NBSIR 73-228

Summary of Flame Spread and Smoke Generation Tests Conducted for Operation Breakthrough

John B. Ferguson

Center for Building Technology
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National Bureau of Standards
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Final Report

Prepared for
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U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary

NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

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SI Conversion Units

The conversion factors and units contained in this appendix are in accordance with the International System of Units (abbreviated SI for System International d'Unites). The SI was defined and given official status by the 11th General Conference on Weights and Measures which met in Paris in October 1960. For assistance in converting U.S. customary units to SI units, see ASTM E 380, ASTM Standard Metric Practice Guide available from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103. The conversion factors for the units found in this Standard are as follows:

Length

1 in = 0.0254* meter

1 ft = 0.3048* meter

1 mil = 0.001* in

Area

1 in^2 = 6.4516* x 10^{-4} $meter^2$

1 ft^2 = 0.09290 $meter^2$

Volume

1 in^3 = 1.638 x 10^{-5} $meter^3$

1 liter = 1.000* x 10^{-3} $meter^3$

Mass

1 grain = 6.479 x 10^{-5} kilogram

1 ounce-mass (avoirdupois) = 2.834 x 10^{-2} kilogram

1 pound-mass (avoirdupois) = 0.4535 kilogram

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*Exactly

Pressure or Stress (Force/Area)

1 inch of mercury (60°F) = 3376 newton/meter^2

1 pound-force/inch^2 (psi) = 6894 newton/meter^2

Energy

1 inch-pound-force (in-lbf) = 0.1130 joule

Plane Angle

1 degree (angle) = 1.745 x 10^{-2} radian

Power

1 watt = 1.000* x 10^7 erg/second

Temperature

°C = 5/9 (Temperature °F - 32)*

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*Exactly

Summary of Flame Spread and Smoke Generation

Tests Conducted for Operation BREAKTHROUGH

by

John B. Ferguson
Building Fires and Safety Section
Center for Building Technology

ABSTRACT

This document is a listing of the flame spread and smoke generation results of a range of materials that were tested as part of the Operation BREAKTHROUGH housing evaluation program. The test results reported here were obtained under differing conditions and should not be considered the results of a comprehensive and unified research program for evaluation of interior finish materials. Tables of test results and a brief discussion of the results are presented for walls, ceilings, kitchen cabinets and floor coverings.

Key Words: Carpets; flame spread; kitchen cabinets; Operation BREAKTHROUGH; smoke generation; wall and ceiling

1.0 INTRODUCTION

The various housing systems in the Operation BREAKTHROUGH Program of the Department of Housing and Urban Development were evaluated in relation to the performance criteria recommended and presented in the "Guide Criteria for the Evaluation of Operation BREAKTHROUGH Housing Systems"[1][1/]. In many cases fire tests had to be conducted to determine whether or not the recommended fire safety criteria were satisfied by proposed building designs. The flame spread and smoke generation data obtained from this testing were compared to the limits recommended in the criteria.

In order to present the results of these tests on the multitude of floor, wall and ceiling coverings, and kitchen cabinet materials submitted for evaluation in a comprehensive format, the Building Fires and Safety Section of the Center for Building Technology has summarized these small scale fire tests performed for Operation BREAKTHROUGH.

The broad categories for reporting the test results are:

3.1 Wall and Ceiling Coverings

3.2 Kitchen Cabinets

3.3 Floor Coverings - Carpets

3.4 Floor Coverings - Other than Carpets.

2.0 TEST METHODS

The flame spread test method used was ASTM E 162, "A Standard Method of Test for Surface Flammability of Materials Using a Radiant

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[1/] The numbers in brackets refer to the list of reference given at the end of this paper.

Heat Energy Source"[2]. The ASTM E 84 method was called out in the Guide Criteria. Because the Housing System Producer (HSP) was not always able to provide NBS with E 84 flame spread ratings, and because of time limitations, NBS tested materials according to the ASTM E 162 radiant panel method. Flame spread tests are conducted to determine a flame spread index number which reflects the rate of flame propagation over the surface of a material. An inclined 6-inch x 18-inch specimen of the material is situated in front of a radiant heat source (12-inch x 18-inch panel). Ignition is induced near the upper edge and the flame front progresses downward. A factor derived from the rate of progress of the flame front (ignition properties) and another relating to the rate of heat liberation by the material under test are combined to provide a flame spread index.

The smoke generation test method used and called out in the Guide Criteria is described in NBS TN 708, "Interlaboratory Evaluation of the Smoke Density Chamber Test Method," Appendix II, by T. G. Lee, December 1971[3]. The material systems are subjected to smoke generation tests by measuring the progressive attenuation of a light beam passed through the smoke aerosol within the enclosed smoke chamber. The smoke level is reported in terms of specific optical density, a dimensionless attenuation coefficient which defines the amount of smoke accumulated from a specimen of unit surface area in terms of its photometric obscuration over a unit path length within a chamber of unit volume[4]. The specimens are cut into 3-inch x 3-inch sizes. The tests involve a thermal irradiation exposure of 2.5 W/cm^2 normal to the exterior surface of a test specimen, and are performed under both flaming and nonflaming

(smoldering) exposure. To induce open flaming a small pilot natural gas diffusion flame is applied at the base of the specimen.

Specific optical density, Ds, is a property of a specimen of given thickness, and represents the optical density measured over unit path length (L), within a chamber of unit volume (V), produced from a specimen of unit surface area (A). Thus,

$$Ds = D\left(\frac{V}{AL}\right) = \frac{V}{AL}\left[\log \frac{100}{T}\right]$$

where T = percent light transmission, and D is normally referred to as "optical density." For the standard test chamber, V = 18 ft^3, A = 0.0456 ft^2, and L = 3 ft. The change in Ds with time should depend only on the thickness of the specimen, its chemical and physical properties and exposure conditions.[4]

Standard conditioning procedures were followed for both test methods. These conditions are 24 hours at 60°C (140°F) and then to equilibrium at 23°C (73°F) and 50% R.H.

In the testing of carpeting, the complete carpet and underlayment system was tested. This procedure was followed because the underlayment has been found to have a significant effect upon small scale test results for carpeting. Refer to tables 3.1, 3.2, 3.3 and 3.4, respectively, for the descriptions of the materials tested and for the test results. The relative frequency distribution of these results is displayed in figures 3.1.1, 3.1.2, 3.1.3, 3.2.1, 3.3.1, 3.3.2, and 3.4.1.

3.0 RESULTS

3.1 Wall and Ceiling Coverings

Refer to table 3.1 and figures 3.1.1, 3.1.2 and 3.1.3. It can be observed from the figures that both glass-reinforced polyester-surfaced

panels and cellulose-based boards have essentially the same range of flame spread and smoke generation test values.

The Operation BREAKTHROUGH Guide Criteria flame spread recommendation for normal habitable areas, other than exit areas and hazardous areas, was 200. Virtually all the glass reinforced polyester-surfaced panels and cellulouse-base panels tested had flame spread values reported of less than 200. The Operation BREAKTHROUGH Guide Criteria recommendation for smoke generation for normal habitable areas was 450. Most specimens tested had maximum values of specific optical density for smoke generation of less than 450.

3.2 Kitchen Cabinets

Refer to table 3.2 and figure 3.2.1. It is clear from the frequency distribution for flame spread of kitchen cabinet doors and end panels that the range of values and variety of materials tested and reported was large. It appears that the thicker the cabinet material, the lower the flame spread rating. Smoke generation tests were not run for kitchen cabinets in Operation BREAKTHROUGH as no smoke generation criteria were recommended. This is due to the fact that kitchen cabinets generally involve only a small part of the wall area of a kitchen. Moreover, the primary fire safety problem associated with kitchen cabinets has been considered to be their ignitability by kitchen range fires. To minimize testing, based on the fact that early in the Operation BREAKTHROUGH program consistently low flame spread test results were obtained for melamine and vinyl clad kitchen cabinets, in the latter stages of the program similarly coated specimens were not considered to require testing for compliance with the recommended flame spread criterion.

3.3 Floor Coverings - Carpets

Refer to table 3.3 and figures 3.3.1 and 3.3.2. The majority of carpets tested in the Operation BREAKTHROUGH program had reported flame spread values in excess of 200 (which is again the Operation BREAKTHROUGH Guide Criteria recomendation for flame spread).

No broad statement can be made in a comparison of Olefins and Polyamides, other than to say that for the smoke generation tests conducted, the Polyamide carpets had a wider range of smoke generation values than did the Olefins, which were centered in the same 200 to 350 range as the Polyamide carpets (see figure 3.3.2).

It should be pointed out, however, that the burning characteristics of carpets are perhaps most greatly affected not by the type of carpeting alone but also by the type of underlayment material used, the kind of adhesives employed, and the nature of the structural substrate.

3.4 Floor Coverings - Other than Carpets

Refer to table 3.4 and figure 3.4.1. No general conclusions can be drawn concerning the category of Floor Coverings Other Than Carpets, all of which were vinyl floor coverings, due to the small number of specimens tested.

4.0 DISCUSSION

In evaluating the test data one should be mindful of factors which prohibit statistical analysis techniques based upon ideal random sample selection. One reason is that true random sampling is impossible to obtain due to test specimens being cut from the same parent specimen.

The materials tested and reported here are not necessarily typical of all the materials eventually used in Operation BREAKTHROUGH. For instance, materials with unacceptably high test results were either product improved or were replaced in the program with specimens that did pass the appropriate tests.

For further information on the test methods used, and to obtain flame spread data and smoke generation test data for further comparison, refer to references 4 - 7 in the bibliography.

5.0 REFERENCES

[1] "Guide Criteria for the Evaluation of Operation BREAKTHROUGH Housing Systems, NBS-10200 - 4 Volumes (NTIS Accession Numbers PB-212055, 056, 057 and 058).

[2] "A Standard Method of Test for Surface Flammability of Materials Using a Radiant Heat Energy Source," ASTM E 162, Annual Book of ASTM Standards, Part 14, pp. 500-511.

[3] Lee, T. C., "Interlaboratory Evaluation of the Smoke Density Chamber Test Method: NBS TN 708, Appendix II, December 1961.

[4] Gross, et al, "Smoke and Gases Produced by Burning Aircraft Interior Materials," NBS Building Science Series 18, February 1969.

[5] Gross, et al, "Method for Measuring Smoke from Burning Materials," Special Technical Publication No. 422, the American Society for Testing and Materials, 1967.

[6] Gross, D. and Loftus, J., "Flame Spread Properties of Building Finish Materials," ASTM Bulletin No. 230, May 1958.

[7] Marcy, John F. and Johnson, Richard, "Flaming and Self-Extinguishing Characteristics of Aircraft Cabin Interior Materials," Report NA-68-30, for the Federal Aviation Administration, July 1968 (AD 673 084, available from NTIS).

RELATIVE FREQUENCY DISTRIBUTION: WALL AND CEILING COVERINGS

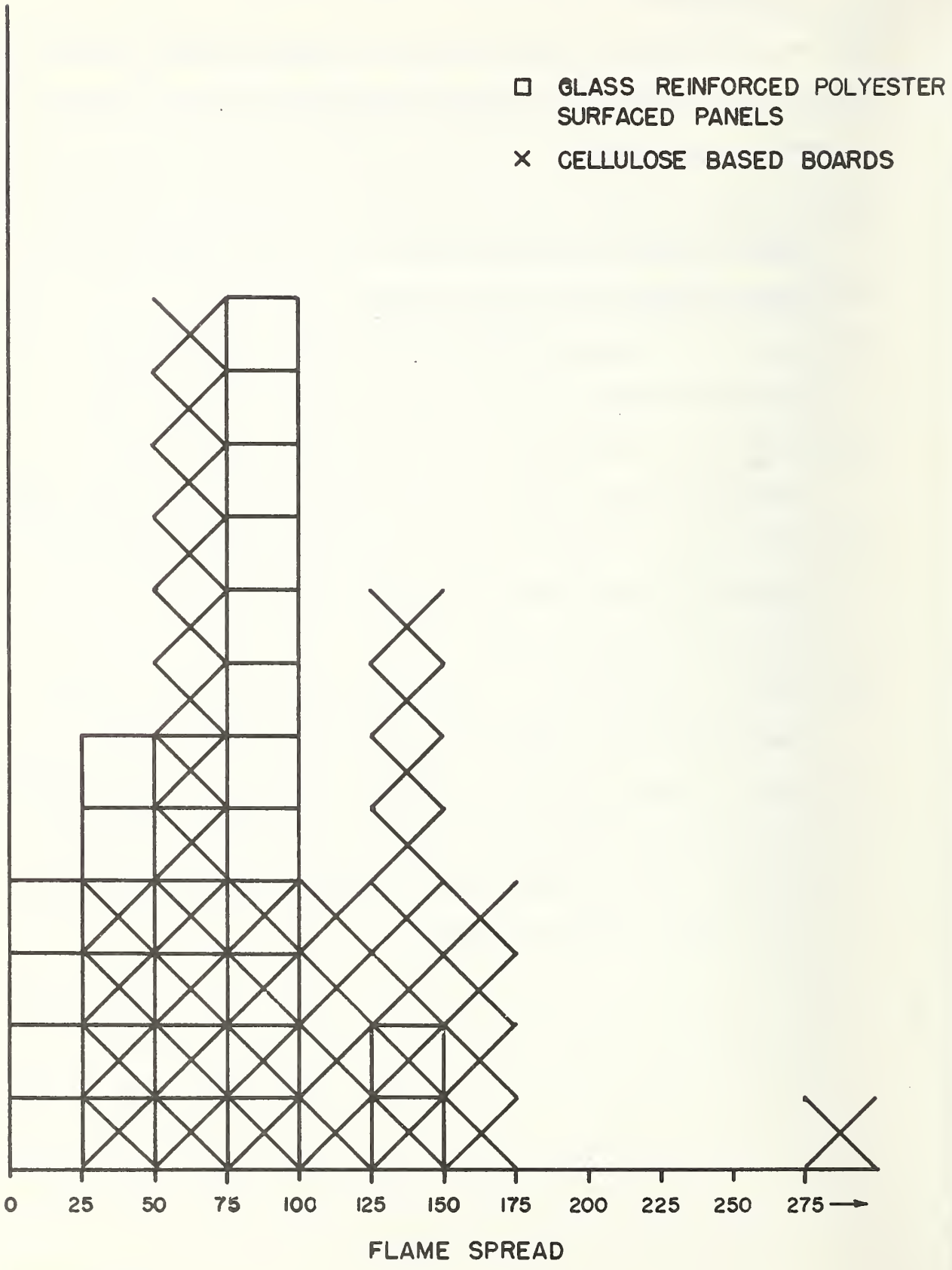

FIGURE 3.1.1

RELATIVE FREQUENCY DISTRIBUTION: WALL AND CEILING COVERINGS

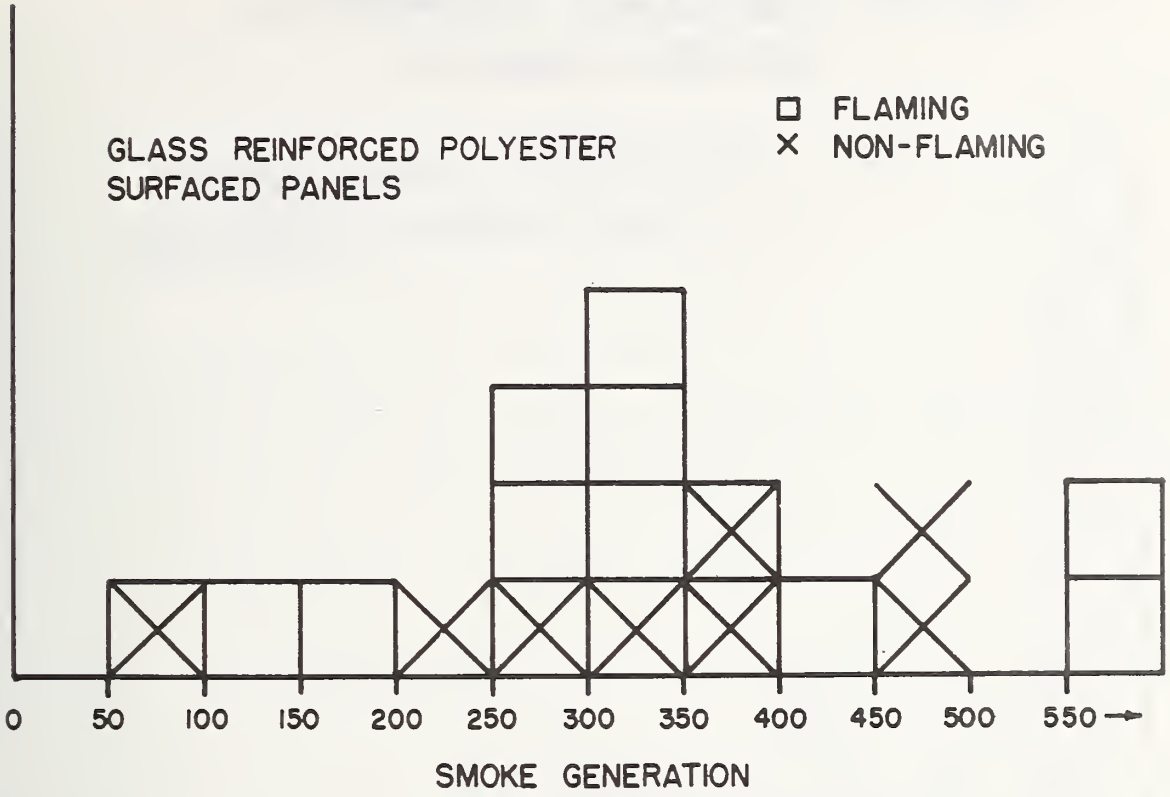

FIGURE 3.1.2

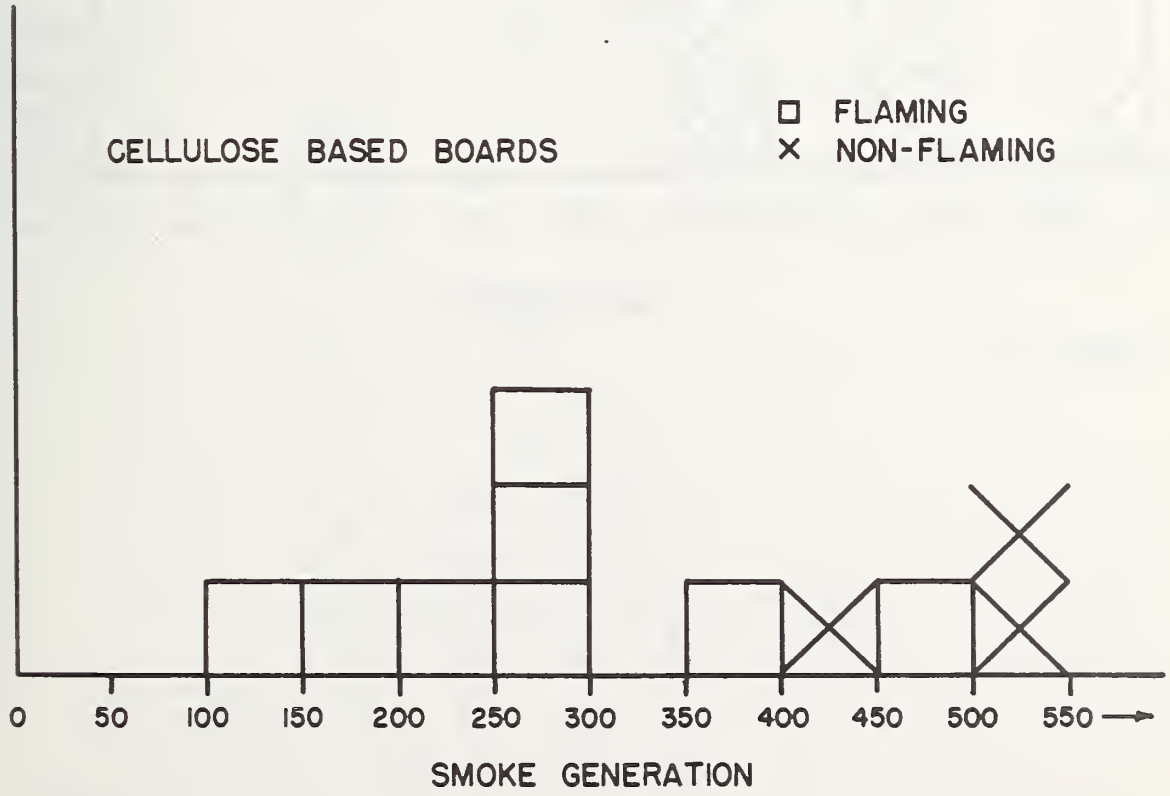

FIGURE 3.1.3

RELATIVE FREQUENCY DISTRIBUTION: KITCHEN CABINETS

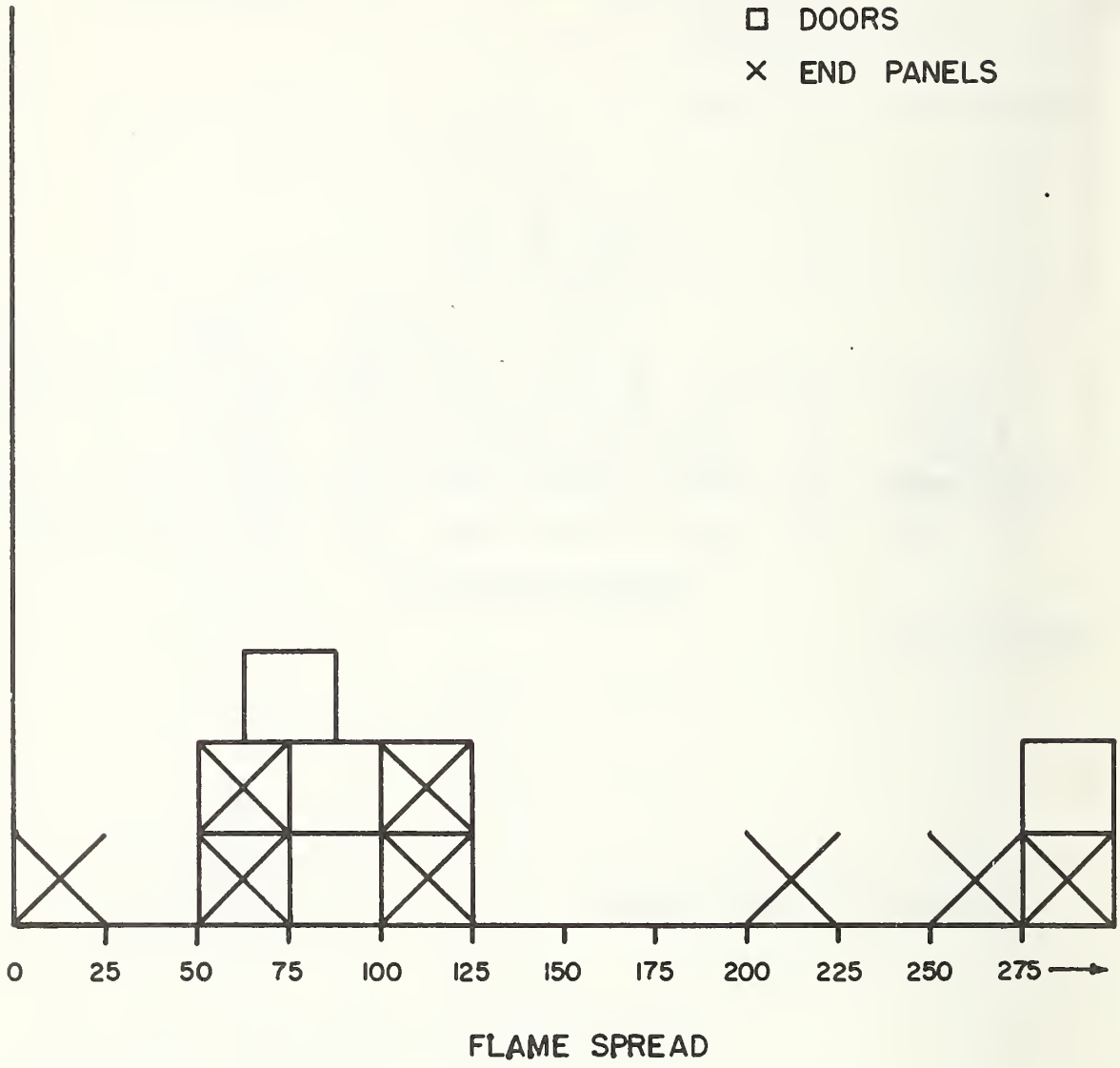

FIGURE 3.2.1

RELATIVE FREQUENCY DISTRIBUTION: CARPETS

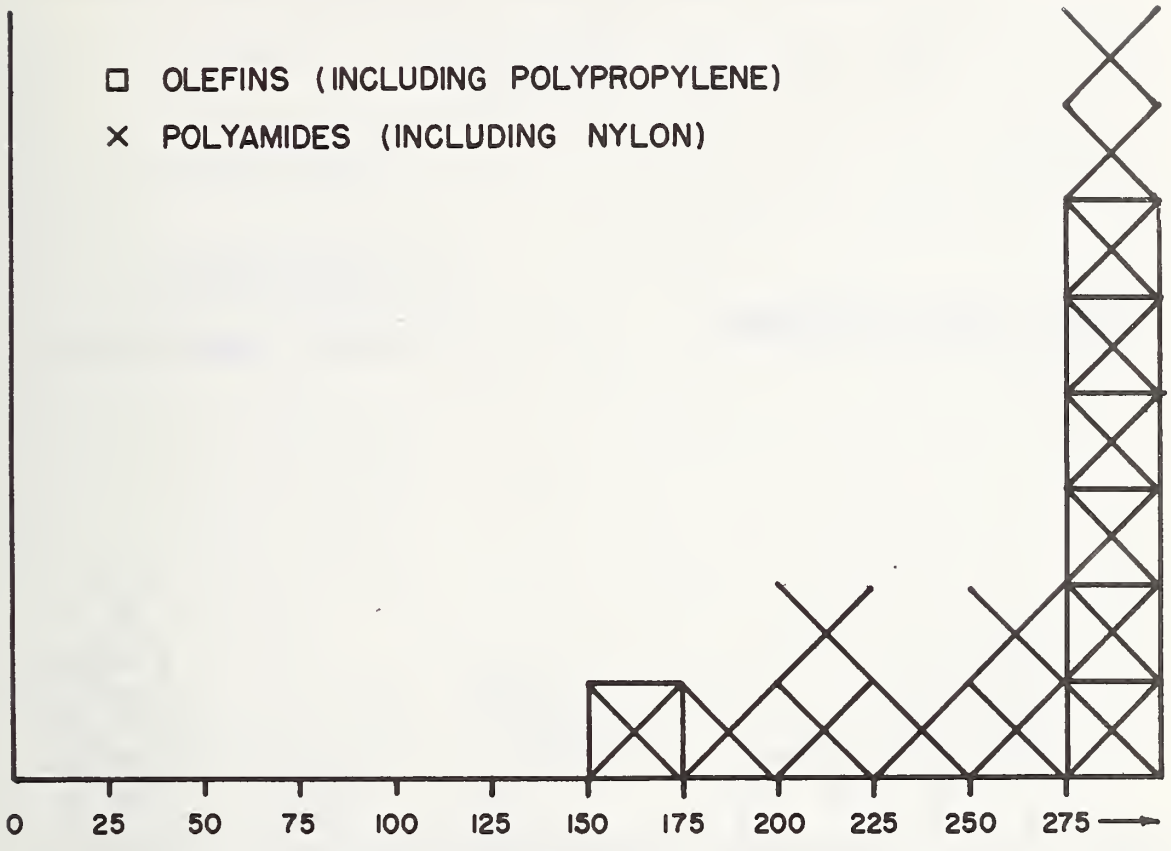

FIGURE 3.3.1

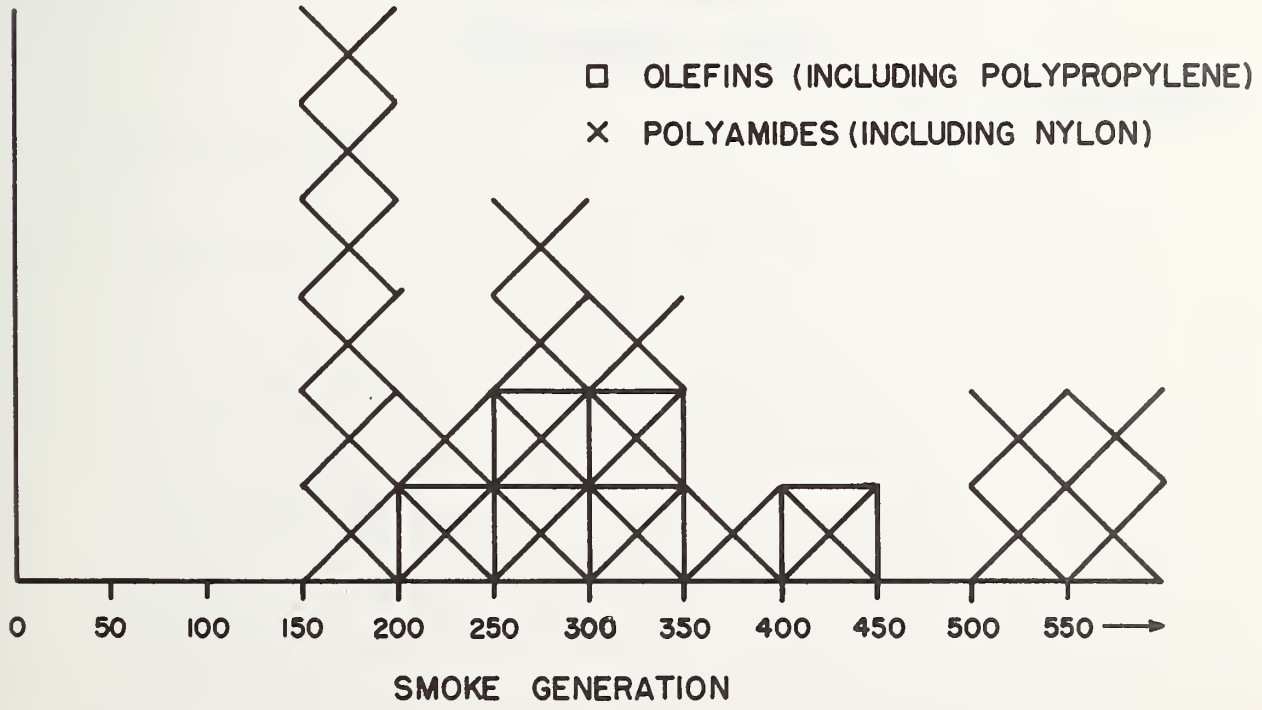

FIGURE 3.3.2

RELATIVE FREQUENCY DISTRIBUTION: FLOOR COVERINGS OTHER THAN CARPETS

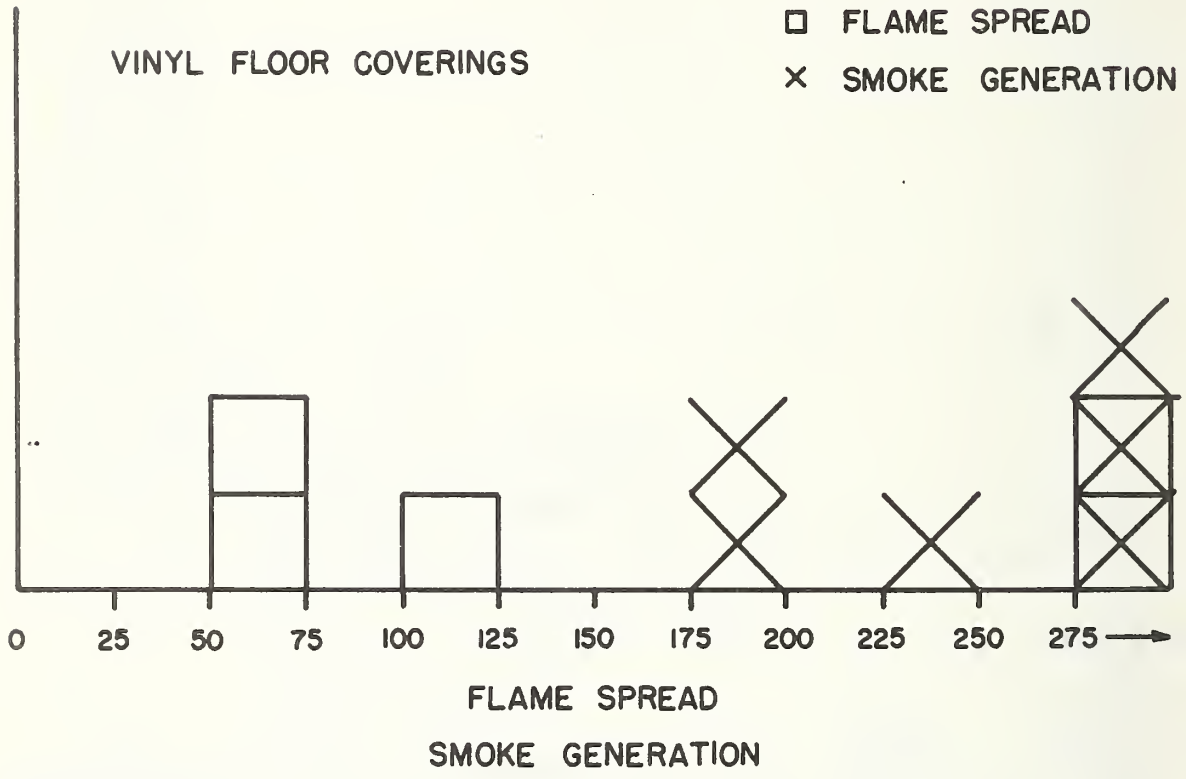

FIGURE 3.4.1

TABLE 3.1

WALL AND CEILING COVERINGS

FR NUMBER	SAMPLE DESCRIPTION	SPECIMEN THICKNESS (inches)	SPECIMEN DENSITY (lb/ft^2)	CATEGORY	RESULTS No. Tested	Flame Spread	MODE	No. Tested	Smoke Generation
3736	Glass reinforced polyester panel (approximately 20% glass and tetra bromo phthalic anhydride flame retardant in polyester resin.	0.085	0.6	GRP	1	74	Flaming Nonflaming	2 2	614 472
3738	Glass reinforced polyester panel (with tetra bromo phthalic anhydride flame retardant in polyester resin).			GRP					
	Interior Specimen	0.082	0.80		2	36	Flaming	4	310
	Exterior Specimen	0.100	0.85		2	44	Flaming	4	374
3744	Paper honey comb sandwich wall panel (using glass cloth and polyester resin, having a double thickness of 5/8 inch gypsum board on one side for an interior surface, or having a single 5/8 inch gypsum board together with sand and polyester resin for an exterior surface).			GRP					
	Interior Specimens	5 1/4	8.9		3	8	Flaming	2	27
	Exterior Specimens				3	18	Flaming	3	62
3746	Polyester resin and fiberglass composition sprayed on 3/8 inch plywood (wood stud partition filled in with two layers of foil faced glass fiber insulation sandwiched between two sheets of 3/8 inch coated plywood. The plywood was spray coated with with a layer of pigmented polyester resin and fiberglass).	4 3/8	plywood and sprayed coating =1.3 psf	GRP	3	58	Flaming	3	293
3748	White vinyl cushion wall on paper (with 3/8 inch plywood backing).	vinyl+ paper+ plywood film 1/16"+ 3/8"	1.7	Cellulose Based	3	55		2	156
3754	Exterior plywood, clear grain plywood(material used for the adjacent walls in reentrant corners).	1/2"	27 lb/ft^3	Cellulose Based	3	104			
3755	Laminate of gel-coated fiberglass on 3/4 inch plywood (smooth white finish)	13/16"	3.1	GRP	4	90			
	Front Face (smooth side)							2	579
	Back Face (matter surface)							2	443
3761	Smooth and granular finishes on 3/8" plywood and 3/8" gypsum board (smooth white finish on 3/8" plywood, and gray granular finish on 3/8" plywood; smooth white finish on 3/8" wood base fiber board and gray granular finish on 3/8" wood base fiber board.)			Cellulose Based					
	3/8" plywood, smooth white finish	7/16	1.2		2	129		2	187
	3/8" plywood, gray granular finish				2	165		2	367

TABLE 3.1 (Continued)

WALL AND CEILING COVERINGS

FR NUMBER	SAMPLE DESCRIPTION	SPECIMEN THICKNESS (inches)	SPECIMEN DENSITY (lb/ft^2)	CATEGORY	RESULTS No. Tested	Flame Spread	MODE	No. Tested	Smoke Generation
	3/8" wood base fiber board, smooth white finish	2	128		2	128		2	260
	3/8" wood base fiber board, gray granular finish	2	286		2	286		2	255
3768	Fiber glass polyester with intumescent coating (white in color)	1/8	1.6	GRP	2	5		3	342
3770 3779	Gel coated fiberglass laminate on 3/4" plywood (front side, smooth white finish; rear side, a rough finish).	25/32"	3.1	GRP					
	Smooth side	3			3	93	Flaming	2	198
							Nonflaming	2	384
	Rough side				3	95	Flaming	2	180
							Nonflaming	2	262
3771	1/16" Formica glued to 5/8" gypsum board (light green)	11/16	2.7		3	18		3	99
3782	Exterior 3/8" plywood on 1/2" gypsum board(stained light green in color).	7/8	2.9	Cellulose Based	3	86			
3783	Particle board with vinyl wall covering (flower design)		42.8	Cellulose Based					
	Particle Board Wall covering	1 1/8 1/64			3	63		2	260
3789	Fiber board ceiling tile (fiberboard with interlocking edges, white surface exposed).	1/2	0.8	Cellulose Based	2	32	Flaming	2	122
							Nonflaming	2	333
3791	1/2 Inch Plywood ceiling panel, with 1/16 inch layer of fiberglass resin coating on each side.	5/8	2.2	Cellulose Based	2	60	Flaming	2	219
							Nonflaming	2	522
3798	Plywood exterior wall panel (latex painted)	5/8	1.8	Cellulose Based	3	72	Flaming	5	489
							Nonflaming	2	506
3805	Polyester and chopped glass fiber interior and exterior surfacing material.			GRP					
	Interior	.125	0.8		2	99		2	98.5
	Exterior	.200	0.9		2	147		2	138
3826	Glass reinforced plastic interior panel	1/8	1.04	GRP	2	7	Flaming	2	269
							Nonflaming	2	206
3827	Glass Reinforced plastic exterior panel	1.75	0.9	GRP					
	White				2	47	Flaming	2	190
	Beige				2	82	Flaming	2	208
3829	Interior wall partition white asbestos, laminated covering with polystyrene inner panel	4	3.75 lb/ft^3		2	55		2	207
	Asbestos covering only				1	30			
3833	Polyester resin and fiberglass composition			GRP					
	Brown, rough I	1/4	63 lb/ft^3				Flaming	2	344
							Nonflaming	2	364
	Brown, rough II	1/4	69 lb/ft^3				Flaming	2	383
							Nonflaming	2	464
	White, smooth	11/64	78 lb/ft^3				Flaming	2	414
							Nonflaming	2	90
	White, rough	1/4	61 lb/ft^3				Flaming	2	315
							Nonflaming	2	264

TABLE 3.1 (Continued)

WALL AND CEILING COVERINGS

FR NUMBER	SAMPLE DESCRIPTION	SPECIMEN THICKNESS (inches)	SPECIMEN DENSITY (lb/ft^2)	CATEGORY	RESULTS No. Tested	Flame Spread	MODE	No. Tested	Smoke Generation
3835	Joint laminate 40% resin, exterior finish.	.200	62.4 lb/ft^3	GRP			Flaming	2	337
							Nonflaming	2	342
	Joint Laminate, 41% resin exterior finish	.200	59 lb/ft^3				Flaming	2	319
							Nonflaming	2	360
	Polyester skin, 31% resin exterior finish	.175	57 lb/ft^3		1	70	Flaming	2	266
							Nonflaming	2	244
	Polyester skin, 34% resin exterior finish	.200	62.5 lb/ft^3		1	80	Flaming	2	368
							Nonflaming	2	319
	Polyester skin, 36% resin exterior finish	.200	64 lb/ft^3		1	82	Flaming	2	298
							Nonflaming	2	304

TABLE 3.2

KITCHEN CABINETS

FR NUMBER	SAMPLE DESCRIPTION	SPECIMEN THICKNESS (inches)	SPECIMEN DENSITY (lb/ft^2)	CATEGORY	No. Tested	Flame Spread	MODE	No. Tested	Smoke Generation
3772	Kitchen cabinet doors with plastic outer finish and paper honeycomb interior (brown in color).	3/4	1.2		3	93			
	Outer plastic	1/16							
	Honeycomb paper	5/8							
3773	Kitchen cabinet end panels with plastic and lacquer finish on 1/8" poplar with 1-1/2"x3/4" white pine batten (brown in color).	7/8	0.5		2	985			
	Panel	1/8							
3784	Particle board core door and end panels; doors with polyester laminate overlap and panels with birch veneers.	1/2							
	Doors		52 lb/ft^3		3	114			
	End panels		46 lb/ft^3		3	117			
3786	Simulated woodgrain kitchen cabinet doors and end panels (color-brown).								
	End panels		57.6 lb/ft^3		2	216			
	Town house doors (end panels)	1/8	75 lb/ft^3		2	66			
	Scandinavian doors (doors)	7/16	74.6 lb/ft^3		2	107			
3790	Plywood kitchen cabinet doors and end panels (door panels, plywood, with dark brown wood grain veneer-lacquer finish; end panels, plywood with dark brown wood grain veneer).	3/4							
	Door panel		2		2	477			
	End panel		2.2		2	70			
3796	Plywood kitchen cabinets door and end panels (rerun of 3790)	3/4							
	Doors		1.8		2	417			
	End panels		2.0		1	262			
3792	3/16" mahogany plywood kitchen cabinets, and end panels with Melamine woodgrain veneer on one side.	3/16	.75		2	14			
3810	3/4" Plywood kitchen cabinet door panel (color-light brown finish).	3/4	2		2	72			
3814	Composition wood door panel for kitchen cabinets with 1/32" wood grain veneer on both sides (color-dark stained finish).	7/16	2.2		1	91			
3825	Particle baord with vinyl clad walnut wood grain finish kitchen cabinet doors (5/8") and end (3/8") panels.	5/8							
	Door panels		2.6		2	93			
	End panels		2.0		2	70			
3828	Particle board kitchen cabinet doors and end panels (door panel 3/8" wood grain finish on both sides; end panel 1/2" varnish on both sides, wood grain on exterior).								
	Door panels	3/8	26		2	75			
	End panels	1/2	22		2	109			

TABLE 3.3 (Continued)

FLOOR COVERINGS (CARPETS)

FR NUMBER	SAMPLE DESCRIPTION	SPECIMEN THICKNESS (inches)	SPECIMEN DENSITY (lb/ft^2)	CATEGORY	No. Tested	Flame Spread	MODE	No. Tested	Smoke Generation
3777	16 oz. 100% continuous filament nylon looped carpet with polypropylene and jute backing (color-blue and green).	19/32		Polyamide	3	439		2	162
	Rug		$51.8 oz/yd^2$						
	Underlayment		$36.4 oz/yd^2$						
3778	100% Continuous filament nylon looped carpet with polypropylene and jute backing (multicolored-green and black).	19/32		Polyamide	3	482		2	184
	Rug		$51.8 oz/yd^2$						
	Underlayment		$36.4 oz/yd^2$						
3781	100% nylon pile carpet with 3/8" jute backing, with 1/4" rubberized hair underlayment on 3/4" plywood (color-green with sculpture pattern).			Polyamide	3	180		3	267
	Rug	3/8	$53.7 oz/yd^2$						
	Jute	1/8							
	Underlayment		$34.5 oz/yd^2$						
3788	100% Olefin fiber with jute backing carpet (color-green)	1/4	$60 oz/yd^2$	Olefin				2	287
3797	100% nylon short loop pile carpet with polypropylene primary back and jute secondary backing (tested with and without rubberized hair pad underlayment).			Polyamide					
	Rug	5/16"	$75 oz/yd^2$						
	Pad	3/8	$26 oz/yd^2$						
	With hair pad						Flaming	2	192
							Nonflaming	2	302
	Without hair pad						Flaming	1	164
							Nonflaming	1	289
	100% nylon yellow shag carpet with double jute backing, (tested with and without rubberized hair pad underlayment).								
	Rug	.75 to 1.0"	$69 oz/yd^2$						
	Pad	3/8"	$26 oz/yd^2$						
	With hair pad						Flaming	2	260
							Nonflaming	2	524
	Without hair pad						Flaming	1	231
							Nonflaming	1	446
3802	Gold hi-lo carpet, rubber backing-	1/2	$64 oz/yd^2$						
	With 5/8" plywood backing							2	311
	Without 5/8" plywood backing							2	361
3806	Nylon carpet, level loop, polypropylene primary back, jute secondary back.			Polyamide					
	Dark blue	1/4	$62.5 oz/yd^2$		2	222		2	264
	Light blue	5/16	$76 oz/yd^2$		2	154		2	306
3818	100% polypropylene fiber carpeting with woven jute backing (color-black and gray or high density foam rubber backing; color-bronze and green)			Olefin					
	With rubber backing and hair underlayment	.375	$85.3 oz/yd^2$		2	584			
	With jute backing (no hair pad)	.300	$57.7 oz/yd^2$		2	485			
	Without jute backing and hair pad underlayment				2	536			
	With jute backing, adhered to 1/4" asbestos board with AP Green Insulation Adhesive.				1	154			
3831	100% nylon continuous filament carpeting (orange, with 2 ply backing of 3.5 oz. polypropylene primary and 7 oz. jute secondary ply.)	9/32	$69 oz/yd^2$	Polyamide	2	203	Flaming	2	193
							Nonflaming	2	183

TABLE 3.3

FLOOR COVERINGS (CARPETS)

FR NUMBER	SAMPLE DESCRIPTION	SPECIMEN THICKNESS (inches)	SPECIMEN DENSITY (lb/ft^2)	CATEGORY	No. Tested	Flame Spread	MODE	No. Tested	Smoke Generation
3747	Olive gold, loop pile with jute backing (mounted on 3/8" plywood with carpet adhesive. The carpet fiber was unidentified "but may have been polypropylene").	5/16	55oz/yd^2	Olefin	3	295		3	238
	Carpet only							1	293
3748	Nylon shag carpet with 1/4" integral foam rubber backing (mounted on 3/8" plywood, 4 different colors tested).		1.6 lb/ft^2	Polyamide				3	518
	Shag	1							
	Rubber	1/4							
	Plywood	3/8							
	Yellow gold				3	323			
	Blue Green				2	288			
	Brown gold				2	324			
	Yellow green				3	308			
3756	100% Nylon (20 oz) carpet with jute backing; gold in color and mounted on 5/8" plywood, on 3/8" foam underlayment.	1	20oz/yd^2	Polyamide	3	246		2	714
	Plywood	5/8							
3757	100% Nylon (20 oz) carpet with high density foam backing, gold in color, 1/8" 38 oz. foam underlayment, on 5/8" plywood substrate.	17/32	2.4	Polyamide	3	270		3	658
	Foam	1/8							
3762	Continuous filament Olefin loop carpet with jute backing; mixed colors of gold, green, and yellow with rubberized hair pad underlayment.		51.3oz/yd^2	Olefin	3	408		2	402
	Rug	3/16							
	Jute	1/16							
	Underlayment	1/2	40oz.						
	Carpet and jute without underlayment							1	342
3766	Continuous filament Olefin loop carpet with jute backing (mixed colors of gold, green, and yellow with rubberized hair pad underlayment.	5/8		Olefin	3	528		2	338
	Rug		51.6oz/yd^2						
	Underlayment		44 oz/yd^2						
3774	100% Continuous filament nylon shag carpet with 3/8" foam backing (blue and green in color).		83 oz/yd^2	Polyamide	2	260		3	325
	Pile	1 1/4							
	Foam	3/8							
3775	100% Continuous filament nylon looped carpet with polypropylene and jute backing (mixed colors, orange and green).			Polyamide	3	359		2	244
	Rug	5/16	59.5oz/yd^2						
	Jute backing	3/32							
	Underlayment	3/8	36.4 oz/yd^2						
3776	20 oz 100% nylon clipped loop carpet with polypropylene and jute backing (color- green)	27/32"		Polyamide	3	276		2	351
	Rug		57.6oz/yd^2						
	Underlayment		36.4oz/yd^2						

TABLE 3.4

FLOOR COVERINGS (OTHER THAN CARPETS)

FR NUMBER	SAMPLE DESCRIPTION	SPECIMEN THICKNESS (inches)	SPECIMEN DENSITY (lb/ft^2)	CATEGORY	No. Tested	Flame Spread	MODE	No. Tested	Smoke Generation
3780	Vinyl floor covering on 3/4" plywood 1/64" vinyl backed with 1/16" cardboard; color-light brown and green with rough surface.	57/64	3		4	70		2	181
3795	Vinyl floor covering, color yellow, green, and brown	0.065	$42oz/yd^2$		2	350		2	185
3802	Vinyl sheet flooring								
	Brand X	0.075	$37oz/yd^2$					2	529
	Brand Y	0.075	$35.9oz/yd^2$					2	244
3803	Vinyl floor covering 1/16" thick, underlayment-3/8" flakeboard.	7/16	1.7		2	72		2	767
3832	Vinyl floor covering (mounted on 1/4" asbestos board with adhesive).	.150	$75oz/yd^2$		2	137	Flaming	2	617
								2	545

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16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

This document is a listing of the flame spread and smoke generation results of a range of materials that were tested under the Operation BREAKTHROUGH housing evaluation program. The test results reported here were obtained under differing conditions and should not be considered the results of a comprehensive and unified research program for evaluation of interior finish materials. Tables of test results and a brief discussion of the results are presented for walls, ceilings, kitchen cabinets and floor coverings.

17. KEY WORDS (Alphabetical order, separated by semicolons) Carpets; flame spread; kitchen cabinets; Operation BREAKTHROUGH; smoke generation; wall and ceiling.

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