ENCLOSURE 2

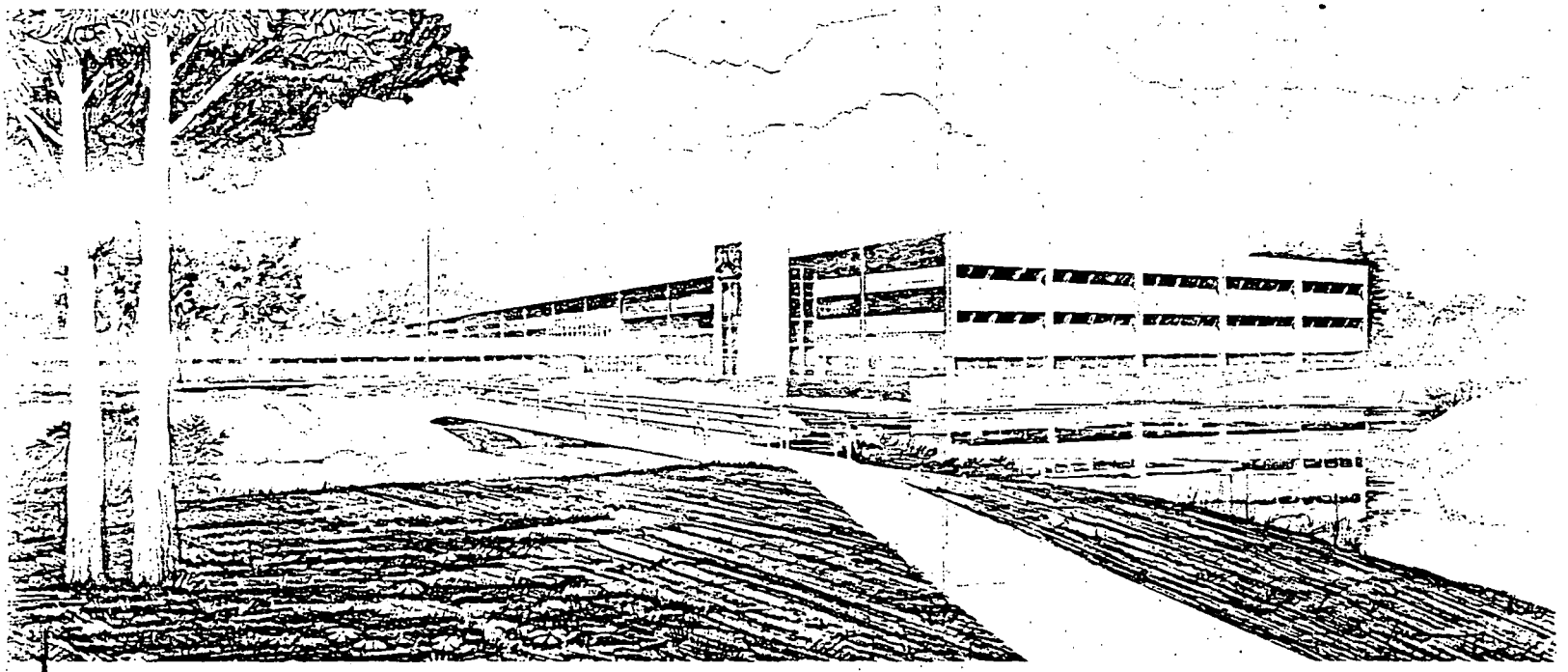
EGG-EA-5627

OCTOBER 1981

SYSTEMATIC EVALUATION PROGRAM, TOPIC VIII-4, ELECTRICAL PENETRATIONS OF REACTOR COMPARTMENT, DRESDEN NUCLEAR STATION, UNIT NO. 2

D. J. Morken

U.S. Department of Energy
Idaho Operations Office • Idaho National Engineering Laboratory



This is an informal report intended for use as a preliminary or working document

Prepared for the
U.S. Nuclear Regulatory Commission
Under DOE Contract No. DE-AC07-76ID01570
FIN No. A6425-1

EG&G Idaho

Dupe of 8112030244

EG&G Idaho, Inc.

FORM EG&G-398
(Rev 11-79)

INTERIM REPORT

Accession No. _____

Report No. EGG-EA-5627

Contract Program or Project Title:

Electrical, Instrumentation, and Control Systems Support for the Systematic Evaluation Program (II)

Subject of this Document:

Systematic Evaluation Program, Topic VIII-4, Electrical Penetrations of Reactor Compartment, Dresden Nuclear Station, Unit No. 2

Type of Document:

Informal Report

Author(s):

D. J. Morken

Date of Document:

October 1981

Responsible NRC Individual and NRC Office or Division:

R. F. Scholl, Jr., Division of Licensing

This document was prepared primarily for preliminary or internal use. It has not received full review and approval. Since there may be substantive changes, this document should not be considered final.

EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

Prepared for the
U.S. Nuclear Regulatory Commission
Washington, D.C.
Under DOE Contract No. DE-AC07-76ID01570
NRC FIN No. A6425-1

INTERIM REPORT

0090J

SYSTEMATIC EVALUATION PROGRAM

TOPIC VIII-4
ELECTRICAL PENETRATIONS OF REACTOR COMPARTMENT

DRESDEN NUCLEAR STATION, UNIT NO. 2

Docket No. 50-237

October 1981

D. J. Morken
EG&G Idaho, Inc.

10-20-81

ABSTRACT

This SEP technical evaluation, for the Dresden Nuclear Station, Unit No. 2, reviews the capability of the overcurrent protection devices to protect the electrical penetrations of the reactor containment for postulated fault conditions concurrent with an accident condition.

FOREWORD

This report is supplied as part of the "Electrical, Instrumentation, and Control Systems Support for the Systematic Evaluation Program (II) being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Licensing by EG&G Idaho, Inc., Reliability & Statisitics Branch.

The U.S. Nuclear Regulatory Commission funded the work under the authorization B&R 20-10-02-05, FIN A6425-1.

CONTENTS

SYSTEMATIC EVALUATION PROGRAM

TOPIC VIII-4
ELECTRICAL PENETRATIONS OF REACTOR COMPARTMENT

DRESDEN NUCLEAR STATION, UNIT NO. 2

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 containment 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 rating 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."

3.0 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.

Commonwealth Edison provided information (Reference 1, 2 and 3) on typical penetrations. Commonwealth Edison has established a temperature limit of 171°C for 6 hours and 328°C for 4 seconds before seal failure for two penetrations based on testing. Maximum short circuit current available (I_{sc}) was provided by Commonwealth Edison for a three-phase bolted fault. Rated current (I_r) for each penetration was also provided.

To evaluate 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

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 LOCA environment with a short circuit current, Formula 1 was used to calculate the time required to heat the conductor from the initial 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. Commonwealth Edison has identified penetration X205E (GE-type NS04) as being typical of low voltage penetrations. This penetration provides 480 V ac power to Recirculation Pump 2A Motor Operated Discharge Valve M02-0202-5A.

This penetration uses #10 AWG cable and has a continuous current rating of 16 amps. The maximum short circuit current available has been determined by a study performed by Sargent and Lundy[3] to be 1000 amps. The same study also established a temperature limit of 622°F (328°C) before seal failure based on testing. At a maximum short circuit current (1000 amps), overtemperature will be reached in 0.682 seconds from an initial temperature 110°C. Sargent & Lundy[3] established 110°C as the maximum penetration temperature after a LOCA based on analysis.

From an initial temperature of 110°C, the primary breaker will operate to clear fault currents above 600 amps. Below 200 amps the overload device will clear fault currents. Between 200 amps and 600 amps the temperature vs time curve is between the upper and lower limits of the breaker trip curves.

From 110° initially, the secondary breaker will not operate to clear any fault currents prior to exceeding the 622°F (328°C) penetration seal temperature limit. However, Commonwealth Edison has committed[3] to environmentally qualify the circuitry inside containment.

3.1.1 Low Voltage Penetration Evaluation. With the initial penetration temperature at 110°C (LOCA), penetration X205E does not meet current requirements of RG 1.63 and IEEE Std. 317 with a failure of the primary breaker. However, Commonwealth Edison has committed[3] to environmentally qualify the circuitry inside the containment. It may not meet the requirements for fault currents between 200 amps and 600 amps even if the primary breaker operates as designed.

3.2 Typical Medium Voltage (>1000 V) Penetration. Commonwealth Edison has identified penetration X202D (GE-type NS03) as being typical of medium voltage penetrations. This penetration provides 4160 V ac power to Recirculating Pump 2A.

This penetration uses 1000 MCM cable with a continuous current rating of 735 amps. The maximum available short circuit current has been determined by CE to be 4300 amps. Commonwealth Edison has established 622°F (328°C) as the limiting temperature before seal failure based on testing. At the maximum short circuit current (4300 amps), overtemperature would be reached in 273 seconds from 146°C initially.

There are no circuit protective devices located between the motor generator output and the Recirculation Pump 2A. 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 $\geq$120 amps of current difference between the generator output and the motor input, the differential relay will cause a trip of the motor generator in 0.18 second or less. At line current in excess of 1200 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 1200 amps prior to reaching the penetration seal temperature limit from LOCA temperature initially. For fault currents less than 1200 amps, this relay will not operate to trip the motor generator. With 1200 amps total fault current at the line current relay, each penetration will see essentially half the total current or 600 amps per penetration. This is below the penetration ratings of 735 amps.

3.2.1 Medium Voltage Penetration Evaluation. From LOCA temperature initially, penetration X202D meets current requirements of RG 1.63 and IEEE Std. 317. For short circuit faults of the line overcurrent relay the differential relay will clear the fault prior to reaching the penetration seal temperature limit. With a failure of the differential current relay under LOCA temperature, the line current relay will operate to clear the fault at currents greater than 1200 amps prior to reaching penetration seal temperature. At 1200 amps total current each penetration will see approximately 600 amps, which is within the penetrations continuous rating of 735 amps.

4.0 SUMMARY

From an initial temperature of 110°, penetration X205E does not meet the requirements of RG 1.63 and IEEE Std. 317 for a short circuit fault with random failure of the primary protective device. Penetration X205E may not meet current requirements for fault currents between 200 amps and 600 amps even if the primary breaker operates as designed. However, Commonwealth Edison has committed[3] to environmentally qualify the circuitry inside the containment.Penetration X202D does meet current licensing requirements for short circuit fault with random failure of either the primary or secondary protective device.

5.0 REFERENCES

1. Commonwealth Edison letter (Janecek) to NRC (Ziemann) dated March 14, 1979.

2. Commonwealth Edison letter (Smith) to EG&G Idaho, Inc. (Udy) dated August 27, 1979.

3. Commonwealth Edison Letter (Rausch) to NRC (Crutchfield) dated June 25, 1981.

4. IPC&A Publication P-32-382, "Short Circuit Characteristics of Insulated Cable."