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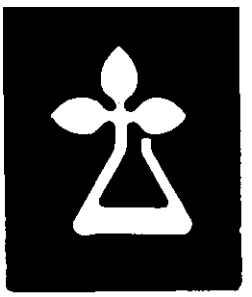

U. S. FOREST SERVICE
RESEARCH NOTE
FPL-0186
FEBRUARY 1968

SURFACE FLAMMABILITY OF VARIOUS WOOD-BASE BUILDING MATERIALS

Summary

Surface flammability of 29 species of wood in lumber form and 50 commercially produced plywoods, hardboards, fiberboards, and particleboards was measured at the Forest Products Laboratory in the 8-foot tunnel furnace. Results indicate the range in surface flammability that can be expected from the types of lumber and fabricated boards tested.

SURFACE FLAMMABILITY OF VARIOUS WOOD–BASE BUILDING MATERIALS[1]

By

Forest Products Laboratory[2], Forest Service
U. S. Department of Agriculture

Introduction

Building codes and fire protection engineers frequently limit the use of building materials based on the potential surface flammability, or ease with which flames may spread over their surfaces. There have been numerous laboratory test methods developed for measuring this characteristic, with the greatest recognition being given by the code authorities to the 25–foot tunnel furnace method (ASTM Standard E84) developed by the Underwriters' Laboratories, Inc. This large tunnel method requires the use of test specimens 20 inches by 25 feet; this limits the tunnel's use for research and development purposes when a large number of test variables are to be evaluated.

Therefore, the Forest Products Laboratory has developed a smaller scale 8–foot tunnel furnace method for research and development purposes, particularly in the wood product field. This report presents test data obtained by this method on the surface flammability of 29 species of wood in lumber form and 50 commercially produced plywoods, hardboards, fiberboards, and particleboards.

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[1]This research note is a revision of Forest Products Laboratory Report No. 2140, under the same title, originally written in 1959 by H. D. Bruce and L. E. Downs.

[2]Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

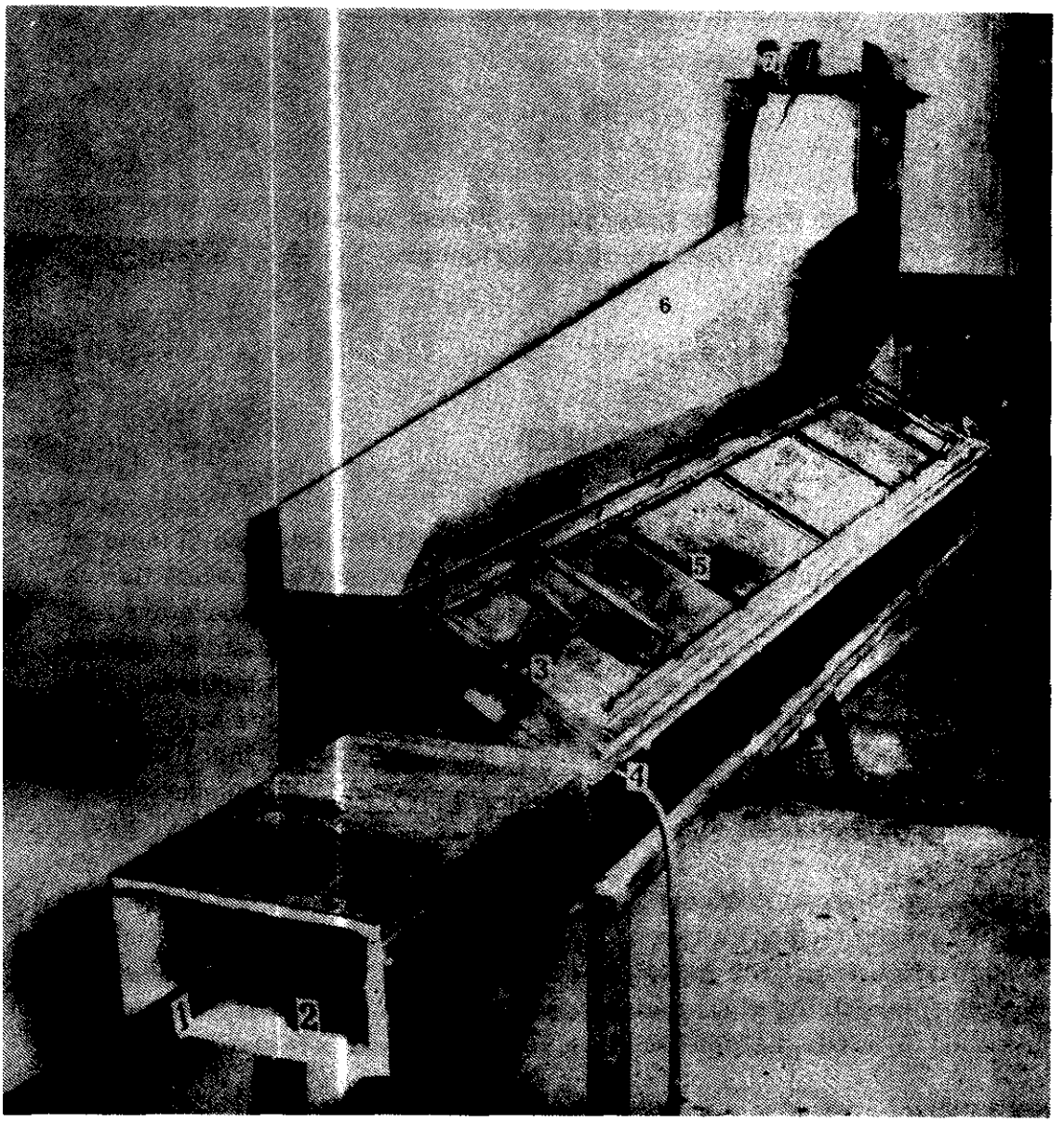

Figure 1. --Specimen side of FPL 8-foot tunnel furnace. 1, Gas supply to main burner; 2, firebox; 3, clamp to hold down cover over test specimen; 4, gas supply to igniting burner: 5, cover over test specimen; 6, hood to collect combustion gases for temperature and smoke measurement; and 7, photoelectric cell for smoke-density measurement.

ZM 110 169

Test Method

The 8-foot tunnel-furnace method was described by Bruce and Miniutti in 1958,[3] and the current version is listed as ASTM Method E286-65T.[4]

In this test a specimen 14 inches wide by 8 feet long, conditioned to moisture equilibrium in an atmosphere at 30 percent relative humidity and 80° F., is laid in the furnace (fig. 1). The specimen is weighted down by a heavy cover, with asbestos millboard directly against its back. Ignition is provided by a small pilot burner near the lower end of the specimen (specimen slopes slightly lengthwise upward at an angle of 6° from the horizontal). A graduated source of radiant heat is applied to the face of the test specimen from a stainless steel partitioning plate heated by a large T-head gas-burner flame. As the ignition flame moves along the underside of the specimen, this progressionis measured and expressed as an index number. Basis for this index is a rating of 100 for flame movement on red oak flooring, (39 pounds per cubic foot in density) and a rating of 0 for progression on asbestos millboard.

Along with flame-spread rates, smoke density and heat contributed by the test specimen were also measured and expressed as index numbers relative to red oak and 'asbestos, as explained in the reports describing the test method.

Test Materials

The fiberboards, hardboards, particleboards, and plywoods were obtained largely through the courtesy of the respective manufacturers' associations.[5] All sheets were specimens of commercial mill-run production, and usually 4 by 8 feet in size. From each 4- by 8-foot sheet, three test specimens 14 inches wide by 8 feet long were cut.

The lumber, nominally 1 inch thick, was obtained from sawmills or retail dealers. When conditioned to moisture equilibrium at 30 percent relative

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[3] Bruce, H. D. and Miniutti, V. P. Small Tunnel-Furnace Test for Measuring Surface Flammability. American Society for Testing and Materials Bulletin 230, May 1958.

[4] Other reports on the 8-foot tunnel-furnace method, as well as its use, are given at the end of this report.

[5] The Insulation Board Institute, the Hardboard Association, the Particleboard Association, the Hardwood Plywood Institute, and the Douglas Fir Plywood Association (now American Plywood Association).

humidity and 80° F., the boards were surfaced to a thickness of about 3/4 inch, tongued and grooved,[6] and assembled into panels held together by three nailed cleats on the back Pieces shorter than 8 feet were end-squared and butt-joined. Two tests were made on each material, with a third test when the results of the first two were not in adequate agreement.

Results

The results of all tests are given in tables 1 through 5. No attempt was made to analyze the results to explain the differences in the index values; to do so would require an intimate knowledge of the composition of the commercial materials and research on the effects of various ingredients. The tests, however, indicate the range in surface flammability that can be expected from the types of lumber and fabricated boards tested, and now available for construction purposes.

In earlier tests, close correlation was foundbetween results of the 8-foot tunnel tests and ,wall-corner tests, which simulate roomfires, on 11 different materials. It is believed, therefore, that the results given in this report provide a realistic relative measure of the surface flammability of the various materials tested.

[6] An exception to this method of assembly was made for the redcedar, which could not be tongued and grooved. The redcedar boards were nailed to a backing of 1/4-inch Douglas-fir plywood to form the test panel.

Table 1.--Results of tunnel-furnace tests on 1-inch lumber

Species	Weight	Moisture content	Index numbers[1]		
			Flame-spread	Smoke-density	Heat-contributed
	Lb. per cu. ft.	Percent			
1.Alder (Alnus rubra)	29.6	6.4	118	108	122
.....do.....	29.9	6.5	124	116	119
2.Aspen (Populus tremuloides)	26.5	6.1	128	63	130
.....do.....	28.4	5.9	110	36	108
.....do.....	27.0	6.4	125	118	134
3.Basswood (Tilia americana)	28.6	5.4	123	78	131
.....do.....	27.4	5.4	134	80	124
4.Beech (Fagus grandifolia)	46.5	6.1	99	112	136
.....do.....	47.0	5.4	102	152	144
5.Baldcypress (Taxodium distichum)	29.2	6.6	103	420	109
.....do.....	27.2	7.2	122	359	105
.....do.....	32.4	6.8	107	388	112
6.Birch (Betula alleghaniensis)	39.6	5.4	91	93	92
.....do.....	39.2	5.8	106	84	101
.....do..(grain perpendicular)	39.4	6.0	100	83	95
.....do..(.....do.....)	39.4	5.9	86	143	99
7.Chestnut (Castanea dentata)	28.5	6.1	114	16	89
.....do.....	29.5	6.2	127	17	95
8.Cottonwood (Populus trichocarpa)	27.6	4.9	136	134	135
.....do.....	27.0	5.0	132	115	135
9.Douglas-fir (Pseudotsuga menziesii)	27.7	5.9	117	93	79
.....do.....	26.5	5.9	115	69	72
.....do.(grain perpendicular)	27.1	6.3	108	46	89
.....do.(.....do.....)	27.1	6.3	102	54	88
10.Elm, slippery (Ulmus rubra)	37.4	6.3	79	130	111
.....do.....	38.8	6.2	93	169	102
.....do.....	39.4	5.9	96	155	110
.....do.(grain perpendicular)	38.5	5.6	76	179	98
.....do.(.....do.....)	38.5	5.8	98	177	102
.....do.(.....do.....)	40.1	5.8	84	171	116
11.Fir, white (Abies concolor)	30.0	6.5	112	112	93
.....do.....	29.7	6.9	118	106	98

Table 1.--Results of tunnel-furnace tests on 1-inch lumber (Continued)

Species	Weight	Moisture content	Index numbers[1]		
			Flame-spread	Smoke-density	Heat-contributed
	Lb. per cu. ft.	Percent			
12.Hemlock (Tsuga heterophylla)	29.9	7.3	113	87	95
.....do.....	28.2	7.5	102	69	95
13.Lauan, Philippine mahogany	31.7	5.2	109	38	86
.....do.....	37.6	5.5	103	72	76
.....do.(grain perpendicular)	34.6	5.2	98	59	74
.....do.(.....do.....)	34.6	5.0	99	68	70
14.Larch (Larix occidentalis)	34.4	6.8	107	72	98
.....do.....	35.4	6.8	105	41	98
15.Mahogany (Swietenia macrophylla)	30.7	6.5	100	52	69
.....do.....	28.6	6.6	107	15	70
16.Maple, sugar (Acer saccharum)	43.4	6.2	93	79	79
.....do.....	40.0	6.2	97	73	86
17.Oak, red (Quercus rubra)	39.0	5.2	100	100	100
....do..(grain perpendicular)	39.0	4.5	99	59	102
....do..(.....do.....)	39.0	5.2	99	69	105
18.Oak, white (Quercus alba)	40.8	6.3	99	32	90
.....do.....	40.7	6.5	91	49	92
19.Pine, northern white (Pinus strobus)	23.7	5.7	130	149	100
.....do.....	24.0	5.7	134	237	108
20.Pine, ponderosa (Pinus ponderosa)	26.6	6.5	110	182	100
.....do.....	27.0	6.6	124	183	102
.....do.....	29.6	6.3	109	325	103
21.Pine, southern yellow[2]	28.4	6.8	102	158	111
.....do.....	30.0	6.7	102	157	120
22.Pine, sugar (Pinus lambertiana)	24.7	6.3	118	282	88
.....do.....	22.7	5.9	130	255	104
.....do.....	24.7	6.4	128	248	101
23.Pine, western white (Pinus monticola)	26.4	6.1	128	282	123
.....do.....	27.0	6.1	113	362	112
.....do.....	24.2	5.8	129	177	104

Table 1.--Results of tunnel-furnace tests on 1-inch lumber (Continued)

Species	Weight	Moisture content	Index numbers[1]		
			Flame-spread	Smoke-density	Heat-contributed
	Lb. per cu. ft.	Percent			
24.Redcedar (Juniperus virginiana)	33.5	9.0	105	212	94
.....do.....	34.2	8.8	114	236	94
25.Redwood (Sequoia sempervirens)	25.9	6.4	120	170	64
.....do.....	25.2	6.4	122	207	72
26.Spruce, Sitka (Picea sitchensis)	27.0	7.0	116	72	77
.....do.....	26.6	6.5	108	42	82
27.Sweetgum (Liquidambar styraciflua)	31.2	6.4	94	66	82
.....do.....	32.4	6.2	107	86	114
.....do.....	33.2	7.2	113	52	119
28.Walnut, black (Juglans nigra)	35.6	5.0	105	80	111
.....do.....	39.3	5.2	108	90	118
29.Yellow-poplar (Liriodendron tulipifera)	30.9	5.7	121	123	120
	31.2	5.7	128	188	130

[1]Relative to 100 for red oak lumber and 0 for asbestos board.

[2]Botanical species not determinable from wood alone.

Table 2.--Results of tunnel-furnace tests on plywood

Description of plywood	Thickness	Weight	Moisture content	Index numbers[1]		
				Flame-spread	Smoke-density	Heat-contributed
	Inch	Lb. per cu. ft.	Percent			
30.Douglas-fir, 3 ply, Interior, A-D, cold-press, protein glue	1/4	31.2	6.6	129	152	125
	1/4	31.0	6.5	117	182	121
31.Douglas-fir, 3 ply, Interior, A-D, hot-press, protein glue	1/4	30.0	6.2	120	111	111
	1/4	30.4	6.0	125	99	117
32.Douglas-fir, 3 ply, Interior, A-D, hot-press, extended phenol resin glue	1/4	34.7	4.9	119	95	120
	1/4	34.6	5.1	123	68	125
33.Douglas-fir, 3 ply, Exterior, A-C, resin glue	3/8	32.0	4.8	118	77	116
	3/8	32.0	5.0	114	41	102
34.Douglas-fir, 3 ply, Exterior, A-C, resin glue	3/8	35.7	4.7	112	57	120
	3/8	36.6	4.6	115	97	124
35.Douglas-fir, 3 ply, Exterior, A-C, resin glue	3/8	$\frac{2}{}$32.8	5.1	114	140	107
	3/8	$\frac{2}{}$32.8	4.9	112	166	100
36.Douglas-fir, 3 ply, Exterior, A-C, resin glue - 1 coat of fire-retardant paint A.	3/8	34.8	5.0	83	406	56
	3/8	34.9	4.7	83	548	59
37.Douglas-fir, 3 ply, Exterior, A-C, resin glue - 2 coats of fire-retardant paint A.	3/8	34.0	5.1	52	1022	18
	3/8	33.7	5.1	53	914	21
38.Douglas-fir, 3 ply, Exterior, A-C, resin glue - 1 coat of fire-retardant paint B.	3/8	$\frac{2}{}$34.1	5.0	59	722	16
	3/8	$\frac{2}{}$34.1	5.0	70	773	26
39.Douglas-fir, 3 ply, Exterior, A-C, resin glue - 2 coats of fire-retardant paint B.	3/8	$\frac{2}{}$34.1	5.0	34	1117	9
	3/8	$\frac{2}{}$34.1	5.0	34	1169	11
40.Douglas-fir, 3 ply, Exterior, A-C, resin glue, 2 coats fire-retardant paint C.	3/8	$\frac{2}{}$34.1	5.2	79	1000	37
	3/8	$\frac{2}{}$34.1	4.8	84	1001	39
41.Douglas-fir, 3 ply, Exterior, medium density paper plastic overlay	3/8	32.3	4.7	115	135	120
	3/8	32.4	4.9	118	113	118

Table 2.--Results of tunnel-furnace tests on plywood (Continued)

Description of plywood	Thickness	Weight	Moisture content	Index numbers[1]		
				Flame-spread	Smoke-density	Heat-contributed
	Inch	Lb. per cu. ft.	Percent			
42. Douglas-fir, 3 ply, Exterior, medium density paper plastic overlay	3/8	36.7	5.0	97	194	115
	3/8	37.3	5.5	86	163	111
43. Douglas-fir, 3 ply, Exterior, medium density paper plastic overlay	1/2	40.6	4.6	113	232	119
	1/2	40.2	4.7	113	234	112
44. Douglas-fir, 3 ply, Exterior, high density paper plastic overlay	3/8	35.9	4.3	105	166	102
	3/8	36.4	4.2	105	146	101
45. Douglas-fir, 3 ply, Exterior, high density paper plastic overlay	3/8	33.4	4.9	106	116	115
	3/8	33.4	5.3	108	96	115
46. Birch face, 40 mils, yellow poplar core, urea glue	1/4	35.0	5.9	117	78	122
	1/4	39.0	5.9	116	59	135
47. Lauan face, 44 mils, lauan core, urea glue, 3 ply	1/4	29.4	6.7	111	32	113
	1/4	32.3	6.8	113	68	99
48. Red oak face, 40 mils, lauan core, urea glue	1/4	35.2	6.3	124	74	139
	1/4	34.2	6.3	124	85	146
49. Water oak, 3 ply, Exterior, phenolic film glue	1/4	41.4	3.7	108	49	127
	1/4	43.0	3.8	111	65	137
50. Pecan, 3 ply, Exterior, phenolic film glue	1/4	42.9	4.2	119	38	134
	1/4	44.2	4.2	125	40	151
51. Tupelo gum face, 50 mils, tupelo core, urea glue	1/4	40.4	5.1	107	148	138
	1/4	41.7	5.6	111	139	145
52. Black walnut face, 30 mils, lauan core	1/4	28.5	7.5	117	72	90
	1/4	31.2	6.4	130	94	140
53. Black walnut face, 30 mils, fuma core	1/4	25.8	6.2	122	39	95
	1/4	27.6	6.6	135	65	72

[1] Relative to 100 for red oak lumber and 0 for asbestos board.

[2] Approximate.

Table 3.--Results of tunnel-furnace tests on fiberboards

Description of fiberboard	Thickness	Weight	Moisture content	Index numbers[1]		
				Flame-spread	Smoke-density	Heat-contributed
	Inch	Lb. per cu. ft.	Percent			
STRUCTURAL INSULATING BOARD						
54. Douglas-fir fiber,	1/2	18.0	4.6	124	171	73
"D" factory	1/2	18.0	4.7	72	153	71
finish	1/2	18.0	4.8	76	238	59
55. Southern yellow pine	1/2	18.5	6.0	59	168	40
fiber, "F" factory	1/2	18.3	5.8	46	213	36
finish	1/2	18.2	5.3	47	122	34
56. Southern yellow pine fiber, "D"	1/2	19.2	5.5	127	95	114
factory finish, acoustical	1/2	19.2	5.5	130	55	109
tile (no perforations)						
57. Aspen fiber, "D" factory	1/2	19.3	5.2	153	41	138
finish	1/2	19.3	5.0	163	47	138
58. Aspen fiber, asphalt im-	3/4	19.8	3.6	170	954	173
pregnated	3/4	20.2	3.7	169	969	172
59. Bagasse fiber, "D" factory	1/2	21.0	4.7	135	52	57
finish	1/2	21.0	4.7	145	94	59
60. Southern yellow pine and cotton-	1/2	24.1	3.7	145	2167	148
wood fiber, asphalt impreg-	1/2	24.0	3.6	158	2323	198
nated						
MEDIUM DENSITY BUILDING FIBERBOARD						
61. Reclaimed paper, laminated	3/16	31.8	6.0	100	197	81
.....do.....	3/16	31.7	5.8	132	100	96
.....do.....	3/16	29.8	5.6	139	68	204
62. Reclaimed paper, laminated,	3/8	31.8	4.9	144	156	208
weatherproof	3/8	31.6	5.2	144	128	205
63. Aspen fiber, resin impregnated	0.43	33.6	1.8	102	1201	160
factory primed for house paint	0.43	33.5	1.8	97	1214	174

[1] Relative to 100 for red oak lumber and 0 for asbestos board.

Table 4.--Results of tunnel-furnace tests on hardboards

Description of hardboard	Thickness	Weight	Moisture content	Index numbers[1]		
				Flame-spread	Smoke-density	Heat-contributed
	Inch	Lb. per cu. ft.	Percent			
64. Aspen and yellow pine fiber, phenol resin, wax, wet felted, screen back	1/4	60.6	3.9	100	330	195
	1/4	61.7	3.9	99	406	201
65. Douglas-fir fiber plus bark, phenol resin, wet felted, screen back	1/4	58.8	4.3	97	225	150
	1/4	61.3	4.7	97	272	156
66. Douglas-fir fiber, wax, phenol resin, air felted, dry pressed	1/4	67.5	5.0	93	576	163
	1/4	65.6	5.0	94	596	170
67. Douglas-fir fiber, wax, phenol resin, wet felted, screen back	1/4	57.6	3.9	94	424	162
	1/4	57.9	3.9	93	428	161
68. Willow plus oak fiber, wax, resin, wet felted, dry pressed	0.22	50.5	3.2	119	147	176
	0.22	52.3	3.1	119	116	178
69. Douglas-fir fiber, oil-tempered, wax, phenol resin, wet felted, screen back	1/4	61.3	4.3	94	227	165
	1/4	63.6	4.1	94	259	178
70. Douglas-fir and redwood fiber, oil-tempered, wet felted, dry pressed	1/4	72.0	3.2	87	662	164
	1/4	69.6	3.0	92	652	167

[1] Relative to 100 for red oak lumber and 0 for asbestos board.

Table 5.--Results of tunnel-furnace tests on particle boards

Description of particle board	Thickness	Weight	Moisture content	Index numbers[1]		
				Flame-spread	Smoke-density	Heat-contributed
	Inch	Lb. per cu. ft.	Percent			
71. Douglas-fir hammer-mill particles, wax, phenol resin	3/4	36.0	5.0	98	270	107
	3/4	35.8	5.1	102	270	107
72. Ponderosa pine sawdust, phenol resin	1/4	68.4	5.4	87	742	149
	1/4	67.3	5.3	87	654	157
73. Southern yellow pine chips, phenol resin, extruded	7/8	41.4	6.0	83	52	75
74. Southern yellow pine chips, urea resin, extruded	7/8	36.9	5.5	90	59	87
75. Southern yellow pine flakes and chips, urea resin	3/4	47.4	6.6	92	71	117
	3/4	46.7	6.7	97	87	120
76. Pine, maple, cottonwood chips and fiber, urea resin	11/16	42.1	4.6	99	64	110
	11/16	42.2	5.2	97	73	114
77. Pine, ash, maple, sweetgum chips, urea resin, extruded	1.2	50.2	4.2	97	182	111
	1.2	48.8	3.6	95	208	113
78. Pine, ash, maple, sweetgum chips, phenol resin, extruded	1.2	50.1	3.8	91	124	104
	1.2	47.5	3.8	93	155	109
79. White pine chips, urea resin	3/4	41.3	6.0	102	144	135
	3/4	38.8	6.1	106	157	142

[1] Relative to 100 for red oak lumber and 0 for asbestos board.

REPORTS DEALING WITH DEVELOPMENT AND USE

OF FPL 8–FOOT TUNNEL–FURNACE METHOD

"Small Tunnel–Furnace Test for Measuring Surface Flammability," by H.D. Bruce and V. P. Miniutti. U.S. Forest Products Laboratory Report 2097, 1957. (This report was brought up to date in 1967 and published, under the same title, as U.S. Forest Service Research Note FPL–0167, Forest Products Laboratory, Madison, Wis.)

"Surface Flammability as Determined by the FPL 8–Foot Tunnel Method," by C. C. Peters and H. W. Eickner. U. S. Forest Products Laboratory Report 2257, 1962.

"Surface Flammability of Various Decorative and Fire–Retardant Coatings for Wood as Evaluated in FPL 8–Foot Tunnel Furnace," Official Digest of Paint Technology and Engineering 35(463): 800–813, 1963.

"Correlation Between 8-Foot Tunnel Furnaces," by H. W. Eickner. U.S. Forest Service Research Note FPL–058. Forest Products Laboratory, Madison, Wis., 1964.

"Method of Test for Surface Flammability of Building Materials Using an 8-Foot (2.44 meter) Tunnel Furnace," American Society for Testing and Materials Method E286–65T.

"Fire–Retardant Effects of Individual Chemicals on Douglas–fir Plywood," by H. W. Eickner and E. L. Schaffer. Fire Technology, May, pp. 90–104, 1967.

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