NATIONAL BUREAU OF STANDARDS REPORT

5943

FIREPROOFING STRUCTURAL STEEL

by

E. W. Bender

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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E. W. Bender

Report to
Office of the Chief of Engineers
Bureau of Yards and Docks
Headquarters U. S. Air Force

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

FIREPROOFING STRUCTURAL STEEL

ABSTRACT

Work has been continued on an investigation of the effectiveness of fire-retardant materials sprayed directly on structural steel members. Data on the performance of 1-in. thick coatings of a number of such materials are presented. Similar data on 1/2-in. thick coatings of the materials have been reported previously.

1. INTRODUCTION

The need for information on the effectiveness of available fire-retardant materials which can be sprayed directly on structural steelwork, and the results of fire tests on specimens protected by 1/2-in. thick coatings, were presented in NBS Report No. 5821, dated March 27, 1958. The present report provides data on the performance of the same fire-retardant materials applied in coatings 1-in. thick.

2. MATERIALS

The fire-retardant materials included in the investigation, and the preparation of the fire test specimens, were described in NBS Report No. 5821.

In addition to fire exposure tests conducted as described in the previous report, thermal conductivity measurements also were made on the 1-in. thickness of the materials. Two specimens of each material were prepared for these conductivity measurements by spray-filling wooden frames having inside dimensions of 8 x 8 x 1 in., and lined with polyethylene film to prevent sticking of the fire-retardant to the wood. The specimens were removed from the frames for test.

3. METHODS OF TEST

The method of performing the fire exposure tests has been fully described in the previous report, No. 5821.

The thermal conductivity measurements were made in an 8-in. guarded hot-plate apparatus conforming with the requirements of Federal Specification LLL-F-321b and of ASTM Standard C177-45. The specimens were air-dried to constant weight in an oven at 215°F immediately prior to the conductivity measurements.

4. RESULTS

The density, weight per sq ft for 1-in. application, and time to reach 1000°F on the steel plate are given in Table 1. The materials are listed in order of performance in the fire test, that with the longest average endurance being listed first.

The results of the thermal conductivity tests are given in Table 2. The materials are listed in order of performance, that with the lowest conductivity listed first.

5. DISCUSSION

The results obtained with the materials, in both 1/2-in. and 1-in. thickness, are shown graphically in Figure 1, where endurance or time required for the steel plate to reach 1000°F is plotted against density in lbs/ft^3. The curves show an appreciable difference in relative behavior of the materials for the two thicknesses of the fibrous specimens, but not for the vermiculite or the perlite and bentonite clay mixtures. In spite of these differences, the curves indicate that, generally, the fire endurance varied with the density of the material. A few of the materials showed some deviation from this relationship which was not entirely consistent for the two thicknesses. However, the material consisting entirely of asbestos fibers, showed, at both thicknesses, greater fire endurance for a given density than the other materials tested.

The fire endurance data given in this report may be used in estimating the protection which might be obtained for a roof, floor, or ceiling section. Predictions of the endurance of columns, beams, or braces from these data is not simple, although it is expected that some estimates of this type may be feasible with the use of the analog computer. The endurance of 2-in. thick materials will be reported when the tests are finished.

6. CONCLUSIONS

Eight materials when applied in a 1-in. thickness, continued to bond to the steel plate for the duration of the fire exposure. The results indicate that these eight materials show some merit for use as fire-protective coverings when applied directly to steel work.

TABLE 1

Fire Test Results on Specimens with One-Inch Fireproofing

Manufacturer and Material	Finish on Plate and Specimen Number		Density lbs/ft^3	Weight for 1-in. Thickness lbs/ft^2	Time Steel Plate reached 1000°F Min	Fiber or Mineral
Nat'l Gypsum Co.						
Thermocoustic	Unpainted	9	20.10	1.68	135	Glass &
do	Unpainted	10	22.35	1.86	170	Asbestos
do	Shop-coated	63	18.39	1.53	77	
do	Shop-coated	64	21.69	1.81	200	
	Average		20.63	1.72	146	
U. S. Gypsum Co.						
Audicote	Unpainted	51	19.59	1.63	164	Perlite &
do	Unpainted	52	19.17	1.60	170	Asbestos
do	Shop-coated	106	17.73	1.48	75	
do	Shop-coated	105	20.43	1.70	75	
	Average		19.23	1.60	121	
Columbia						
Acoustics &	Unpainted	3	19.08	1.59	126	All Glass
Fireproofing Co.	Unpainted	4	18.48	1.54	155	
Cafco Spray	Shop-coated	57	15.30	1.27	58	
Standard Fiber	Shop-coated	58	19.89	1.66	80	
	Average		18.19	1.52	105	
Keasbey & Mattison Co.						
Limpet	Unpainted	27	9.75	.81	78	All
do	Unpainted	28	10.53	.88	90	Asbestos
do	Shop-coated	81	12.27	1.02	110	
do	Shop-coated	82	11.11	.93	85	
	Average		10.92	.91	91	
Larson Products						
Plaster Weld	Unpainted	45	53.52	4.46	75	Perlite
do	Unpainted	46	53.82	4.48	163	Asbestos
do	Shop-coated	99	42.96	3.58	65	Gypsum
do	Shop-coated	100	39.57	3.29	56	
	Average		47.47	3.95	90	
Zon-O-Lite Co.						
Zon-O-Lite	Unpainted	39	18.21	1.52	93	Vermiculite
Acoustical	Unpainted	40	18.21	1.52	75	and
Plastic	Shop-coated	93	15.84	1.32	55	Asbestos
do	Shop-coated	94	16.05	1.34	60	
	Average		17.08	1.42	71	

TABLE 1 (continued)

Manufacturer and Material	Finish on Plate and Specimen Number	Density lbs/ft^3	Weight for 1-in. Thickness lbs/ft^2	Time Steel Plate reached 1000°F Min	Fiber or Mineral
Smith & Kanzler					Glass
Jetbestos Inc.	Unpainted 33	13.56	1.13	91	and
Spray Craft	Unpainted 34	14.28	1.19	74	Asbestos
do	Shop-coated 87	14.07	1.17	70	
do	Shop-coated 88	14.76	1.23	50	
	Average	14.17	1.18	71	
Air-O-Therm					
Application Co.	Unpainted 15	16.80	1.40	68	All
Jet-Sulation	Unpainted 16	15.96	1.33	68	Glass
do	Shop-coated 69	15.57	1.30	47	
do	Shop-coated 70	23.34	1.94	47	
	Average	17.92	1.49	58	

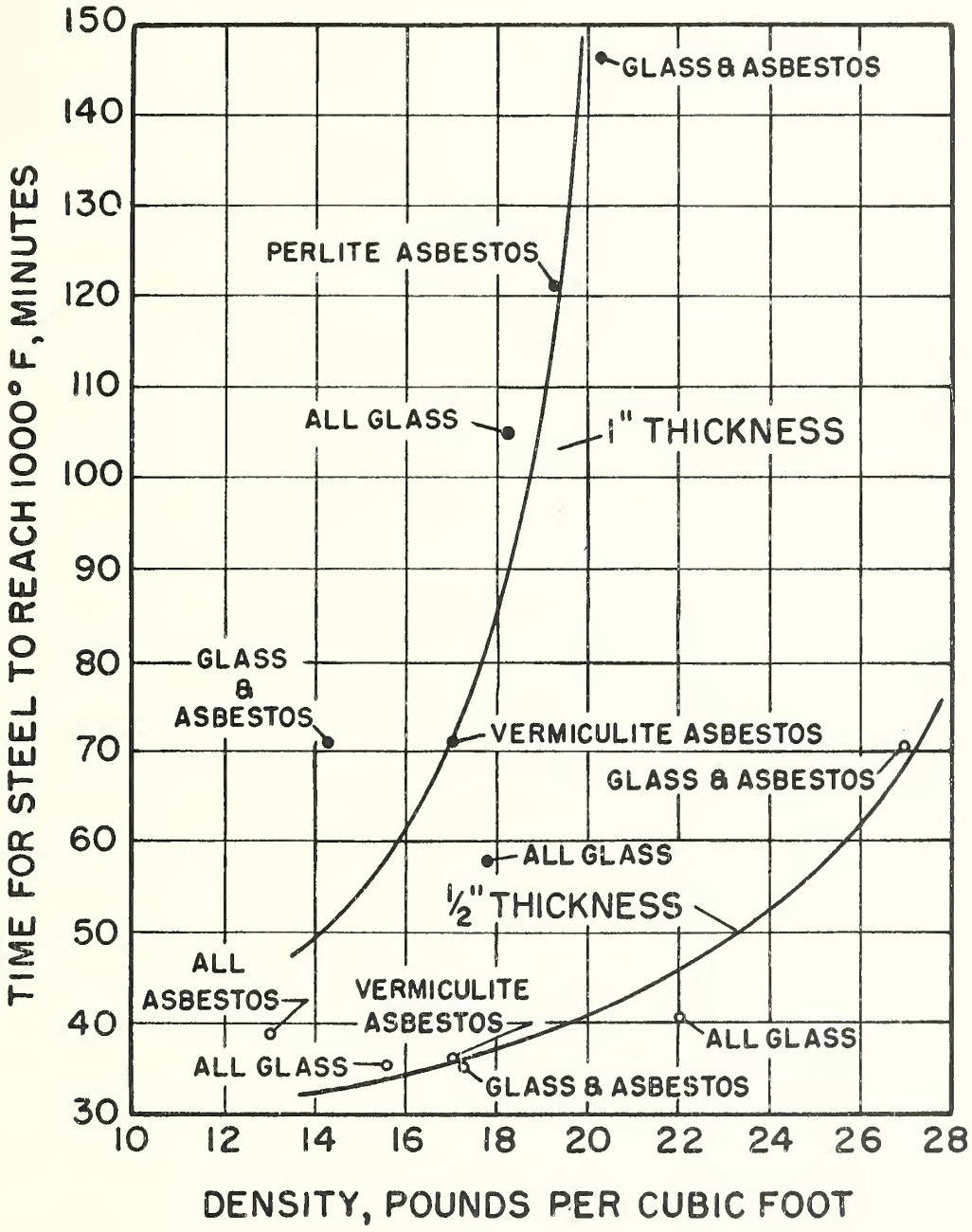

FIG. 1 – FIRE ENDURANCE

TABLE 2

Results of Thermal Conductivity Measurements

Manufacturer and Material	Density as Tested lb/ft^3	Mean Temperature of Specimens °F	Temperature Gradient in Specimens °F/in.	Loss of Weight on Drying %	Thickness as Tested 1-in.	Thermal Conductivity BTU/hr/ft^2/-°F/in.
Air-O-Therm Application Co. Jet-Sulation	20.0	73.6	43.0	1.9	1.01	0.33
Nat'l Gypsum Co. Thermocoustic	20.8	73.6	42.5	0.8	1.02	0.34
Keasbey & Mattison Co. Limpet	12.5	73.8	44.4	2.5	0.99	0.35
Columbia Acoustics & Fireproofing Co. Cafco Spray	19.8	73.9	41.4	0.9	1.06	0.43
Smith & Kanzler Jetbestos Inc. Spray Craft	20.8	73.9	43.7	0.9	1.01	0.48
Zon-O-Lite Co. Acoustical Plastic	15.8	73.8	48.6	2.2	0.89	0.65
U.S. Gypsum Co. Audicote	18.5	73.6	43.8	1.8	0.99	0.68
Larson Products Plasterweld Gypsum Perlite Acoustic Plaster	46.1	73.8	43.5	13.4*	1.00	0.79

*At the prescribed drying temperature the gypsum was partially calcined.

U. S. DEPARTMENT OF COMMERCE
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NATIONAL BUREAU OF STANDARDS
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THE NATIONAL BUREAU OF STANDARDS

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Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

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• Office of Basic Instrumentation.

• Office of Weights and Measures.

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