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TECHNICAL EVALUATION REPORT, DEGRADED GRID PROTECTION FOR CLASS 1E POWER SYSTEMS, THREE MILE ISLAND NUCLEAR STATION UNIT 1, DOCKET NO. 50-289

NRC Research and Technical Assistance Report

C. J. Cleveland

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TECHNICAL EVALUATION REPORT
DEGRADED GRID PROTECTION FOR CLASS 1E POWER SYSTEMS

THREE MILE ISLAND NUCLEAR STATION UNIT 1

Docket No. 50-289

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ABSTRACT

In June 1977, the NRC sent all operating reactors a letter outlining three positions the staff had taken in regard to the onsite emergency power systems. Metropolitan Edison Company (Met-Ed) was to assess the susceptibility of the safety-related electrical equipment at the Three Mile Island Nuclear Station Unit 1, to a sustained voltage degradation of the offsite source and interaction of the offsite and onsite emergency power systems. This report contains an evaluation of Met-Ed's analyses, modifications, and technical specification changes to comply with these NRC positions. The evaluation has determined that Met-Ed complies with the NRC positions.

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1.0 INTRODUCTION

On June 3, 1977, the NRC requested the Metropolitan Edison Company (Met-Ed) to assess the susceptibility of the safety-related electrical equipment at the Three Mile Island Nuclear Station Unit No. 1 (TMI-1) 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, Met-Ed 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.

By letter dated July 22, 1977, Met-Ed acknowledged receipt of the NRC letter and requested an extension of 31 days.[2] On August 19, 1977, Met-Ed proposed certain design modifications and technical specification changes to satisfy the staff positions.[3] A review of this submittal revealed several areas in need of clarification by the licensee. On August 14, 1979, a request for additional information was sent to Met-Ed by the NRC.[4] On May 15, 1980, and June 27, 1980, Met-Ed submitted design modifications and answers to the request for additional information.[5,6] The modifications consist of the installation of a second-level undervoltage (UV) protection system for the class 1E equipment and a redesign of the loss-of-offsite power relay scheme.

On November 7, 1980, Met-Ed submitted proposed changes to the plant's technical specifications as required by the staff positions.[7] The NRC required that the UV relay setpoint and time delay, with maximum and minimum allowable limits, surveillance requirements, and certain test requirements be included in these technical specification changes.

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 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, "Class 1E Power 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 TMI-1; in Subsection 3.2, a description of the licensee's proposed modifications for the second-level undervoltage protection; and in Subsection 3.3, a discussion of how the proposed modifications meet the design base criteria.

3.1 Existing Undervoltage Protection. On each of the two 4160V engineered safety (ES) buses and on the 480V ES buses 1P, 1R, 1S, and 1T, there are three electromagnetic, inverse time UV relays to detect loss of offsite power. They are arranged in a two-out-of-three logic scheme with setpoints of 3588V and 410V, respectively. The 4160V relays are set to close at a slower rate than the 480V relays so as not to exceed the diesel generator block-1 loading conditions.[12] Upon a loss of voltage on these buses, the feed breakers to the 4160V ES buses are tripped, the diesel generator to the associated bus is started, and the buses are load-shed. The diesel generator breakers automatically close as the unit comes up to rated speed and voltage.

3.2 Modifications. The licensee has proposed a complete redesign of his undervoltage protection scheme. All electromagnetic relays on the 4160V safety buses will be replaced by solid-state instantaneous relays and timers.

Three relays on each bus will be arranged in a two-out-of-three coincident logic scheme with a voltage setpoint of 2400V (-200V, +460V) and a time delay of 1.5 seconds (-0.5, +0.5 second). These relays will be used to sense a loss-of-offsite power condition. If tripped, these relays will trip the safety bus feed breaker, initiate load shedding, and start the buses respective diesel generator. These relays will also initiate an annunciator in the main control room.

For second-level undervoltage protection, three additional solid state instantaneous relays, arranged in a two-out-of-three coincident logic will be added to each 4160V safety bus. The setpoint of these relays will be 3595V (+55V, -35V) and the timer will be set at 10 seconds (+2, -2 seconds).

If tripped, these relays and timer will trip the associated safety bus feeder breaker, initiate load shedding, and start the diesel generator. These relays will also trip an annunciator in the main control room.

In addition, the relays on the 480V safety buses will have the breaker tripping function removed and will be used solely as a means to initiate an annunciator in the main control room. These relays will be set to trip at or about 92% of 460V.[13] This annunciator will be used to alert the operators of low voltage conditions to allow them time to shed unnecessary loads to restore voltage and preclude trips if possible.

Load-shedding, once the diesel generator is supplying the class 1E buses, will be disabled. The load-shed feature will be reinstated when the buses are supplied from the offsite source.

Proposed changes to the plant'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 protection) were also furnished by the licensee.

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 3595V at the 4160V bus is 89.9% of motor rated voltage of 4000V. This setpoint reflected down to the 480V buses is 82.8% of nominal system voltage. Whereas the licensee has substantiated and documented that the motor starters will pick-up at 75% voltage and that the control circuitry can withstand a voltage lower than the setpoint, I find the setpoint acceptable at this level.

   At the 460V motor terminals, the nominal setpoint will correspond to 393.3V (85.5%) and, with the minimum allowable limit, the setpoint will correspond to 389.7V (84.7%). The licensee has used several reasons to justify this seemingly low setpoint voltage. He has documented that all 460V motors have a service factor rating of 1.15, and that the motors operate at 1.0 service factor. Using these facts, along with NEMA MG1-1972[15] and IEEE 141-1976[16], the licensee has calculated that the motors could withstand a voltage of 397.7V (86.5%) for a sustained length of time without exceeding the motor's specified heat rise. Another factor considered by the licensee was that, for the voltage to go below 90% of rated motor voltage, three circumstances would have to happen simultaneously; the loss of one auxiliary transformer, the grid would have to be degraded to 225kV, and an ES signal. Lastly, the licensee considered the fact that immediately following an ES signal, the balance of plant loads (BOP) will decrease, thereby helping to increase the voltage.

In view of these considerations and the fact that the 480V buses are annunciated before this low voltage can be reached, by a considerable margin (5%), I find this setpoint acceptable at this level also.

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

   The proposed modification incorporates a two-out-of-three 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."

      The proposed maximum time delay of 10 seconds (+2, -2 seconds) does not exceed this maximum time delay. A review of the licensee's FSAR substantiates that this maximum time delay is not exceeded.

      The proposed time delay will not be the cause of any thermal damage to the safety-related equipment.

   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 8 seconds is long enough to override any short, inconsequential grid disturbances. Further, I have reviewed the licensee's analysis and agree with the licensee's finding that any voltage dips caused from the starting of 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[5] indicates that the time delay will not cause any failures of the safety-related equipment since the voltage setpoint is acceptable as discussed in 1 above.

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 in his proposal that the modifications are designed to meet or exceed IEEE Standard 279.

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's proposal for technical specification changes includes all the required items. The setpoint of 3595V ($\pm$55, -35) does not infringe into the expected operating envelope and will not compromise the life of the motors. Spurious trips are, thereby, not foreseen. The limiting conditions for operation, calibration checks, and surveillance requirements 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 current undervoltage relaying scheme for all ES buses already has these features incorporated. They will be maintained when the system is modified for second-level undervoltage protection as well.

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 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 the full intent of this position.[7] Load-shedding on offsite power trip is tested. Load-sequencing, once the diesel generator is supplying the safety buses, is tested. The time duration of the tests (equal to or greater than 5 minutes) will verify that the time delay is sufficient to avoid spurious trips and that the load-shed bypass circuit is functioning properly.

4.0 CONCLUSIONS

Based on the information provided by Met-Ed, it has been determined that the proposed modifications comply with NRC staff position 1. All of the staff's requirements and design base criteria have been met. The modifications will protect the class 1E equipment from a sustained degraded voltage condition of the offsite power source.

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

The proposed 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 setpoint, and allowable values meet the intent of staff position 1.

It is therefore concluded that Met-Ed's proposed modifications and technical specification changes are acceptable.

5.0 REFERENCES

1. NRC letter (R. W. Reid) to Met-Ed (J. G. Herbein), dated June 3, 1977.

2. Met-Ed letter (J. C. Herbein) to NRC (R. W. Reid), dated July 22, 1977.

3. Met-Ed letter (J. C. Herbein) to NRC (R. W. Reid), dated August 19, 1977.

4. NRC letter (R. W. Reid) to Met-Ed (J. C. Herbein), dated August 14, 1979.

5. Met-Ed letter (J. C. Herbein) to NRC (R. W. Reid), dated May 15, 1980.

6. Met-Ed letter (J. C. Herbein) to NRC (R. W. Reid), dated June 27, 1980.

7. Met-Ed letter (H. D. Hukill) to NRC (R. W. Reid), dated November 7, 1980.

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. Met-Ed letter (R. C. Arnold) to NRC (R. W. Reid), dated September 16, 1976.

13. Telecon, J. Torcivia, GPUSC, C. J. Cleveland, EG&G Idaho, Inc., January 16, 1981.

14. Final Safety Analysis Report (FSAR) for the Three Mile Island Nuclear Station Unit 1.

15. IEEE Standard 141-1976, "IEEE Recommended Practice for Electric Power Distribution for Industrial Plants."

16. NEMA Standard, NEMA MG1-1972, "Motors and Generators."