, arranged in a two out-of-two logic scheme, with associated auxiliary relays and a timer added to the undervoltage logic circuitry. The setpoint of the second-level protection relays will be 3840V ± 2% with a time delay of 5 minutes. Should the two undervoltage relays remain tripped for 5 minutes, or if a LOCA signal occurs during that 5 minute period, the diesel is started, and the undervoltage condition is annunciated in the control room, the incoming line breakers are tripped, load-shedding is initiated, and finally the diesel generator breaker is closed when the voltage and the frequency from the diesel generator are satisfactory. The loss-of-voltage relays function as before, with a setpoint of 3045V ± 5%.

Once the diesel generator is supplying its associated Class 1E bus, load-shedding is blocked by the "b" contact of the diesel generator breaker.

Proposed changes to the station's technical specifications, adding the surveillance requirements, allowable limits for the setpoint and time delay, and limiting conditions for operation for the second-level undervoltage monitors, were furnished by the licensee.[7]

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 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 3840V at the 4160V bus is 96.0% of the motor nominal voltage rating of 4kV. This voltage setpoint was chosen after a system voltage analysis was completed.[12] The time delay allows operator action to improve the voltage levels. The time delay is defeated immediately should a LOCA signal occur.

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

The relay logic is arranged in a two-out-of-two logic scheme, 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."

      There is no induced time delay for undervoltage protection should an accident signal be present. The Class 1E bus will be ready for transfer to diesel-generator power before the diesel is up to speed.

   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 minimum time delay of 5.6 seconds is long enough to override any short inconsequential grid disturbances.

   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[12] indicates that the time delay will not cause any failures of the safety-related equipment since the nominal voltage setpoint is within the allowable tolerance of the equipment voltage rating.

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 operations, surveillance requirements, trip setpoints with minimum and maximum limits, and allowable values for the second-level voltage protection monitors."

The licensee's proposal for technical specification changes includes all the required items. The voltage setpoint, with the maximum allowable limit included, is 3917V. A high setpoint is needed to assure adequate voltages to all Class 1E equipment. The lowest bus voltage available to the undervoltage relays, as determined by CE, is 3840V.[2] Therefore, if both undervoltage relay setpoints drifted to the upper limit, spurious trips of the offsite source due to operation of the undervoltage relays could occur. It is unlikely that both setpoints would drift to the upper limit concurrently. Therefore, the proposed setpoint and tolerances are acceptable. The limiting conditions for operation, the surveillance requirements, the channel test frequency and the calibration frequency are included in the technical specifications, and while not in conformance with the model technical specifications, do meet the criteria of the staff's positions.

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 has modified the Quad Cities Station to incorporate this feature in the circuit design. The load-shed is blocked by an auxiliary contact of the diesel generator circuit breaker.

The third NRC staff position requires that certain test requirements be added to the technical specifications. These tests were 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 testing procedures proposed by the licensee comply with most of this position. Load-shedding on the trip of offsite power is tested. Load-sequencing, once the diesel generator is supplying the safety buses, is tested. A simulated loss of the diesel generator and subsequent load-shedding and load-sequencing once the diesel generator is back on-line is not tested. A loss of the diesel generator prohibits automatic restarting. The load sequencer is controlled by a contact of the diesel generator breaker, and therefore, by design, tripping of the diesel generator breaker will reset the load shedding and the load sequencing circuitry. The time duration of the test will verify that there is no interaction between the offsite and the onsite power sources and that the load-shed bypass circuit is functioning properly.

4.0 CONCLUSIONS

Based on the information provided by CE, 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.

The load-shed circuitry has been modified to comply with staff position 2 and it will prevent adverse interaction of the offsite and onsite emergency power systems.

The changes to the technical specifications adequately test the system modifications and comply with staff position 3. The surveillance requirements, limiting conditions for operation, minimum and maximum limits for the trip point, and allowable values satisfy staff position 1.

Therefore, CE's proposed changes and technical specification changes are acceptable. It is recommended that the proposed technical specification changes be approved and implemented to coincide with the completion of the modifications.

5.0 REFERENCES

1. NRC letter to R. L. Bolger, CE, June 3, 1977.

2. CE letter, R. L. Bolger to E. R. Goller, NRC, "Onsite Emergency Power Systems," July 22, 1977.

3. CE letter, R. F. Janecek to D. G. Eisenhut, NRC, "Second Level of Undervoltage Protection for CE Onsite Emergency Power Systems," June 28, 1978.

4. CE letter, R. F. Janecek to T. M. Novak, NRC, "Response to Request for Information Concerning Undervoltage Protection," October 1, 1980.

5. CE letter, T. J. Rausch to D. G. Eisenhut, NRC, "Draft Technical Specifications Concerning Undervoltage Protection," October 28, 1981.

6. CE letter, T. J. Rausch to P. O'Connor, NRC, "Draft Technical Specification Concerning Undervoltage Protection," January 6, 1982.

7. CE letter, T. J. Rausch to H. R. Denton, NRC, "Proposed Technical Specification Changes to Implement Second-level Undervoltage Relays," March 8, 1982.

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

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

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

11. ANSI C84.1-1977, "Voltage Ratings for Electric Power Systems and Equipment (60 HZ)."

12. "Adequacy of Station Electric Distribution System Voltages, Quad Cities Station, Unit Nos. 1 and 2," EG&G Idaho, Inc. Informal Report EGG-EA-5323, A. Udy, March 1981.