Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690 - 0767

March 23, 1988

Mr. T. E. Murley
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC. 20555

Attn: Document Control Desk

Subject: Braidwood Unit 2
Environmental Qualification
Bunker Ramo Penetration
NRC Docket No. 50-457

Dear Mr. Murley:

The purpose of this letter is to provide the NRC staff with additional documentation to provide support for the environmental qualification, under 10CFR 50.49, of a Bunker Ramo Penetration used at Braidwood Station Unit 2. This piece of equipment is a Bunker-Ramo manufactured instrument penetration used to provide access through the Unit 2 containment wall in four (4) locations for circuits that carry electrical signals from instrumentation inside the containment to main control room indicators and protective circuitry. This penetration provides this function while maintaining the integrity of the containment pressure boundary. This penetration is identified at the four (4) locations as 2SI05E, 06E, 07E and 08E. Though substantial substative documentation exists to provide support for environmental qualification, additional documentation has been determined to be necessary by the NRC staff to make the documented basis for environmental qualification fully auditable. Exhibit I shows the location of the penetration as installed in the containment wall.

As agreed upon during our telecon of 03-22-88, Attachment I identifies the preliminary Bunker Ramo Instrumentation Penetration information being submitted to you for your review and acceptance. Additional supportive information as described in Attachment I will be transmitted to you on Monday, March 28, 1988.

Please address any questions concerning this matter to this office.

Very truly yours,

S. C. Hunsader

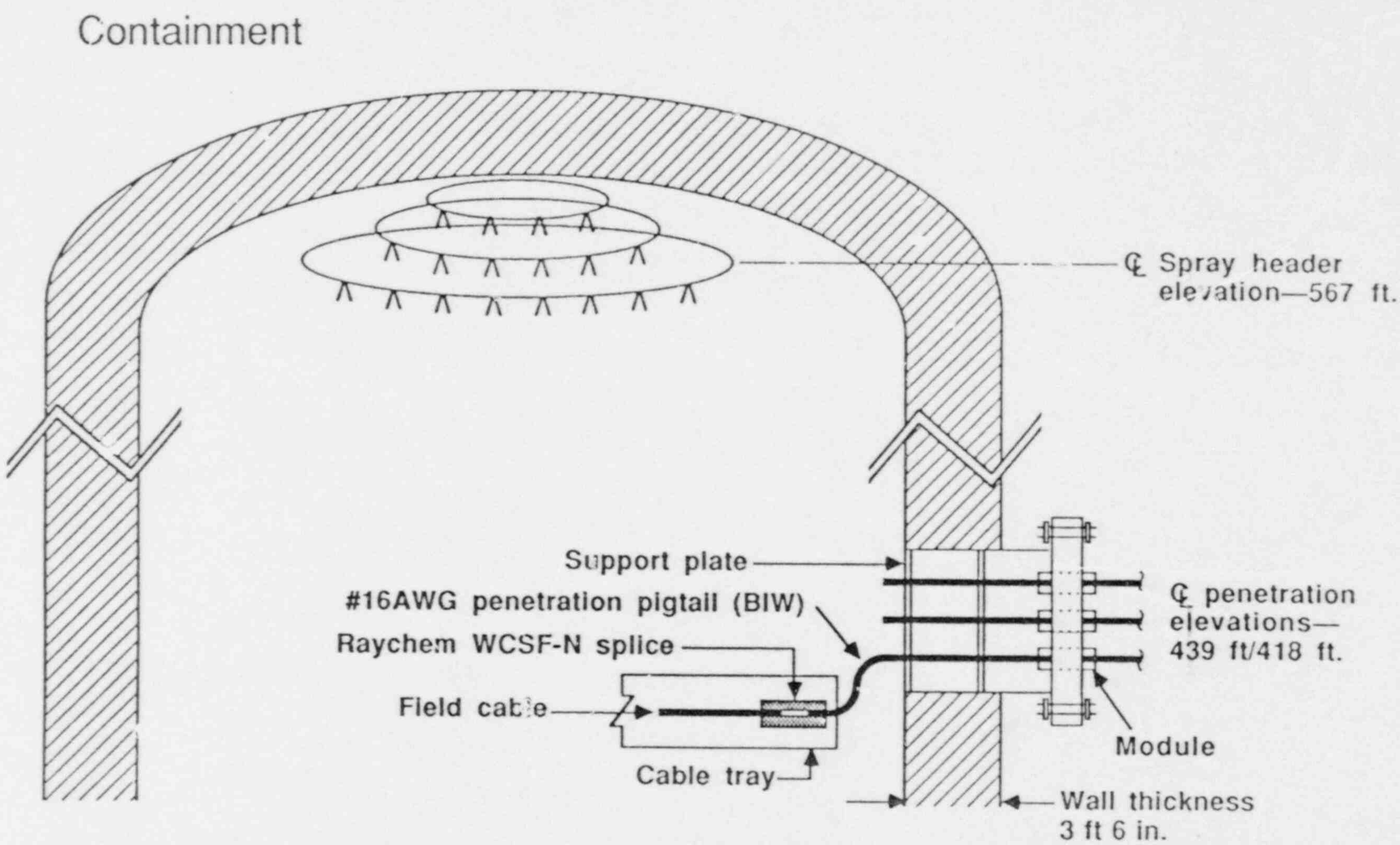
S. C. Hunsader
Nuclear Licensing Administrator

/klj
cc: NRC Region III
Braidwood Resident
S. Sands
4363K

A048
1/1

Braidwood Unit 2—Penetration Location Relative to Chemical Spray Header

Exhibit 1



March 23, 1988

ATTACHMENT 1

Bunker Ramo Instrumentation Penetration
Preliminary Information Submittal

1. Appendix A - Braidwood Unit 2 Environmental Qualification Evaluation for the Bunker Ramo Instrumentation Penetration Assemblies

*2. Appendix B - Supporting Qualification Data for the Environmental Qualification of Braidwood Unit 2 Bunker Ramo Instrumentation Penetration Assemblies

3. Supplement to Appendix B to Answer NRC Questions of March 16, 1988

4. Midland II Test Curve of a Bunker Ramo Instrumentation Penetrations

**5. Bunker Ramo Design Qualification Test Report 123-2201, Rev. A, dated February 1979.

* Handed out at the March 16, 1988, NRC/CECo Washington meeting

** Air mailed to the NRC (Washington) on 03-22-88

BRAIDWOOD UNIT 2 ENVIRONMENTAL QUALIFICATION EVALUATION FOR THE BUNKER RAMO INSTRUMENTATION PENETRATION ASSEMBLIES

1. PURPOSE

The purpose of this evaluation is to demonstrate the acceptability of the Bunker Ramo Environmental Qualification of the Braidwood Unit 2 instrumentation penetration assemblies. The Bunker Ramo Test Report identified an anomaly regarding insulation resistance values. The anomaly has no affect on the pressure-retaining capability of the penetration assemblies. As explained below, the anomaly is only applicable to the test situation and not to the installed plant configuration.

2. IDENTIFICATION OF ANOMALY

The Bunker Ramo Test Procedure (Reference A) indicates that two low voltage prototype penetration assemblies were tested. Table V of the Test Report (see Exhibit 1) summarizes the insulation resistance values recorded for selected circuits in these prototype assemblies, during and after the LOCA test. Exhibit 1 reveals that some of the insulation resistance values for the selected penetration circuits are low. The selected circuits listed in Table V did not include insulation resistance measurements for a #16AWG penetration module pigtail assembly which is similar to that installed at the Braidwood Unit 2 penetrations in question. However, the low insula-

tion resistance values recorded for the circuits listed in Table V (utilizing a similar module design) prompted the questions by the NRC regarding the integrity of the penetration module.

Generally, the low insulation resistance values for the circuits in Table V have been identified in the Test Reports as anomalies. These anomalies have been attributed/dispositioned as either the result of "shorting during the LOCA" or the occurrence of "a service interruption for periodic testing which may have resulted in an unusual voltage stress, i.e., I.R. was high (2.7×10^7) just prior to anomaly and 100 Ohms immediately after." Furthermore, the Test Reports state that (a) "these circuits met the continuity and gas leak rate requirements", (b) "all insulating materials reflect the impact of the specified environment (c) "no significant deterioration occurred in the Amphenol module or seal material", and (d) the test results conservatively scope Class 1E safety related requirements". (References A & B).

3. TEST SPECIMEN CONFIGURATION

The Bunker Ramo Test Procedure (Reference A) states that the tested Low Voltage Penetration assemblies shall have additional junction box internals installed on the outboard and inboard side to qualify these items under LOCA/DBE conditions.

These internals connect the penetration circuits to terminal blocks and connectors in addition to the hardware utilized to connect the required instrumentation for monitoring the insulation resistance during the LOCA test.

Exhibit 2 provides an illustration of the tested configuration and construction of a typical Bunker Ramo instrumentation penetration module and pigtail assembly utilizing terminal blocks. It should be concluded from this illustration and the anomaly discussion in Section 2 above, that the root cause of the low insulation resistance values experienced during the LOCA test can be attributed (a) to the shorting of the penetration pigtails at the terminal block connections and at the connectors within the junction boxes and (b) to the service interruption that occurred during the LOCA test. The low insulation resistance values were not caused by a failure within the penetration module itself.

The above conclusion can be further substantiated by examining the installation and construction attributes of a typical Bunker Ramo Instrumentation Penetration utilizing the "post-crimp" module design (See Exhibits 2 & 3). It can be seen from these exhibits that the module feedthrough conductors are insulated from one another and from the header plate via a glass reinforced epoxy. The pigtail conductors are crimped directly onto the module conductors and again insulated with the glass reinforced epoxy. A leak free assembly is achieved

by mounting seals on both ends of each module. Furthermore, the area between the seals is pressurized with dry nitorgen at all times (during shipment, storage, and operation) to assure a dry atmosphere and thus maintain the integrity of the module insulation resistance (i.e. the module feedthrough conductors between the seals are isolated from the LOCA environment). The penetration pigtail conductors were manufactured by Boston Insulated Wire (BIW). These cables have been independently qualified by tests and have exhibited negligible insulation resistance degradation. Therefore, we do not believe that the low insulation resistance values should be attributed to the penetration module and pigtail assembly.

As a matter of information, we have reassessed IE Bulletin 82-04 for identified deficiencies that could be pertinent to these penetrations. All of the reported deficiencies have either been corrected or were determined as not applicable to the installed Braidwood Unit 2 penetration assemblies.

4. INSTALLED PENETRATION CONFIGURATION

There is one major and distinct difference between the instrumentation penetration assemblies tested configuration and installed configuration. As illustrated in Exhibit 2, the installed termination method utilized within the containment at Braidwood Unit 2 consists of in-line butt splices. These splices are insulated with Raychem WCSF-N heat shrinkable

tubing, in place of the terminal blocks or connectors used in the test. Braidwood's Environmental Qualification (EQ) Binder EQ-BB-120, documents that Raychem splices have been independently tested in the LOCA environment and have exhibited negligible insulation resistance degradation. As a result, we believe the insulation resistance values recorded in Table V of the Bunker Ramo Test Report are not applicable to the Braidwood installation of these electrical penetrations. All other test results in the Bunker Ramo test report are acceptable and representative of the installed penetration configuration.

In view of the above, we had utilized the insulation resistance values in the BIW and Raychem splice LOCA tests for our instrument loop accuracy calculations (rather than the insulation resistance values in the Bunker Ramo test report) since they are representative of the Braidwood installation. These insulation resistance values provide the required instrumentation accuracy with substantial margin. We believe that this qualification approach meets the guideline and intent of NUREG-0588 requirements.

5. CONCLUSION

Based on the above review and analysis of the qualification test information, Commonwealth Edison believes that the Bunker Ramo penetration assemblies, as installed, are qualified and meet 10CFR50.49.

6. **REFERENCES**

A. Bunker Ramo Generic I Qualification Test Procedure 123-2159, Rev. 5A, dated 06/01/79

B. Bunker Ramo Design Qualification Test Report 123-2220, Rev. 4, dated 10/10/79

C. Bunker Ramo Loss of Coolant Accident (LOCA) Test Report 123-2159-18, Revision 1, dated 06/18/79

7. **EXHIBITS**

Exhibit 1 - Table V from Bunker Ramo Test Report (Reference A)

Exhibit 2 - Tested/Installed Penetration Pigtail/Module Configuration

Exhibit 3 - Top Assembly Drawing - Instrumentation Penetration Assembly

EXHIBIT 1

TABLE V

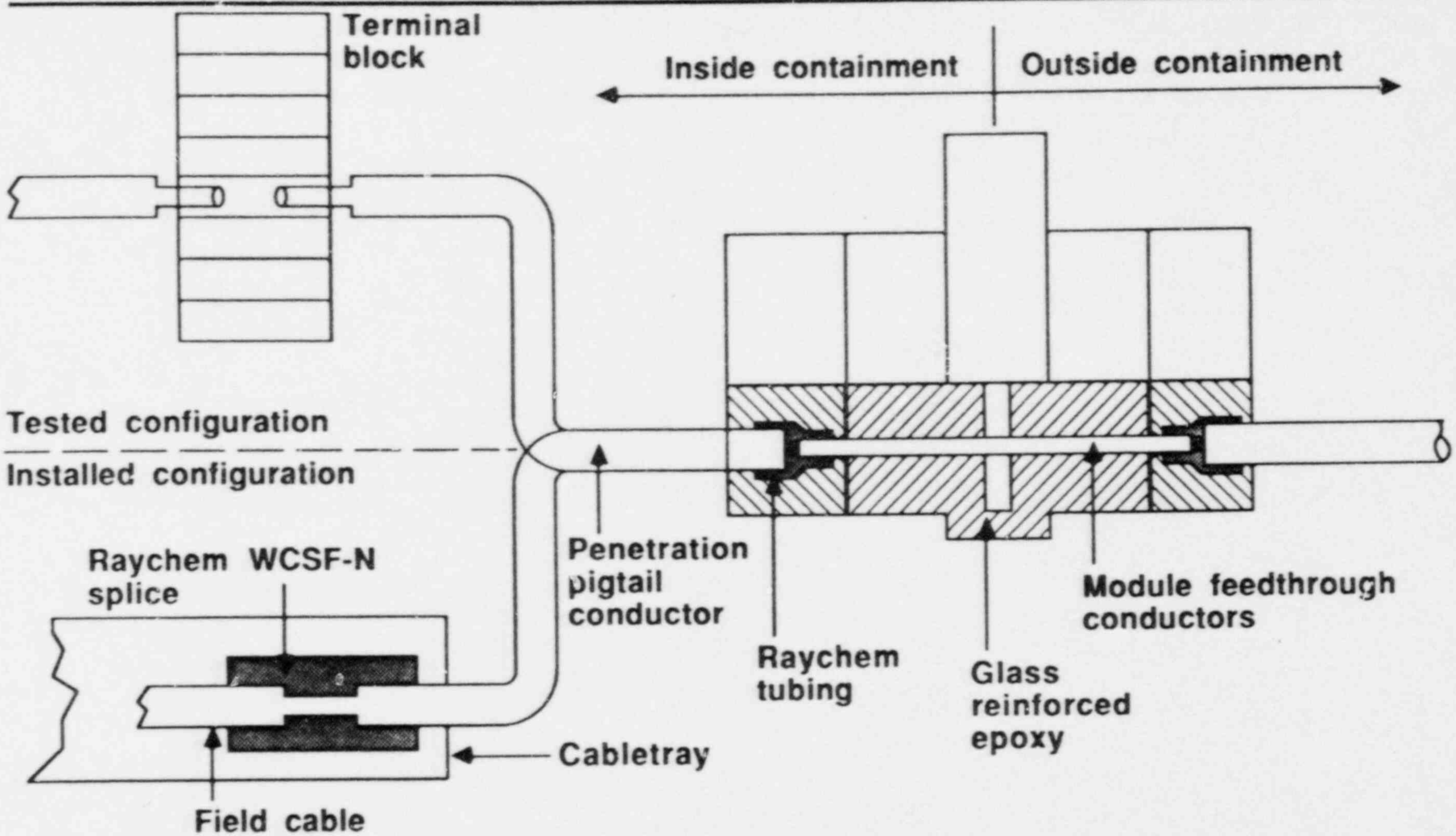
LOSS OF COOLANT ACCIDENT (LOCA) RESULTS: (OHMS)

Circuit	Classification	Initial	1st Ramp	2nd Ramp	4th Ramp	5th Ramp	7th Day	14th Day	22nd Day	28th Day	30th Day	Final
Triax	Inst.	1.8×10^{11}	3.7×10^{6}	8.5×10^{5}	2000	1.3×10^{5}	1.0×10^{3}	2.5×10^{3}	1.3×10^{4}	1.5×10^{4}	1.5×10^{4}	1.8×10^{4}
Coax, TNC	Inst.	3.6×10^{12}	3.4×10^{7}	1.9×10^{6}	220	1.2×10^{5}	65	1.2×10^{3}	2.0×10^{4}	1.0×10^{4}	1.2×10^{4}	4.0×10^{4}
3x350	LVP	1.2×10^{11}	3.4×10^{6}	1.4×10^{5}	2.8×10^{5}	1.5×10^{5}	8.0×10^{4}	4.0×10^{4}	1.4×10^{4}	3.4×10^{4}	3.2×10^{4}	3.0×10^{7}
69#14(T.B)	LVC	4.2×10^{11}	4.3×10^{7}	1.1×10^{5}	800	100	3.6×10^{4}	2.8×10^{4}	7.0×10^{3}	2.1×10^{4}	1.4×10^{5}	2.3×10^{7}
69#14(RFR/TB)	LVC	8.0×10^{11}	2.4×10^{7}	1.2×10^{5}	600	1200	1.0×10^{4}	3.3×10^{4}	4.5×10^{4}	3.4×10^{4}	1.9×10^{5}	1.6×10^{8}
MV	MVP	5.4×10^{10}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.1×10^{6}
Twinax	Inst.	3.7×10^{8}	1000	9.0×10^{4}	3000	1.5×10^{5}	2.5×10^{4}	2.0×10^{3}	5.0×10^{4}	1.0×10^{4}	1.2×10^{4}	2.3×10^{4}
Coax, BNC	Inst.	1.0×10^{13}	1000	9.5×10^{4}	100	100	40	80	150	180	185	230
69#14(MCSF)	LVC	8.0×10^{11}	2.5×10^{7}	1.4×10^{6}	2.7×10^{7}	8.0×10^{4}	4.6×10^{4}	3.6×10^{4}	9.0×10^{4}	1.8×10^{4}	5.7×10^{4}	2.3×10^{7}
Conditions:												
Temperature (°F)		Room	340	340	300	265	240	240	243	240	240	Room
Pressure (psig)		0	104	104	53	25	10	11	10	10	10	0
pH		0	>11	>11	>11	>11-9.4	8.2	5.8	6.6	6.6	6.4	0

NOTE: I.R. values $<1\times10^{7}$ are based on Simpson meter @ 22.5 VDC.

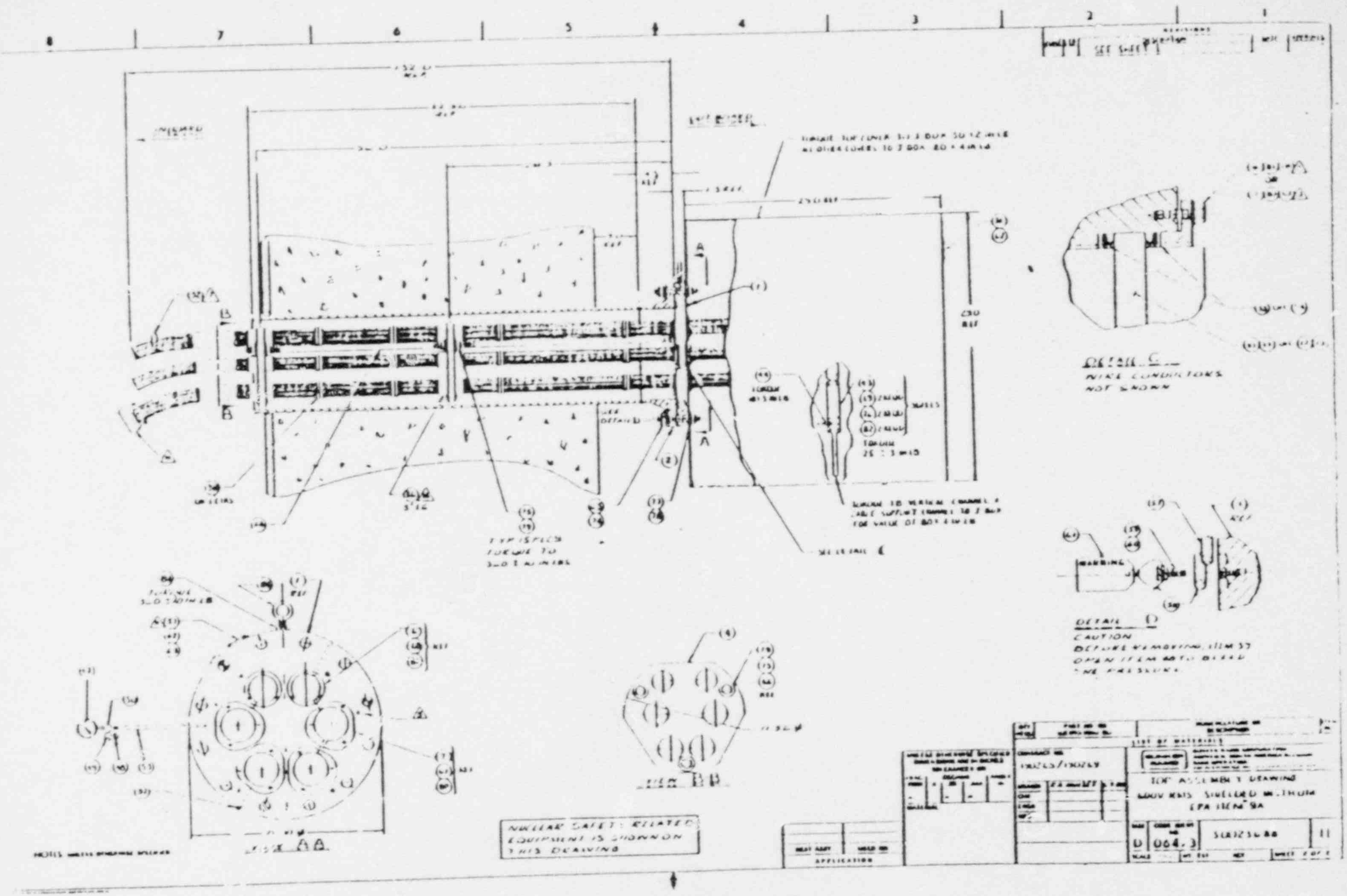
Exhibit 2

Typical Bunker Ramo Instrumentation Penetration Module and Pigtail Assembly Design Tested and Installed Configuration



C1595.006/M 03-88

Exhibit 3



DETAIL C
WIRE CONDUCTORS NOT SHOWN
DETAIL D
CAUTION
NUCLEAR SAFETY RELATED EQUIPMENT IS SHOWN ON THIS DRAWING
TOP ASSEMBLY DRAWING
APPLICATION

SUPPORTING QUALIFICATION DATA
FOR
THE ENVIRONMENTAL QUALIFICATION OF BRAIDWOOD UNIT 2
BUNKER RAMO INSTRUMENTATION PENETRATION ASSEMBLIES

INTRODUCTION

In addition to the environmental qualification (EQ) data presented for the Bunker Ramo instrumentation penetration assemblies used at Braidwood Unit 2, there have been other EQ test data which further support the adequacy of these penetrations. These tests were performed for:

a) Midland Station Unit 2 test of Bunker Ramo penetration assemblies by Engineering Analysis and Test Laboratory, (EATL)

b) Viking Industries penetration test by Wyle Laboratories

c) Amphenol penetration test by Conax

d) Bunker Ramo penetration test for Calvert Cliffs

This appendix will provide the penetration test configurations (when applicable) and parameters and discuss how the test results apply to Braidwood Unit 2 installed configurations.

MIDLAND TEST REPORT

Exhibit 1 shows the Midland 2 tested configurations (terminal blocks and Raychem splices) and the Braidwood Unit 2 installed configuration. The Midland 2 configuration with the Raychem splices and the Braidwood Unit 2 configuration are quite similar with two differences:

a) Midland 2 pigtail material is Raychem flamtrol while Braidwood Unit 2 is Boston Insulated Wire (BIW). However, both materials are qualified for this application.

b) The Midland 2 RFR Raychem splices do not provide an environmentally sealed connection. The Braidwood Unit 2 WCFS-N Raychem splices do provide an environmentally sealed connection.

Exhibit 2 shows a comparison between the Midland 2 EQ test parameters and Braidwood Unit 2 committed EQ requirements. Exhibit 3 shows the Braidwood Unit 2 test, committed, actual Main Steam (MS) break and Reactor Coolant System (RCS) break profiles as well as the Midland 2 test profile overlapping each other. Exhibits 2 and 3 show that the Midland 2 test conditions are equal to the Braidwood Unit 2 requirements with the following exceptions:

a) The Midland 2 Insulation Resistance (IR) measurement voltage is 500 VDC, while the maximum Braidwood Unit 2 circuit voltage is 40 VDC. The IR values at 40 VDC would be much higher than those at 500 VDC. Therefore, using the Midland 2 test results is very conservative.

b) The concentration of the Boron in the Midland 2 test (13,000 ppm) exceeds the Braidwood Unit 2 requirements (2,000 ppm). The Midland spray is more electrically conductive.

c) The pH value of the Midland 2 spray (7.0-7.5) is about neutral. This value is not detrimental. Increasing the pH value to the Braidwood Unit 2 level (8.5-10.5) will not degrade the electrical performance of the circuit. Moreover the spray period of the Midland 2 test was much longer than the Braidwood required duration.

d) The peak temperature of Midland 2 test is 300°F while the committed peak temperature of Braidwood Unit 2 is 320°F. Exhibit 3 also shows the worst two actual accident profiles, from which the committed enveloped curve was derived. Only the Main Steam break has a peak temperature exceeding 300°F for 60 seconds. The 320°F only occurs momentarily at the middle of this 60 second period. It is our opinion that the temperature at the penetration location would not exceed 300°F in the actual accident condition based on thermal lag considerations.

e) Exhibit 3 shows also that the transient temperatures of the Midland 2 test are slightly lower than the Braidwood Unit 2 committed values. Experience has shown that failures generally occur at the peak temperature rather than the lower temperature range.

Exhibit 4 shows the IR values recorded during different phases of the Midland 2 test. These values are acceptable for Braidwood Unit 2 application.

Exhibit 5 shows the measured IR values for both terminal blocks and Epoxy End Seal configurations. This data is reported through a letter from ANCO Engineers, dated March 11, 1988. The configuration utilizing terminal blocks has much lower IR values which supports our previous conclusions.

VIKING TEST REPORT

Exhibits 6 and 7 show the test configuration and parameters as well as the available results. The configuration has some similarity to the Braidwood Unit 2 configuration, with Braidwood Unit 2 having compatible or better materials. The Viking test parameters exceed Braidwood Unit 2 requirements and the test results show acceptable IR values.

AMPHENOL PENETRATION TEST REPORT BY CONAX

Exhibit 8 states the test conditions and describes the configuration. The configuration has soft Epoxy versus the hard Epoxy used in Braidwood Unit 2 which should perform as well or better. The lowest IR value associated with the 224°F saturated steam is 3×10^7 ohms.

CALVERT CLIFF ANALYSIS OF AMPHENOL PENETRATION TEST REPORT

Exhibit 9 shows the configuration of the Amphenol penetration used at Calvert Cliff. It also shows the test parameters as they are available in the Calvert Cliff analysis report. The leakage current during the test was reported to be less than 1 mA. This is equivalent to an acceptable IR value which supports the Braidwood Unit 2 conclusions.

CONCLUSION

The above analysis and the additional qualification test data of the Bunker Ramo penetration assemblies further confirm that the Braidwood Unit 2 installed configuration is qualified for the Braidwood Unit 2 EQ requirements in accordance with 10CFR50.49.

INTRODUCTION

- NRC AGREED WITH OUR POSITION WITH TWO CONCERNS:

  a. NO ELECTRICAL MEASUREMENTS TAKEN FROM THE INSTALLED CONFIGURATION

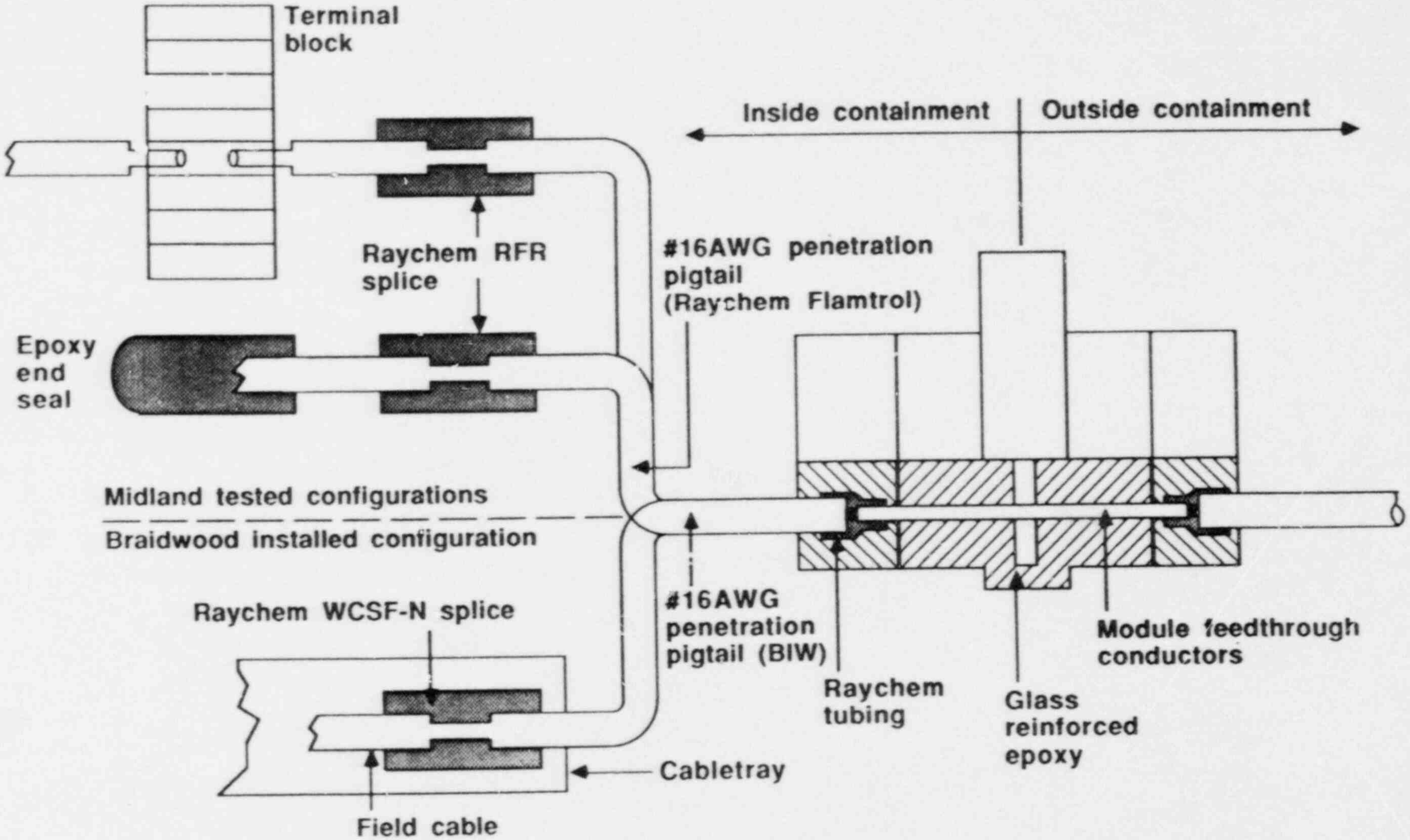
  b. ADDITIONAL TEST DATA SHOULD BE FOR A CONFIGURATION THAT IS SIMILAR TO THE INSTALLED CONFIGURATION

- CECO LOCATED ADDITIONAL INFORMATION TO RESPOND TO THESE CONCERNS

- IN THIS PRESENTATION WE WILL SHARE WITH YOU THIS INFORMATION AND SHOW HOW IT RESOLVES YOUR ABOVE CONCERNS.

Exhibit 1

Midland II Tested Configurations Versus Braidwood Unit 2 Installed Configuration



C1595.037/M 03-88

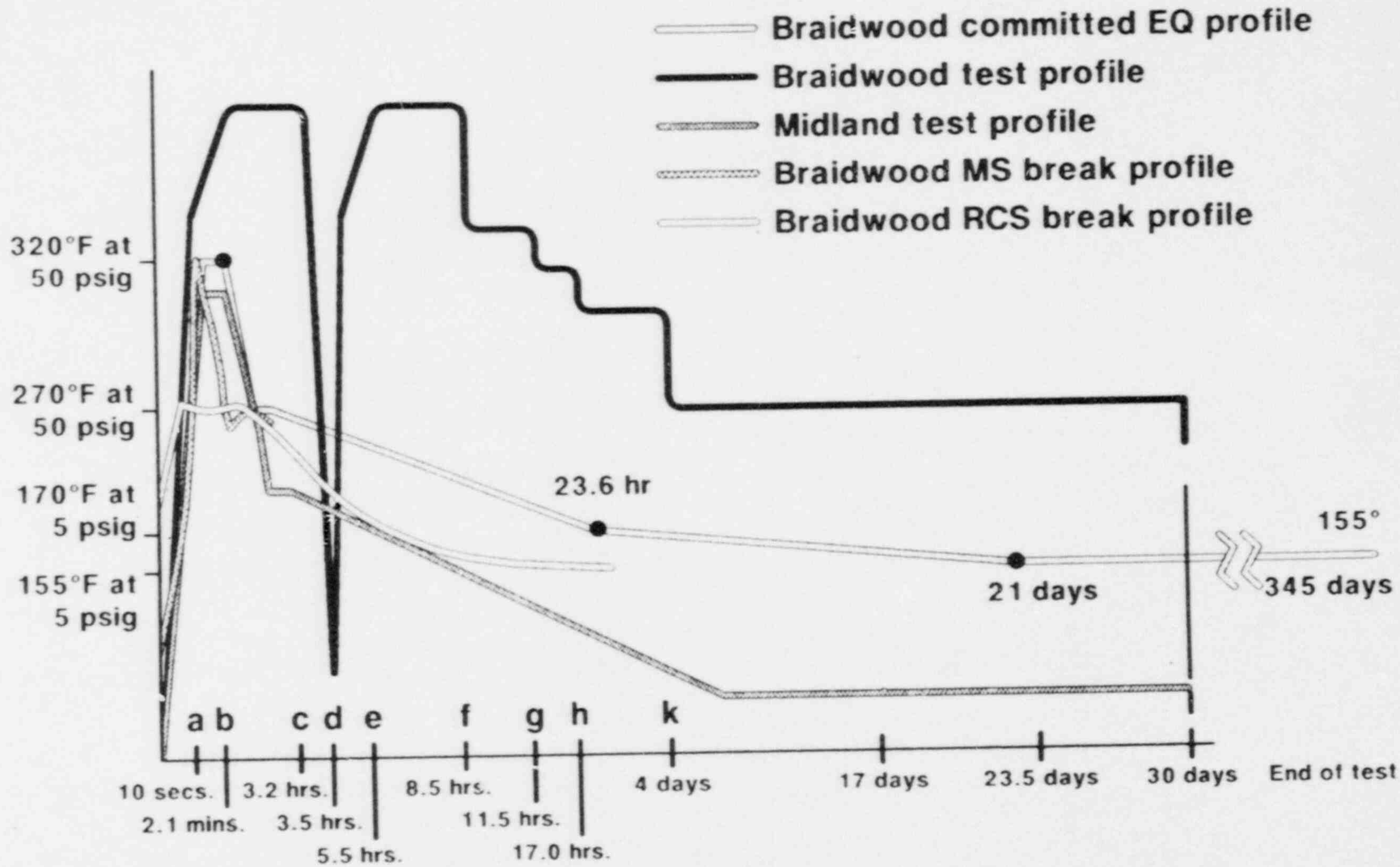
Midland Environmental Qualification Test Parameters Versus Braidwood Committed EQ Requirements

Exhibit 2

	Midland	Braidwood
Radiation	2×10^8 rads.	2×10^8 rads.
Humidity	100% R.H.	100% R.H.
Peak LOCA temperature	300°F max. for 190 secs.	320°F max. for 170 secs.
Voltage	500 Vdc—IR measurement	40V—max. circuit
Chemical spray	0.15 gpm/ft^2 13,000 ppm boric acid pH 7 - 7.5 30 days	0.15 gpm/ft^2 2,000 ppm boron pH 8.5 - 10.5 1 hour

Environmental Qualification Profiles

Exhibit 3



C1595.007 3-15-88

Midland II Test—Reported IR Values

Exhibit 4

Inspection (min.) (max.)	Thermal aging (min.) (max.)	Radiation aging (min.) (max.)	Post LOCA (min.) (max.)
3×10^{11} - $5 \times 10^{13}\Omega$	1.6×10^{11} - $2 \times 10^{14}\Omega$	6×10^{10} - $1 \times 10^{14}\Omega$	5.5×10^{6} - $1.4 \times 10^{11}\Omega$

Note: The above IR values represent the range (minimum and maximum) of insulation resistance values reported for the following tested penetration modules:

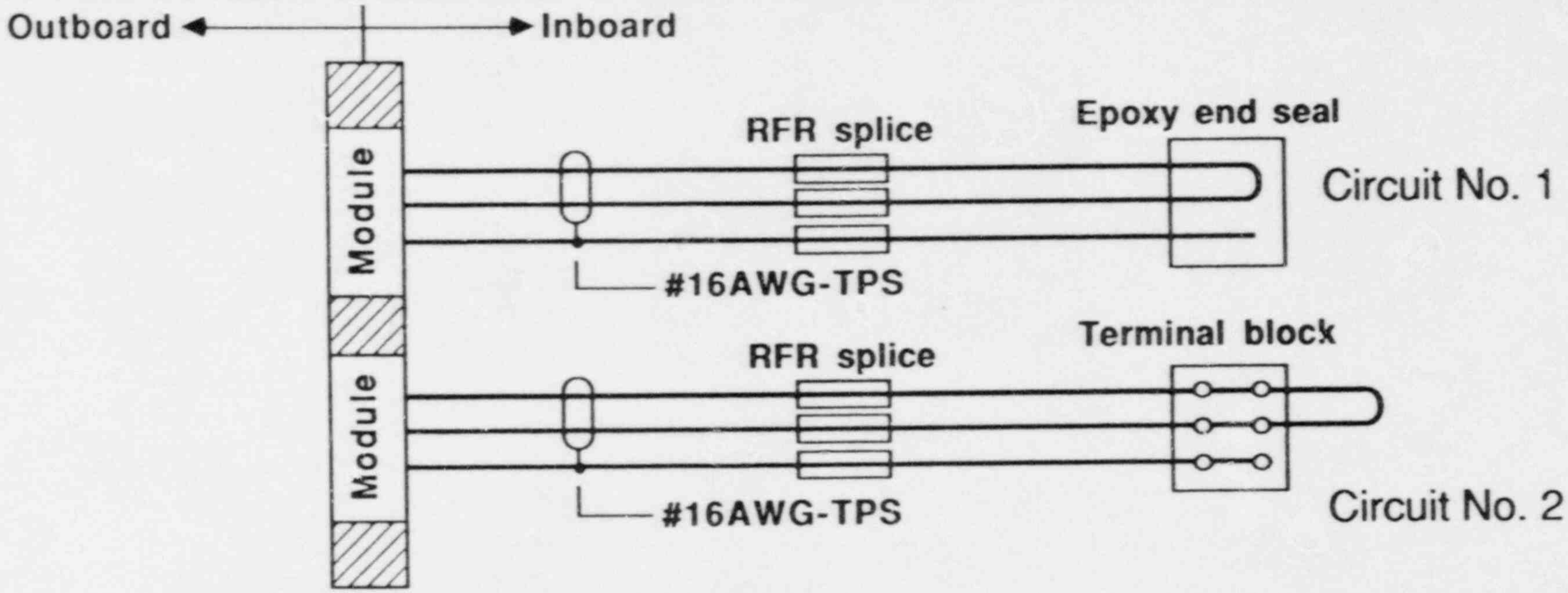
Module A: 69 # 16AWG
Module B: 22 # 6
Module C: 3 x 350

The above reported values are not attributed to a specific module but they do bound the results for all modules

C1595.039/M 03-88

Midland II Test Configurations and LOCA IR Values From the Test Log

Exhibit 5



Recorded insulation resistance values (Ohms) during LOCA (#16AWG-TPS only)

	Measurement 1	Measurement 2
Circuit No. 1	1.5×10^6 conductor to conductor	4.7×10^6 conductor to conductor
	1.0×10^6 conductor to ground	3.6×10^6 conductor to ground
Circuit No. 2	4.2×10^3 conductor to conductor	1.6×10^5 conductor to conductor
	7.2×10^3 conductor to ground	1.8×10^5 conductor to ground

C1595.038/M 03-88

CONCLUSIONS DRAWN FROM MIDLAND II TEST:

- THE RESULTS OF THE MIDLAND TEST SUPPORT THE CONCLUSION PREVIOUSLY DRAWN FROM THE BRAIDWOOD TEST THAT THE INSTALLED PENETRATIONS ARE QUALIFIED IN ACCORDANCE WITH 10CFR50.49.

- MIDLAND II TEST MEETS BRAIDWOOD UNIT 2 TEST REQUIREMENTS

- CIRCUITS UTILIZING TERMINAL BLOCKS EXHIBIT LOW IR VALUES

- COMPARISON OF IR VALUES OBTAINED FROM SPLICES VS THOSE FROM TERMINAL BLOCKS DEMONSTRATE THE INTEGRITY OF THE PENETRATION MODULE ITSELF

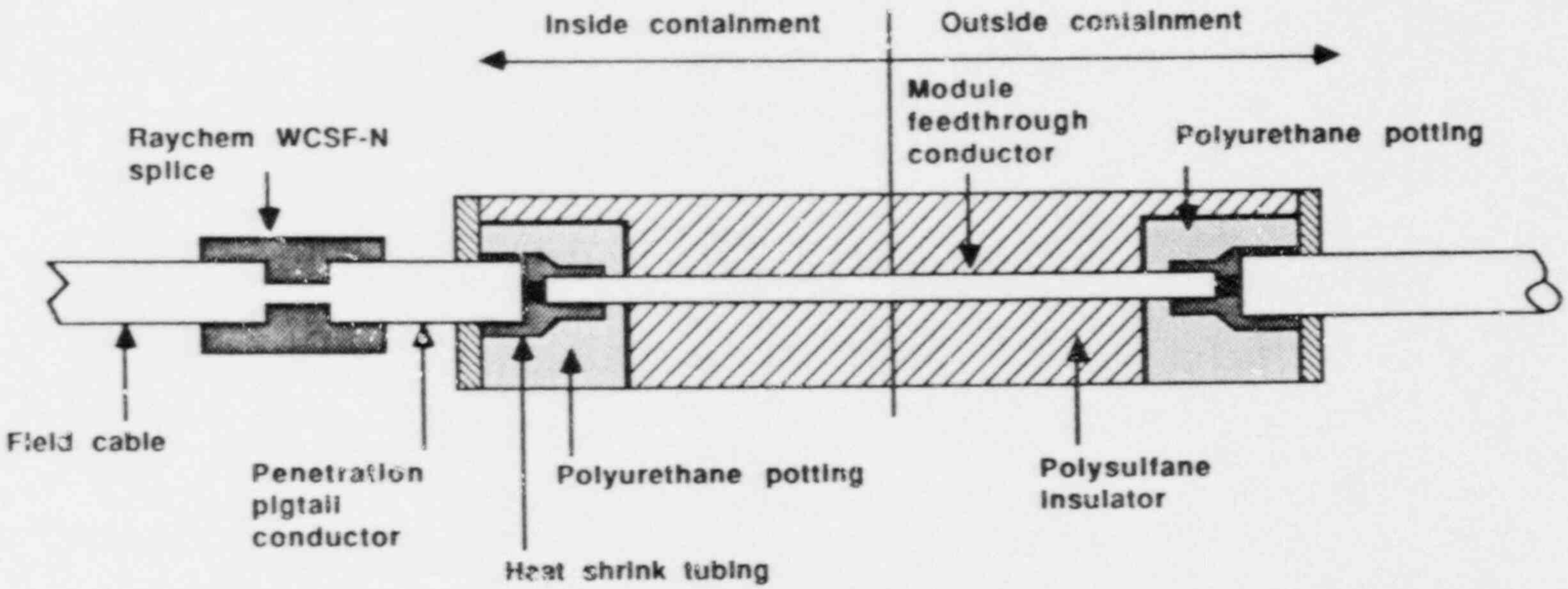
- BRAIDWOOD UNIT 2 WCSF-N SPLICES SHOULD YIELD BETTER IR VALUES THAN THE RFR SPLICES IN THE MIDLAND II TEST
  (i.e. RFR SPLICES DO NOT PROVIDE AN ENVIRONMENTAL SEAL, THE WCSF-N SPLICES DO)

Containment Penetration

Exhibit 6

Penetration type: Viking Industries

- Tested configuration:



- Test report: WYLE's NEQ 46880-1
- Maximum LOCA test temperature—430°F

C1595.029/M 03-88

Containment Penetration

Exhibit 7

Penetration type: Viking Industries

Highlights

- Test configuration is the same as Braidwood installed configuration
- Leakage current reported at t=200 sec in test at 375°F—2 mA at 50.47 V for 5 circuits in series (i.e., 1.26 x $10^5\Omega$ IR for single circuit)
- Leakage current reported at 1 hour in test at 300°F—1 mA at 50.28 V for 5 circuits in series (i.e., 2.5 x $10^5\Omega$ IR for single circuit)
- Test conditions more severe than Braidwood Station
- Braidwood Station electrical penetration material is the same as or of superior quality than the tested one

Containment Penetration

Exhibit 8

Penetration type: Amphenol module assembly

- Test report: Conax No. IPS-1077
- Test condition:

  Steam and humidity environment

  Module assembly was installed in a header plate test fixture

  Raychem WCSF heat shrinkage sleeves were installed on the inboard ends

  Soft epoxy was used in module

  Maximum saturated steam temperature—224°F

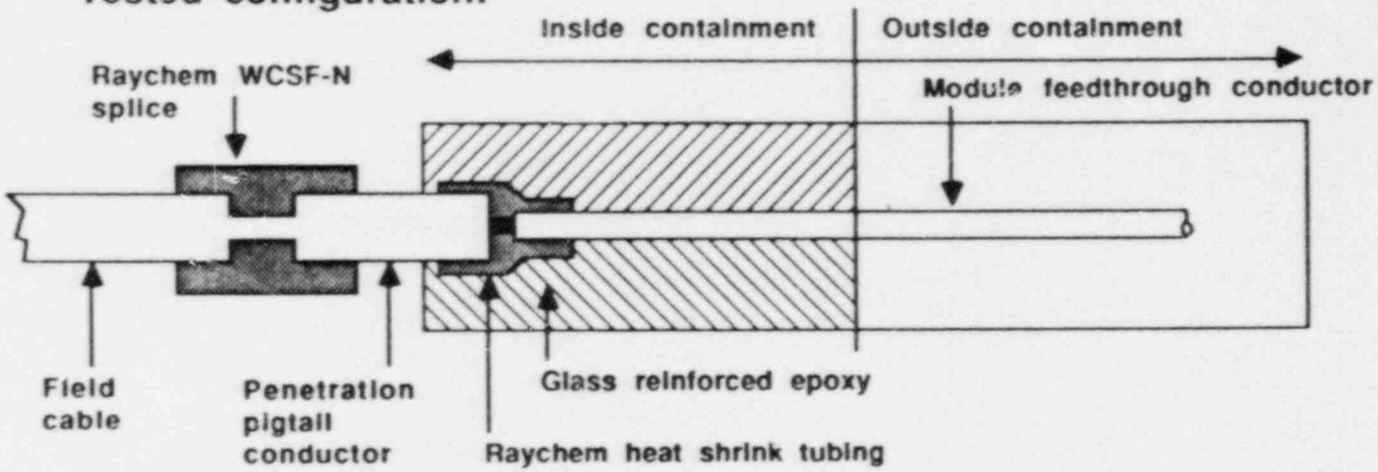
Highlights

- Lowest IR reported at 100 Vdc—3.0 x $10^7\Omega$ (conductor to shield)
- Braidwood penetrations contain hard epoxy which should perform as well or better if protected from mechanical damage
- We have addressed mechanical damage in our response to IE Bulletin 82-04

Containment Penetration

Penetration type: Amphenol

- **Tested configuration:**



- **Test report: Amphenol No. 123-1252**
- **Maximum LOCA test temperature—276°F for 10.5 minutes**
- **Temperatures between 276°F and 250°F for 24 hours**

Highlights

- **Test configuration is similar to Braidwood installed configuration**
- **Leakage current reported during the test is less than 1 mA**

03-22-88

SUPPLEMENT TO APPENDIX B

In the March 16, 1988 meeting in Washington, several questions were posed by the NRC Staff. The following are responses to specific NRC questions regarding the acceptability of the Midland II test results presented in Appendix B and the extent of their applicability to the Braidwood Unit 2 instrumentation penetrations:

1. **NRC QUESTION**

The Midland II test results presented in Appendix B indicate that the minimum Insulation Resistance (IR) recorded during the LOCA, for the #16 AWG instrumentation circuits utilizing the Raychem RFR splices and Epoxy End Seal, was 1.0×10^6 Ohms. This IR value was measured "eight hours into the LOCA" (Reference Page 14 of the Midland II Test Report 123-2201). Based on the Midland II Test Report LOCA profile, eight hours into the LOCA corresponds to 180°F. However, the Braidwood Unit 2 peak LOCA temperature is 320°F. Therefore, what assurance is there that the recorded IR value of 1.0×10^6 Ohms represents the lowest value that may be encountered since it was not measured at the peak temperature of the LOCA profile?

CECO RESPONSE

To address the above NRC question we have separated our response into three sections. Section A discusses the activities we went through and the documentation acquired from ANCO Engineers, Inc., to further substantiate the recorded IR value of 1.0×10^6 Ohms; Section B discusses the analytical model of the time vs. temperature transients, at the penetration feedthrough modules' location; and Section C

discusses the synergestic effects on the penetrations' IR values from LOCA parameters versus temperature alone. Based on the information that follows, Commonwealth Edison believes that the Bunker Ramo penetration assemblies, as installed, are qualified and meet 10CFR50.49

A. Subsequent to the March 16, 1988 Washington meeting, ANCO Engineers Inc., provided correspondence (dated March 21, 1988) that demonstrated when and at what temperature the Midland II instrumentation penetration assemblies IR values were measured. ANCO Engineers, Inc., indicated a review was conducted of the temperature strip chart records for the Midland II penetration LOCA test. ANCO concludes from their review of the strip charts and the log book, that the initial IR readings were taken between 3:12 and 7:00 a.m., October 25, 1978. ANCO states that during this time the temperature in the test chamber ranged between 200°F and 250°F. ANCO documented that the second IR reading was taken at 10:00 a.m. on October 27, 1978. At this time the temperature in the test chamber was between 200°F and 250°F. ANCO further states that during October 25 and 27, 1978, the temperature was above 200°F except for four very short periods (less than 5 minutes) where the temperature dropped to 175°F-220°F.

The ANCO information as provided in their March 21, 1988 letter is the basis for our use of 200°F as the minimum temperature for the measured Midland IR value of 10^6 Ohms. Section B below documents the use of the Bunker Ramo penetration assemblies based on the information from the Midland test. Section C below independently documents the qualification of the Bunker Ramo penetration assemblies via an analysis of the Braidwood test report data.

B. To provide additional confidence, we have performed calculations indicating that the MSLB peak temperatures will not be seen by the penetrations prior to ESF actuation and during the time frame when the Post Accident Monitoring (PAM) instrumentation would be used. This evaluation documents that the temperatures at the penetration feed through modules will not exceed 200°F prior to initiation of the necessary instrument signals to trip the reactor and initiate safety injection. This evaluation also documents that the temperature at the feed through module will remain at a value well below 200°F during the time frame when the Post Accident Monitoring System (PAMS) is required. This evaluation documents that the temperatures at which the IR values were taken in the Midland II test envelope the anticipated feed through module temperatures during the accidents.

To evaluate the effect of the accident temperature pressure transient on the feed through module, a computer model of the containment and the penetration was prepared. The first node in the model was the area between the center support plate and the closure flange of the penetration. The feed through module is partially exposed to the environment in this node. The second node in the model was the portion of the penetration assembly between the inboard support plate and the center support plate. The third node in this model was the containment volume. The nodes communicate with each other by means of the openings in the support plates. The model also accounts for heat transfer into the surrounding steel and concrete and into the Auxiliary Building Electrical Penetration area. A diagram of the model is given in Exhibit B-1.

The accident that was chosen for this evaluation was the Main Steam Line Break (MSLB). This accident was considered limiting for two reasons:

1. A comparison of the pressure temperature curves in the FSAR Chapter 6 shows that the peak containment temperature of 318°F for the main steam line break significantly exceeds the peak temperature of 267°F for the LOCA (Ref. Table 6.2-1)

2. A comparison of the time to actuate for the protective functions for LOCA and MSLB shows that the protective function actuates in 10 seconds for MSLB (p. 15.1-19) and in one second for LOCA (p. 15.6-30).

This computer analysis utilized the Westinghouse mass-energy release data and the containment pressure - temperature curves from FSAR Chapter 6 to establish the time dependent conditions in Node 3. Using this input, the time history of the pressure/temperature conditions in Nodes 1 and 2 was calculated. Exhibit B-2 shows the temperature on Node 1 (adjacent to the feed through module) plotted on the containment temperature curve for the Main Steam Line Break (FSAR Figure 6.2-14). It should be noted that the maximum temperature at the feed through module prior to trip initiation (10 seconds) is 151°F. This temperature is well below the temperature at which the Midland IR value was measured of 200°F. Because the temperature at the Braidwood penetration feed through module will never exceed the 200°F value at which the Midland IR test data was taken, the MSLB computer analysis is considered binding for the Main Feedwater Line Break, also. This is based on FSAR Section 6.2.1.4.

Finally, an evaluation of the long term penetration temperature was made. As can be seen from Exhibit B-2, the model predicted that the penetration would return to less than 130°F after approximately 400 seconds. A steady state evaluation is being performed using the longer term conditions to demonstrate that no significant heatup due to convective mixing between the vapors in the penetration and the vapors in the containment was expected in the long term. This evaluation envelopes the long term LOCA and MSLB environments. No significant heatup of the penetration due to convection is expected.

In summary, calculations were performed that demonstrate that the temperature rise at the Braidwood feed through modules during the initiation of the MSLB, will not exceed the 200°F temperature where the Midland IR data was collected. This calculation envelops the LOCA and FWLB and demonstrates the actuation of reactor trip and safety injection prior to achieving an excessive temperature. An additional evaluation is being performed to confirm that a long term heat up of the penetration is not expected in the post-accident mode that would potentially affect the post accident monitoring instrumentation. The purpose of this evaluation is to provide further support for the use of the Midland penetration qualification data. The completed evaluation will be summarized and available for NRC review on Monday, March 28, 1988.

Based on the above, it should be concluded that the IR value of 1.0×10^6 Ohms measured during the Midland II LOCA test at 200°F represents the minimum IR value that may be encountered at the Braidwood Unit 2 penetrations. This conclusion is conservative because (a) the maximum temperature at the installed Braidwood Unit

2 penetrations has been calculated to be under the 200^{O}F that was measured in the Midland II test (i.e. a higher IR value should be expected at the lower calculated temperatures at Braidwood Unit 2) and (b) the installed penetrations include environmentally sealed connections while the Midland II test specimens did not.

C. This section analyzes the Braidwood test report IR data collected during the LOCA and independently arrives at the same conclusion as stated above.

Material Insulation Resistance varies inversely with temperature (i.e., lower IR values should be expected at higher temperatures). However, when IR is measured during the LOCA test, one must consider the synergistic effects on IR from all LOCA parameters present (i.e., pressure, humidity, and chemical spray) rather than temperature alone. An examination of the IR values recorded during the Braidwood LOCA test (see Table V, Exhibit B-3) demonstrates that the overwhelming cause for the low IR values cannot be attributed to temperature. The IR values recorded are generally higher at the peak temperature (i.e., at 340^{O}F in the first and second LOCA ramps) than the IR values recorded at lower temperatures. This is not indicative of IR behavior based on effects of temperature alone. In fact, this behavior is opposite of that expected. The lower IR values can, therefore, be attributed directly to leakage from the unsealed connections (i.e., terminal blocks, connectors, and splices) used in the test and caused by the presence of the humid/chemical spray environment. The final Braidwood IR values recorded, indicate substantial recovery thus reflecting the diminishing effects of the humid/chemical spray environment

which provided a higher conductive medium for the leakage current during the LOCA through the unsealed connections. As previously stated, the IR values recorded for Braidwood at the peak temperature of 340°F were substantially higher and include all of the expected IR drop due to temperature alone as well as the initial effects of the humidity/chemical spray.

Based on the above analysis of the test data and the fact that the installed Braidwood Unit 2 penetrations, which only include environmentally sealed connections, we expect to encounter the higher IR values as described in Appendix A and certainly not lower than the 1×10^6 Ohms recorded during the LOCA in the Midland II test.

2. NRC QUESTION

The Midland II and Braidwood Unit 2 Test IR values were measured at 500 Vdc. However, the installed Braidwood Unit 2 instrumentation circuit voltage is 40 Vdc. Demonstrate that IR measurements at the installed circuit voltage of 40 Vdc would be more conservative than those taken during the test at 500 Vdc.

CECo RESPONSE

Higher voltages produce higher corona effects and voltage stresses on cable conductors causing insulation breakdowns. It is, therefore, expected that IR measurements at 40 Vdc will result in higher IR values than measurements at 500 Vdc. However, the improvement of IR at the lower circuit voltage cannot be quantified. Therefore, we have utilized a conservative approach by utilizing the IR values measured at 500 Vdc for qualification of the penetrations.

3. NRC QUESTION

The Midland II Test Report indicates that throughout the thirty day LOCA test, the low voltage power penetration modules were supplied with the rated voltage and current. Demonstrate that the resulting heat from these energized circuits did not result in better IR measurements (i.e., the heat produced from the energized circuits may have provided a less conductive (dryer) atmosphere resulting in better IR values).

CECo RESPONSE

The heat contribution from the energized circuits is negligible and would not result in a less conductive path around the conductors due to its potential drying effect. This heat contribution is calculated as follows:

Resistance of #16 AWG conductor = 0.523 Ohms/100 feet

$$\frac{500 \text{ Vdc}}{10^6 \text{ Ohms}} = 5 \times 10^{-4} \text{ Amperes}$$

$$\text{Heat produced} = I^2R$$
$$= (5 \times 10^{-4})^2 \text{ Amperes} \times 0.523 \text{ Ohms/foot} = 1.3 \times 10^{-9} \text{ watts}$$

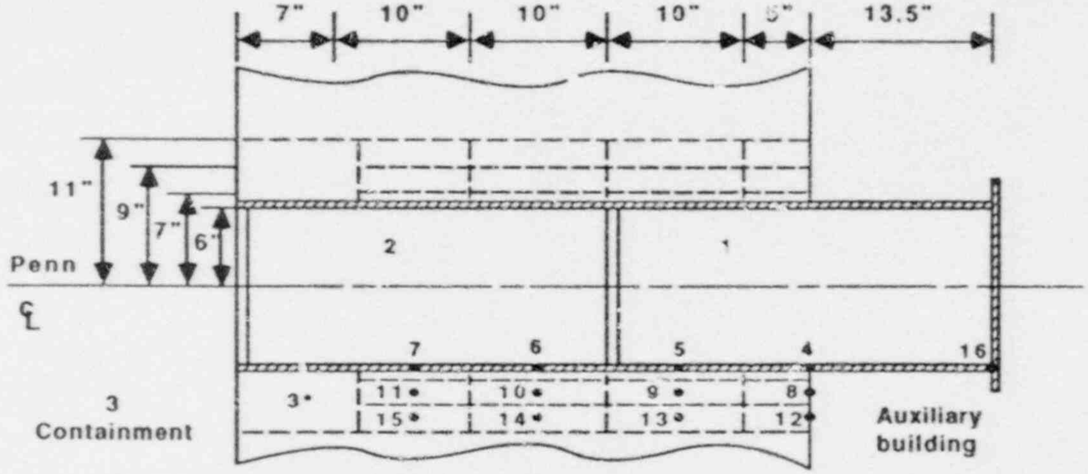
Even if the circuit was carrying rated current throughout the LOCA test, (e.g. 5 amperes) the resulting heat can be calculated as follows:

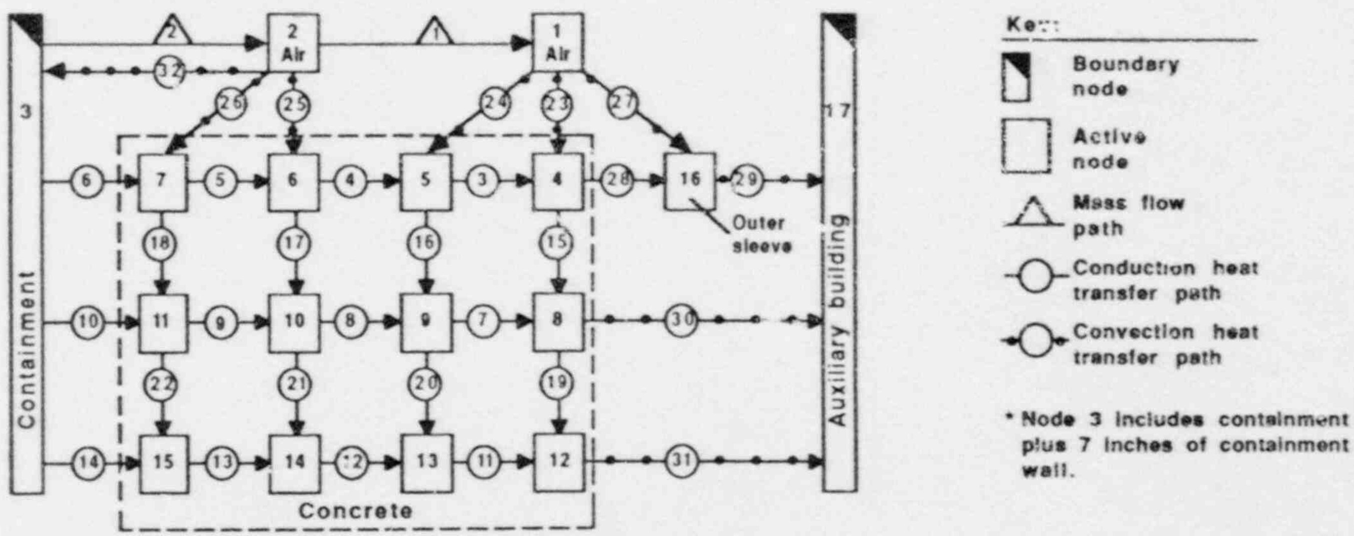
$$\text{Heat produced} = I^2R = (5)^2 \text{ Amperes} \times 0.0523 \text{ Ohms/foot} = 0.13 \text{ watts}$$

The above produced heat is negligible when compared to the test LOCA temperatures and it would not result in a less conductive (dryer) atmosphere to cause higher IR measurements.

Braidwood Unit 2 Bunker-Ramo Penetration Heat Transfer Model

Exhibit B-1

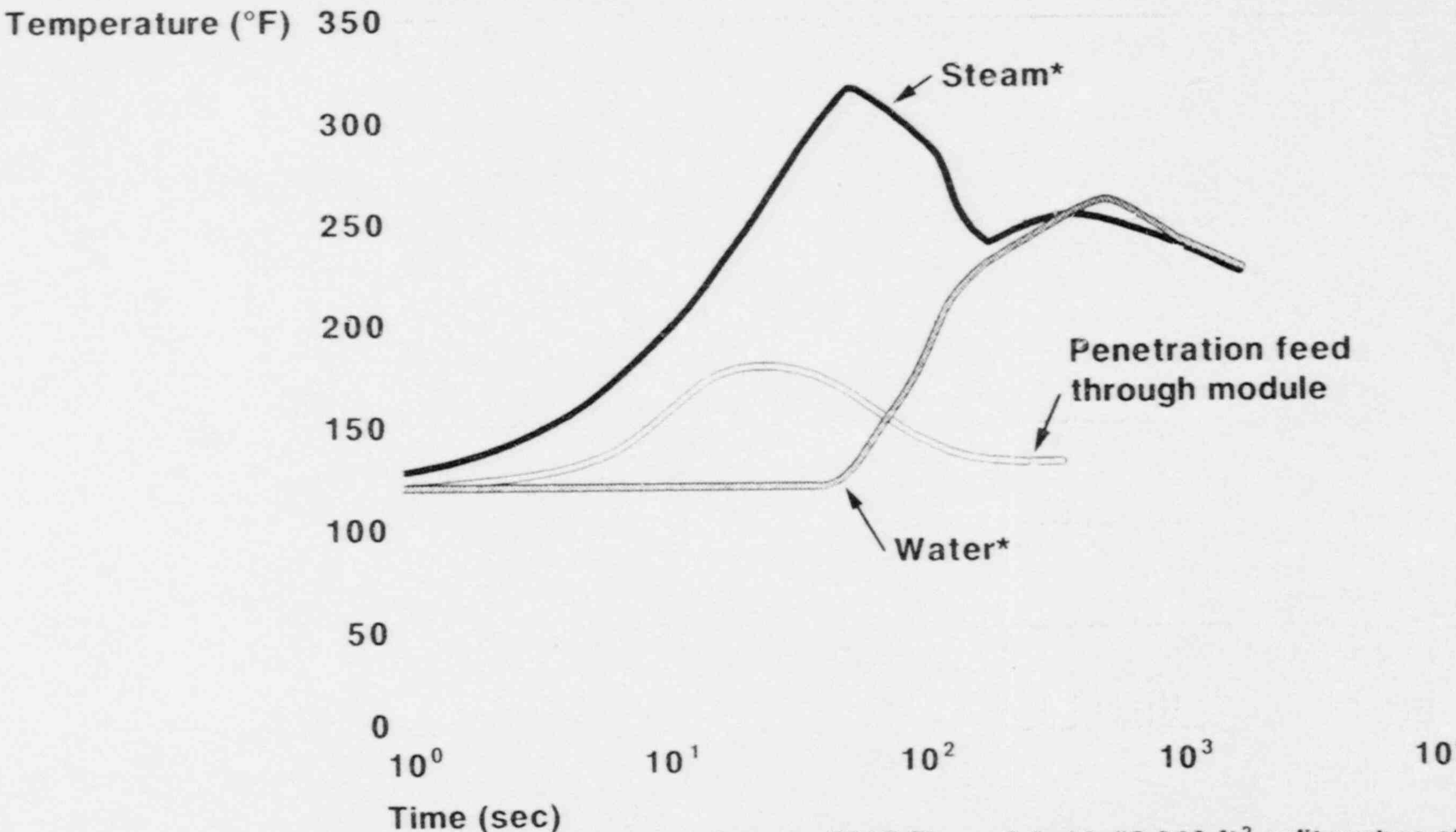




C1595.0042/M 03-88

Braidwood Unit 2 Bunker-Ramo Penetration Short-Term Heatup Curve

Exhibit B-2



* Source: FSAR Figure 6.2-14, "0.942 ft^2 split rupture at 30% power with steamline stop valve failure"

C1595.0C8 3-23-88

TABLE V

LOSS OF COOLANT ACCIDENT (LOCA) RESULTS: (OHMS)

Circuit	Classification	Initial	1st Ramp	2nd Ramp	4th Ramp	5th Ramp	7th Day	14th Day	22nd Day	28th Day	30th Day	Final
Triax	Inst.	1.8×10^{11}	3.7×10^{6}	8.5×10^{5}	2000	1.3×10^{5}	1.0×10^{3}	2.5×10^{3}	1.3×10^{4}	1.5×10^{4}	1.5×10^{4}	1.8×10^{4}
Coax, TNC	Inst.	3.6×10^{12}	3.4×10^{7}	1.9×10^{6}	220	1.2×10^{5}	65	1.2×10^{3}	2.0×10^{4}	1.0×10^{4}	1.2×10^{4}	4.0×10^{4}
3x350	LVP	1.2×10^{11}	3.4×10^{6}	1.4×10^{5}	2.8×10^{5}	1.5×10^{5}	8.0×10^{4}	4.0×10^{4}	1.4×10^{4}	3.4×10^{4}	3.2×10^{4}	3.0×10^{7}
69#14(T.B)	LVC	4.2×10^{11}	4.3×10^{7}	1.1×10^{5}	800	100	3.6×10^{4}	2.8×10^{4}	7.0×10^{3}	2.1×10^{4}	1.4×10^{5}	2.3×10^{7}
69#14(RFR/TB)	LVC	8.0×10^{11}	2.4×10^{7}	1.2×10^{5}	600	1200	1.0×10^{4}	3.3×10^{4}	4.5×10^{4}	3.4×10^{4}	1.9×10^{5}	1.6×10^{8}
MV	MVP	5.4×10^{10}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.1×10^{6}
Twinax	Inst.	3.7×10^{8}	1000	9.0×10^{4}	3000	1.5×10^{5}	2.5×10^{4}	2.0×10^{3}	5.0×10^{4}	1.0×10^{4}	1.7×10^{4}	2.3×10^{4}
Coax, BNC	Inst.	1.0×10^{13}	1000	9.5×10^{4}	100	100	40	80	150	180	185	230
69#14(WCSF)	LVC	8.0×10^{11}	2.5×10^{7}	1.4×10^{6}	2.7×10^{7}	8.0×10^{4}	4.6×10^{4}	3.6×10^{4}	9.0×10^{4}	1.8×10^{4}	5.7×10^{4}	2.3×10^{7}
Conditions:												
Temperature (°F)		Room	340	340	300	265	240	240	243	240	240	Room
Pressure (psig)		0	104	104	53	25	10	11	10	10	10	0
pH		0	>11	>11	>11	>11-9.4	8.2	5.8	6.6	6.6	6.4	0

NOTE: I.R. values <1 x 10^{7} are based on Simpson meter @ 22.5 VDC.

MIDLAND II TEST CURVE OF A BUNKER RAMO INSTRUMENTATION PENETRATIONS

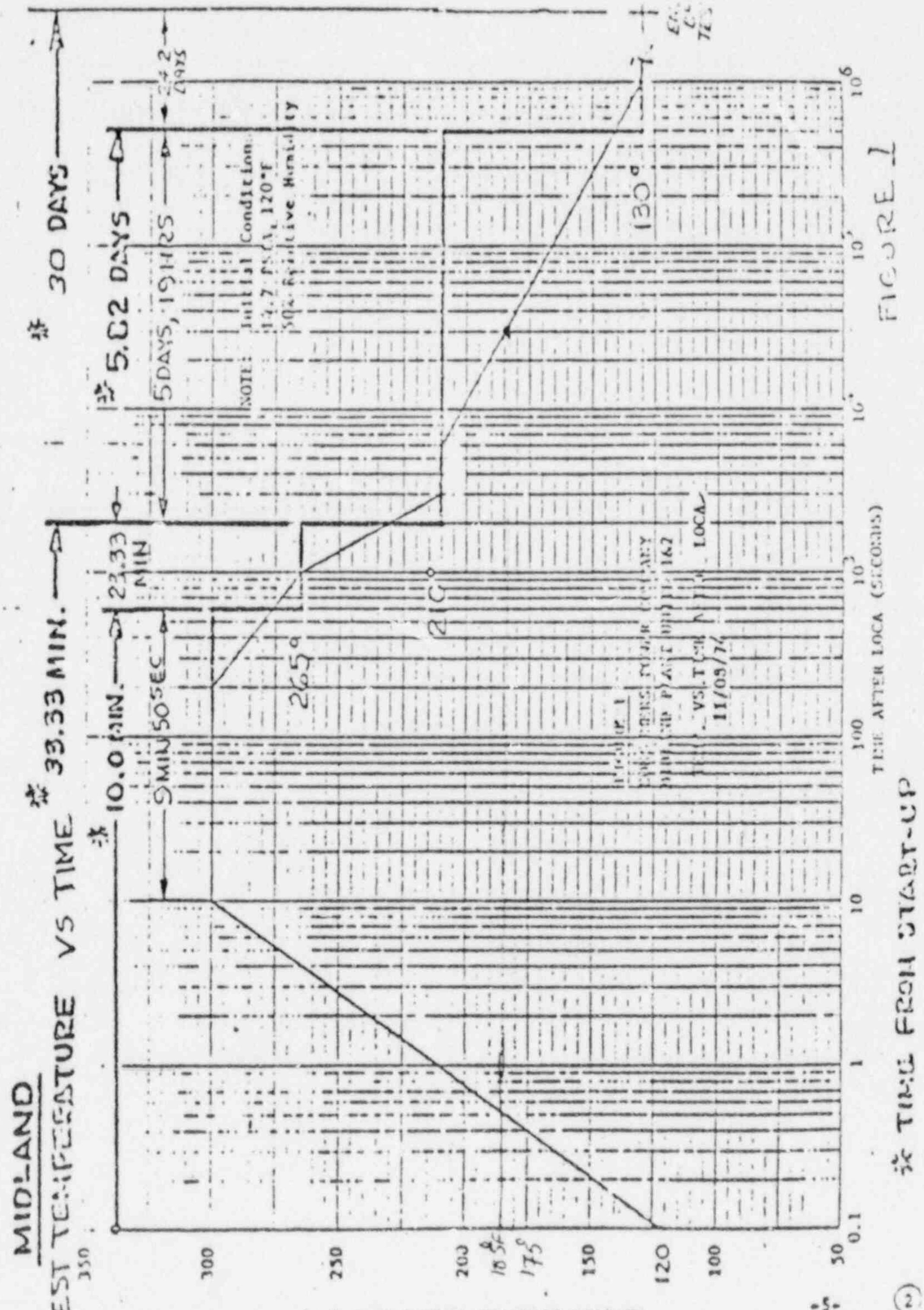


FIGURE 1

-5-

②