July 7, 1981

Docket No. 50-245
LS05-81- 07-011

Mr. W.G. Counsil, Vice President
Nuclear Engineering and Operations
Northeast Nuclear Energy Company
Post Office Box 270
Hartford, Connecticut 06101

Dear Mr. Counsil:

SUBJECT: SEP TOPIC VIII-4, ELECTRICAL PENETRATIONS OF REACTOR CONTAINMENT SAFETY EVALUATION REPORT (MILLSTONE NUCLEAR POWER STATION UNIT 1)

Enclosure 1 is the staff's safety evaluation report for SEP Topic VIII-4. The basis for Enclosure 1 is given in Enclosure 2.

Enclosure 2 is our contractor's technical evaluation that has been revised by the additional information and comments provided in your letter of May 20, 1981.

Enclosure 1 is the staff's position with regard to the acceptability of the electrical penetrations for your facility. The staff has concluded that your facility meets current licensing criteria.

Sincerely,

Dennis M. Crutchfield, Chief
Operating Reactors Branch #5
Division of Licensing

Enclosure:
As stated

cc w/enclosure:
See next page

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ENCLOSURE 1

SEP TOPIC VIII-4

ELECTRICAL PENETRATIONS OF REACTOR CONTAINMENT

I. INTRODUCTION

The safety objective of Topic VIII-4, "Electrical Penetrations of Reactor Containment," is to assure that all eletrical penetrations in the containment structure are designed not to fail from electrical faults during a high energy line break.

As part of the Systematic Evaluation Program (SEP) the NRC staff performed an audit, comparing sample containment electrical penetrations in SEP facilities with current licensing criteria for protection against fault and overload currents following a postulated accident.

II. REVIEW CRITERIA

The review criteria are presented in Section 2.0 of EG&G Report 0105J, "Electrical Penetrations of the Reactor Containment." In addition, in licensing new plants, the staff requires compliance with the recommendations of Regulatory Guide 1.63 or an acceptable alternative method.

For each containment electrical penetration, the protective systems should provide primary and backup circuit protection devices to prevent a single failure in conjunction with a circuit overload from impairing containment integrity. The primary and backup protection devices must have trip time vs. current response characteristics which assure protection against penetration failure. The protection devices are to be periodically tested to verify trip setpoints and adequacy of response.

No single failure should allow excessive currents in the penetration conductors that will degrade the penetration seals. Where external control power is used for actuating the protection systems the power for primary and backup breakers should be derived from separate sources. Overcurrent signals for tripping primary and backup system devices should be electrically independent and physically separated.

III. RELATED SAFETY TOPICS AND INTERFACES

The scope of review for this topic was limited to avoid duplication of effort since some aspects of the review were performed under the related topic III-12, Environmental Qualification. The related topic report contains the acceptance criteria and review guidance for its subject matter.

Theoretically, there are no safety topics that are dependent on the present topic information for their completion, however the results of the present topic have a definite impact upon the capability of equipment inside of containment to function after a high energy line break.

IV. REVIEW GUIDELINES

The review guidelines are presented in Section 3.0 of EG&G Report 0105J.

V. EVALUATION

As noted in the EG&G Report on this topic with a LOCA environment inside containment, the penetrations conform to the current licensing criteria.

VI. CONCLUSIONS

As a result of our review we have concluded that, with a LOCA environment inside containment, the penetrations conform to the current licensing criteria and are, therefore, acceptable.

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ENCLOSURE 2

SEP TECHNICAL EVALUATION REPORT

ELECTRICAL PENETRATIONS OF REACTOR COMPARTMENT

FINAL DRAFT

MILLSTONE NUCLEAR STATION, UNIT NO. 1

Northeast Utilities

June 1981

S. E. Mays

6-9-81

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SEP TECHNICAL EVALUATION REPORT

ELECTRICAL PENETRATIONS OF REACTOR COMPARTMENT

MILLSTONE NUCLEAR STATION, UNIT NO. 1

1.0 INTRODUCTION

This review is part of the Systematic Evaluation Program (SEP), Topic VIII-4. The objective of this review is to determine the capability of the electrical penetrations of the reactor compartment to withstand short circuit conditions of the worst expected transient fault current resulting from single random failures of circuit overload protection devices.

General Design Criterion 50, "Containment Design Basis" of Appendix A, "General Design Criteria for Nuclear Power Plants" to 10 CFR Part 50 requires that penetrations be designed so that the containment structure can, without exceeding the design leakage rate, accommodate the calculated pressure, temperature, and other environmental conditions resulting from any loss-of-coolant accident (LOCA).

IEEE Standard 317, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations", as augmented by Regulatory Guide 1.63, provides a basis of electrical penetrations acceptable to the staff.

Specifically, this review will examine the protection of typical electrical penetrations in the containment structure to determine the ability of the protective devices to clear faults prior to exceeding the penetration design ratings under LOCA temperatures.

2.0 CRITERIA

IEEE Standard 317, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations" as supplemented by Nuclear Regulatory Commission Regulatory Guide 1.63, "Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants" provides the basis acceptable to the NRC staff. The following criteria are used in this report to determine compliance with current licensing requirements:

1. IEEE Standard 317, Paragraph 4.2.4 -- "The rated short circuit current and duration shall be the maximum short circuit current in amperes that the conductors of a circuit can carry for a specified duration (based on the operating time of the primary overcurrent protective device or apparatus of the circuit) following continuous operation at rated continuous current without the temperature of the conductors exceeding their short circuit design limit with all other conductors in the assembly carrying their rated continuous current under the specified normal environmental conditions."

   This paragraph is augmented by Regulatory Guide 1.63, Paragraph C-1 -- "The electric penetration assembly should be designed to withstand, without loss of mechanical integrity, the maximum possible fault current versus time conditions that could occur given single random failures of circuit overload protection devices."

2. IEEE Standard 317, Paragraph 4.2.5 -- "The rated maximum duration of rated short circuit current shall be the maximum time that the conductors of a circuit can carry rated short circuit current based on the operating time of the backup protective device or apparatus, during which the electrical integrity may be lost, but for which the penetration assembly shall maintain containment integrity."

3. IEEE Standard 317, paragraph 6.4.14 -- "The maximum duration of rated short circuit shall be verified by the test. The test shall be conducted at maximum postulated design bases event temperature and pressure and relative humidity. The test current and duration shall be in accordance with Section 4.2.5 plus margin. The test duration shall be not less than the time required for the backup overcurrent protection device to function."

3.0 DISCUSSION AND EVALUATION

In this evaluation, the results of typical containment penetrations being at LOCA temperature initially concurrent with a random failure of the circuit protective devices will be analyzed.

Northeast Utilities (NU) provided information (Reference 1) on typical penetrations. No evaluation of the data was provided. A temperature limit of 352°F (177°C) before seal failure for the three penetrations has been establisned based on testing done by Oyster Creek Nuclear Station for identical type connectors (Reference 2) in lieu of docketed data from NU describing tests or analysis to specify a temperature limit.

Maximum short circuit current available (I_{sc}) was provided by Northeast Utilities for a three-phase bolted fault. Rated current (I_r) for each penetration was also provided.

Since NU has not docketed any testing per IEEE Std 317 to verify the ability of the penetration to withstand a LOCA environment, the following formula (Reference 3) was used to determine the time allowed before a short circuit would cause the penetration to heat up to the temperature limit.

$$t = \frac{A^2}{I^2} \quad .0297 \log \frac{T_2+234}{T_1+234} \qquad \text{(Formula 1)}$$

where

- t = time in seconds
- I = current in amperes
- A = conductor area in circular mils
- T_1 = initial temperature (138°C, LOCA condition)
- T_2 = maximum penetration temperature before failure.

This is based on the heating effect of the short circuit current on the conductor and does not take into account heat losses of the conductor. For times less than several seconds, this heat loss is negligible.

In evaluating the capability of the penetration to withstand a LOCA temperature with a short circuit current, Formula 1 was used to calculate the time required to heat the conductor from the LOCA temperature to penetration failure temperature for currents from rated current to maximum short circuit current in 20% increments. Times for the primary and secondary overcurrent devices to interupt these fault currents were calculated. Where breaker ratings provided by the licensee indicated minimum and maximum fault clearing times, the maximum time was used for conservatism.

3.1 Typical Low Voltage (0-1000V) Penetrations. Northeast Utilities has identified penetration X-105D (GE type NS04) as being typical of low voltage penetrations. This penetration provides 480 V ac power to motor-operated valve 1-IC-1.

This penetration uses two #8 AWG cables in parallel and has a continuous current rating of 20 amps per conductor. The maximum available short circuit current has been determined by NU to be 1600 amps. A temperature limit of 352°F (177°C) before seal failure has been determined based on testing. At the maximum short circuit current (1600 amps), overtemperature will be reached in 0.64 second from LOCA temperature initially.

From LOCA temperature initially, the secondary breaker will not operate to clear any fault currents before penetration seal limiting temperature is attained. However, NU has determined that the outboard seal of this penetration will have an intitial temperature of not more than 90°C. From this temperature initially, the secondary breaker will still not operate to clear the fault before the conductor reaches 177°C. However the #10 AWG cable external to the penetration will fuse before this temperature is reached. The primary breaker will clear the fault currents before seal limiting temperature is attained provided that both conductors are intact. There are no Technical Specification requirements to verify that both conductors have continuity. However, NU verifies continuity upon penetration installation.

3.1.1 Low Voltage Penetration Evaluation. With an initial penetration temperature of 138°C (LOCA), penetration X-105D does not meet current requirements of RG 1.63 and IEEE Std. 317 for any short circuit fault with a failure of the primary breaker. However for an initial temperature of 90°C at the outboard seal the external cable will fuse prior to reaching the 177°C temperature limit on that seal. The penetration does meet current requirements for short circuit faults if the primary breaker operates as designed provided that both cables in the penetration are operable.

3.2 Typical Medium Voltage (≥1000 V) Penetration. Northeast Utilities has identified penetration X-101A (GE type NS03) as being typical of medium voltage penetrations. This penetration provides 4160 V ac power to Reactor Recirculation Pump 1.

This penetration uses two 500 MCM cables in parallel and has a continuous current rating of 550 amps per conductor. The maximum available short circuit current has been determined by NU to be 1700 amps. A temperature limit of 352°F (177°C) has been established based on testing. At the maximum short circuit current (1700 amps), overtemperature will be reached in 440 seconds from LOCA temperature initially.

Overcurrent protection is provided by a differential current sensing relay and a line overcurrent sensing relay, each of which will operate to trip the motor generator by securing power to the motor generator motor and opening the generator field windings. At ≥156 amps of current difference between the output of the generator and the input to the motor, the differential relay will cause a trip of the motor generator in 0.133 second or less. At line current in excess of 780 amps, the overcurrent relay will cause a trip of the motor generator in 0.18 second or less.

The line overcurrent relay will operate to clear all fault currents in excess of 780 amps prior to reaching the penetration seal temperature limit from LOCA temperature initially. For fault currents less than 1100 amps, the conductors will carry less than their rated continuous current (550 amps) provided both conductors have continuity. If one conductor is open, the overcurrent device will not operate for faults between 550 and 780 amps and penetration overheating may occur. There are no Technical Specifications requiring continuity of the conductors to be checked. However, continuity is verified during installation of the penetration.

3.2.1 Medium Voltage Penetration Evaluation. At LOCA temperature, penetration X-101A meets current requirements of RG 1.63 and IEEE

Std. 317 for short circuit faults with a failure of the line overcurrent relay since the differential relay will operate to clear the fault prior to reaching the penetration seal temperature limit. With a failure of the differential current relay at LOCA temperature, the penetration meets current requirements for all fault currents provided that both conductors in the penetration are operable.

3.3 Typical Direct Current Penetration. Northeast Utilities has identified penetration X-100A (GE type NS04) as being typical of DC penetrations. This penetration provides 125 V dc power to the solenoid valve on main steam isolation valve 203-1A.

This penetration uses #14 AWG cable and has a continuous current rating of 10 amps. The maximum available short circuit current has been determined by NU to be 95 amps. A temperature limit of 352°F (177°C) before seal failure has been determined based on testing. At the maximum short circuit current (95 amps), overtemperature will be reached in 2.38 seconds from LOCA temperature initially.

At LOCA temperature, both the primary and secondary fuses will operate to clear all fault currents before the penetration seal temperature limit is reached.

3.3.1 DC Penetration Evaluation. At LOCA temperature, penetration X-100A meets current requirements of RG 1.63 and IEEE Std. 317 for all fault currents with a failure of the primary protective device.

4.0 SUMMARY

At LOCA temperature, penetration X-105D does not meet current requirements of RG 1.63 and IEEE Std. 317 for any fault current with a failure of the primary protective device. However, based on NU's evaluation that the outboard seal will have an initial temperature less than 90°C, the external cable will fuse before the limiting temperature of 177°C is reached. If the primary device functions as designed, penetrations X-105D and X-101A meet current requirements provided that both of the conductors in the penetration are operable. There are no Technical Specification requirements to verify continuity of both conductors in penetrations using two parallel conductors per phase, but continuity is verified during penetration installation.

At LOCA temperature, penetration X-100A meets current requirements of RG 1.63 and IEEE Std. 317 for all fault currents with a failure of the primary protective device.

5.0 REFERENCES

1. Northeast Utilities letter (Counsil) to NRC (Ziemann) dated March 14, 1979.
2. Final Description and Safety Analysis Report, Oyster Creek Nuclear Station, Ammendment 62 (Docket No. 50-219-102).
3. IPC&A Publication P-32-382, "Short Circuit Characteristics of Insulated Cable."
4. Northeast Utilities letter (Counsil) to NRC (Crutchfield) dated August 29, 1980.
5. Northeast Utilities letter (Counsil) to NRC (Crutchfield) dated January 29, 1981.
6. Northeast Utilities letter (Counsil) to NRC (Crutchfield) dated May 20, 1981.
7. Millstone Nuclear Power Station Control Wiring Diagram B-187613, Sheet 434 (25205-31001)