NATIONAL BUREAU OF STANDARDS REPORT

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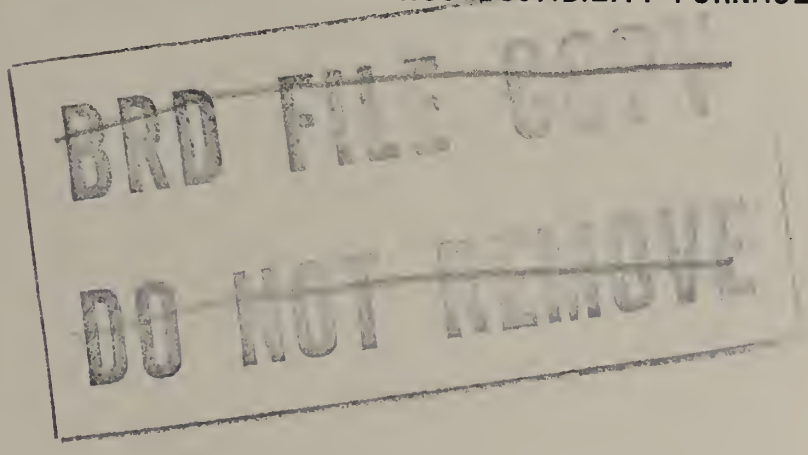
CALIBRATION OF ISO NONCOMBUSTIBILITY FURNACE



NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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Office of Standard Reference Data—Clearinghouse for Federal Scientific and Technical Information [3]—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

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CALIBRATION OF ISO NONCOMBUSTIBILITY FURNACE

by
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Prepared for
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NBS Test 70-120

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C. 20234

REPORT OF TEST

on

Calibration of ISO Noncombustibility Furnace

for

United States Coast Guard

Report No. TG10210-2189:FR3726

1.0 INTRODUCTION

At the request of the United States Coast Guard, MIPR Z-70099-9-94285, a series of calibration tests were made on the ISO noncombustibility furnace. This involved:

(a) Radiation impact tests using gold-plated and blackened copper blocks

(b) A vertical temperature survey.

Radiation impact tests were also made in the heated tube ("Setchkin") furnace used in USCG Specification 164.009 for noncombustibility. During these tests, the power input to the furnace heating coils, and the ambient temperature in the laboratory were measured. These data supplement earlier measurements reported in NBS Report No. TG10210-2183:FR3720.

2.0 TEST MATERIAL

Electrolytic copper blocks were fabricated by the NBS shops in two shapes: rectangular with dimensions 40mm x 40mm x 50mm high; and cylindrical of diameter 45mm and 50mm high. The blocks were gold-plated to provide a surface of uniform high reflectivity. Each block had a 1.6mm diameter hole drilled in the center to accommodate a 1mm diameter sheathed thermocouple. Two rectangular blocks and one cylindrical block were sent to the ISO representatives in France, Belgium, Denmark and Great Britain for similar tests. Also sent was a can of high-temperature black spray paint of the following designation:

TEMPO Products Co. No. 13-2 (UHT-2) Black ultra high temperature paint; pigment 12.7% (magnesium silicate and assorted oxides); Hydrocarbons 80.3%; vehicle, 7.0% (silicone resin).

Coating instructions called for the application of two coats, each coat to be cured at 275 °F (135 °C).

3.0 TEST RESULTS

3.1 Vertical Temperature Survey

Temperature distribution in the ISO furnace was measured with 1mm o.d. sheathed chromel-alumel thermocouples. Measurements were made along the central vertical axis and at a distance 10mm from the furnace wall. The results are reported in Table I and shown graphically in Figure 1. During this survey, the power input was maintained at a constant level (0.95 KW) so as to yield a 750 °C temperature at mid-height, 10mm from the wall. The temperature distribution curves are very similar in shape to those obtained previously (FR3720).

3.2 Radiation Impact Tests - ISO Furnace

The power input to the furnace was adjusted and then maintained constant to yield a temperature of 750 °C, as indicated by a 1mm o.d. shielded chromel-alumel thermocouple located 10mm from the furnace wall at mid-height. Each block was immersed in the ISO furnace and a record made of the rise in temperature of a 1mm o.d. shielded thermocouple at its center. The results are given in Table 2. A record was also made of the power input to the furnace using a wattmeter, and the ambient conditions in the laboratory.

Immersion of the (cold) copper block in the ISO furnace causes a severe temperature drop. This is illustrated in Figure 2 where the furnace and copper block temperatures are shown for a blackened rectangular block.

The heat received by the copper block was calculated from the following equation:

$$E = 4.185 \frac{mc}{A} \frac{\Delta T}{\Delta t}$$

Where m = weight of copper block, g

c = specific heat of copper, 0.094

A = area of copper block

= 112 cm^2 for the rectangular block

= 102.1 cm^2 for the cylindrical block

ΔT = temperature rise, °C

Δt = corresponding time period, sec.

Repeat tests on rectangular blocks agreed to within 5 to 8 percent. There was very good agreement between the rectangular blocks and the cylindrical blocks at the same level of power input. For the blackened copper blocks, the average heat received is 12% less than previously measured (4.48 w/cm^2 vs 5.09 w/cm^2) in report FR3720.

3.3 Radiation Impact Test - Setchkin Furnace

Results of radiation impact tests using the same copper blocks in the Setchkin furnace are also listed in Table 2. An even more severe temperature drop was noted upon immersion in this furnace as indicated by the temperature record in Figure 3. This is based on a thermocouple located close to the (cool) copper block.

For the blackened copper blocks, the average heat received in the Setchkin furnace was 3.69 w/cm^2, which is 18% less than the 4.48 w/cm^2 measured in the ISO furnace.

4.0 CONCLUSIONS

At 750 °C, there is a characteristic temperature gradient, both along the central axis and 10mm from the furnace wall, which makes the attainment of 750 ± 5 °C over a height of 60mm difficult to achieve.

The average rate of heat received by gold-plated and blackened copper blocks immersed in the ISO noncombustibility furnace and in the Setchkin heated tube furnace were as follows:

ISO FURNACE

Gold-plated block	0.90 w/cm^2
Blackened block	4.48 w/cm^2

SETCHKIN FURNACE

Blackened block	3.69 w/cm^2

Neither the contents of this report nor the fact that the test was made at the National Bureau of Standards shall be used for advertising or promotional purposes.

For the Director

by Irwin A. Benjamin

IRWIN A. BENJAMIN
Chief, Fire Research Section
Building Research Division, IAT

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USCOMM-NBS-DC

TABLE I Temperature Survey of ISO Furnace

Thermocouple Depth in Furnace in.	Temperature at Central Axis °C	Temperature 10mm From Wall °C
0	555	605
0.5	600	665
1	660	725
1.5	695	750
2	720	762
2.5	735	765
3	740	750
3.5	735	738
4	725	722
4.5	690	685
5	645	632
5.5	583	580
6	505	520

TABLE 2 Radiation Impact Tests

ISO FURNACE

Room Temp. °C	Relative Humidity RH	Power Input KW	Block	Weight g	ΔT °C	Δt sec.	$\frac{\Delta T}{\Delta t}$ °C/sec.	Heat Rec'd. w/cm^2
26	30	0.86	Rectangular-Gold-plated	707.0	100	272	0.368	0.91
26	30	0.86	Rectangular-Gold-plated	701.6	100	274	0.365	0.90
26	30	0.86	Cylindrical-Gold-plated	706.0	100	310	0.323	0.88
26	30	0.94	Rectangular-Black	707.0	122	70.5	1.73	4.29
26	30	1.02	Rectangular-Black	701.6	122	65.0	1.88	4.63
26	30	1.02	Cylindrical-Black	713.1	122	74.0	1.65	4.53
			Average					4.48

"SETCHKIN" FURNACE

26	30	0.64	Cylindrical-Gold-plated	713.1	122	287	0.425	1.17*
26	30	0.64	Rectangular-Black	707.0	122	85	1.44	3.57
26	30	0.64	Rectangular-Black	701.6	122	80.5	1.52	3.74
26	30	0.64	Cylindrical-Black	713.1	122	89	1.37	3.76
			Average					3.69

* May be high due to oxidation of the gold-plating.

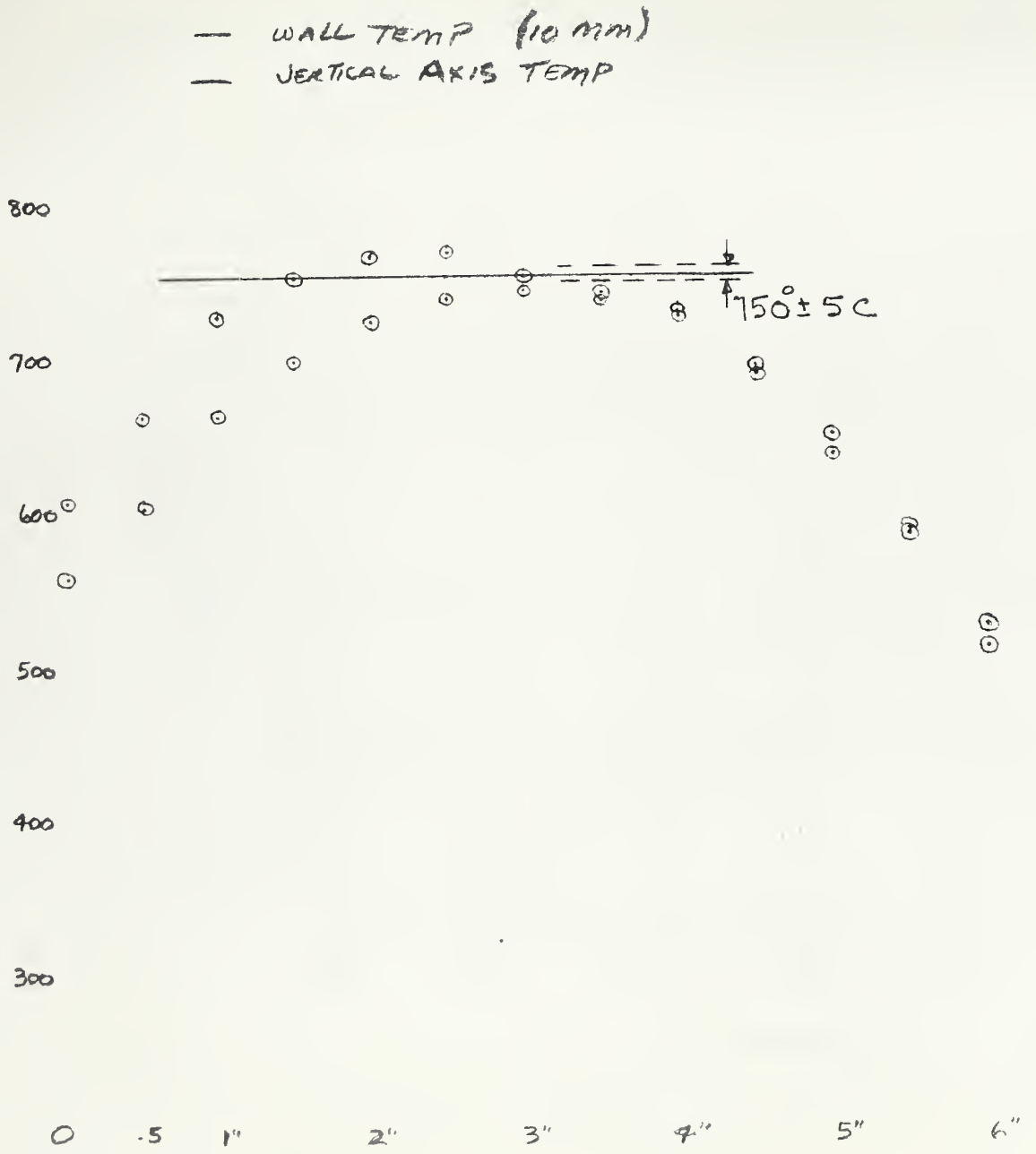

FIG. 1 150 FURNACE TEMPERATURE SURVEY

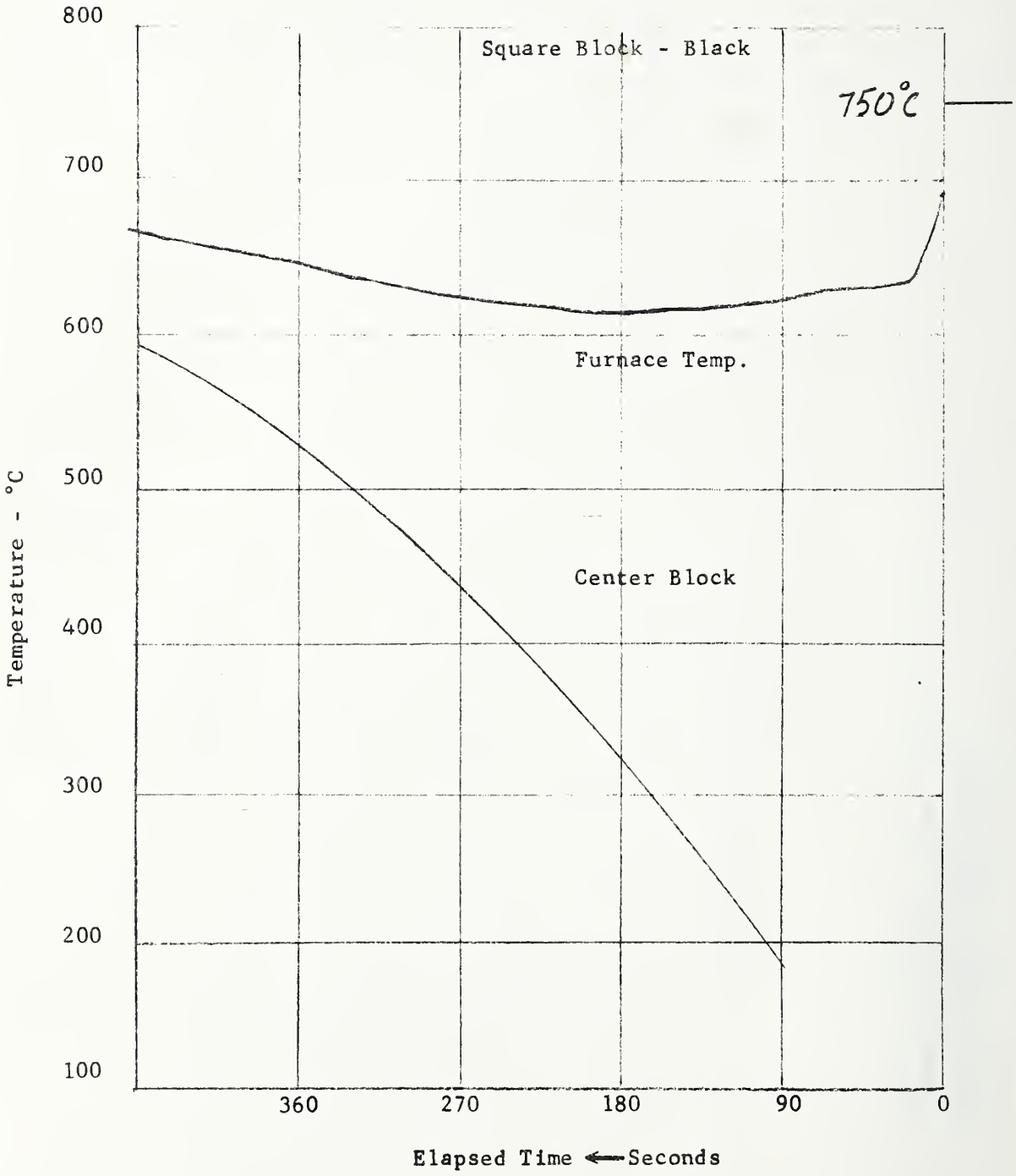

Figure 2 Radiation Impact Test
ISO Furnace

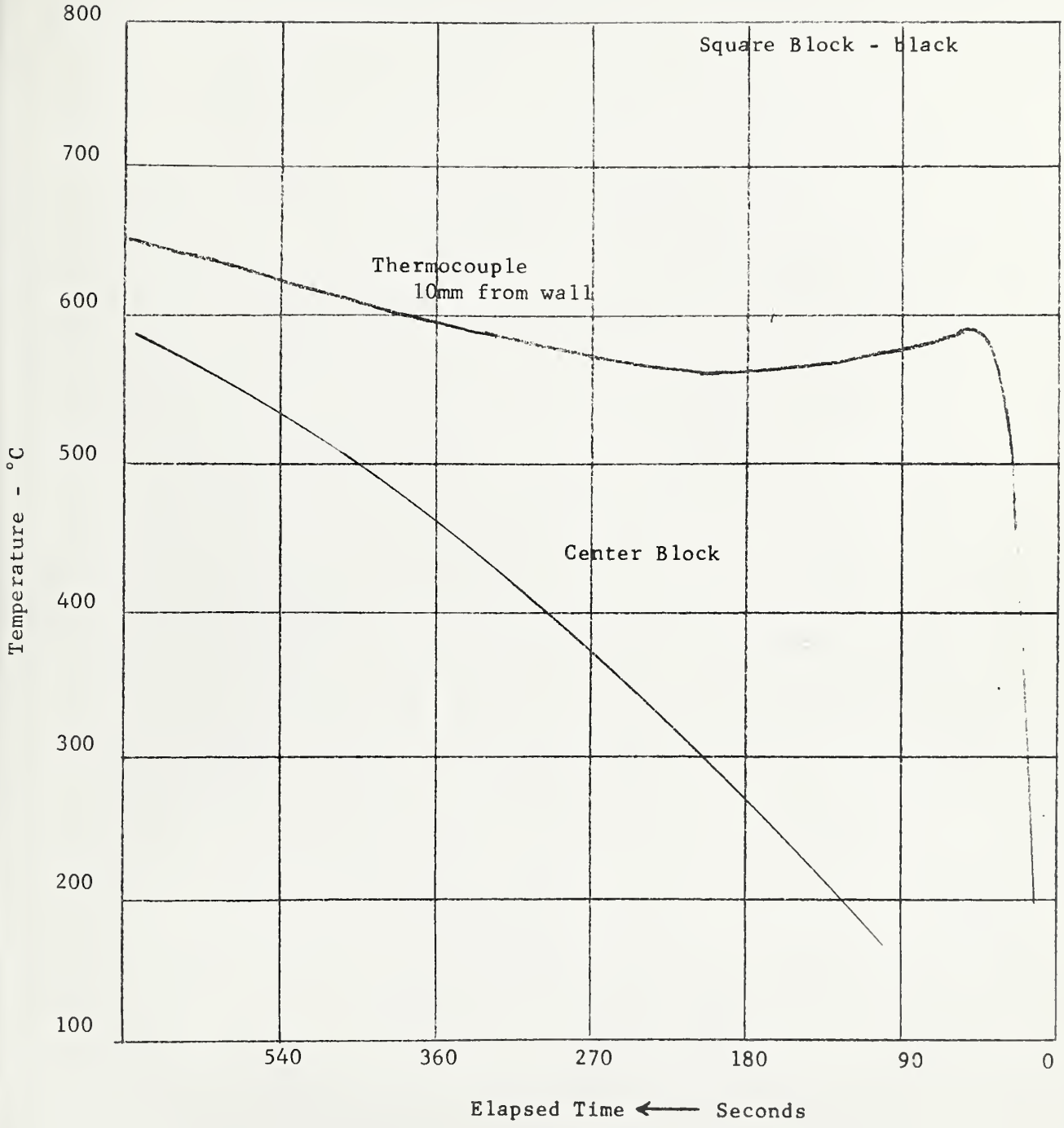

Figure 3 Radiation Impact Test
Setchkin Furnace


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