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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

July 1, 1980

Docket No. 50-155

Mr. David P. Hoffman
Nuclear Licensing Administrator
Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201

Dear Mr. Hoffman:

RE: SEP TOPIC VIII-4 ELECTRICAL PENETRATIONS OF REACTOR CONTAINMENT (Big Rock Point)

Enclosed is a copy of our evaluation of Systematic Evaluation Program Topic VIII-4, Electrical Penetrations of Reactor Containment. This assessment compares your facility, as described in Docket No. 50-155 with the criteria currently used by the regulatory staff for licensing new facilities. Please inform us if your as-built facility differs from the licensing basis assumed in our assessment within 60 days of receipt of this letter.

This evaluation will be a basic input to the integrated safety assessment for your facility unless you identify changes needed to reflect the as-built conditions at your facility. This topic assessment may be revised in the future if your facility design is changed or if NRC criteria relating to this topic are modified before the integrated assessment is completed.

Sincerely,

Dennis M. Crutchfield

Dennis M. Crutchfield, Chief
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Enclosure:
Completed SEP
Topic VIII-4

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See next page

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SEP TECHNICAL EVALUATION

TOPIC VIII-4
ELECTRICAL PENETRATIONS OF THE REACTOR CONTAINMENT

BIG ROCK POINT NUCLEAR STATION

Consumers Power Company

Docket No. 50-155

DATE: July 1, 1980

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1.0 INTRODUCTION

This review is part of the Systematic Evaluation Program (SEP), Topic VIII-4. Consumers Power Company (CPC) has provided information (Reference 1) describing typical penetrations, typical in-containment loads, and fault currents. They did not provide an analysis of their suitability in Reference 1. The objective of this review is to determine the capability of the overcurrent protective devices to prevent exceeding the design rating of the electrical penetrations through the reactor containment during short circuit conditions at LOCA temperatures.

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 the circuit during a short circuit condition prior to exceeding the containment electrical penetration test or design ratings while at an initial LOCA temperature.

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."

3.0 DISCUSSION AND EVALUATION

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

Consumers Power Company (CPC) has provided information (Reference 1) on typical penetrations in the Big Rock Point plant. All were field manufactured per a plant design specification. CPC calculated short circuit overload limits for the penetrations. Verification test data was not available.

The penetrations consist of pipe canisters with steel headers welded to each end. Header flanges are later welded to the containment liner. Each penetration is sealed at each of two header plates by compression-type bushings providing a double barrier against leakage. Neoprene rubber insulated wires pass through the compression bushings. It is unknown if molten insulation will cause a hole in containment when the insulation melts at a temperature of 250°F (121°C). Reference 1 indicates that the Big Rock Point penetrations are identical to those of the Dresden 1 plant. The penetrations at Dresden 1 were tested to 307°F (153°C), and this temperature is used as the limiting temperature of this report.

In supplying the value of the maximum short circuit current available (I_{sc}), CPC supplied values for a bolted fault (three-phase on AC system); this type being able to supply the most heat into the penetration.

The following formula (Reference 7) was used to determine the time allowed for a short circuit before the penetration temperature would exceed its qualification value.

$$\left[\frac{I}{A}\right]^2 t = 0.0297 \log \left[\frac{T_2 + 234}{T_1 + 234}\right]$$

$$t = \frac{0.0297\ A^2}{I_{sc}^2} \log \left[\frac{T_2 + 234}{T_1 + 234}\right] \qquad \text{(Formula 1)}$$

where

t	=	Time allowed for the short circuit — seconds
I_{sc}	=	Short circuit current — amperes
A	=	Conductor area — circular mils
T_1	=	Maximum operating temperature (113°C, LOCA condition)
T_2	=	Maximum short circuit temperature (limiting temperature supplied by CPC).

This is based upon the heating effect of the short circuit current on the conductors.

Under accident conditions, a peak temperature of 235°F (113°C) is expected for the Big Rock Point plant. This figure is used for T_1 in Formula 1, to account for an elevated conductor temperature caused by pre-existing current flow and above normal ambient temperatures.

3.1 Typical Low Voltage (0-1000 VAC Penetration. This penetration has 20 #8 conductors and is rated by the manufacturer for a full-load current of 34 amperes and for a short circuit current as defined on submitted graphs (Reference 1). The circuit identified is power to the reactor clean-up pump. The source can supply 1541 amperes at the penetration due to a bolted fault.

It is calculated that the time for the penetration conductors to reach 153°C from an initial 113°C (assumed connector temperature under a LOCA environment) is 0.16 second.

The circuit breaker curves supplied by CPC show that the primary circuit breaker (100 amperes) clears this fault instantaneously [.05 second per IEEE Standard 242-1975, Table 33 (Reference 8)]. They also show that the secondary circuit breaker takes a minimum of 220 seconds to clear the fault should the primary circuit breaker fail. Faults of less magnitude showed both circuit breakers respond too slowly to adequately protect the hermetic seal of the penetration, when the current is less than 100 amperes (the penetration conductors are rated for 34 amperes).

3.1.1 Low Voltage Penetration Evaluation. With an initial penetration temperature of 113°C (the peak LOCA containment temperature), this penetration is utilized in a way that is not in conformance with the criteria of Section 2.0 of this report.

3.2 Typical Medium Voltage (>1000 VAC Penetration. CPC has identified the 2400-V reactor recirculation pump penetration as typical. Each penetration is constructed of #4/0 copper conductor w/neoprene rubber insulation through the bushings described in Section 3 and is rated for 176 full-load amperes. CPC has identified the total fault current from all sources to be 18,450 rms amperes symetrical and 25,461 amperes asymetrical.

It is calculated that the time for the penetration conductors to reach 153°C from an initial temperature of 113°C (assumed penetration temperature under a LOCA environment) is 0.18 second.

The breaker curves supplied by CPC show that the primary air circuit breaker will trip instantaneously [total clearing time, .17 second per IEEE Standard 242-1975, Table 33 (Reference 8) above 900 amperes], and the secondary air circuit breaker will clear the 18,450-ampere fault independently in 0.18 second at this maximum I_{sc}. At lower values of fault current, both circuit protective devices clear the fault in less time than it takes for the penetration conductor to reach 153°C.

3.2.1 Medium Voltage Penetration Evaluation. With an initial assumed conductor temperature equal to the peak LOCA containment temperature (113°C), this medium voltage AC penetration is utilized in conformance with the criteria described in Section 2.0 of this report.

3.3 Typical Direct Current Penetration. The penetration identified by CPC as typical for this type has 11 #8 conductors and is part of the circuit powering the emergency condenser outlet valve. CPC rates the full-load circuit capability of this penetration at 34 amperes. The circuit can supply 635 amperes into a short circuit at the penetration.

It is calculated that, with an initial conductor temperature of 113°C (the peak containment temperature under LOCA conditions), 0.95 second elapse between the occurrence of a fault condition and when the conductor temperature reaches 153°C.

The circuit breaker curves supplied by CPC show that the primary circuit breaker clears this fault instantaneously [.019 second per IEEE Standard 242-1975, Table 33 (Reference 8)]. The curves also show that the secondary circuit breaker takes between 150 and 1000 seconds to clear the same fault current. At lower fault currents, the primary circuit breaker clears, while the secondary circuit breaker does not clear the fault before the penetration conductor temperature exceeds 153°C.

3.3.1 Direct Current Penetration Evaluation. With an initial temperature of the penetration at 113°C as expected with a LOCA condition, this penetration is utilized in a way that is not in conformance with the criteria described in Section 2.0 of this report.

4.0 SUMMARY

This evaluation looks at the capability of the protective devices to prevent exceeding the design ratings of the selected penetrations in the event of (a) a LOCA event, (b) a fault current through the penetration, and simultaneously (c) a random failure of the circuit protective devices to clear the fault. The environmental qualification tests of the penetrations is the subject of SEP Topic III-12.

This assessment neglects any heat transfer from the penetration to the containment liner. To account for full-rated current in the penetration conductors, an initial penetration temperature equal to the peak LOCA in-containment temperature was assigned uniformly throughout the penetration. This report also does not account for the circuit conductor outside the penetration being smaller than the penetration conductor.

With a LOCA environment inside containment, the protection of the medium voltage AC penetration conforms to the specified criteria while the protection of low voltage AC and the DC penetrations does not conform to the same criteria which assumes a short circuit fault and random failure of the primary circuit protective devices.

The review of Topic III-12, "Environmental Qualification," may result in changes to the electrical penetration design and therefore, the resolution of the subject SEP topic will be deferred to the integrated assessment, at which time, any requirements imposed as a result of this review will take into consideration design changes resulting from other topics.

5.0 REFERENCES

1. David P. Hoffman, Docket Nos. 50-155 and 50-255, Licenses DPR-6 and DPR-20, Palisades and Big Rock Point Plants, Electric Penetrations of Reactor Containment, SEP Topic VIII-4, March 19, 1979, CPC letter.

2. General Design Criterion 16, "Containment Design" of Appendix A, "General Design Criteria of Nuclear Power Plants," 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

3. Nuclear Regulatory Commission Standard Review Plan, Section 8.3.1, "AC Power Systems (Onsite)."

4. Regulatory Guide 1.63, Revision 2, "Electrical Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants."

5. IEEE Standard 317-1976, "IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations."

6. Bechtel Test Report, PO 5935-E-20-AC, Report No. 7, January 14, 1969.

7. IPCEA Publication P-32-382, "Short Circuit Characteristics of Insulated Cable."

8. IEEE Standard 242-1975, "IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power System."

9. Letter from M. S. Turback (Commonwealth Edison) to Edson Case, December 9, 1977.