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April 7, 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

Reference (a): March 23, 1988 S.C. Hunsader letter to T.E. Murley

Dear Mr. Murley:

Reference (a) provided the NRC staff with additional documentation to provide support for the environmental qualification, under 10 CFR50.49, of a Bunker Ramo Penetration used at Braidwood Station Unit 2.

As indicated in reference (a) additional supportive documentation addressing the application for post-accident monitoring would be provided for the NRC staff's review. Attached to this letter you will find Attachment A, entitled "Summary or Calculations, Thermal Analysis of Bunker-Ramo Containment Penetrations" which includes this information.

Attachment A provides an expansion of the answer to NRC questions included in pages 3 through 6 of the Supplement to Appendix B, attached to reference (a). It provides a further description of the heat transfer model for the penetration and includes the thermal analysis model representative of the post-accident monitoring (PAM) condition. Also included in Attachment A is a description of the subsequent review performed of the Midland II environmental qualification test time/temperature strip charts. This review shows that temperatures seen by the penetration module during the first two days that insulation resistant values were measured, on average, were 228°F and 230°F, respectively. These values envelope the maximum temperature (224.1°F) expected to be seen by the Bunker Ramo penetration at Braidwood Unit 2 during the PAM condition.

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Overall, the evaluation shows that the Midland II LOCA test accurately represents the Braidwood Station parameters to support the environmental qualification of the Bunker Ramo penetrations.

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
4432K

ATTACHMENT A

SUMMARY OF CALCULATIONS

Thermal Analysis of Bunker-Ramo Containment Penetrations

Calculations have been performed to determine the effects of the Containment Building pressure-temperature transient on the Bunker-Ramo instrumentation penetration assemblies. The time dependent temperature profile in the vicinity of the penetration feed through module is calculated for comparison to the available qualification data. This calculation documents that the temperatures at the penetration feed through modules will not exceed 157°F prior to initiation of the necessary instrument signals to trip the reactor and initiate safety injection. This calculation also documents that the temperature at the feed through module was similar to the temperature in the Midland II test during the remainder of the accident profile. The calculation 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 period following the accident when the instrumentation circuit, passing through the penetrations are required.

To evaluate the effect of the accident pressure-temperature transient on the feed through module, a computer model of the containment and the penetration was prepared. The first node in the model is 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 is the portion of the penetration assembly between the inboard support plate and the center support plate. The third node in this model is the containment volume. The nodes communicate with each other by means of the openings in the support plates.

The initial analysis performed for this study utilized the KITTY Computer Code and took into account the heat transfer into the penetration sleeve and the surrounding concrete. This analysis was sufficient to demonstrate that the temperature of the steam-air mixture in Node 1 was below 157°F at the time when the reactor trip and safety injection signals would be initiated. The results of this analysis was provided to the NRC as a part of the Supplement to Attachment B to the March 23, 1988 letter from S. Hunsader to T. Murley. The model utilized was given in Exhibit B-1 to that letter and the temperature curve was given in Exhibit B-2.

In order to evaluate the long term temperature profile at the feed through module location a new computer model was prepared. This computer model, utilizing the COMPARE/MODT Code, took into consideration several heat transfer processes. These heat transfer processes are as follows:

1) Isentropic compression of the gas in the assembly due to pressurization of containment.

2) Convection and conduction to the penetration steel and surrounding concrete and to the Auxiliary Building air.

3) Influx of mass and heat into the penetration due to condensation.

4) Condensation heat transfer to the penetration steel surfaces.

5) Natural circulation flows around the cable support plates and the resultant mass transfer into the penetration assembly.

This new model simultaneously incorporated the above processes for the three nodes and also modeled the penetration sleeve, the containment concrete, and the Auxiliary Building environment (See Exhibit B-3 for a description of this model).

The COMPARE/MODT analysis accounted for the flow from Node 3 to Node 2 and from Node 2 to Node 1 due to the pressurization of the containment. These flow paths are shown respectively as mass flow paths 2 and 1 on Exhibit B-3. The analysis modeled the natural circulation flows between the adjacent nodes. Upper bounding time dependent flow rates based on the density differences between nodes were input. These mass flow paths are shown as paths 1A, 1B, 2A and 2B on Exhibit B-3. The analysis modeled axial conduction along the penetration sleeve and radial conduction into the sleeve and through the sleeve into the adjacent concrete. The model accounted for this two-dimensional affect in the one-dimensional COMPARE/MODT Code by using air nodes and dummy heat sinks as shown on Exhibit B-3. The capacitances and conductances of the air nodes and sleeve and the heat sinks were modeled to represent the sleeve and the adjoining concrete.

Node 4 on Exhibit B-3 represents the portion of the penetration sleeve exposed to the auxiliary building environment. The COMPARE/MODT model used natural convection to transfer energy from the outer surface of this node to the auxiliary building environment. Axial conduction of thermal energy along the penetration sleeve was included in the model as represented by the heat transfer path from Nodes 8 to 6 to 5 to 4. In accordance with NUREG-0588, the larger of natural convection or condensation heat transfer was applied at the inner surface of the sleeve. The COMPARE/MODT Code also accounts for the influx of mass and heat into the penetration due to condensation effects.

The accident that was chosen for this calculation was the Main Steam Line Break (MSLB). This accident was considered limiting for three 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 (FSAR 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 (FSAR p. 15.1-19) and in one second for LOCA (FSAR p. 15.6-30).

3. As shown on Exhibit B-4, the Main Steam Line Break (MSLB) envelopes the Double Ended Hot Leg (DEHL) LOCA except for two relatively insignificant periods. The first period is in the first ten to twenty seconds of the transient. This period is after actuation of the safety injection and reactor trip instruments for the LOCA (FSAR p. 15.6-30) but well before the PAMS would be required to operate. The second period is from 150 - 300 seconds into the events. During this period, the differences in temperature between two curves is not significant when compared to the earlier peak of MSLB curve.

The computer analyses utilized the Westinghouse mass-energy release data and the containment pressure - temperature curves from FSAR Figures 6.2-13 and 6.2-14 to establish the time dependent conditions in the containment node (Node 3). Using this input, the time history of the pressure-temperature conditions in Nodes 1 and 2 was calculated. Exhibit B-4 shows the temperature on Node 1 (adjacent to the feed through module) plotted on the containment temperature curve for the Main Steam Line Break/Double Ended Hot Leg LOCA (FSAR Figures 6.2-11 and 6.2-14).

It should be noted that the maximum temperature at the feed through module prior to trip initiation (10 seconds) is 157°F. This temperature is well below the temperature at which the Midland IR value was measured.

In order to more accurately determine the temperature at which the penetration IR value was recorded during the Midland II LOCA test, a more detailed review of the time/temperature strip charts from the test was performed. Exhibit B-5 is a sample of a portion of the Midland II LOCA test strip chart. The first IR measurement was made between 3:12 a.m. and 7:00 a.m. on October 25, 1978. The second IR measurement was made at 10:00 a.m. on October 27, 1978. These times are documented in ANCO Engineers, Inc. March 21, 1988 letter. The time/temperature strip charts for these time periods record temperature data from several thermocouples in the test chamber. Because neither the test report nor the test log document the installed location for each thermocouple, the average temperature of all thermocouples during the periods when the IR measurements were made will best represent the temperature of the penetration feed through module. This methodology is consistent with that used in other test applications in which several redundant instruments are used to reduce calibration error.

ANCO Engineers, Inc. reassessed the time/temperature strip chart data recorded between 3:00 a.m. and 7:10 a.m. on October 25, 1978. Exhibit B-6 documents the results of this review. ANCO counted the number of temperature data points recorded in each 10°F increment between 190°F and 250°F. By averaging the data provided by ANCO, we can establish an average temperature of 228°F (Standard deviation 12.3°F) at the time when the IR measurements were made on October 25, 1978. Additionally, we can

establish that 81% of the temperature data points recorded, when the IR measurement was made, are above 220°F. A similar evaluation was performed for the time period between 9:42 a.m. and 10:42 a.m. on October 27, 1978. The results of this review are documented on Exhibit B-7. By averaging the data provided by ANCO, we also can establish an average temperature of 230°F (Standard deviation 11°F) at the time when the IR measurement was made on October 27, 1978. We can establish that 70% of the temperature data points recorded at this time are above 225°F.

Exhibit B-4 shows the calculated temperature in Node 1 of our model during the MSLB transient. As can be seen on the Exhibit, the Node 1 temperature initially peaks at 157°F after 20 seconds and gradually drops off. This early peak is due to the initial pressurization of the containment forcing the steam/air mixture from containment into the penetration. The Node 1 temperature cools somewhat when the heat sink provided by the containment penetration steel and the containment concrete begin to absorb heat. From about 25 seconds into the transient onward, the other modeled phenomena (especially natural convection) become predominant. The calculated Node 1 temperature crosses 210°F approximately 335 seconds after initiation of the transient. It approaches the MSLB containment temperature curve and peaks at 224.1°F approximately 15 minutes into the transient. The calculated Node 1 temperature parallels the MSLB containment temperature for the duration of the transient returning below 210°F approximately 48 minutes into the transient. From this point onward, the calculated penetration temperature decreases slowly as does the containment temperature.

A comparison of the time/temperature strip chart data for the Midland II LOCA test and the calculated Node 1 temperature for the COMPARE/MODT model of the Braidwood Unit 2 containment instrumentation penetration assemblies, provides additional justification for our use of the Midland II LOCA test to evaluate the Braidwood Unit 2 instrumentation penetration assemblies. The calculated temperature is well below the test temperature during the time frame when the Safety Injection and Reactor Trip instruments are required to activate. During the later stages of the accident, instruments passing through the subject penetration are only used for the Post Accident Monitoring System (PAMS). However, even during this time frame, the temperatures predicted by a conservative model of the penetration assembly during the transient are less than the average temperatures at which Bunker-Ramo measured IR values during the Midland II LOCA test. Therefore, we believe that the Midland II LOCA test also establishes a basis that supports the qualification and demonstrates the acceptability of the Bunker-Ramo instrumentation penetration assemblies during the time frame PAMS is required.

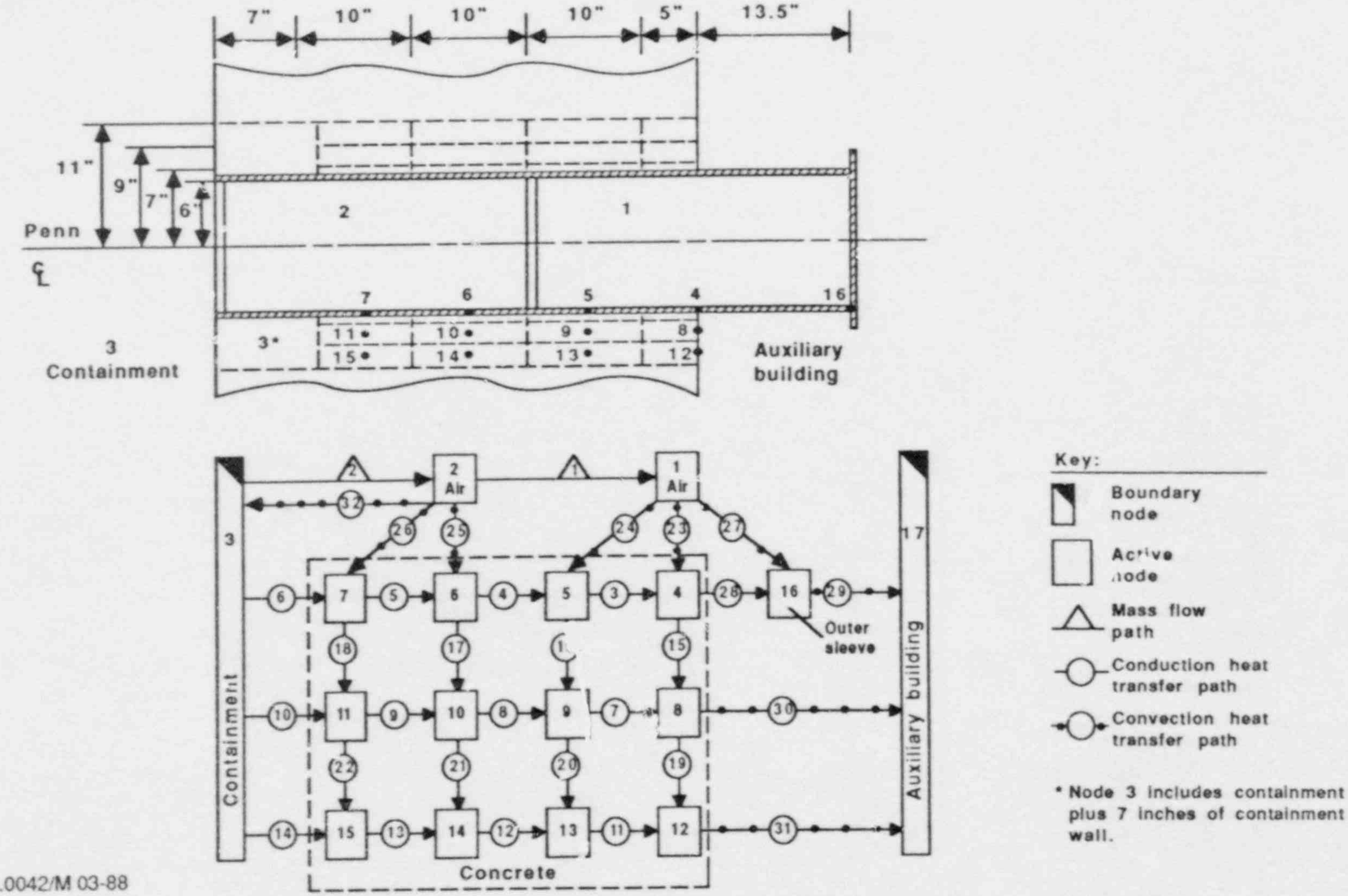
It should be noted that the use of the Midland II LOCA test is conservative for several other reasons as discussed previously. The chemical spray used in the Midland II LOCA test is more electrically conductive than the chemical spray used at Braidwood Unit 2. Independent test data has shown that the penetration IR measurements are affected much more significantly by chemical spray initiation than by temperature. This was included in "Supplement to Appendix B" attached to S. C. Hunsader's letter to T. E. Murley, dated March 23, 1988. However, during the LOCA test, the synergistic effects on IR measurements from all parameters (i.e., pressure, humidity, chemical spray) must be considered. We have shown in this evaluation that the Midland II LOCA test accurately represents the Braidwood Station parameters for acceptance of these penetrations. In addition, the Midland II LOCA test specimens did not contain envi-

ronmentally sealed connections. The installed Braidwood Unit 2 penetrations utilize environmentally sealed connections that have been qualified separately for the LOCA environment.

In summary, we believe that the documentation submitted with our March 23, 1988, letter and supplemented by the above evaluation, provides additional bases to support the environmental qualification and demonstrates the acceptability of the Braidwood Unit 2 Bunker-Ramo Instrumentation Penetrations.

Braidwood Unit 2 Bunker-Ramo Penetration Heat Transfer Model

Exhibit B-1



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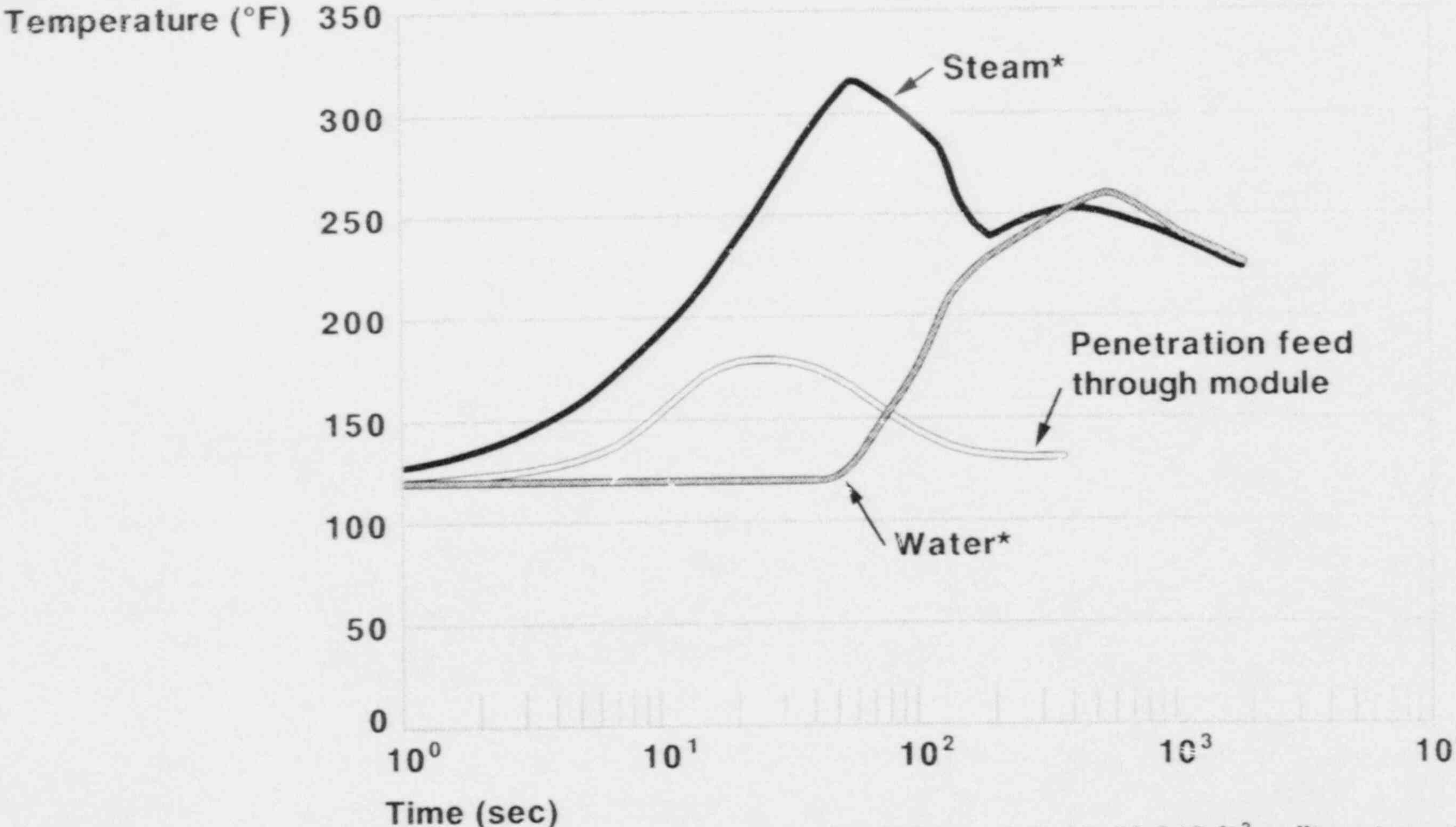
Braidwood Unit 2 Bunker-Ramo Penetration Short-Term Heatup Curve

Exhibit B-2



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

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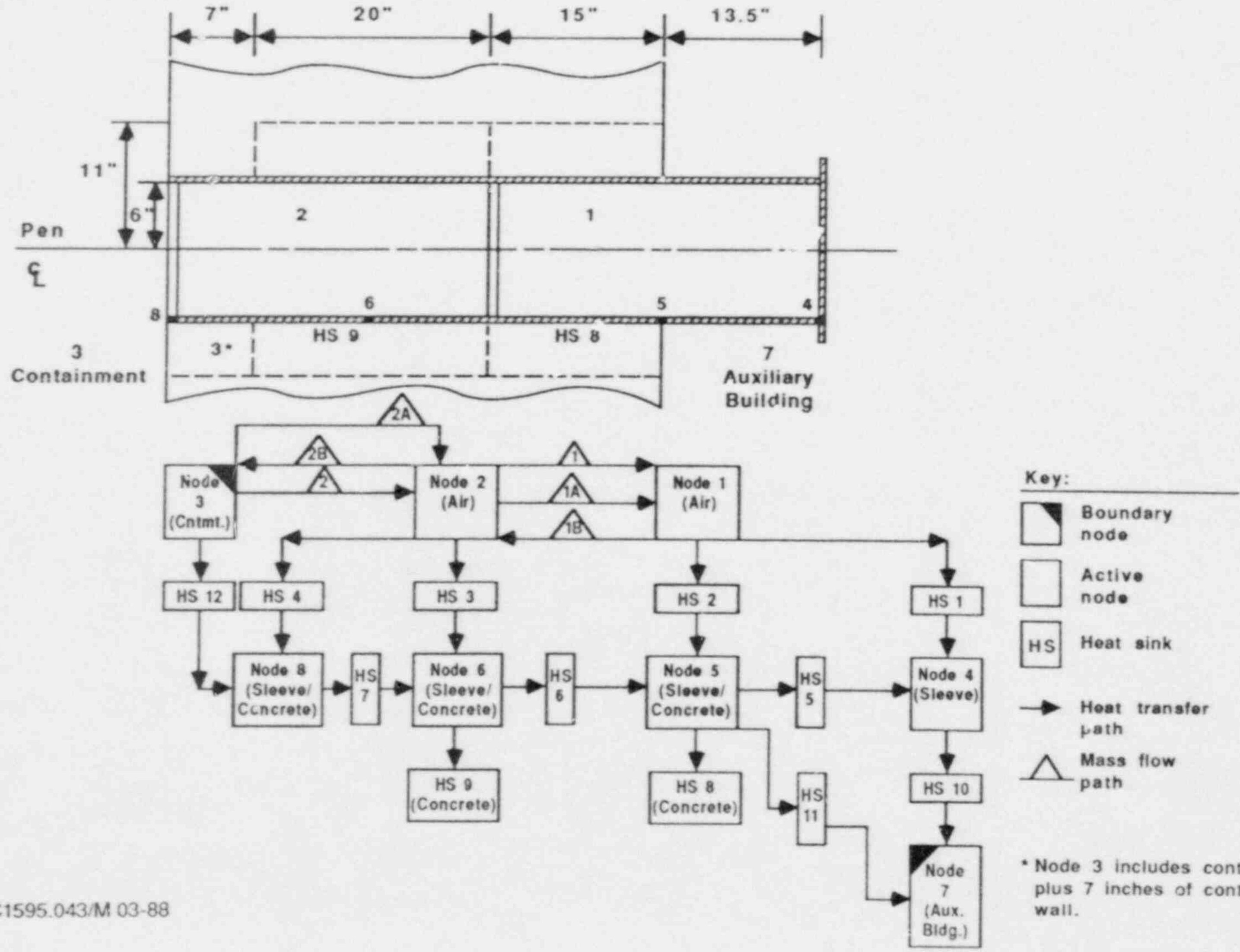
Braidwood Unit 2 Bunker-Ramo Penetration Model—COMPARE/MODT

Exhibit B-3



* Node 3 includes containment plus 7 inches of containment wall.

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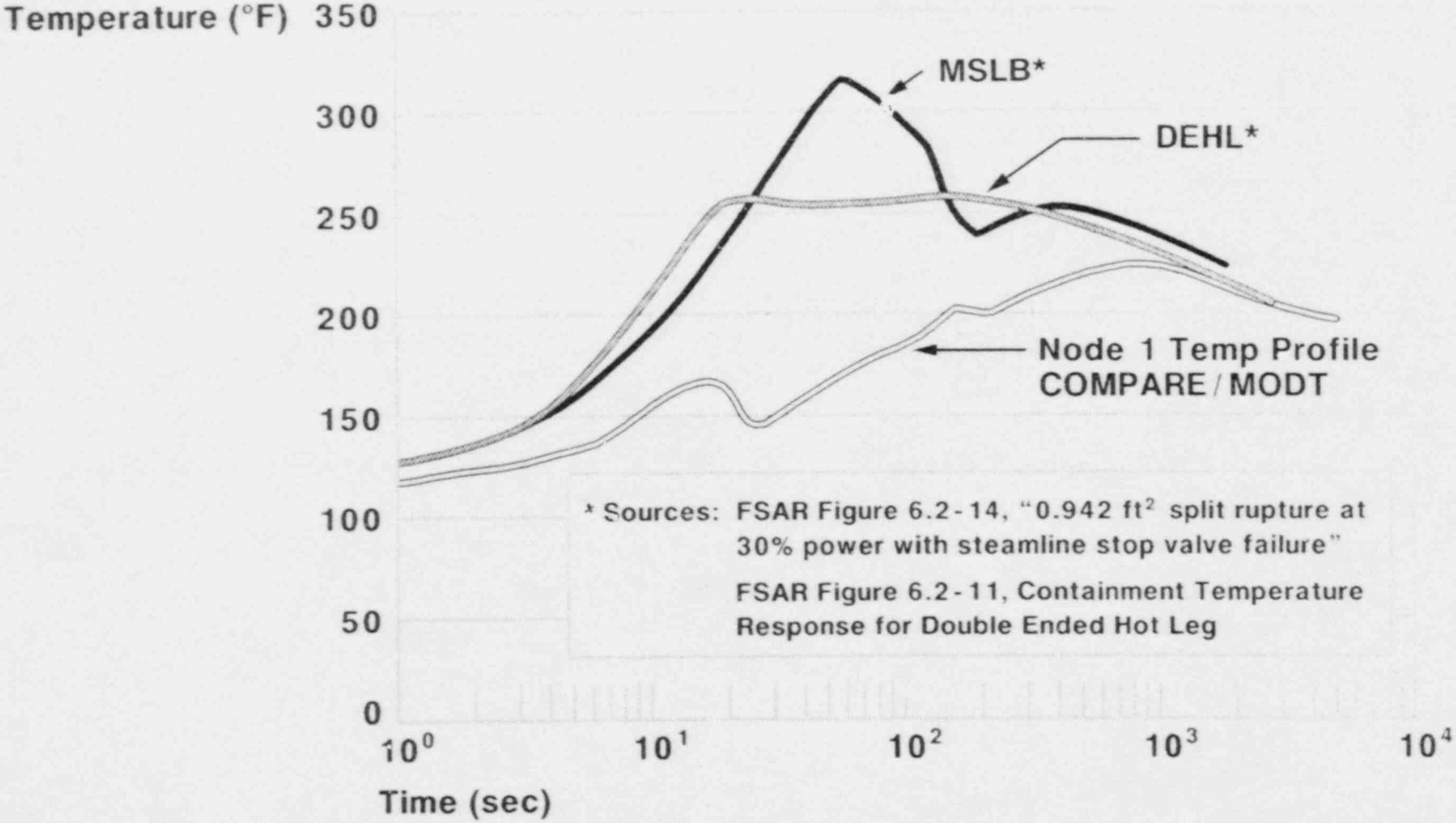
Braidwood Unit 2 Bunker-Ramo Penetration Short-Term Heatup Curve

Exhibit B-4



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

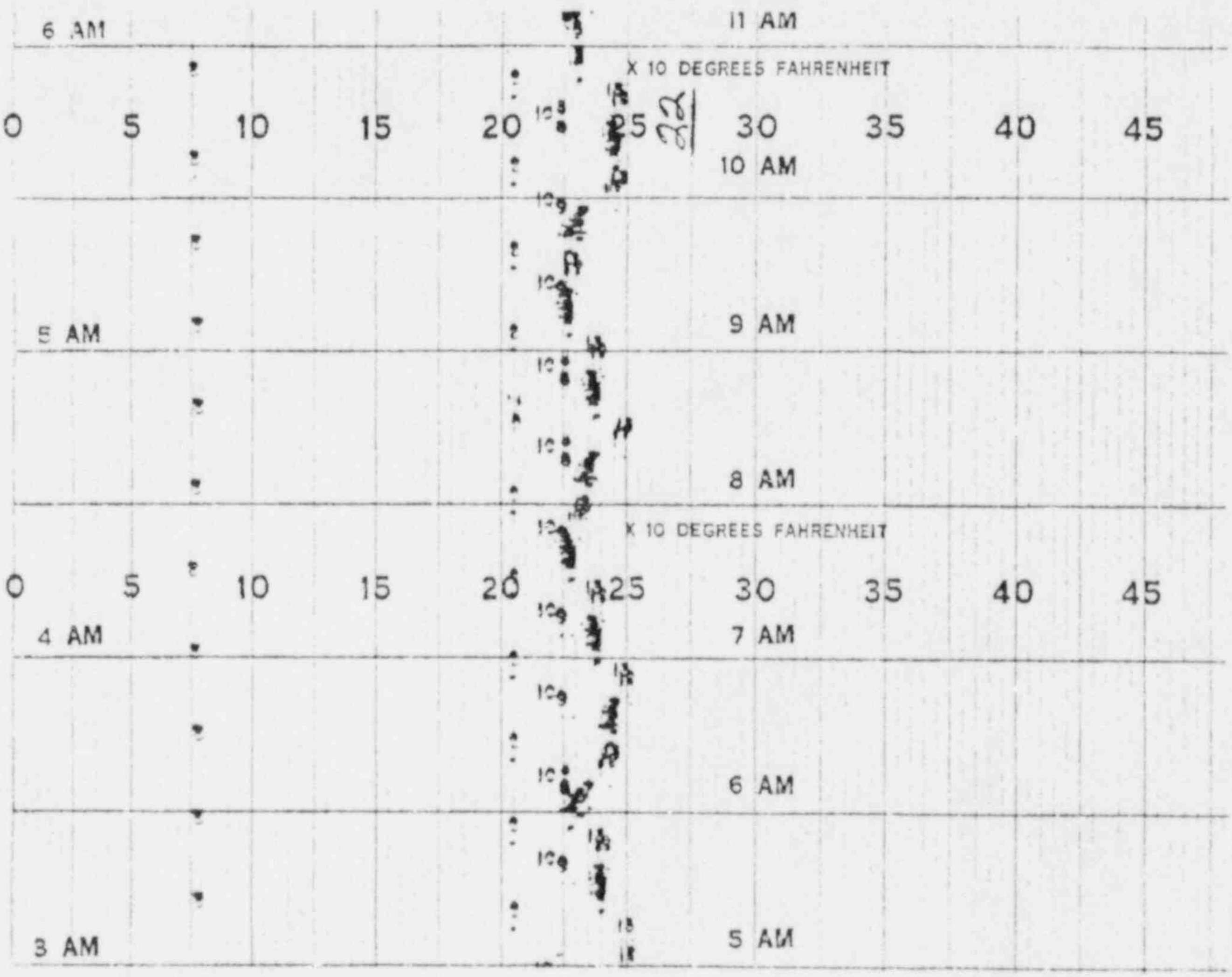
FSAR Figure 6.2-11, Containment Temperature Response for Double Ended Hot Leg

Bunker-Ramo

Midland II LOCA Test

Example Strip Chart Recordings of 10-25-78

(Data from 3:00 a.m. to 7:10 a.m.)



<u>Note</u>: The above Midland II strip chart represents a sample portion of the data points recorded on October 25, 1978, during the period from 3:00 a.m. to 7:10 a.m. The time increments noted on the chart <u>do not</u> reflect the actual test time periods shown above. The test data was recorded at a scale of one (1) inch = two (2) minutes <u>not</u> one (1) inch = one half (1/2) hour. The ambient temperature during the test was 75°F. The temperature recorded is in degrees Fahrenheit and must be multiplied by 10 degrees to obtain actual recorded temperature.

Bunker-Ramo

Midland II LOCA Test

Strip Chart Recordings of 10-25-78

(Data from 3:00 a.m. to 7:10 a.m.)

Temperature Range (°F)	(A) Midpoint Temperature (°F)	(B) Data Points	(B÷C)=(D) %	(DxA) %
190 - 200	195	50	.019	3.844
200 - 210	205	200	.079	16.167
210 - 220	215	271	.1068	22.975
220 - 230	225	778	.307	69.026
230 - 240	235	872	.344	80.804
240 - 250	245	365	.1439	35.262
250 >	Ø	Ø	Ø	Ø
	Total (C)	2536	0.9997	228.08

(A) Average Temperature = 228°F

(B) Total Percentage @ 210°F and above $\frac{2557}{2807}$ = 91%

(C) Total Percentage @ 220°F and above $\frac{2286}{2807}$ = 81%

EXHIBIT B-7

Bunker-Ramo

Midland II LOCA Test

Strip Chart Recordings of 10-27-78

(Data from 9:42 a.m. to 10:42 a.m.)

Temperature Range (°F)	(A) Midpoint Temperature (°F)	(B) Data Points	(B÷C)=(D) %	(DxA) %
205 - 210	207.5	56.4	.10	20.75
215 - 220	217.5	112.8	.20	43.50
225 - 250	237.5	394.8	.70	166.25
	Total (C)	564	1.00	230.5

(A) Average Temperature = 230.5°F

(B) Total Percentage @ 215°F and above = $\frac{507.6}{564}$ = 90%

(C) Total Percentage @ 225°F and above = $\frac{394.8}{564}$ = 70%