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NATIONAL BUREAU OF STANDARDS REPORT

9529

EXPERIMENTS WITH A PROPOSED TEST PROCEDURE FOR NON-COMBUSTIBLE MATERIALS

by

J. J. Loftus and A. F. Robertson

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U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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ABSTRACT

A furnace, similar to that proposed for adoption by IMCO, for qualifying non-combustible materials was constructed. The performance of a variety of materials when subjected to test in this furnace as well as by a similar test method used in this country, USCG"Specification for Incombustible Materials," were compared. It was observed that the proposed test procedure was more restrictive for glass fiber insulation material and less restrictive for marine boards incorporating wood sawdust material, than the USCG method.

1. Introduction

Some years ago the National Bureau of Standards made an extensive study [1]**of problems related with heated tube test methods for defining materials considered acceptable for use as non-combustibles. As a result, the Setchkin's modified version of the British test furnace was developed. This furnace currently forms the basis of the U. S. Coast Guard regulations [2] test method for qualifying materials as non-combustible for marine use. The same equipment but with somewhat different qualifying criteria are currently used as the ASTM test procedure E-136 [3].

When, therefore, it became evident that a similar but somewhat different test method was being proposed as both an ISO and IMCO test procedure, the NBS constructed equipment intended to correspond with that described in [4].

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* The test procedure involved is the same as that described in ISO/TC 92/WG 2 (Secretariat-4) 12 E. The study reported was conducted to to explore its applicability for use as an IMCO Standard.

** Numbers in brackets refer to references listed at the end of paper.

The studies conducted with this equipment and reported in this paper are based on work done for the U. S. Coast Guard, especially with reference to classification of materials as non-combustible for use as bulkhead and as insulation materials in merchant vessels.

2. Equipment

Sectional views of the two furnaces used for this study are shown in Figures 1 and 2.

The main differences between these two test methods may be summarized as follows:

a. The Proposed method makes use of a metal diffuser cone as an air flow control device, the cool air entering from the bottom of the furnace. On the other hand, the Setchkin furnace uses a concentric tube forming an annular space surrounding the furnace lining for preheating the metered air supply furnished to provide an oxidizing atmosphere.

b. The length diameter ratio of the Proposed furnace is 2.0 as compared to 2.8 in the Setchkin furnace. The specimen radiation losses at the furnace ends are likely to be much greater in the Proposed furnace. This less favorable ratio of the Proposed furnace is made more important because no insulating closures such as used in the Setchkin unit are provided at both the top and bottom of the heated tube.

c. As a result of above, it was found necessary to use very non-linear heat supply rate along the furnace length to meet the temperature linearity requirement specified in paragraph 2.1.3 of the proposed ISO recommendation [4].

d. During test, two specimen thermocouples are used, one in the center and one on the surface of the specimen for both the USCG and ASTM methods while, for the Proposed procedure, one thermocouple at the center of the specimen and one nearby, but in the furnace air space, are used as the basis of measuring specimen performance.

The construction of the proposed test furnace was found to be simple and straightforward with several exceptions:

a. Difficulty was experienced in arranging the proper non-uniformity of furnace heater winding to meet the temperature uniformity requirements.

b. Paragraph 2.1.3 of [4] can be interpreted in several ways. For the purpose of this study, it was assumed to require that the furnace was adjusted properly when a 60 cm length of the furnace can be shown by a thermocouple 10 mm from the furnace wall, to be constant at 750 °C ± 5 °C.

c. The description of the shielded thermocouples in paragraph 2.1.4 is not adequate to define the thermocouple design.

3. Experiments and Results

Figure 3 presents data on temperature variations along the furnace axis. Also shown is a corresponding curve along the axis of the Setchkin furnace. It is obvious that with the proposed test method, temperatures on the axis are both significantly below 750 °C as well as much less uniform than in the Setchkin furnace. The non-uniformity is aggravated by the end losses from the proposed furnace.

A variety of materials were tested by both the USCG, the ASTM and the proposed procédure. The results of this study are shown in Table I. From this, it is evident that significant differences in material classification result by the three different procedures. The reasons for these differences become evident from study of TableII, where performance requirements for non-combustible materials by three test procedures are presented. Perhaps the most important differences between the procedures are the following:

a. The failure of the Proposed procedure to use a thermocouple on the surface of the test specimen.

b. The special treatment accorded glass fiber insulation material by the USCG method.

c. The larger temperature rise permitted by the proposed procedure. This is limited to 50 °C above the indication of the initial furnace temperature. However, since the axial temperature is about 7 °C below the temperature of the furnace thermocouple, this permits a rise of 57 °C at the center of the specimen, nearly three times that permitted by the USCG procedure.

From these findings, it is obvious that real differences in classification result from application of different procedures studied. Additional studies were therefore made to determine if, by the use of a thermocouple of the proposed ISO type on the specimen surface, and the neglect of flaming during the first two minutes of test of fibrous insulation materials, similar classifications would be achieved for the materials listed in Table I, by use of the two furnaces. The result showed that such agreement was achieved although it was evident that the larger temperature rise permitted under the proposed procedure as compared with that of USCG might still result in some comflicting classifications of borderline materials.

Table II also presents information on the Potential Heat [5] determinations for the materials studied. This calorimetric technique for measurement of the potential heat release capability of such materials appears to show promise for use in defining materials of low combustibility.

4. Conclusions

The study conducted has suggested the following conclusions:

a. Real and important differences in classification of materials can result from application of the three test methods studied.

b. Failure to include a surface thermocouple adjacent to the specimen in the Proposed test method prevents disqualification of materials with rather significant combustible content.

c. By excluding flaming and temperature rise limitations in the first two minutes of tests of fibrous insulation materials, the USCG method provides special treatment of such materials and their resulting qualification.

d. Much closer agreement in the classification of materials could be achieved by the Proposed and USCG methods,if the Proposed procedure were modified to require the use of a specimen surface thermocouple,and special exception were made for performance during the first two minutes of tests of fibrous materials.

e. The Potential Heat method of determining heat release potential seems to deserve more consideration.

f. Construction and use of test equipment for the proposed procedure would be facilitated by inclusion of more detail on furnace construction and calibration.

TG 10210-2147: FR3684

5. References

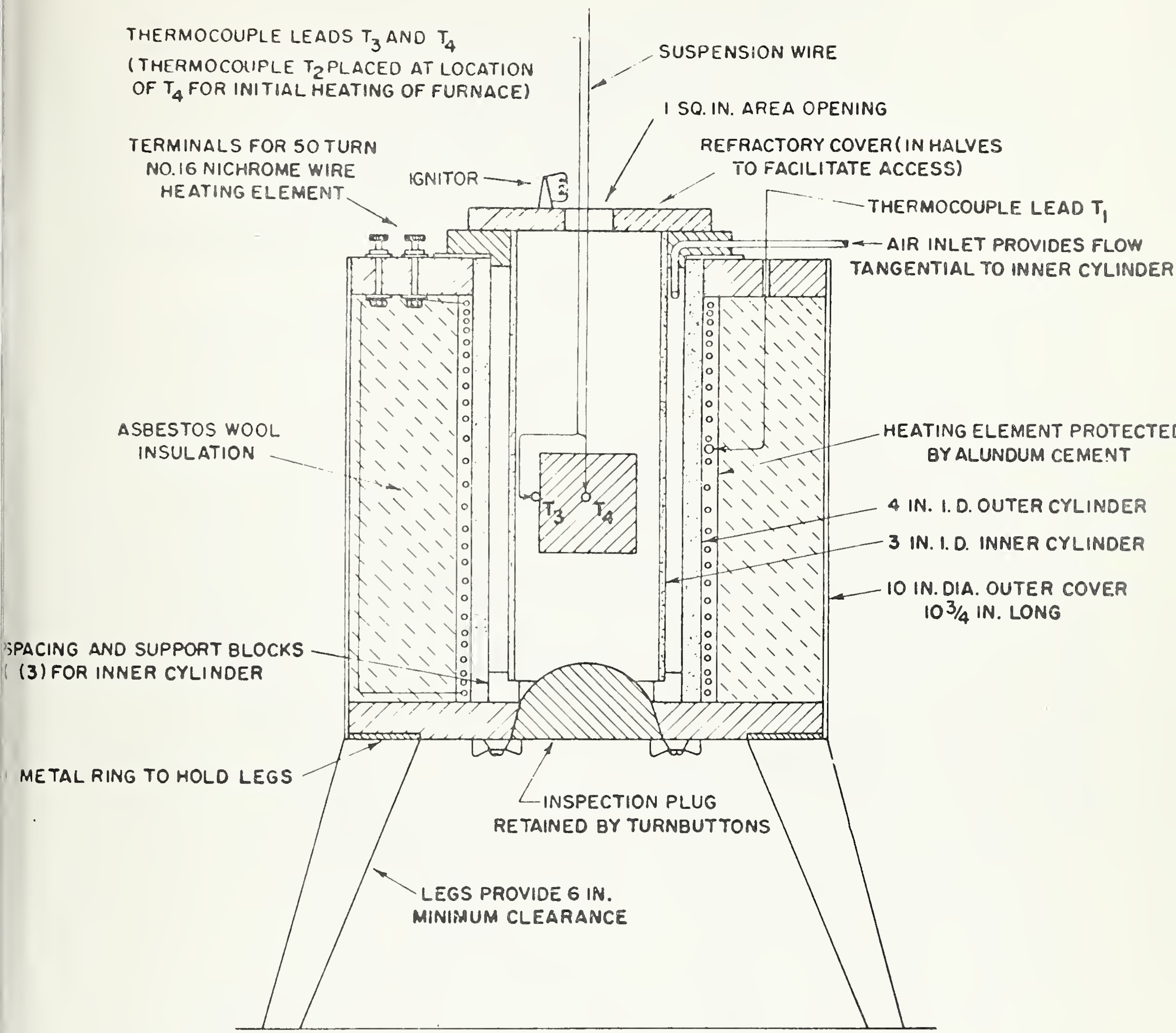
[1] "A Method and Apparatus for Determining the Ignition Characteristics of Plastics" N.P. Setchkin, J Res NBS V-43 Dec. 1949.

[2] "Specification for Incombustible Materials for Merchant Vessels" Subpart 164.009 6th ammendment, 8 Sept. 1965, U.S. Coast Guard.

[3] "Test for Determining Non Combustibility of Elementary Materials" ASTM Procedure E 136.

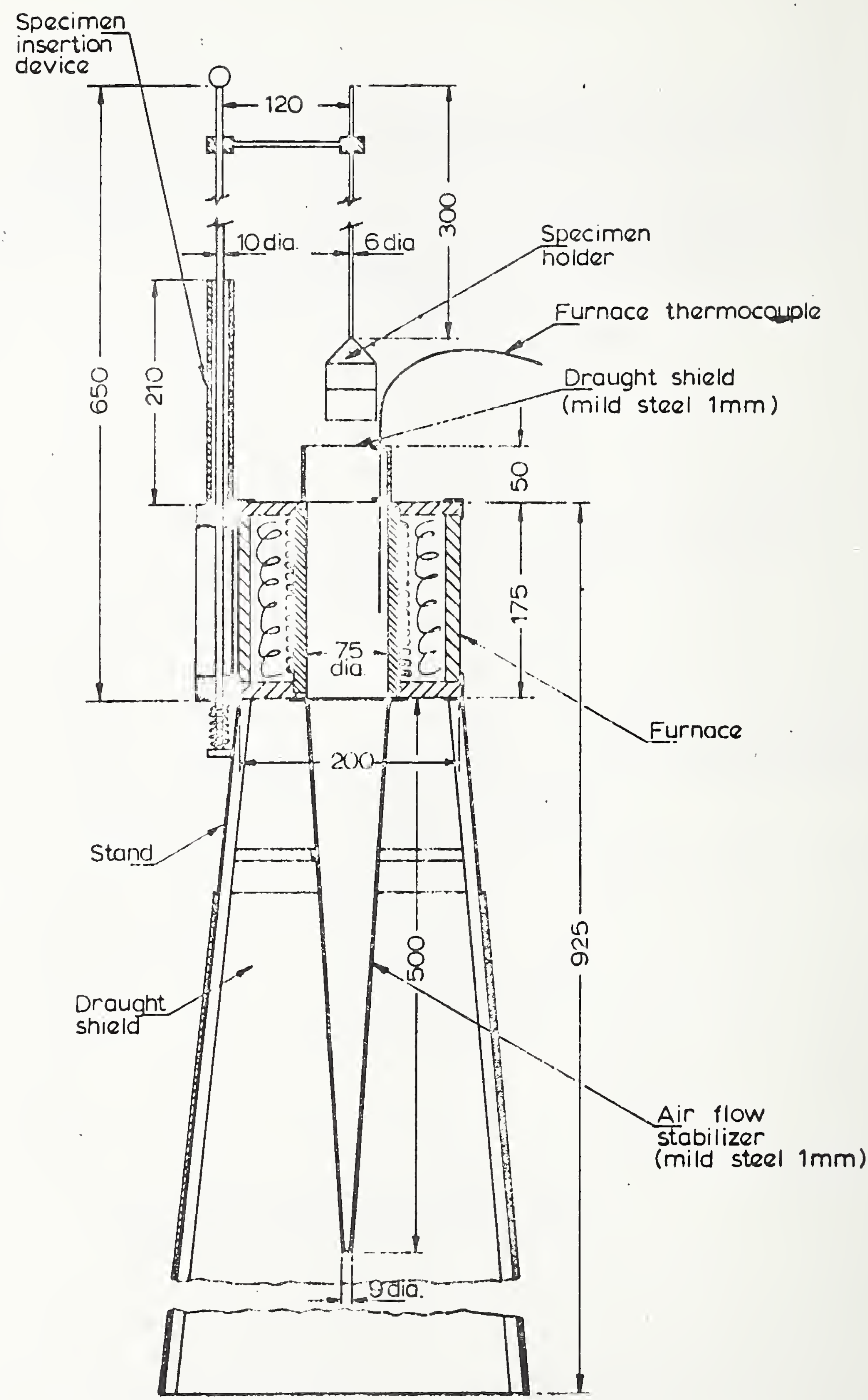
[4] Draft Proposal for an ISO Recommendation "Non Combustibility Test for Building Materials" ISO/TC 92/WG-2 (Secretariat-4) 12E.

[5] "Potential Heat-A Method for Measuring the Heat Release of Materials in Building Fires" J.J. Loftus, D. Gross & A.F. Robertson Proc. ASTM V61, 1961.



SECTION THROUGH FURNACE

1. Setchkin Furnace as used for both ASTM and USCG standards



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

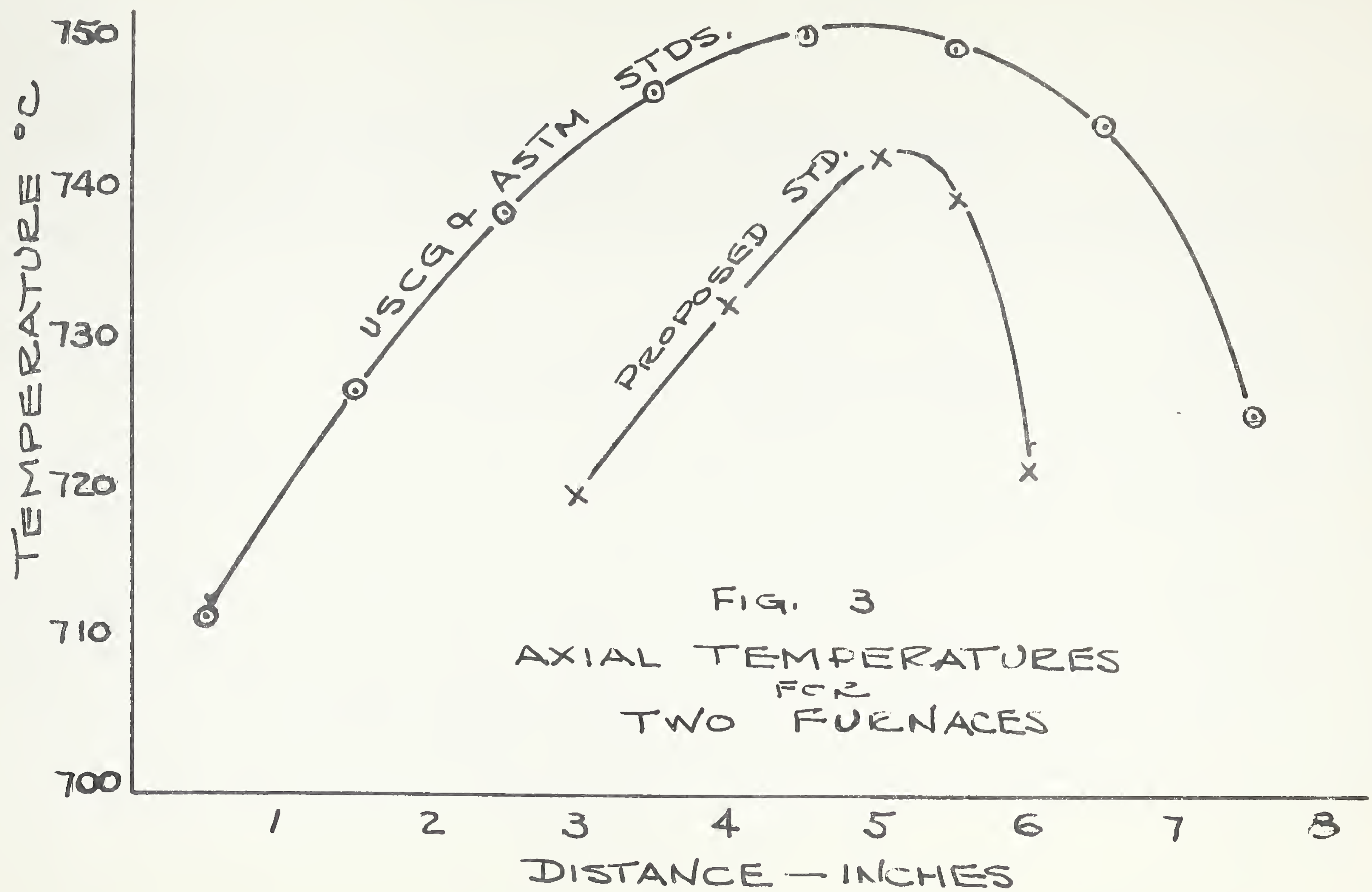


FIG. 3
AXIAL TEMPERATURES FOR TWO FURNACES

Table I: Summary Data from Application of Two Test Methods to Various Materials

			Center Temperature Rise**		Surface or Air Temperature Rise		Classification		
	Density lb/ft^2	Potential Heat BTU/lb	Proposed °C	USCG °C	Proposed °C	USCG °C	Prop	USCG	ASTM * E136-65
1. Retardant-treated wood	38	8290	+130	+175	+260	+190	Comb.	Comb.	Comb.
2. Marine board incorporating wood	34	1730	-230	-327	+ 35	+ 55	Non-comb.	Comb.	Comb.
3. Marine board shellac face	54	290	-101	-125	+ 6	+ 35	Comb.	Comb.	Comb.
4. Marine boards range for 7 tested	32 68	42 270	- 33 -130	- 40 -125	+ 3	- 5 + 20	Non-comb.	Non-comb.	Non-comb.
5. Glass fiber with resin binder	4	275	+ 5	+ 6	+ 8	+ 15	Comb.	Non-comb.	Comb.
6. Glass fiber no binder	9	90	+ 5	+ 5	+ 5	+ 15	Non-comb.	Non-comb.	Non-comb.

* The scope of the ASTM Procedure states that it is not applicable to laminated or coated materials but only to the elementary materials of which building materials are made. Its use therefore for reporting performance of the materials studied neglects this restriction.

** Negative values shown indicate that temperatures at termination of test were below the initial furnace temperature level by the indicated number of degrees.

Table II: Performance Requirements for Non-Combustible Materials

Criterion	Proposed Furnace	U.S. Coast Guard *	ASTM Method E-136 **
Test Duration	20 minutes	15 minutes	Until failure or maximum temperature rise
Flaming	No continuous flaming of more than 10 seconds duration	No flaming other than for 30 seconds or less in first 2 min exposure from paper or paint-coated surfaces	No flaming after first 30 seconds of test.
Temperature rise			
a. Furnace air	Less than 50 °C above initial level.	-------------------------	----------------------
b. Specimen center	Less than 50 °C above initial furnace air temperature.	Less than 20 °C rise above the initial air temperature.	Less than 30 °C above the initial furnace air temp.
c. Specimen surface	------------------------	Same as specimen center	Same as above.
Specimen glow	No requirement.	No glow brighter than furnace walls. Any glow should not increase on removal of specimen from furnace.	No requirement.
Combustible gases	No requirement	No gases capable of being ignited by heated platinum wire.	No requirement

* The requirements listed are applicable only to the last 13 minutes of the test for fibrous insulation materials. Such materials are also subject to a reheating test as described in subpart 164.009-3 (e) of the U.S. Coast Guard specifications.

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