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SUBJECT: Forwards environ qualification of Class IE control cable mfg by Continental Wire & Cable Co.Requests receipt of malt be ack.

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January 16, 1981

Mr. Frank J. Miraglia, Chief
Licensing Branch No. 3
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Re: Docket No. 50-275
Docket No. 50-323
Diablo Canyon Units 1 and 2

Subject: Environmental Qualification of Class IE Control Cable Manufactured by Continental Wire and Cable Co. for Diablo Canyon Units 1 and 2

Dear Mr. Miraglia:

The attached information describes the thermal analysis which demonstrates the environmental qualification for Continental control cable installed at Diablo Canyon.

Kindly acknowledge receipt of the material listed above on the enclosed copy of this letter and return it to me in the enclosed addressed envelope.

Very truly yours,

Philip A. Crane, Jr.

Attachment
CC w/attachment: Service List

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Environmental Qualification of Class 1E Control Cable

Manufactured by Continental Wire and Cable Co. for Diablo Canyon Units 1 and 2

1. Introduction

The cable has been qualified to a temperature of 281°F (see Continental Wire and Cable Company test report No. CC2193S, March 1971). However, as stated in our letter dated December 27, 1978, the main steam line break peak temperature is 344°F. The purpose of this analysis is to determine the transient temperature response of the cable exposed to the MSLB conditions depicted in Figures 8 and 9 of our December 27, 1978, letter and compare the resulting temperature history of the critical point of the cable to the qualification temperature of 281°F. If the critical point remains below 281°F, analysis indicates the cable has been tested sufficiently for the MSLB environment.

2. Worst-Case Configuration

Figure 1 shows the cable cross section including material layers and thicknesses. The outermost layer is a 3/4 inch galvanized steel conduit housing a single cable containing two copper conductors insulated as shown. This is the worst-case configuration for this type of electric cable - a larger conduit or a conduit with several cables has higher thermal resistance than the case shown. The critical point of the cable chosen for this study, is the outer surface of the conduit (Node 2 in Figure 2).

3. Thermal Analysis Model

To solve the two dimensional transient heat transfer relation

i.e. $$\frac{d^2T}{dx^2} + \frac{d^2T}{dy^2} = \frac{1}{\alpha}\frac{dT}{dt}$$

where T = temperature

x = x dimension

y = y dimension

t = time

α = thermal diffusivity

for the temperature T(r, Ø, t) of the system, a computer program (TRUMP written by A. Edwards of Lawrence Livermore Lab), using finite element numerical solution was employed. To model the cable system, a nodal representatiion was constructed (see Figure 2). As shown, the calculational model is composed of each of the material

3. Thermal Analysis Model (Continued)

layers were determined by making the thickness equivalent to the actual thickness, the depths (perpendicular to the plane of the page) all unity, the lengths equal to 2π x mean radius of each layer, thereby retaining the equivalent total volume, and, therefore, total heat capacity of Figure 1. Each layer is divided into homogeneous regions (nodes) with corresponding node centers, areas, volume and thermal connections. The volumes of the nodes were made roughly continuous (smoothly dimishing) so that the resulting calculational time step $= \chi \rho C \forall / KA$ is stable; the numbers correspond to node centers except 1, 2, 3, 70, 71, 72 which are zero-volume nodes.

Assumptions made in making the calculational model are:

a. The cylindrical sections may be modeled as rectangular sections.

b. Air in conduit may be treated as perfect insulator.

c. The critical heat path at Point A and Point B of Figure 1 crosses a finite surface area of 0.01375 sq. ft. and 0.00107 sq. ft. respectively. Beyond these areas the air and asbestos act as perfect insulators.

d. Thermal properties of the materials (Figure 3) remain constant.

e. Radiation effects are negligible.

f. Heat generated by conductors is negligible.

Boundary Condition Considerations

During the initial period of a main steamline break, the temperature of the cable, initially at 120°F, is below the saturation temperature corresponding to the partial pressure of the entering steam. As a result, condenation occurs on the surfact of the conduit until the surface temperature approaches Tsat, when the liquid film vaporizes and the cable is exposedto superheated vapor. This effect results in two temperature environments to which the cable is exposed: T saturation during the condemnation period, and T containment during the convective period. The corresponding heat transfer coefficients are h condensation and h convection. This point is noted in a PGandE letter dated December 18, 1978. The condensation time was found to be approximately 10 seconds. A conservative value of 25 seconds was used in the analysis; at $t_{cond.}$ the condensation heat transfer coefficient of 400 Btu/hr ft^2°F drops to the convective coefficient of 16 Btu/hr ft^2°F.

4. Results

Figure 4 gives the critical layer temperature vs. time. After 165 seconds, the maximum temperature is 263.3°F. After this time the layer temperature will decrease as the conduit surface cools to saturation temperature. A copy of the computer printout is shown in Figure 5.

The values of h convection and t condensation used in the analysis were chosen such that the critical layer temperature calculated is the upper bound temperature.

5. Conclusion

The Continental Cable, as installed in the containment of the Diablo Canyon Power Plant, meets all requirements for nuclear safety related (Class 1E) wires and cables.

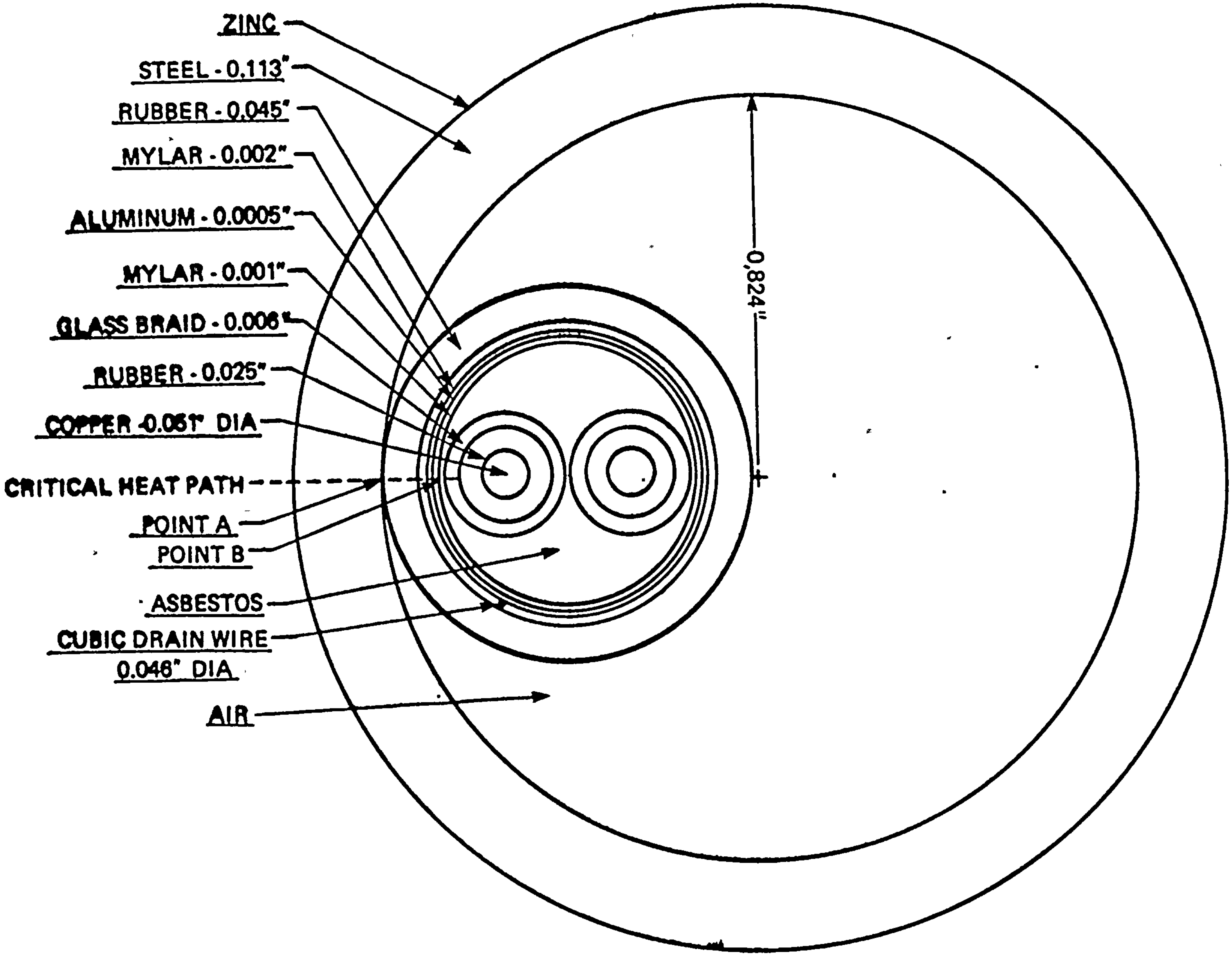
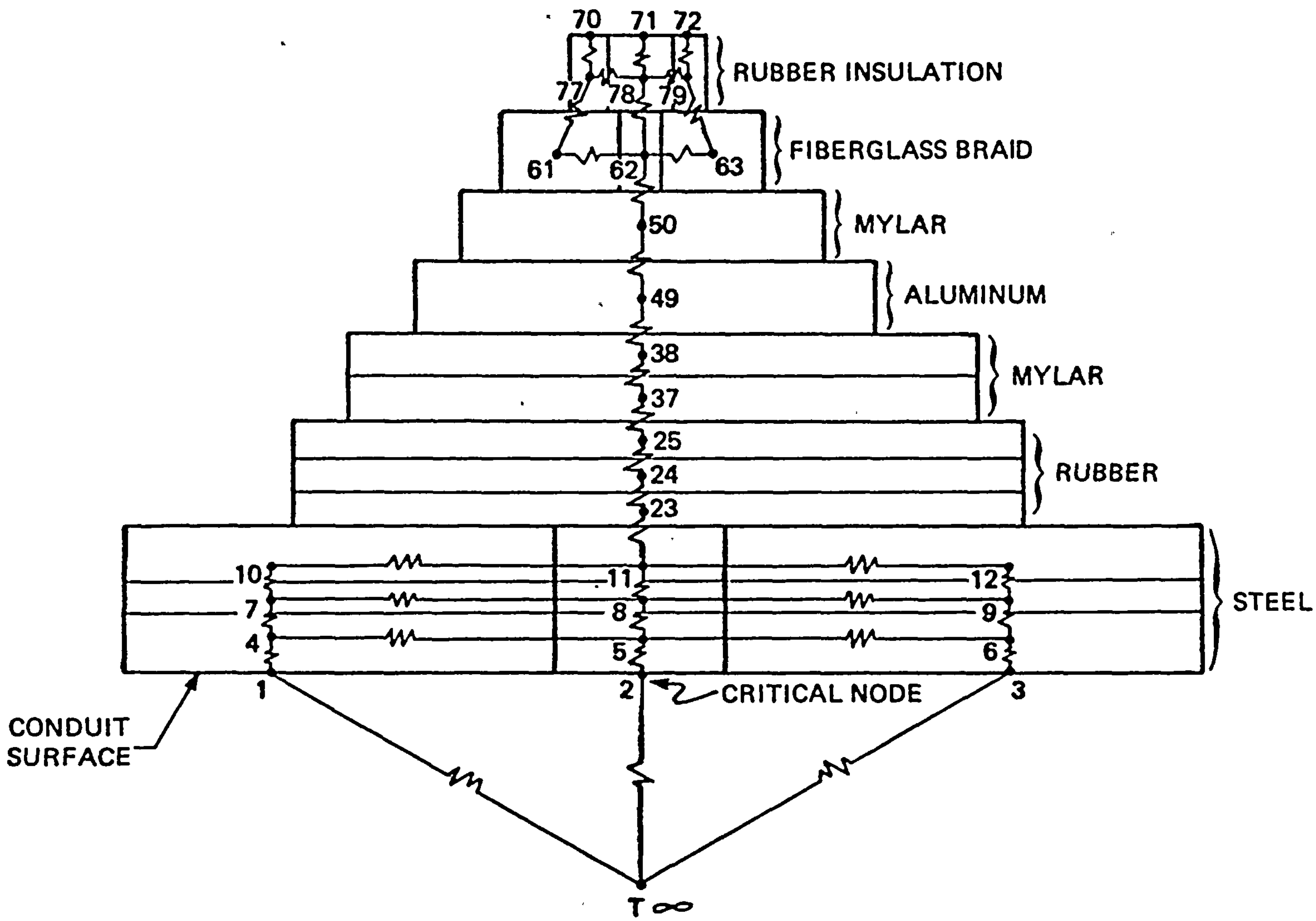


FIGURE 1 - CABLE DIAGRAM
(Not to scale)

FIGURE 2 - NODE COMPUTER CALCULATION MODEL



HEAT FLOW PATH WITH THERMAL RESISTANCE

Figure 3 Material Properties

Dimensions and material properties supplied by manufacturer

Material	Density (lbm/ft.^{3})	Capacity (Btu/lbm^{o}F)	Conductivity (Btu/hr.ft.^{o}F)
Steel	490.0	0.110	26.0
Silicon Rubber	77.5	0.341	0.18
Mylar	87.5	0.320	0.08
Aluminum	169.0	0.210	119.0
Fiber Glass	159.0	0.920	0.94

Figure 4

Critical Temperature Vs. Time

Temp. Node 2 (^oF)	Time (Sec.)	Hr.
120.	0	
136.7	15	.00417
160.5	30	.00833
173.3	45	.0125
187.8	60	.01667
202.8	75	.0208
217.5	90	.0250
231.1	105	.0292
243.6	120	.0333
256.8	140	.03889
262.9	160	.0444
max. temp. → 263.3	165	.0458
261.8	180	.0500
258.8	200	.0556
256.1	220	.0611

Figure 5

TRUMP OUTPUT DATA DATA DECK 1

TRANSIENT TEMPERATURE RESPONSE OF CABLE TO MSLB TRIAL2-SLAB

PRINTOUT	CYCLE	MF	MSS	KWIT	DELTMX	SMALL	TVARY	DTEMP	DTMAXS	NUTS
39	2833	74	13	0	0.10000D 13	0.88976D-06	0.10000D 00	0.26158D-01	0.99388D-01	2

TOTAL TIME	TIME STEP	HEAT FLOW	TEMP FROM FLUX	FLUX RATE	TEMP RATE
165 sec = 4.58370D-02 hr	1.14793D-05	1.92490D 01	1.44103D 02	4.19944D 02	3.14381D 03

AVG TEMP	HEAT CAPACITY	HEAT CONTENT	GEN RATE	HEAT GEN	TEMP FROM GEN
2.64108D 02	1.33578D-01	3.52790D 01	0.0	0.0	0.0

NODE	TEMP	DT	DDT	GEN RATE	W	H	F
1	0.2650D 03	-0.1896D-02	-0.1651D 03	0.0	0.1428D-19	0.7816D-20	-0.7045D-04
→ 2	0.2633D 03	0.7452D-03	0.6486D 02	0.0	0.1419D-19	0.7723D-20	-0.5950D-05
3	0.2650D 03	-0.1896D-02	-0.1651D 03	0.0	0.1428D-19	0.7816D-20	-0.7045D-04
4	0.2650D 03	-0.1751D-02	-0.1524D 03	0.0	0.7761D 01	0.4246D 01	0.4246D 01
5	0.2633D 03	0.8942D-03	0.7783D 02	0.0	0.9171D 00	0.4991D 00	0.4991D 00
6	0.2650D 03	-0.1751D-02	-0.1524D 03	0.0	0.7761D 01	0.4246D 01	0.4246D 01
7	0.2650D 03	-0.1645D-02	-0.1432D 03	0.0	0.3880D 01	0.2123D 01	0.2123D 01
8	0.2632D 03	0.1112D-02	0.9683D 02	0.0	0.4584D 00	0.2494D 00	0.2494D 00
9	0.2650D 03	-0.1645D-02	-0.1432D 03	0.0	0.3880D 01	0.2123D 01	0.2123D 01
10	0.2650D 03	-0.1610D-02	-0.1401D 03	0.0	0.3880D 01	0.2123D 01	0.2123D 01
11	0.2631D 03	0.1260D-02	0.1097D 03	0.0	0.4583D 00	0.2493D 00	0.2493D 00
12	0.2650D 03	-0.1610D-02	-0.1401D 03	0.0	0.3880D 01	0.2123D 01	0.2123D 01
23	0.2566D 03	0.1296D-01	0.1128D 04	0.0	0.1251D 01	0.6658D 00	0.6658D 00
24	0.2557D 03	0.1415D-01	0.1231D 04	0.0	0.4139D 00	0.2197D 00	0.2197D 00
25	0.2541D 03	0.1604D-01	0.1396D 04	0.0	0.2081D 00	0.1098D 00	0.1098D [illegible]
37	0.2540D 03	0.1613D-01	0.1404D 04	0.0	0.4063D-01	0.2143D-01	0.2144D-[illegible]
38	0.2539D 03	0.1623D-01	0.1413D 04	0.0	0.4062D-01	0.2142D-01	0.2143D-01
49	0.2539D 03	0.1620D-01	0.1410D 04	0.0	0.2562D-01	0.1351D-01	0.1354D-01
50	0.2538D 03	0.1628D-01	0.1417D 04	0.0	0.3872D-01	0.2042D-01	0.2042D-01
61	0.2416D 03	0.2615D-01	0.2277D 04	0.0	0.1223D 00	0.6152D-01	0.6152D-01
62	0.2513D 03	0.1840D-01	0.1602D 04	0.0	0.1966D-01	0.1027D-01	0.1027D-01
63	0.2416D 03	0.2615D-01	0.2277D 04	0.0	0.1223D 00	0.6152D-01	0.6152D-01
77	0.2416D 03	0.2616D-01	0.2277D 04	0.0	0.3984D-01	0.2005D-01	0.2005D-01
78	0.2450D 03	0.2357D-01	0.2051D 04	0.0	0.4040D-01	0.2061D-01	0.2061D-01
79	0.2416D 03	0.2616D-01	0.2277D 04	0.0	0.3984D-01	0.2005D-01	0.2005D-01
70	0.2416D 03	0.2616D-01	0.2277D 04	0.0	0.5804D-20	0.2921D-20	0.1692D-07
71	0.2450D 03	0.2357D-01	0.2051D 04	0.0	0.5886D-20	0.3003D-20	0.1623D-07
72	0.2416D 03	0.2616D-01	0.2277D 04	0.0	0.5804D-20	0.2921D-20	0.1692D-07

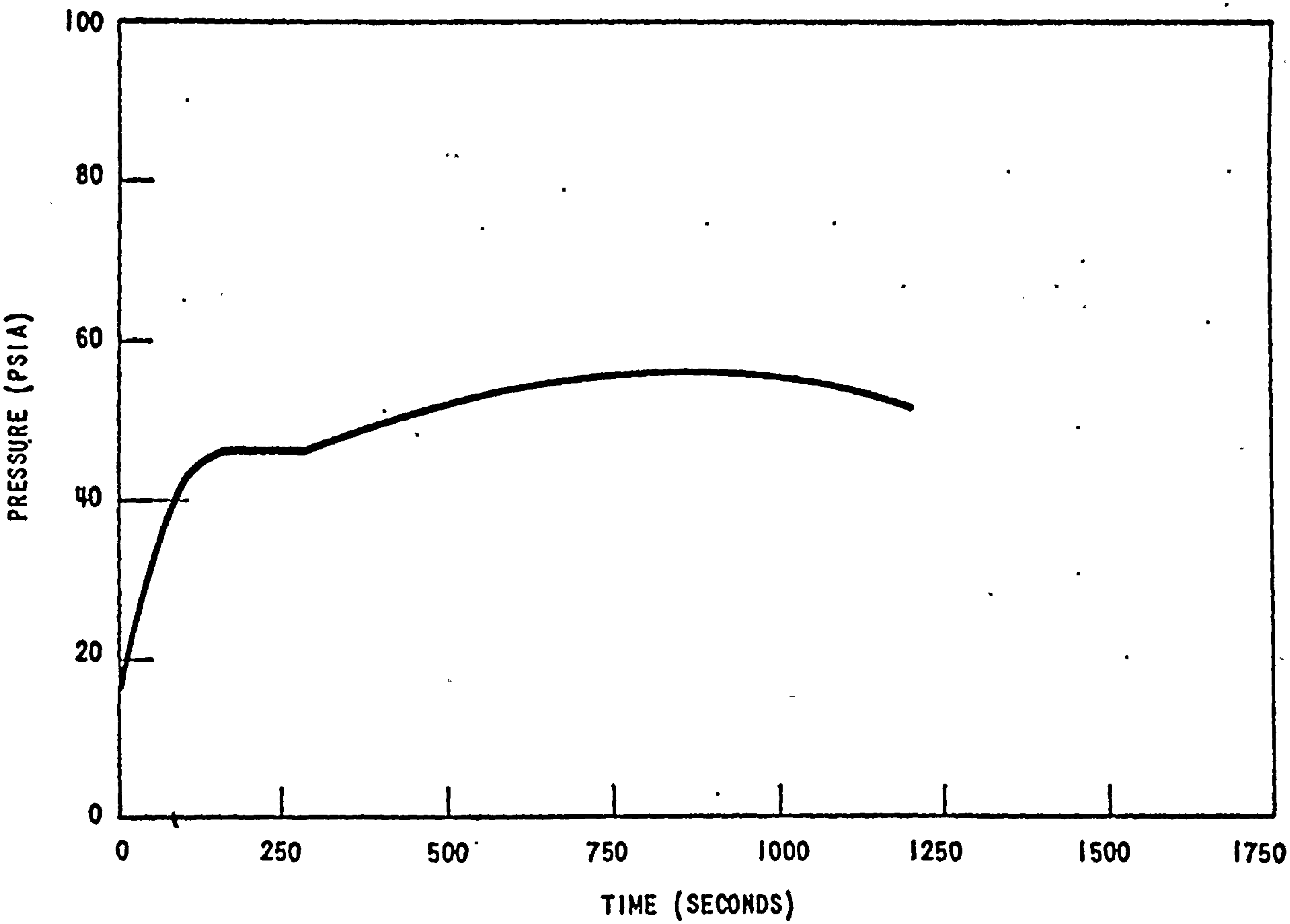


Figure 8 Containment Pressure Transient for 0.910 ft^2 Split Break at 70% Power with Minimum Safeguards (NRC Model)

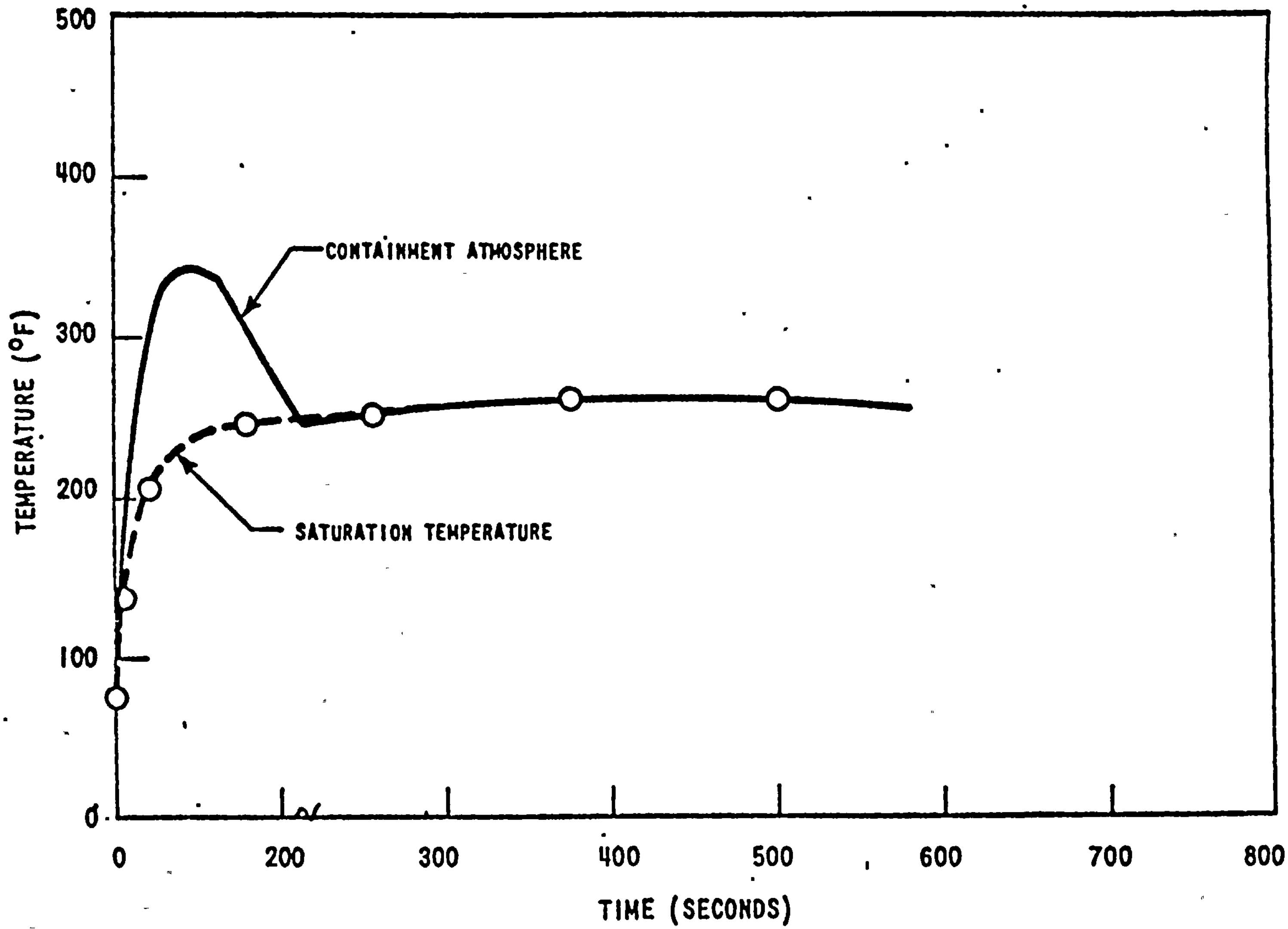


Figure 9. Containment Temperature Transient for 0.910 Ft^2 Split Break at 70% Power

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