ABSTRACT

This report documents the technical evaluation of the proposed design modifications and Technical Specification changes for protection of Class 1E equipment from grid voltage degradation for the Millstone Nuclear Power Station, Unit 1. The review criteria are based on several IEEE standards and the Code of Federal Regulations. The evaluation finds that the licensee has not provided sufficient information on the undervoltage protection system to allow a complete evaluation into the adequacy of protecting the Class 1E equipment from sustained voltage degradation

FOREWORD

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

The U. S. Nuclear Regulatory Commission funded the work under the authorization entitled "Electrical, Instrumentation and Control System Support," B&R 20 19 04 031, FIN A-0250.

UCID--19139

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TECHNICAL EVALUATION REPORT ON THE
PROPOSED DESIGN MODIFICATIONS AND TECHNICAL SPECIFICATION CHANGES
ON GRID VOLTAGE DEGRADATION
FOR THE
MILLSTONE NUCLEAR POWER STATION, UNIT 1
(Docket No. 50-245)

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1. INTRODUCTION

By letter dated June 3, 1977 [Ref. 1], the U. S. Nuclear Regulatory Commission (NRC) requested the Northern Utilities (NU), the licensee, to assess the susceptibility of the Class 1E electrical equipment to sustained degraded voltage conditions at the offsite power sources and to the interaction between the offsite and onsite emergency power systems at the Millstone Nuclear Power Station, Unit 1. 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 that the licensee propose plant modifications, as necessary, to meet the NRC staff positions, or provide a detailed analysis which shows that the facility design has equivalent capabilities and protective features. Further, the NRC required certain Technical Specifications be incorporated into the facility's operating license.

By letters dated August 1, 1977 [Ref. 2], August 10, 1979 [Ref. 3], April 29, 1980 [Ref. 4], July 16, 1980 [Ref. 5], August 20, 1980 [Ref. 6], and April 21, 1982 [Ref. 7], the licensee submitted certain design modification details, additions to the Technical Specifications, and limiting conditions for operation (LCO's). The design modification details include a degraded voltage protection system for the Class 1E equipment. The additions to the Technical Specifications and LCO's are in regard to calibrations, surveillance requirements, test requirements, and "action" statements associated with the existing undervoltage protection system.

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

2. DESIGN BASIS CRITERIA

The design basis criteria that were applied in determining the acceptability of the system modification to protect the 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," 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 undervoltage protection system design consists of the following:

(1) There are two undervoltage relays (induction disc type) connected to the Reserve Station Service Transformer (RSST) bushing potential devices to sense the 345 kV system. The RSST is the preferred off-site source. These relays (level 1 of undervoltage protection) are used to sense a loss of offsite power condition. The voltage setpoint for these relays is 71% 345 kV (246 kV) with a time delay of 6 seconds at 50% of 345 kV. The output of each relay supplies each of two identical and redundant "loss of normal power" (LNP) circuits. The LNP circuits initiate the start of the onsite sources (diesel generator and gas turbine), isolation of the Class 1E buses, and load shedding. Once the onsite sources reach operating speed, the output breakers are closed. A block of Class 1E loads is energized immediately while the remaining loads are sequenced on by the load sequencer.

(2) There are also four solid state bistable voltage sensors installed at the bushing potential devices on the RSST to sense degraded voltage conditions (level 2 of undervoltage protection). Two of

the bistable sensors monitor phases one and two and the remaining two sensors monitor phases two and three. This sensing system makes up two protective channels, each requiring a signal from both devices (2-out-of-2 logic). The setpoint for these devices is 336 kV (97% of 345 kV) with a time delay of one second. Actuation of any one of the four sensors will alarm in the control room. The trip signal from any one of the channels is interlocked with a SI signal. Therefore, for a degraded voltage condition concurrent with a SI, automatic disconnection from the RSST and transfer to the onsite sources will occur. Otherwise, operator action is required to restore adequate voltage. The licensee's basis for not providing automatic disconnection under all degraded conditions is that the auto-tripping of the unit from the transmission grid could cause a "cascading effect". This cascading effect could cause other nuclear plants to subsequently trip, further degrading the system. By means of corrective measures the grid voltage could be increased to acceptable levels for continued plant operation.

The load shed feature is presently disabled once the onsite sources are supplying the Class 1E buses. Should the onsite sources trip, the load shed feature is not auto-reinstated. The operator would then manually load shed and re-energize the buses.

3.2 MODIFICATIONS

The licensee has proposed the following modifications to the existing undervoltage protection system:

(1) The present loss of offsite power (level 1) undervoltage protection scheme and the level 2 protection scheme will be redesigned to provide undervoltage protection directly at the Class 1E buses as required by IEEE 279-1971. The redesign will include new undervoltage protection setpoints and time delays to allow for short duration transients and Class 1E equipment protection. System level actuation will remain the same as the existing undervoltage protection schemes. That is, automatic disconnection from the offsite source will only occur if a SI signal is present concurrent with level 2 actuation.

(2) Circuit design changes will be made, in addition to the above, to automatically reinstate the load shed feature following tripping of the onsite sources.

3.3 DISCUSSION

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

3.3.1 NRC Staff Position 1: Second Level of 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 has not submitted details on the selection of the new voltage and time delay setpoints as the system redesign is not yet completed.

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

Since new design details have not been submitted, determination for providing the required coincident logic cannot be made.

(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 assured in the FSAR accident analysis."

Since new design details have not been submitted, determination of the adequacy of the time delay selected cannot be made.

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

The licensee states that the time delay associated with the redesign will be such that it will allow for short duration transients caused from grid voltage fluctuations or motors starting.

(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."

Since the system redesign is not complete, the licensee has not submitted an analysis to show that the setpoints selected will provide equipment protection at all Class 1E power system distribution levels.

(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 level 2 of undervoltage protection system redesign will only allow for automatic disconnection from the degraded offsite sources whenever an accident condition occurs concurrently. Without an accident condition present, actuation of the level 2 undervoltage protection scheme will initiate an alarm which signals the operator of a degraded voltage condition. Plant procedures will then direct the operator for corrective actions.

The licensee has not provided the following information to support this method of providing undervoltage protection for the Class 1E equipment from sustained voltage degradation:

(a) Time versus voltage degradation limits for continued plant operation.

(b) Minimum voltage limit at which disconnection would occur if voltage restoration is not completed.

(c) Analysis of the Class 1E equipment operating capabilities versus the time and voltage limits established.

(d) List of the normally running Class 1E equipment which could be lost as a result of the time/voltage limits established for continued plant operation.

(e) Basis for the time limits for continued plant operation.

(f) Details of the corrective actions being taken to restore adequate voltage.

The licensee has submitted a list of reactor systems [Ref. 7] still available to safely shutdown the plant should the normally running Class 1E equipment be lost as a result of continued plant operation under sustained voltage degradation conditions. These systems are presently being evaluated by the Reactor Systems Branch of the NRC.

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

The licensee states that the proposed design modifications will comply with the requirements of IEEE 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."

Limiting conditions for operation, surveillance requirements and the trip setpoints for the existing undervoltage protection schemes are included in the licensee's proposed Technical Specifications.

[redacted]

The second position requires the system be designed to prevent automatic load shedding of the emergency buses once the onsite sources are supplying power to 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 licensee is bypassing the load shed feature once the onsite sources are supplying the Class 1E buses. The licensee also states that design modifications will be incorporated into the new undervoltage protection system redesign to automatically reinstate the load-shed feature following the tripping of the onsite sources. Design details for the modification should be submitted.

3.3.3 NRC Staff Position 3: Onsite Power Source Testing

The third position requires that certain test requirements 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 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 circuitry, and that there is no adverse interaction between the onsite and offsite power sources.

Existing Technical Specifications include tests to demonstrate the full functional operability and independence of the onsite power sources by simulating loss of offsite power in conjunction with a safety injection signal. Since design modifications will include the auto-reinstatement of the load shed feature following onsite source tripping, a test must be included in the Technical Specifications to demonstrate the operability that the bypassing of the load shed feature will automatically be reinstated following onsite source tripping with subsequent load sequencing.

3.4 TECHNICAL SPECIFICATION

The licensee submitted Technical Specifications on the existing undervoltage protection system. The Technical Specifications include:

(1) Trip setpoints without tolerances for the level 1 (loss of voltage) and level 2 (degraded voltage) undervoltage protection schemes.

(2) Coincident logic (1-out-of-2 for level 1 and 2-out-of-2 per each of the two channels for level 2).

(3) Surveillance requirements for channel calibration during refueling shutdown and a functional test during refueling shutdown. No channel check requirements were included.

(4) Action statements reguarding limiting conditions for operation when the number of trip systems required is reduced.

4. CONCLUSIONS

Based on the information provided by Northeast Utilities, it has been determined that the existing undervoltage protection design does not meet the requirements of NRC Staff Position 1. The licensee's proposed system redesign for providing sustained undervoltage protection for the Class 1E equipment cannot be fully evaluated with respect to the requirements of NRC Staff Position 1 until the following information is provided:

(1) Details of the operation and design of the new undervoltage protection schemes. This must include voltage setpoints and time delays with tolerances and the coincident logic circuitry.

(2) Verification that the system design meets the requirements of IEEE 279-1971.

(3) Time and voltage limits defined for continued plant operation should a degraded voltage condition exist without a concurrent accident condition and the basis for these limits.

(4) Minimum voltage limit for tripping should voltage restoration fail.

(5) Analysis to verify the setpoints selected will provide equipment protection at all Class 1E power system distribution levels and will minimize the effect of short duration transients. Analysis should also compare Class 1E equipment operating capability with the voltage/time limits established for continued plant operation.

(6) Define which Class 1E equipment could be lost as a result of continued plant operation under sustained voltage degradation (with respect to the established voltage/time limits for operation).

(7) Details of the actions being taken to restore voltage when the operator receives an alarm.

(8) Proposed Technical Specifications to include the setpoints with tolerances, surveillance requirements, testing and calibration requirements, and limiting conditions for operation.

The licensee is proposing to modify the load shed circuitry to comply with NRC Staff Position 2. Details of the circuitry modification is required to verify the compliance with this position.

Since the system redesign is not complete, a test has not been proposed in the Technical Specifications to demonstrate the operability of the auto-reinstatement of the load shed feature following onsite source tripping, thus all the requirements of NRC Staff Position 3 have not been met.

REFERENCES

1. NRC letter (A. Schwencer) to Northeast Nuclear Energy Company (NNECO), dated June 2, 1977.

2. NNECO letter (D. C. Switzer) to the NRC (G. Lear), dated August 1, 1977.

3. NU letter (W. G. Counsil) to the NRC (D. L. Ziemann), dated August 10, 1979.

4. NU letter (W. G. Counsil) to the NRC (D. M. Crutchfield), dated April 29, 1980.

5. NU letter (W. G. Counsil) to the NRC (D. M. Crutchfield), dated July 16, 1980.

6. NU letter (W. G. Counsil) to the NRC (D. M. Crutchfield), dated August 20, 1980.

7. NU letter (W. G. Counsil) to the NRC (D. M. Crutchfield and R. A. Clark), dated April 21, 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 Standard 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations."

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