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NATIONAL BUREAU OF STANDARDS REPORT

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SURFACE FLAMMABILITY

of

FIRE RETARDANT AND CONVENTIONAL PAINT

ASSEMBLIES

by

J. J. Loftus

NBS

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NBS PROJECT		NBS REPORT
1002-12-10120	June 27, 1960	6885

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ABSTRACT

Surface flammability measurements using the radiant panel test method have been made on three conventional paints and five fire-retardant coatings applied to four common combustible interior linings. With the exception of one intumescent type fire-retardant system, the performance of conventional paints of the flat alkyd and latex emulsion types tested, was comparable to that of the fire-retardant coatings, at the same coverage rate. It is shown that the fire retardant effectiveness of coatings depends to a very large extent upon the coverage rate, the type and density of the substrate material and the application of overcoats. Of the four substrates tested, tempered hardboard exhibited the lowest coefficients of variation and is considered to be a suitable choice as a standard substrate for measuring the fire-retardant effectiveness of paints and other thin surface coating materials intended to reduce the flammability of combustible interior linings.

INTRODUCTION

The results of a previous study [1] have shown that paints and other thin coverings applied to a flammable base material can provide a new surface of substantially lower flammability than that of the untreated base. Although with coatings of more than 0.05-inch thickness the particular base material used did not appreciably affect the flame spread index, it appeared that with thinner finish coatings the base material had an important bearing on the flame spread results obtained.

In another study, in which non-flammable substrates were used, it was found that the flame spread index increased with increasing thickness of a paint coating applied on steel sheet. For example, the flame spread index of a No. 18 gage, red lead primed steel sheet had values of 1, 7, 69, and 110 for oil-base paint coatings of 5, 10, 15, and 20 mils, respectively. An assembly of a 10 mil coating of the same paint applied to 1/8 inch thick asbestos-cement board had a flame spread index of 2. Thus it appears evident that the flame spread behavior of coatings applied to either flammable or non-flammable substrates depends not only on the type and thickness of the paint film but also on the characteristics of the substrate.

In choosing a standard substrate for surface flammability evaluation of paints, the use of an incombustible material such as asbestos cement board would obviously restrict the range of measurements. A study was therefore undertaken for evaluating the surface flammability of a number of conventional paints and fire retardant coatings as applied to four common combustible interior lining materials. The primary objects of the investigation were to evaluate those characteristics of the substrate material which were important in surface flammability measurements on painted assemblies and to select, if possible, one substrate as a standard for paint flammability measurements.

2. MATERIALS

Five fire retardant and three conventional paint finishes were applied to each of four substrates; paper wallboard, plywood, fiberboard and tempered hardboard. The coatings were applied to the smooth finished side of each substrate. Table 1 lists and briefly describes the substrates and Table 2 gives the schedule employed in the preparation of the test assemblies. With the exception of coating systems 7, 7a, and 7b, the coverage rate employed in the preparation of the assemblies was 125 ft^2/gal (two coats at 250 ft^2/gal). This rate, unusually heavy for normal paints, was fairly represnetative of the coverage rates commonly used and recommended for fire retardant coatings. The paints consisted of two alkyd flat paints (Nos. 3 and 8), one latex water emulsion paint (No. 6), four fire retardant paints (Nos. 1, 2, 4, and 5), and one coating system consiting of an intumescent fire retardant undercoat plus top coat (No. 7).

3. SAMPLE PREPARATION

The first step in preparing the test assemblies was to coat the substrate boards, at 450 ft^2/gal coverage, with a white pigmented primer-sealer conforming to Federal Specification TT-P-56. After 72 hours the primed substrates, with the exception of those reserved for coatings 7, 7a and 7b, received two coats of paint at 250 ft^2/gal coverage each, allowing 72 hours between coats. Sample 7 received one coat of flat interior fire retardant paint and one top coat of an interior gloss fire retardant paint, at the same 250 ft^2/gal coverage. Sample 7a received only one coat of the flat interior fire retardant paint at a 350 ft^2/gal coverage. Sample 7b was coated with the same paints as Sample 7 but with coverages of 350 ft^2/gal and 500 ft^2/gal for the undercoat and top coat, respectively. The coatings on samples 7, 7a and 7b were purposely varied to study the effect on flame spread behavior of different rates of coverage of the same paints.

After the application of the finish materials, the assemblies were dried for not less than 72 hours and then cut to produce five specimens, each 6 by 18 inches. The specimens were then dried in an oven at 160°F for 24 hours and again conditioned, in a room maintained at 73°F and 50 per cent relative humidity, for not less than one week prior to testing.

4. METHOD OF TEST

Surface flammability measurements were made using the radiant panel flame spread test method as described in detail by Robertson, Gross and Loftus [2]. The equipment and test procedure are further described in an Interim Federal Standard [3].

5. RESULTS

Four replicate tests were run on each test assembly. The individual and averaged flame spread indices and the coefficients of variation are listed in Table 3. The weight of the smoke deposit listed is the average for replicate tests.

Intumescence was exhibited by paints 1, 7a, and 7b. Paints 2, 4, 6, and 7 blistered, whereas the conventional paints 3 and 8 did not blister or intumesce. Paint 5 flaked off from the substrate during test.

Blister and intumescent formations were responsible for a wide variation in flame spread indices for the paints which exhibited these properties. The conventional paints 3 and 8 showed better reproducibility between replicate tests than those which blistered or intumesced.

Of the four substrates used, the plywood and the hardboard showed the widest range in flame spread index values, affording good opportunity for discrimination between coatings. The hardboard values, however, had lower coefficients of variation than the plywood values, and much lower than those obtained with the other two substrates. Considering the results obtained with the hardboard, the conventional paints 3, 6, and 8 appeared to be comparable to the fire retardant paints 1, 4, and 5, when applied to this substrate at the same coverage rate of 125 ft^2/gal. The intumescent fire retardant coating, 7a, showed both the lowest flame spread index and the lowest smoke deposit value of any of the coatings.

For the coverage rate employed in this investigation, (125 ft^2/gal) the average flame spread index was found to be related to the density of the substrate material. This is shown in the lower curve in Figure 1. The upper line indicates a similar effect for two conventional paints (latex and alkyd flat) applied at a coverage of 370 ft^2/gal in a previous study. Although the lower curve includes values for fire retardant as well as conventional paints, the two curves also indicate the effect of rate of coverage (and therefore coating thickness) on the flame spread index. A more direct demonstration of this effect is given in Table 4 which lists the flame spread indices for the two conventional paint types at the two coverage rates and on two substrate materials.

5.1 STATISTICAL ANALYSIS

An analysis of the data was made to provide a statistical measure of variability. Particular attention was directed toward evaluation of the four substrate materials both from the standpoint of (a) selection of a standard material for paints and other liquid coatings and (b) interpretation of previous and subsequent flame spread data on coated assemblies employing a variety of substrates.

The analysis showed that the wallboard and fiberboard substrates gave a much more consistant behavior of dispersion about the mean than the plywood and hardboard substrates.

The performance of the wallboard was found to be significantly better than the fiberboard when compared according to the following criteria:

a. Better discriminating power, as evidenced by a greater range of flame spread index values for the eight coating materials,

b. More consistent dispersion behavior, as evidenced by a smaller range in coefficient of variation, and

c. Consistency in the ranking of the coating materials with respect to the rankings using other substrates.

Further inspection of the results with the hardboard reveals the following facts. Although coated hardboard assemblies did not show as good conformity to the assumed proportionality between the standard deviation and the mean flame spread index as those of wallboard and fiberboard, they did exhibit:

a. A substantial range of flame spread index values for the eight coating materials, and

b. The lowest coefficients of variation.

It should be noted that considerable variation was observed in the rankings of the eight coatings on the four substrates. In addition, the coefficients of variation were considerably higher than those obtained in an earlier investigation of conventional paints on the same or similar substrates [1]. This is not unreasonalbe when consideration is given to the special types of coatings and rates of application employed here. In view of this, too much weight should not be placed upon the relative rankings of the coating materials. The fact that the coefficient of variation is consistently lower when using a particular substrate is considered to be of much more significance from the standpoint of selection of a standard substrate material. Inasmuch as the hardboard did result in the lowest coefficients of variation and provided a substantial range of flame spread index values for the coating materials tested, its choice as a standard substrate is indicated.

6. CONCLUSIONS

On the basis of the work reported, the following conclusions seem justified:

1. Tempered hardboard may be considered a suitable choice as a standard substrate for evaluating the fire retardant effectiveness of paints and other thin surface coatings. Of the substrates tested, it gave results with the lowest coefficients of variation, and it provided a substantial range in flame spread index values.

2. The fire retardant effectiveness of paints and other coatings is highly dependent upon the coverage rate of application and the type and density of the substrate material, as well as the coating composition and the undercoat-overcoat combination employed.

3. In general, conventional paints of the flat alkyd and latex emulsion types tested, when applied at the heavy rate common for fire retardant coatings, appear to have flame spread indices comparable to those of typical fire retardant coatings. However, one intumescent fire retardant coating showed a flame spread index significantly lower than that of any other covering tested.

7. ACKNOWLEDGEMENTS

Mr. Neil B. Garlock of the National Paint, Varnish and Lacquer Association took a strong interest in the work and kindly provided all the paint coating systems. Mr. Harry Ku of the National Bureau of Standards, Statistical Engineering Section, made the statistical analysis.

[1] D. Gross and J. J. Loftus, Flame Spread Properties of Building Finish Materials, Am. Soc. Testing Mats Bul. No. 230, 56-60, May 1958.

[2] A. F. Robertson, D. Gross and J. J. Loftus, A Method for Measuring Surface Flammability of Materials Using a Radiant Energy Source, Proceedings, Am. Soc. Testing Mats., 56, (1956).

[3] Interim Federal Standard No. 00136 (Com-NBS) July 31, 1959.

Table 1

Substrate Materials

Symbol	Substrate	Thickness in.	Density lb/cu ft
A	Paper Wallboard - Factory Finished one side	3/16	35.0
B	Plywood - Douglas Fir, interior grade	1/4	39.0
C	Fiberboard - Building Board, Class D finish	1/2	19.4
D	Hardboard - Tempered	1/4	67.6

Table 2. Coating Schedule

Coating System	Paint Coat		No. of Coats	Rate	Top Coat			Description
	Density lb/gal	Color		ft^2/gal	Density lb/gal	No. of Coats	Rate ft^2/gal	
1	11.9	Green	2	250	-	-	-	Fire Retardant Paint
2	12.8	White	2	250	-	-	-	" " "
3	12.2	"	2	250	-	-	-	Alkyd Flat Paint
4	10.6	"	2	250	-	-	-	Fire Retardant Paint
5	13.6	"	2	250	-	-	-	" " "
6	11.5	"	2	250	-	-	-	Latex Water Emulsion
7	12.3	"	1	250	11.95	1	250	Paint Coat-intumescent, resin-base, flat, fire retardant coating. Top Coat-interior gloss fire retardant paint.
7a	12.3	"	1	350	-	-	-	Same as 7 Paint Coat
7b	12.3	"	1	350	11.95	1	500	Same as 7
8	12.1	"	2	250	-	-	-	Alkyd Flat

Note: A primer-sealer (10.8 lb/gal density) was applied to all substrates, at a coverage of 450 ft^2/gal, before coating.

Table 3

FLAME SPREAD INDEX OF COATED ASSEMBLIES

	Coating System									
	1	2	3	4	5	6	7	7a	7b	8
Substrate A Paper-Wall Board (126)										
	64	35	14	31	12	45	--	2	35	44
	26	53	37	63	6	92	13	2	0.4	63
	60	34	18	14	12	61	6	0.4	0.0	30
	25	72	12	27	3	40	4	0.2	2	46
Mean Flame Spread Index	44	48	20	34	9	60	8	1.2	9	46
Coefficient of Variation,%	48	37	56	62	55	39	64	86	183	30
Mean Smoke-Deposit, mg	2.5	1.5	1.1	2.6	1.6	2.2	2.1	1.3	1.6	1.0
Substrate B Plywood (167)										
	8	72	25	44	10	51	6	4	7	29
	13	84	28	34	20	81	16	1	3	38
	48	94	27	28	18	32	12	1	17	14
	16	51	29	30	8	18	2	2	2	88
Mean Flame Spread Index	21	75	27	34	14	46	9	2	7	42
Coefficient of Variation,%	85	25	6	21	42	60	69	71	94	76
Mean Smoke Deposit, mg	3.1	1.7	1.4	2.2	2.6	2.8	2.7	1.8	1.5	1.4
Substrate C Fiberboard (83)										
	21	4	2	7	10	36	16	4	20	19
	95	34	7	29	4	14	17	0	1	4
	12	29	7	7	1	6	0	0	3	11
	12	2	13	30	8	3	2	1	13	18
Mean Flame Spread Index	35	17	7	18	6	15	9	1.2	9	13
Coefficient of Variation, %	115	96	62	71	70	101	103	151	96	54
Mean Smoke Deposit, mg	3.1	1.0	0.7	1.9	1.6	2.5	1.4	1.5	1.9	0.9
Substrate D Hardboard (150)										
	46	87	34	36	32	39	28	2	9	30
	22	65	26	36	32	57	16	1	3	33
	27	90	26	39	36	37	52	2	4	25
	22	59	25	--	--	34	62	1	10	24
Mean Flame Spread Index	29	75	28	37	33	42	40	1.5	6	28
Coefficient of Variation, %	39	21	15	5	7	25	54	73	54	15
Mean Smoke Deposit, mg	4.1	4.5	5.0	3.6	4.9	5.1	3.2	1.2	1.9	3.9

Note: Numbers in parentheses are mean flame spread indices of uncoated substrates.

Table 4. Flame Spread Index of Painted Substrates

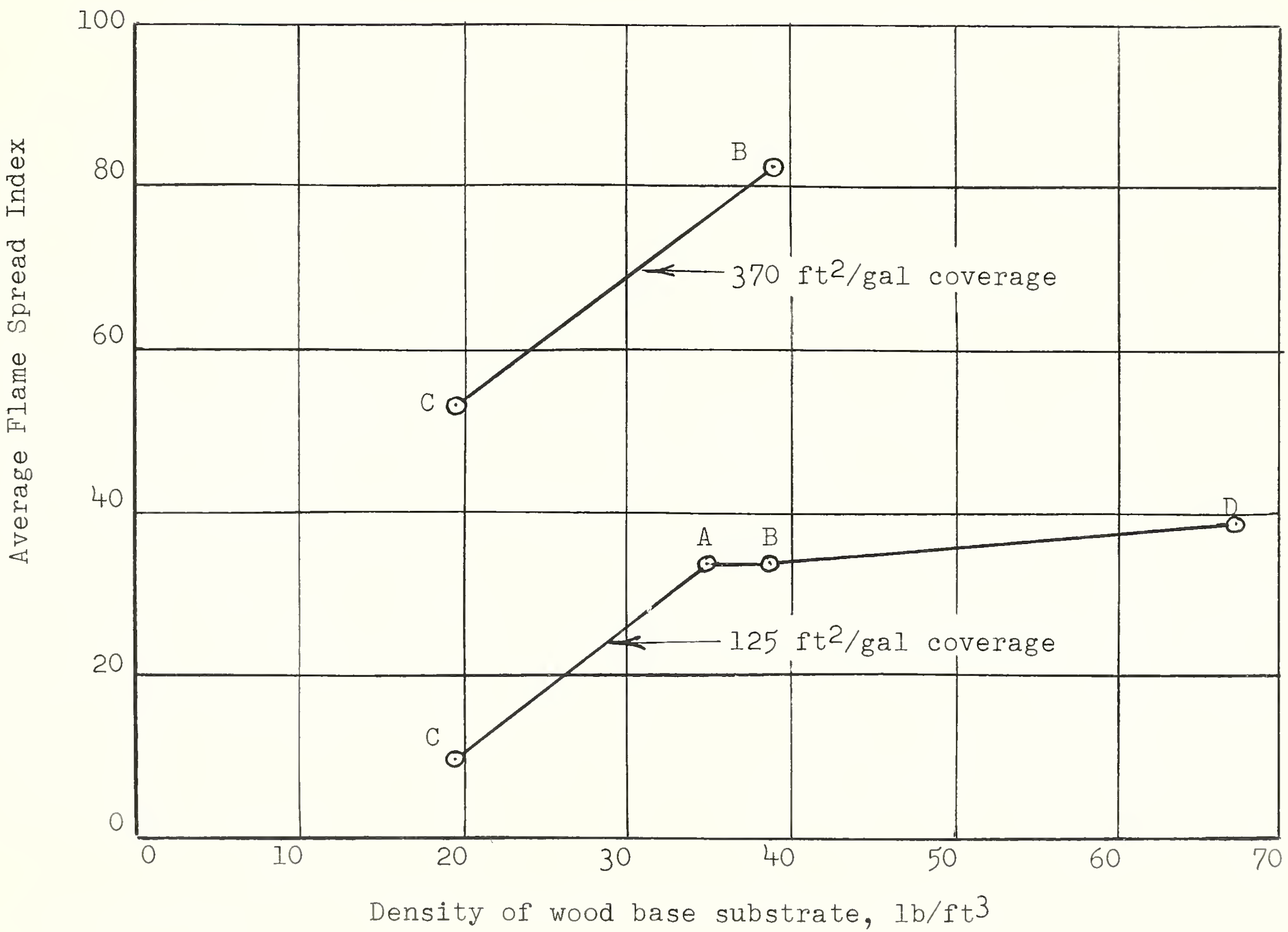
Paint Type	Coverage Rate	Substrate: Fiberboard (19.4 lb/ft^3)	Plywood (39.0 lb/ft^3)
	ft^2/gal		
Alkyd Flat	125	10*	34*
" "	370	40	69
Latex	125	15	46
"	370	66	93

* Average for two paints

Figure 1. EFFECT OF SUBSTRATE DENSITY ON FLAME SPREAD INDEX

Upper curve: avg for 2 conventional paints

Lower curve: avg for 8 coating systems



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