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NATIONAL BUREAU OF STANDARDS REPORT

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NONCOMBUSTIBILITY OF MINERAL WOOL AND GLASS FIBER INSULATION MATERIALS

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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NATIONAL BUREAU OF STANDARDS REPORT

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NONCOMBUSTIBILITY OF MINERAL WOOL AND GLASS FIBER INSULATION MATERIALS

by

J. J. Loftus

Prepared for

U. S. Coast Guard
MIPR No. Z-70099-8-83132
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U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NONCOMBUSTIBILITY OF MINERAL WOOL AND GLASS FIBER INSULATION MATERIALS

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ABSTRACT

A total of 16 mineral wool and 14 glass fiber insulation materials of varying binder content were subjected to both the IMCO* and the USCG heated furnace test methods for incombustibility (noncombustibility). Basic differences between the two test methods account for the observed lack of consistency in classifying materials as noncombustible.

The Potential Heat of six mineral wool and six glass fiber materials were also measured, and found to be proportional to weight loss (binder content). No correlation was found between Potential Heat and peak specimen temperature rise by the IMCO furnace test.

1. Scope

The IMCO subcommittee at its seventh session endorsed a work program on the incombustibility tests of fibrous materials having combustible binders to obtain the necessary technical background for a criterion for noncombustibility.

2. Summary

The IMCO and USCG tests methods for noncombustibility are not comparable. For the fibrous materials tested the IMCO method is far more severe; primarily because the USCG method neglects the first two minutes of test.

There is a relationship between the measured potential heat and the binder content for the fibrous materials tested. However, no correlation was found between the potential heat and the peak specimen temperature rise.

3. Introduction

An interdepartmental purchase request dated 6 February 1968, MIPR Number Z-70099-8-83132 from the United States Coast Guard requested incombustibility (noncombustibility) tests be performed on specially prepared samples of fibrous insulation materials furnished by the Merchant Marine Technical Division, Office of Merchant Marine Safety, U. S. Coast Guard Headquarters. Tests were to be performed in accordance with both the IMCO method and the present Coast Guard method. It was also requested that Potential Heat tests also be performed on a selected number of materials.

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* Method designated as IMCO is a modified ISO test method.

4. Test Methods

Potential Heat - "A Method for Measuring the Heat Release of Materials in Building Fires", Proceedings of the American Society of Testing and Materials, Vol. 61, 1961.

IMCO proposed vertical tube test for incombustibility. (A sectional view of furnace is shown in Figure 1.)

USCG tube furnace "Specification for Incombustibility of Materials for Use on Merchant Vessels" Subpart 164.009, 6th amendment 8 September 1965. (A sectional view of furnace is shown in Figure 2.)

5. Test Materials

Thirty fibrous insulation materials were furnished for test. Sixteen were of a mineral (slag) wool type (nominal melting point 1000 ^{o}C) and fourteen were of a glass fiber type (nominal melting point 600 ^{o}C). Both contained varying percentages of organic binder. Table I lists nominal thickness, density and binder content values for the subject materials, together with measured density and binder content values. The binder contents reported represent weight loss measurements obtained by immersion of samples in the tube furnace for the required test period.

6. Test Results

6.1 Potential Heat Method

Potential heat measurements were made using a method described in ASTM Proceedings, Volume 61, 1961. The method makes use of oxygen bomb calorimetric techniques to provide an indication of the total heat release likely to occur when a material is exposed to simulated fire conditions (2 hours at 750 ^{o}C in air). Results can provide for heat release estimates on an area, volume or weight basis for the material involved. Results for a selected group of glass fiber and mineral (slag) wool samples are listed in Table II. It may be noted that loss in weight at 750 ^{o}C ranged from 0.7% for a nominal 1% binder glass fiber insulation to 31.4% for a nominal 18% binder mineral wool type. The measured weight losses shown are probably a direct measure of the binder content. These values were obtained by heating samples for two hours in air in a muffle furnace operated at 750 ^{o}C.

6.2 IMCO - Proposed Test Method for Incombustibility of Materials

The IMCO method as adopted at the meeting in Hague in November 1967 was used with certain modifications listed below:

1. The test specimen was made cylindrical with a diameter of 45 mm and a height of 50 mm. This gives a volume of 80 cubic centimeters, equal to the ISO-test specimen. The area between the test specimen and the furnace is similar to that of the ISO test. The test results should be independent of the specimen orientation.

2. Four thermocouples for determining the furnace temperature (Figure 3) were positioned only 5 mm from the surface of the test specimen in all places. These couples together with the surface thermocouples give an indication of the temperature rise close to and on the surface.

3. A test comprises the recording of the six temperatures as shown in Figure 3 as well as recording of time and duration of each continuous flame lasting more than 10 seconds.

4. Since the test result is influenced by variations in specific weight as well as content of binder and since these variations might even occur within the same batt, provision has been made to calculate these values for each test.

$$\text{Specific weight: } \frac{P_1}{V_0} \text{ kg/m}^3$$

$$\text{Content of Binder: } \frac{P_1 - P_2 \times 100 \text{ percent}}{P_1}$$

where P_1 = weight of test specimen before test

P_2 = weight of test specimen after test

V_0 = nominal volume of the test specimen.

Range of Tests

Nominal specific weights kg/m^3 -	15	30	60	120	200
Nominal binder content percent -	1.0	2.0	4.0	8.0	20.0
Nominal melting point -	600 °C glass fibers 1000 °C for slag wool				

In order to be rated as noncombustible in accordance with the proposed IMCO test procedure a material must:

1. Not indicate a temperature rise in the sample greater than 50 °C above the initial furnace temperature.

2. Not cause the furnace temperature to rise by more than 50 °C.

3. Not flame continuously for more than 10 seconds.

Results using this test method are listed in Table III.

6.3 USCG Heated Tube Test Method

In order to be rated as incombustible in accordance with the USCG method, "Subpart 164.009 of the Specification for Incombustible Materials for Merchant Vessels", a material must:

1. Not indicate a temperature rise (on its surface or at the center) greater than 20 °C above the furnace temperature of 750 °C after two minutes of test.

2. Not continue to flame after two minutes of test.

Results using this test method are listed in Table IV.

7. Discussion

Mineral wool and glass fiber insulation materials were tested for noncombustibility by both the IMCO and USCG procedures, and the results of this study are shown in Table V. Included also are potential heat values for a selected number of materials having various percent binder content and density values. From the table it is seen that significant differences in material classification result by the different test procedures. The most important test differences are as follows:

1. The IMCO procedure allows flame for only 10 seconds and a temperature rise of 50 °C above furnace temperature of 750 °C.

2. The USCG method sets no limits for fibrous materials for the first two minutes of test. After this period, however, the temperature on the surface or at the center of the specimen is required to be within 20 °C of the furnace temperature of 750 °C.

7.1 From the results obtained it can be seen that:

For Mineral (Slag) Wool (Samples 1-16) -

1. None showed flaming for more than 10 seconds in either the IMCO or USCG test procedures.

2. IMCO - All 1% and 2% nominal binder content samples passed the test with one exception, Sample No. 15.

3. IMCO - All 4% and 6% nominal binder samples failed the test with one exception, Sample No. 2.

4. USCG - Four out of the sixteen materials tested failed due to temperature rise in excess of the allowed 20 ^{o}C after two minutes of test. Three of these were high density (200 kg/m^{3}) materials.

For Glass Fiber (Samples 17-30) -

1. Flaming was evidenced from nine of the fourteen materials tested.

2. IMCO - All 2% binder samples pass the IMCO test.

3. IMCO - Except for two samples (No. 25 and 28), all 4, 8, 18 and 20 percent nominal binder content samples failed the IMCO test.

4. USCG - All samples (except for Sample No. 22) passed the test.

7.2 Thermocouples-IMCO

For this test series, in addition to sample surface and center couples (No. 5 and 6, respectively), four additional couples (No. 1-4) were used to measure furnace air temperatures surrounding the test sample. Averages for tests on the 30 subject materials showed the following results:

Couple No.	Location	Average Temperature
1	Bottom Quarter	781 ^{o}C
2	Middle	786
3	Top Quarter	783
4	Top Edge	751
5	Surface	763
6	Center	806

From the above it is seen that Couples No. 1, 2 and 3 show a range difference of only five degrees. As expected, Couple No. 4 because of its location showed the least temperature increase.

7.3 Weight Loss

Figure 4 shows a plot of specific weight kg/m^3 of the specimen versus measured binder content (percent by weight). Each point represents a material tested in the IMCO furnace. The lines which have been drawn enclose a region containing both combustible and noncombustible ratings, but above which all ratings are combustible and below which all results are noncombustible.

7.4 Potential Heat

Possibly more meaningful than the above is an analysis of the test results where potential heat values in Btu/ft^2 are shown to be a function of the binder content or weight loss in lb/ft^2 (Figure 5). From this data it appears that estimates of potential heat values could be made if the binder content of an insulation material were known or measured. For example, the slope of the line yields a potential heat of approximately 11,800 Btu/lb (6550 cal/g) for the binder.

The data in Figure 5 show a direct proportionality between the potential heat and weight loss, which illustrates the quantitative nature of the Potential Heat Test results particularly for glass fiber materials. However, in the case of mineral wool, and in general where organometallic and metal oxidation reactions may occur, weight loss measurements cannot be assumed equivalent to organic binder content.

No satisfactory correlation was possible between the peak specimen temperature rise and potential heat (either on a weight or volume basis).

TABLE I
MATERIALS

Sample No.		Nominal Thickness		Density			Binder Content*	
				Nominal	Measured		Nominal	Measured
		mm	in.	kg/m^3	kg/m^3	lb/ft^3	%	%
Mineral Wool								
A	1	50	2.0	30	29	1.8	6	3.63
	2	50	2.0	30	35	2.2	4	.73
	3	50	2.0	30	37	2.3	2	.90
	4	50	2.0	30	35	2.2	1	.89
	5	50	2.0	60	50	3.1	6	2.77
	6	50	2.0	60	46	2.9	4	2.76
	7	50	2.0	60	60	3.7	2	3.10
	8	50	2.0	60	56	3.5	1	0.30
	9	52	2-1/16	120	106	6.6	6	4.22
	10	52	2-1/16	120	120	7.5	4	1.95
	11	52	2-1/16	120	106	6.6	2	.96
	12	54	2-1/8	120	134	8.4	1	1.28
	13	54	2-1/8	200	175	10.9	6	4.87
	14	54	2-1/8	200	182	11.4	4	1.64
	15	54	2-1/8	200	156	9.7	2	2.07
	16	57	2-1/4	200	170	10.6	1	0.87
Fiberglass								
B	17	48	1-7/8	---	68.3	4.3	-	7.22
	18	100	4.0	60	27	1.7	2	1.21
	19	50	2.0	60	65	4.0	4	4.97
	20	50	2.0	60	55	3.4	8	4.79
	21	54	2-1/8	60	63	4.0	18	11.48
	22	54	2-1/8	60	75	4.7	20	12.82
	23	76	3.0	30	19	1.2	2	2.10
	24	50	2.0	30	31	1.9	4	3.94
	25	50	2.0	30	28	1.7	8	5.84
	26	48	1-7/8	30	39	2.4	18	25.08
	27	50	2.0	14	12	0.7	2	1.91
	28	50	2.0	14	13	0.8	?	3.68
	29	50	2.0	14	16	1.0	8	7.40
	30	50	2.0	14	18	1.1	18	17.52

*Weight loss determined by the heated tube furnace.

TABLE II

POTENTIAL HEAT TEST METHOD

Sample	Nominal Density	Residue After Firing	Weight Loss*	Gross Heat of Combustion		Potential Heat		
				Air-Dry Material	Residue After Firing	Weight Basis	Unit Area Basis	Sample Thick. Basis
	kg/m^3	%	%	Btu/lb	Btu/lb	Btu/lb	Btu/ft^2	Btu/ft^2
Mineral Wool								
8	60	99.3	0.7	237	66	172	50	100
10	120	97.8	2.2	385	-132	514	308	663
9	120	96.3	3.7	854	128	731	405	836
13	200	94.8	5.2	654	- 23	676	614	1309
1	30	93.7	6.3	777	118	666	100	200
5	60	96.4	3.6	457	134	328	84	168
Fiberglass								
20	60	91.4	8.6	920	- 41	957	271	542
21	60	86.1	13.9	1644	20	1627	644	1139
22	60	83.2	16.8	1972	13	1961	760	1628
23	30	96.9	3.1	316	78	243	24	72
26	30	68.2	31.4	3797	94	3733	910	1422
29	14	91.0	9.0	988	31	961	80	161

* 2 hours in air at 750 ^{o}C.

TABLE III

REPORT OF TESTS FOR NON-COMBUSTIBILITY
COOPERATIVE PROGRAM IMCO

LABORATORY: NATIONAL BUREAU OF STANDARDS

Specimen Details							Furnace Temperatures										Surface Temp.		Specimen Temp.		Flaming		Rating
							No. 1		No. 2		No. 3		No. 4		No. 5								
Date	Sample No.	Weight before test P_1	Weight after test P_2	Volume V_0	Binder $(P_1-P_2)/P_1$	Spec. Weight* P_1/V_0	Initial Temp.	Max. temp.	Time at max temp.	Max. temp.	Time at max temp.	Max. temp.	Time at max temp.	Max. temp.	Time at max temp.	Max. temp.	Time at max temp.	Max. temp.	Time at max. temp.	Max. temp.	Time at max. temp.	Duration of first flaming more than 10 sec.	Time for first flaming more than 10 sec.	C = Comb. N = Noncom. T = Temp. F = Flaming
		g	g	cm^3	%	kg/m^3	°C	°C	min	°C	min	°C	min	°C	min	°C	min	°C	min	°C	min			
7-17				80			750	773	0.4	803	0.3	775	0.4	745	4.7	765	8.0	925	0.8	X	X		
7-17	1	2.66	2.56	80	3.6	33.3	745	774	0.4	775	0.6	782	0.4	745	4.0	775	3.0	913	0.8	X	X	C_T	
7-18				80			750	782	0.7	782	0.5	784	0.3	734	5.4	770	2.8	910	0.8	X	X		
7-17				80			745	763	1.0	769	0.5	770	0.6	745	8.0	770	1.2	780	0.6	X	X		
7-17	2	3.0	2.98	80	0.7	38.2	748	770	1.2	775	1.0	773	1.3	737	4.2	775	1.8	745	4.2	X	X	N	
7-18				80			752	777	1.2	782	1.0	773	0.7	730	3.1	770	2.0	750	1.0	X	X		
7-17				80			745	782	1.7	787	0.8	763	0.4	730	1.4	760	0.5	745	1.5	X	X		
7-18	3	3.03	3.00	80	0.9	37.9	745	765	0.7	775	0.6	775	1.1	735	2.7	745	1.9	765	1.9	X	X	N	

TABLE 111

REPORT OF TESTS FOR NON-COMBUSTIBILITY
COOPERATIVE PROGRAM IMCO

LABORATORY: NATIONAL BUREAU OF STANDARDS

Specimen Details							Furnace Temperatures										Surface Temp.		Specimen Temp.		Flaming		Rating
								No. 1		No. 2		No. 3		No. 4		No. 5							
Date	Sample No.	Weight before test P_1	Weight after test P_2	Volume V_0	Binder $(P_1-P_2)/P_1$	Spec. Weight* P_1/V_0	Initial Temp.	Max. temp.	Time at max temp.	Max. temp.	Time at max temp.	Max. temp.	Time at max temp.	Max. temp.	Time at max temp.	Max. temp.	Time at max temp.	Max. temp.	Time at max. temp.	Duration of first flaming more than 10 sec.	Time for first flaming more than 10 sec.	C = Comb. N = Noncom. T = Temp. F = Flaming
		g	g	cm^3	%	kg/m^3	°C	°C	min	°C	min	°C	min	°C	min	°C	min	°C	min			
7-17				80			750	773	0.4	803	0.3	775	0.4	745	4.7	765	8.0	925	0.8	X	X	
7-17	1	2.66	2.56	80	3.6	33.3	745	774	0.4	775	0.6	782	0.4	745	4.0	775	3.0	913	0.8	X	X	C_T
7-18				80			750	782	0.7	782	0.5	784	0.3	734	5.4	770	2.8	910	0.8	X	X	
7-17				80																		
7-17	2	3.0	2.98	80	0.7	38.2	745	763	1.0	769	0.5	770	0.6	745	8.0	770	1.2	780	0.6	X	X	
7-18				80			748	770	1.2	775	1.0	773	1.3	737	4.2	775	1.8	745	4.2	X	X	N
							752	777	1.2	782	1.0	773	0.7	730	3.1	770	2.0	750	1.0	X	X	
7-17				80																		
7-18	3	3.03	3.00	80	0.9	37.9	745	782	1.7	787	0.8	763	0.4	730	1.4	760	0.5	745	1.5	X	X	
7-18				80			745	765	0.7	775	0.6	775	1.1	725	3.7	745	3.9	765	3.9	X	X	N
							745	780	6.4	775	0.8	780	5.7	763	5.7	780	5.7	755	6.0	X	X	
7-17				80																		
7-17	4	2.91	2.88	80	0.9	36.4	750	775	1.0	795	0.8	775	1.1	727	0.9	762	1.8	750	4.0	X	X	
7-17				80			750	770	2.0	775	0.8	773	0.6	737	4.2	775	4.5	745	4.0	X	X	N
							745	772	0.7	773	4.5	770	0.4	737	3.4	773	4.5	745	4.5	X	X	
7-17				80																		
7-17	5	4.52	4.39	80	2.8	56.5	755	790	0.5	815	0.5	795	0.6	738	1.6	775	1.0	944	0.8	X	X	
7-18				80			750	765	0.7	775	0.8	773	0.6	735	4.6	765	1.0	858	0.8	X	X	C_T
							745	772	0.5	774	0.6	767	0.6	725	3.2	760	0.8	866	0.8	X	X	
7-16				80																		
7-16	6	4.15	4.03	80	2.8	51.9	750	773	0.7	800	0.3	775	0.4	730	5.4	738	1.0	867	0.8	X	X	
7-17				80			745	772	1.0	805	0.5	780	0.4	735	4.8	765	0.9	900	0.8	X	X	C_T
							745	782	0.7	800	0.3	745	0.3	730	4.2	760	1.0	943	0.8	X	X	
7-16				80																		
7-16	-	4.75	4.60	80	3.1	59.4	745	775	1.0	775	1.0	757	0.9	737	3.1	750	1.0	760	0.8	X	X	
7-16				80			745	755	1.0	783	0.8	775	0.8	732	3.4	740	1.0	745	1.0	X	X	N
							748	752	1.2	798	0.5	770	0.6	730	5.3	765	1.2	774	0.8	X	X	
7-18				80																		
7-17	8	4.38	4.37	80	0.3	54.8	745	777	2.2	787	1.0	763	1.1	725	1.9	740	1.4	735	2.0	X	X	
7-17				80			745	780	1.7	787	1.8	773	1.1	728	2.2	758	1.8	743	4.5	X	X	N
							745	775	2.0	775	2.0	775	2.0	745	4.7	775	2.0	745	4.5	X	X	
7-11				80																		
7-11	9	11.20	10.72	80	4.2	140	750	792	0.7	795	0.7	795	0.7	760	1.2	795	1.0	1093	1.8	X	X	
7-11				80			752	787	0.9	810	0.4	800	0.4	750	0.5	777	0.8	1057	1.8	X	X	C_T
							748	775	0.7	805	0.7	795	0.9	743	0.7	775	1.0	1050	1.8	X	X	
7-11				80																		
7-11	10	8.96	8.78	80	1.95	112	747	765	1.0	788	0.8	775	0.9	735	3.1	763	1.5	800	1.5	X	X	
7-16				80			745	793	1.0	798	0.8	775	0.8	760	1.9	757	2.0	860	1.2	X	X	C_T
							745	783	1.2	793	1.0	772	0.6	728	1.9	745	1.7	767	1.5	X	X	
7-11				80			750	775	2.0	782	1.6	782	1.7	743	4.1	770	2.0	758	2.5	X	X	
7-11	11	9.60	9.51	80	0.96	120	745	782	2.0	789	2.0	775	1.6	738	3.6	763	2.0	755	5.2	X	X	N
7-11				80			748	788	1.8	800	0.8	770	1.4	733	4.7	755	2.0	755	5.0	X	X	
7-10				80			750	800	8.2	795	7.9	785	9.5	743	9.8	772	11.0	753	7.0	X	X	
7-10	12	9.90	9.77	80	1.3	124	752	775	1.4	782	1.4	772	1.8	730	1.8	764	2.0	755	3.6	X	X	N
7-10				80			748	780	11.2	795	14.0	778	10.2	745	12.8	764	7.0	765	12.8	X	X	
7-11				80			750	805	1.2	823	0.3	808	0.8	760	0.9	805	0.7	1143	3.2	X	X	
7-11	13	14.40	13.70	80	4.87	180	748	800	0.8	810	0.5	795	1.1	765	1.1	808	1.2	1130	3.2	X	X	C_T
7-16				80			750	790	0.9	814	0.8	795	1.1	755	1.1	790	1.0	1100	3.0	X	X	
7-10				80			747	771	1.2	787	0.9	772	0.9	735	1.0	760	1.2	843	2.0	X	X	
7-10	14	16.8	16.5	80	1.6	210	750	783	1.2	787	1.2	783	1.2	741	1.2	775	1.3	825	2.1	X	X	C_T
7-10				80			750	787	2.2	795	2.2	788	2.2	774	2.0	777	1.5	827	2.2	X	X	
7-9				80			745	770	1.9	772	1.1	773	1.1	748	1.[illegible]	779	1.6	850	2.0	X	X	
7-9	15	14.16	13.86	80	2.1	177	745	760	0.7	780	0.7	775	0.7	735	[illegible]	757	1.2	845	2.0	X	X	C_T
7-9				80			745	770	1.1	786	1.0	770	0.7	737	1.[illegible]	755	1.6	832	2.0	X	X	
7-10				80			745	772	1.7	775	3.2	768	3.2	725	1.0	757	3.25	745	6.5	X	X	
7-10	16	14.64	14.51	80	0.9	183	745	765	0.9	787	0.9	778	1.0	730	1.0	750	4.0	730	7.0	X	X	N
7-10				80			745	768	3.2	780	3.7	767	1.4	723	1.8	760	5.5	737	6.6	X	X	
7-21				80			748	763	0.4	770	0.5	778	0.6	849	0.1	755	0.5	837	1.5	50	10	
7-21	17	4.08	3.78	80	7.22	51.0	745	900	0.2	888	0.4	873	0.10	745	4.1	750	0.4	830	1.2	4	10	$C_{T,F}$
7-31				80			745	799	0.2	780	0.5	812	0.10	807	0.4	790	0.4	820	1.5	15	10	
8-13				80	1.21		748	755	1.2	758	1.5	765	2.1	748	3.3	740	1.5	740	0.5	X	X	
8-13	18	3.05	3.01	80		38.1	750	758	1.6	762	2.3	795	2.6	750	1.6	748	2.7	743	1.6	X	X	N
8-13				80			755	758	1.2	763	1.5	772	2.4	750	3.1	750	2.9	755	2.3	X	X	
8-13		2.4	2.38	80			750	762	2.7	760	1.5	773	2.1	755	2.1	750	2.2	750	2.5	X	X	
8-13				80			753	758	2.4	760	1.3	768	1.4	745	1.4	745	1.7	750	0.6	X	X	
7-18				80			748	787	0.2	765	0.5	758	0.10	750	3.1	752	0.4	770	1.8	22	10	
7-21	19	5.39	5.12	80	4.97	67.4	748	757	0.4	758	0.5	755	0.4	748	2.9	752	3.2	762	1.1	10	25	$C_{T,F}$
7-22				80			745	765	0.9	766	0.5	758	0.6	745	3.6	745	1.3	810	1.2	30	10	
7-21				80			748	810	0.2	770	0.3	770	0.3	765	0.6	765	0.8	803	1.2	19	10	
7-21	20	3.6	3.4	80	4.79	45.3	748	765	0.4	755	0.3	760	0.4	748	2.6	748	0.8	772	1.2	25	10	$C_{T,F}$
7-22							748	775	0.4	784	0.4	770	0.4	745	2.8	740	1.1	780	1.1	22	10	
7-18				80			748	815	0.2	850	.04	815	0.10	755	0.12	775	0.6	803	1.0	10	10	
7-21	21	6.10	5.40	80	11.48	76.2	748	843	0.4	792	0.3	810	0.40	767	0.6	805	0.8	820	3.0	25	10	$C_{T,F}$
7-22				80			748	873	0.2	800	0.5	809	0.40	746	3.8	795	0.5	785	1.5	30	10	
7-18				80			748	810	0.4	845	0.3	867	0.10	875	0.2	843	0.5	835	2.5	22	10	
7-21	22	7.16	6.35	80	12.82	89.5	748	850	0.2	824	0.3	875	0.1	807	0.1	825	0.5	826	1.8	20	10	$C_{T,F}$
7-21				80			745	885	0.4	816	0.3	828	0.1	875	0.1	842	0.8	840	3.8	25	10	
8-12				80			750	755	1.7	765	1.8	773	2.1	745	3.2	748	1.8	772	0.8	X	X	
8-13	23	3.02	2.96	80	2.10	37.7	748	753	1.7	760	2.0	765	2.1	745	2.9	748	2.5	747	2.5	X	X	N
8-13				80			748	751	2.4	758	2.5	767	2.1	746	2.6	742	3.2	740	3.5	X	X	
7-31				80			748	760	0.7	765	2.0	775	0.1	740	2.4	737	2.1	780	0.8	0	10	
8-12	24	2.74	2.63	80	3.94	34.2	750	770	0.4	755	2.3	775	2.4	759	0.1	745	2.2	773	0.8	15	10	$C_{T,F}$
8-12				80			750	750	1.7	760	1.5	775	1.6	755	1.6	748	1.7	780	0.5	8	10	
7-31				80			750	760	1.7	760	1.8	760	0.4	737	1.6	737	2.2	762	0.8	X	X	
8-13	25	2.30	2.16	80	5.84	28.7	748	755	2.7	760	2.8	767	1.8	748	1.6	745	2.7	755	0.8	X	X	N
8-13				80			750	755	2.6	763	1.8	767	1.9	748	2.9	740	1.2	766	0.5	X	X	
7-18				80			750	883	0.2	897	0.03	894	0.1	810	0.1	807	0.4	852	1.5	2	10	
7-21	26	2.65	1.98	80	25.1	33.1	745	925	0.2	920	0.04	887	0.1	810	0.1	803	0.2	855	1.6	10	10	$C_{T,F}$
7-22				80			745	835	0.2	855	0.04	898	0.1	817	0.1	818	0.4	800	1.2	15	10	
7-31				80			750	755	2.4	760	2.0	760	1.6	740	1.7	742	2.0	763	0.5	X	X	
8-12	27	1.21	1.19	80	1.91	15.1	748	755	2.9	763	3.0	767	3.1	737	1.9	740	1.9	758	0.5	X	X	N
8-13				80			750	755	1.7	759	1.3	773	2.8	740	1.4	745	1.9	768	0.5	X	X	
7-31				80			748	768	0.2	760	2.3	763	2.4	738	2.5	735	2.7	775	0.5	X	X	
8-12	28	1.47	1.42	80	3.68	18.4	750	755	2.2	760	2.1	773	2.4	748	2.2	748	2.2	775	0.5	X	X	N
8-12				80			750	750	1.9	755	2.0	773	1.8	745	1.9	743	1.9	770	0.5	X	X	
7-31				80			750	765	2.7	765	2.3	760	2.4	765	2.1	742	3.0	790	0.6	0	0	
8-12	29	1.39	1.29	80	7.4	17.4	748	750	1.4	755	2.3	775	1.8	750	2.6	745	2.7	800	0.5	3	10	$C_{T,F}$
8-13				80			748	750	0.9	755	1.5	760	1.1	746	2.4	746	2.4	803	0.5	0	0	
7-31				80			748	782	0.2	766	0.3	765	3.7	752	0.1	743	0.2	855	0.8	0	0	
7-31	30	1.55	1.28	80	17.52	19.49	750	755	0.2	760	0.5	795	0.1	743	2.4	745	0.8	853	0.6	0	0	$C_{T,F}$
8-12				80			750	758	0.2	768	0.04	812	0.1	775	0.1	762	0.2	850	0.8	2	10	

* Determined from companion specimen.

TABLE IV

COAST GUARD - SPECIFICATION 164.009

Material	Weight gm	Temp Rise Above 750 °C at 2 min		Average Flame Duration sec	Rating*
		Sample	Surface		
1	2.4	- 7	0		N
	1.9	8	8	15	
	2.2	8	8		
2	2.8	- 5	0	--	N
	2.8	- 5	-20		
	2.6	5	5		
3	2.8	0	0	--	N
	2.4	10	5		
	2.5	5	5		
4	2.6	0	0		N
	2.8	0	0	3	
	2.4	5	5		
5	4.6	5	5	5	N
	4.8	10	5		
	4.6	10	10		
6	4.5	0	- 5	3	N
	3.4	10	5		
	4.2	10	10		
7	4.3	10	5	3	N
	4.7	10	10		
	5.5	5	20		
8	4.8	5	5	6	N
	5.1	0	- 5		
	5.2	5	5		
9	10.5	34	255	10	C
	9.6	35	280		
	8.5	30	185		
10	8.1	12	17	5	N
	8.6	0	0		
	9.1	15	20		

*C = Combustible; N = Noncombustible

Material	Weight gm	Temp Rise Above 750 °C at 2 min		Average Flame Duration sec	Rating*
		Sample	Surface		
11	8.2	5	5	--	N
	7.6	17	17		
	7.8	7	7		
12	10.0	0	15	--	N
	10.9	10	0		
	10.9	0	20		
13	13.3	45	-40	--	C
	12.8	50	18		
	14.3	58	-56		
14	15.3	-26	132	--	C
	14.9	20	140		
	15.8	32	190		
15	12.3	20	155	--	C
	13.3	17	125		
	13.6	18	130		
16	15.4	5	-38	--	N
	14.3	5	-50		
	15.2	5	-60		
17	4.8	5	5		N
18	2.6	5	5	--	N
	3.0	5	5		
	3.2	8	8		
19	5.8	10	10	15	N
	4.7	5	5		
	4.8	5	5		
20	3.9	15	13	35	N
	4.9	5	10		
	4.5	0	5		

*C = Combustible; N = Noncombustible

Material	Weight gm	Temp Rise Above 750 °C at 2 min		Average Flame Duration sec	Rating*
		Sample	Surface		
21	5.8	8	8	47	N
	5.5	8	15		
	5.3	10	15		
22	6.6	35	40	45	C
	6.1	18	25		
	5.4	20	23		
23	2.2	5	5	12	N
	2.2	0	0		
	2.4	0	0		
24	2.4	10	10	10	N
	2.8	5	10		
	2.1	5	10		
25	1.9	0	0	14	N
	1.9	15	20		
	2.2	17	17		
26	2.8	15	15	20	N
	2.0	17	17		
	2.2	15	15		
27	1.1	7	7	--	N
	.9	0	0		
	.9	5	5		
28	1.3	0	- 5	3	N
	1.4	7	7		
	1.2	5	5		
29	1.1	10	10	6	N
	1.3	5	5		
	1.1	5	15		
30	1.4	8	10	10	N
	1.2	8	10		
	1.1	18	18		

*C = Combustible; N = Noncombustible

TABLE V

SUMMARY OF TEST RESULTS

Sample No.	IMCO Method	USCG Method	Potential Heat		
			Btu/lb	Area-Basis	
				Unit Thickness Btu/ft^2	Actual Thickness Btu/ft^2
Mineral Wool					
1	C*	N**	666	100	200
2	N	N			
3	N	N			
4	N	N			
5	C	N	328	83	167
6	C	N			
7	N	N			
8	N	N	172	50	100
9	C	C	731	405	836
10	C	N	514	308	663
11	N	N			
12	N	N			
13	C	C	676	614	1309
14	C	C			
15	C	C			
16	N	N			
Fiberglass					
17	C	N			
18	N	N			
19	C	N			
20	C	N	957	271	542
21	C	N	1627	644	1139
22	C	C	1961	760	1628
23	N	N	243	24	72
24	C	N			
25	N	N			
26	C	N	3733	910	1422
27	N	N			
28	N	N			
29	C	N	961	80	161
30	C	N			

*C = Combustible
**N = Noncombustible

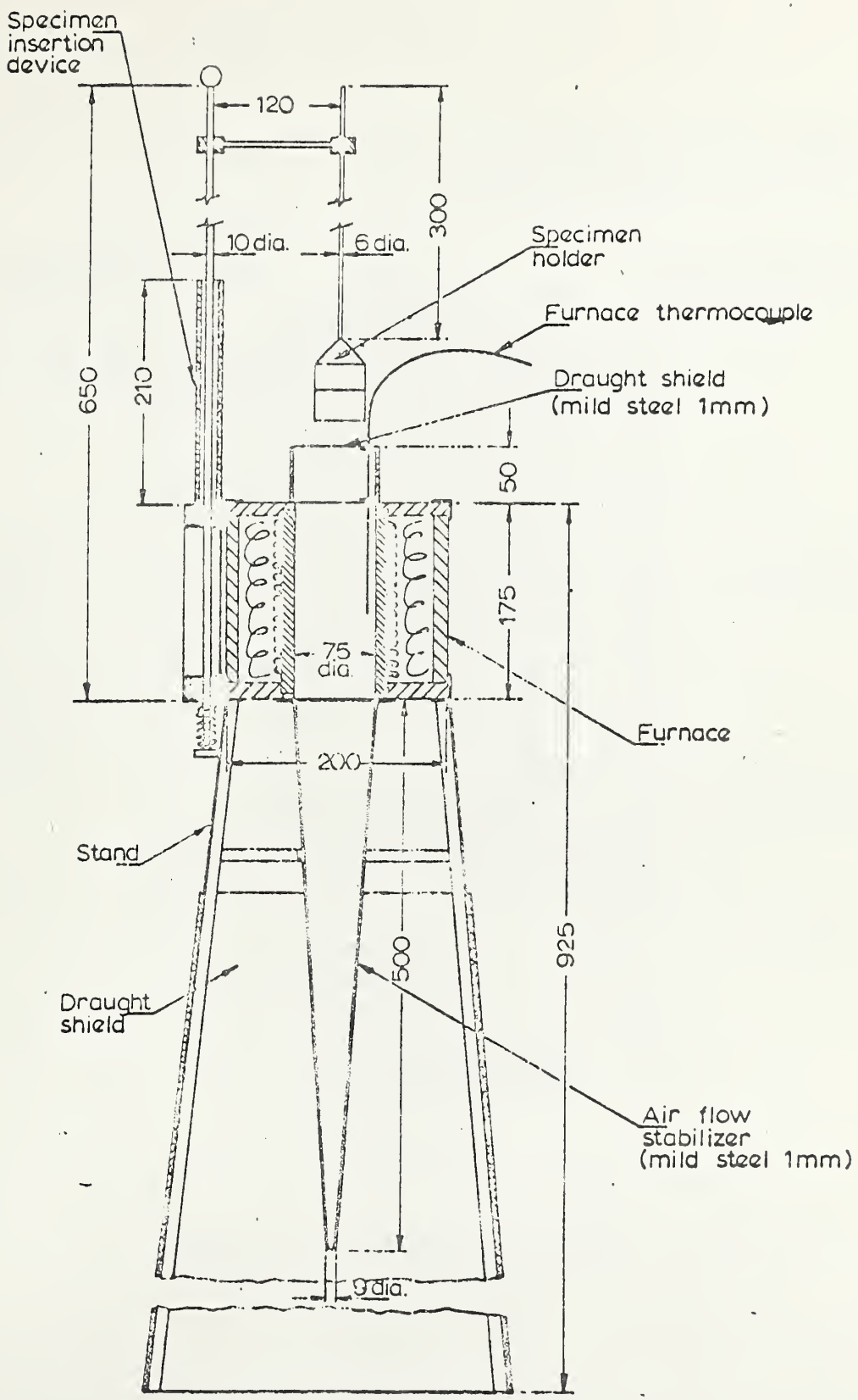
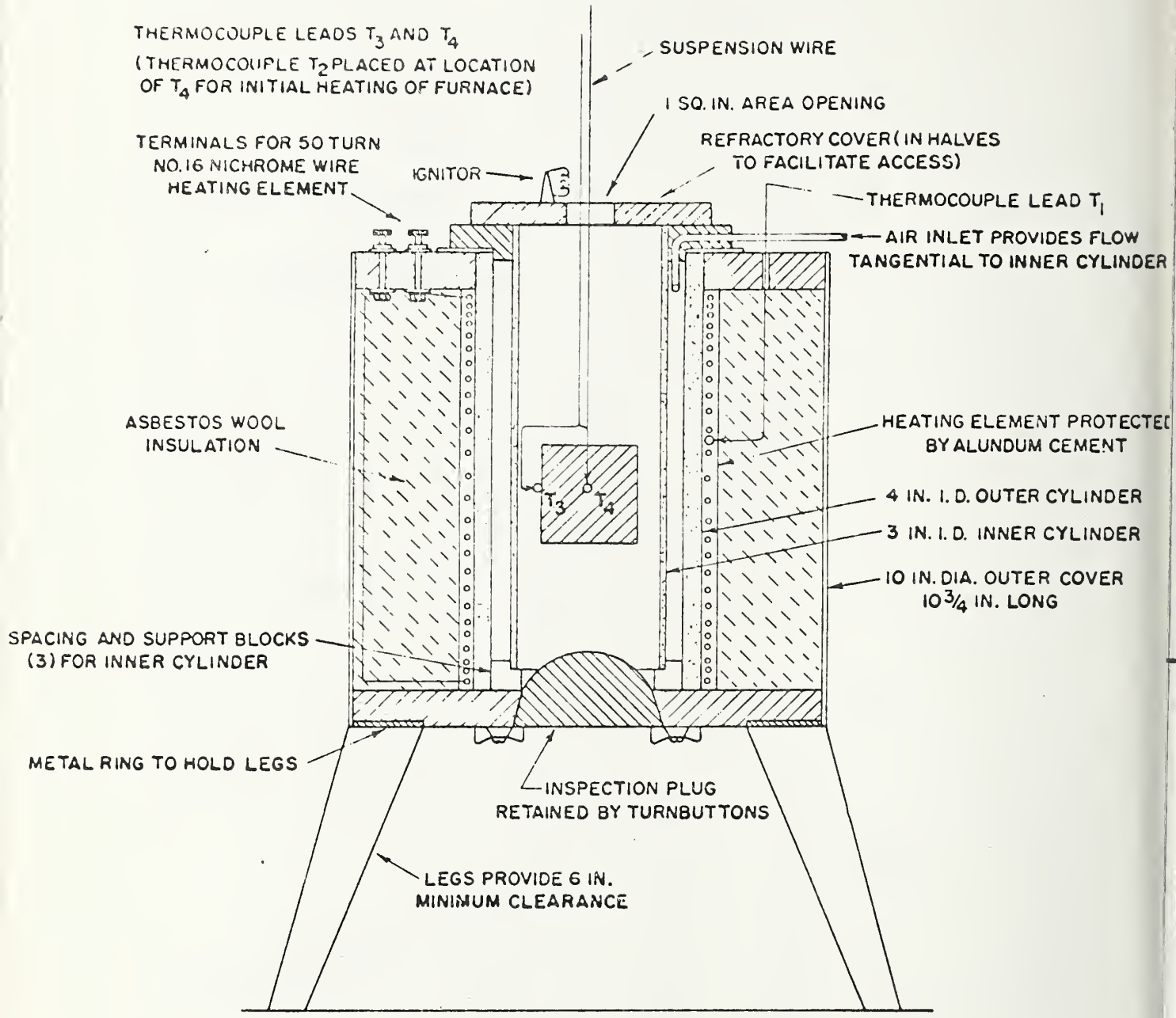
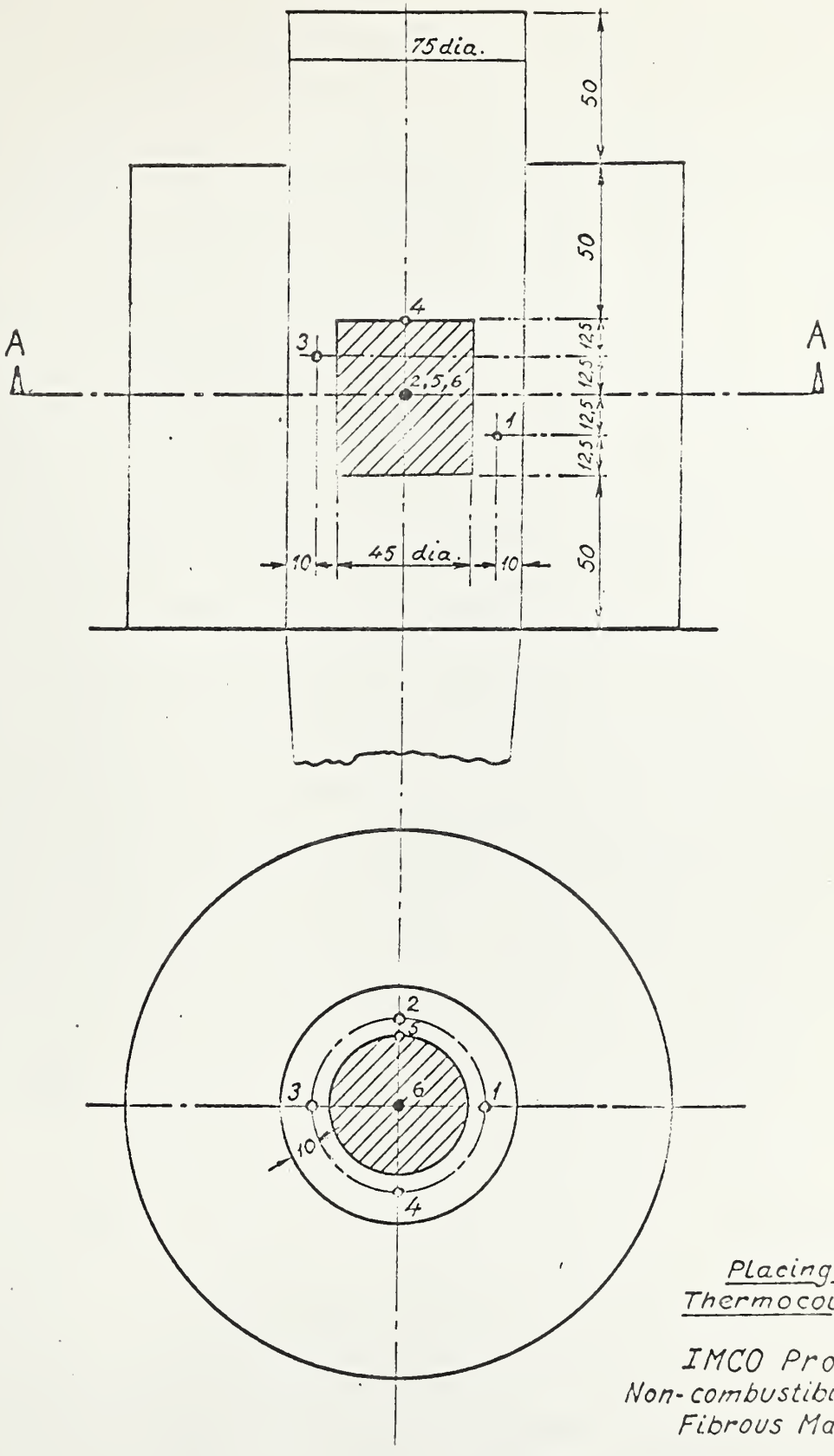


Fig 1. Sectional view of Proposed furnace being considered as both ISO and IMCO standard.



SECTION THROUGH FURNACE

Fig 2. Setchkin Furnace as used for both ASTM and USCG standards



Placing of Thermocouples

IMCO Program
Non-combustibility Test
Fibrous Materials

Distances are given in mm.

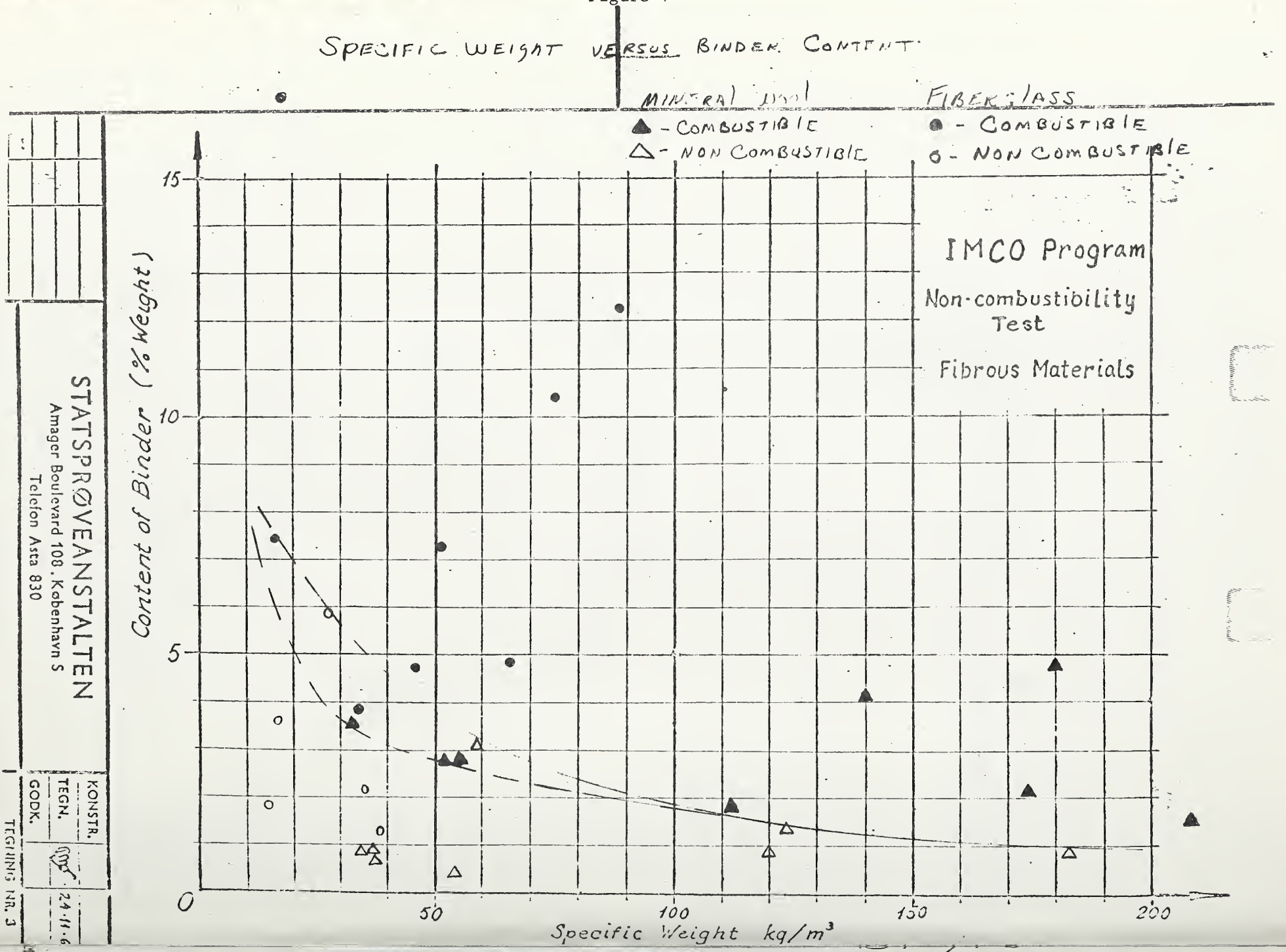
Figure 3

STAT[illegible]ALTEN
Amager Boulevard 108. København S
Telefon Asta 830

KONSTR.		
TEGN.	mp	8-3-67
GODK.		

TEGNING NR. 1

Figure 4


SPECIFIC WEIGHT VERSUS BINDER CONTENT
MINERAL WOOL
▲ - COMBUSTIBLE
△ - NON COMBUSTIBLE
FIBERGLASS
● - COMBUSTIBLE
○ - NON COMBUSTIBLE
IMCO Program
Non-combustibility Test
Fibrous Materials
Content of Binder (% Weight)
15
10
5
0
50
100
150
200
Specific Weight kg/m³
STATSPRØVEANSTALTEN
Amager Boulevard 108 . København S
Telefon Asta 830
KONSTR.
TEGN.
GODK.
24-11-6
TEGNING NR. 3

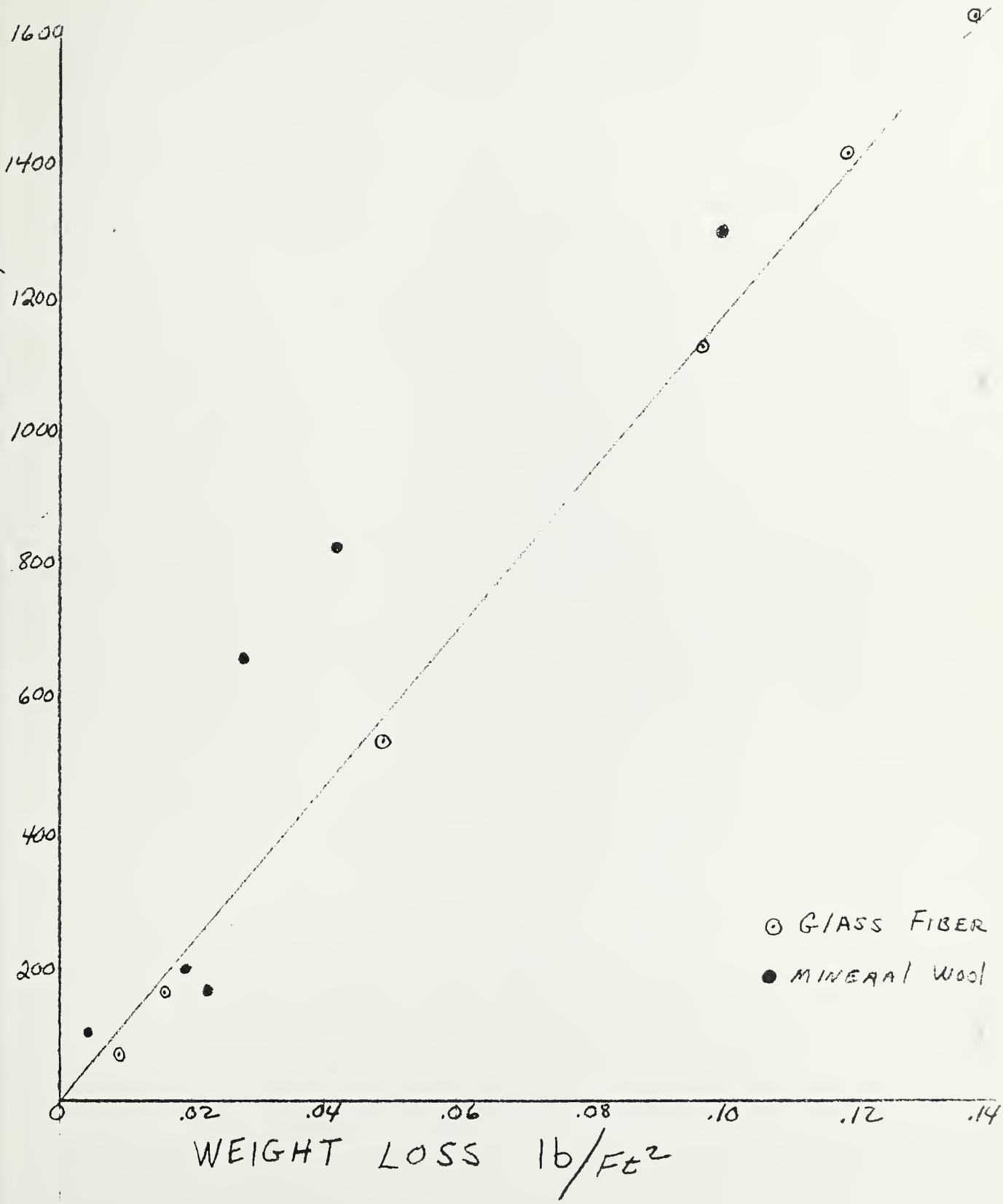

1600
1400
1200
1000
800
600
400
200
0
.02
.04
.06
.08
.10
.12
.14
WEIGHT LOSS lb/Ft²
⊙ GLASS FIBER
● MINERAL WOOL

FIG. 5

M-NBS-DC


DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS