Report 128

Fire-Hazard Classification of Construction Plywood Panels

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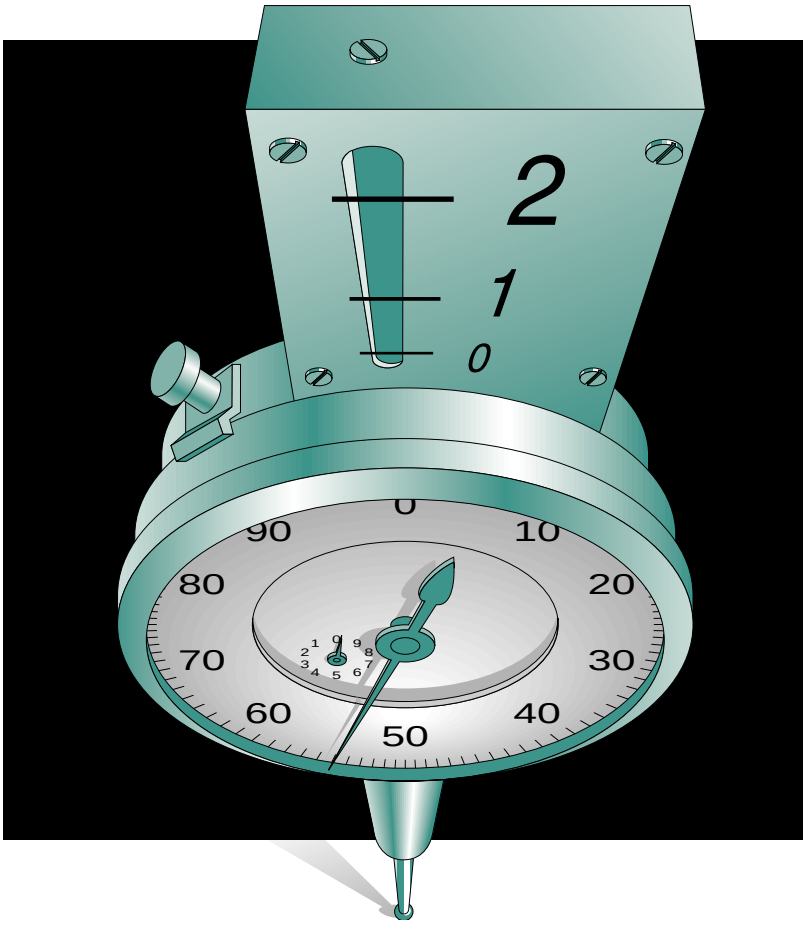

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SUMMARY

Plywood of various types and grades was tested for flame spread (and for smoke developed and fuel contributed). Variables included species groups, glue type, thickness, surface texture and finish. All of the unfinished plywood, based on the average of one or more specimens of each description, had a flame spread index of 200 or less, with most categories considerably lower. There was a small decrease in flame spread with an increase of panel thickness from 1/4 in. to 5/8 in. APA Rated Siding-303 plywood panels, with 5/16-in. minimum thickness, yielded values from 95 to 120.

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FIRE-HAZARD CLASSIFICATION OF CONSTRUCTION PLYWOOD PANELS

INTRODUCTION

This Research Report provides background information, discussion, and conclusions based on the results of testing by the Underwriters' Laboratories, Inc. Appendix A is a copy of the test report from Underwriters' Laboratories. The discussion of results, and conclusions, in the body of this publication, however, are those of *APA – The Engineered Wood Association,* formerly the American Plywood Association, alone.

PURPOSE

The main purpose of this project was to explore the effect on flame spread of major manufacturing variables of plywood made in accordance with U.S. Product Standard PS 1 for Construction and Industrial Plywood, and APA 303 Siding Manufacturing Specification provisions for APA Rated Siding. (Fuel contributed and smoke developed were also checked.) Grades chosen were those used in finish applications. Variables investigated included species groups, glue type, thickness and surface texture. The intent was to find the range of values, and then to determine by test the performance of some of the worst possible combinations, to provide regulatory agencies with a basis for establishing acceptance of plywood as a commodity.

PROCEDURE

Fire-hazard testing was conducted by the Underwriters' Laboratories, Inc. (UL). The general approach to the project was developed in advance discussion with Underwriters' Laboratories staff. This approach involved essentially three steps. First, representative species were chosen, based on those most common, and on specific gravity typical for the group of species represented. Second, these species were intermixed in every way possible in plywood production under U.S. Product Standard PS 1. Third, subsequent tests were conducted using the least favorable combination of species. These subsequent tests covered other variables, such as glue type, thickness and surface texture.

Table 1 shows the specific gravity of common species within the various PS 1 groups, as well as of those species actually used in this project. The approximate percentage of production of each species is listed in Table 2. It may be noted that 97 percent of plywood production is represented by Group 1 species, with half of the remaining production being accounted for by western hemlock and the true firs of Group 2.

For this project, species were arbitrarily divided into three density classes in order to simplify the program. The first density class included species having average specific gravities of 0.45 and over, which represented the Group 1 species; in the second class the specific gravity ranged from 0.35 to 0.44, representing most Group 2 and 3 species in use; and the third class included specific gravities up to 0.35, representative of Group 4 and 5 species.

TABLE 1

SPECIFIC GRAVITY OF WOOD SPECIES COMMONLY USED IN CONSTRUCTION PLYWOOD (Green volume, oven dry weight)

		As used in flame spread tests	
	Species Average	**Phase I**	**Phase II**
Group 1			
Douglas-fir			
Coast	0.45	0.45	0.45
Interior west and north	0.46		
Western larch	0.48		
Southern pine			
Longleaf and slash	0.54	0.55	0.57
Shortleaf and loblolly	0.46-0.68		
Other minor species	0.55-0.68		
Groups 2 and 3			
Western hemlock	0.42	0.36	
True firs	0.31-0.40		
Other minor species	0.33-0.52		
Groups 4 and 5			
Western red cedar	0.31	0.30	0.30
Other minor species	0.30-0.48		

TABLE 2

PROPORTIONS OF PLYWOOD LOGS BY SPECIES (1973)

	(%)
Douglas-fir	60.0
Southern pine*	28.0
Western larch	9.0
Western hemlock — true firs	1.5
Western red cedar	1.0
Others	0.5

*May include an insignificant amount of material in Groups 2 and 3.

TABLE 3

PRODUCTION OF CONSTRUCTION PLYWOOD BY GLUE TYPE (as of 1986)

	(%)
Exterior, phenolic	99.66
Interior hot press, protein and resin fortified protein	0.29
Intermediate, extended phenolic	0.05
Interior cold press, protein	0

Phase I

Species/Density Groups

Phase I of the testing was devoted to determining the effect of species groups and their intermixing as a basis for establishing constructions to be tested in the second phase.

The southern pine species were tested without intermixing because they are geographically isolated and generally are not intermixed with Group 4 species, such as western red cedar. On the other hand, western species are allowed by Product Standard PS 1 to be intermixed. Group 4 inner plies were therefore used in these tests to be conservative, though actual production of such panels is rare.

Phase II

Glue Types, Thicknesses, Surfaces, Finishes

Plywood panels in Phase II were representative of glue types, thicknesses and surfaces normally produced within the plywood industry. Glues included the common exterior and interior hot press, as well as intermediate hot press and interior cold press, the latter two being permitted in the Product Standard but seldom used. (See Table 3.) Panel thicknesses ranged from 1/4 in. to 5/8 in., and surface preparation variables included sanding, overlaying with High Density Overlay and Medium Density Overlay, and surface texturing by rough sawing, grooving and brushing. Three typical finishes were also applied to panel surfaces.

MATERIALS

The species selected to represent each density class were those most commonly used in production. The two Group 1 species selected to represent the first density class were southern pine and Douglas-fir. The southern pine test material had an actual specific gravity of 0.55 or over, and was chosen to represent the upper range of specific gravity within Group 1 species. The Douglas-fir had an actual average specific gravity of 0.45. Western hemlock and true firs having an average specific gravity of 0.36 represented the second density class, and western red cedar, with an average specific gravity of 0.30, was selected for the third class. (Hemlock and the true firs were intermixed, as is common in production since they are difficult to differentiate in the form of veneer; for convenience this material will be referred to as hemlock in this report.)

All veneer obtained for this project was selected from producing mills as being representative of the grades required. All panels containing Douglas-fir veneer in both Phase I and Phase II were reasonably well matched with each other for specific gravity. Southern pine veneer was selected from two mills and from several logs to give a good representation of the species. The western red cedar logs selected for outer plies in the first phase were of similar specific gravity, which allowed reasonable matching across the various constructions containing cedar outer plies. The cedar inner-ply veneer in both Phases I and II was of random selection, as was the hemlock-true-fir used in Phase I only.

There were only 33 different panel descriptions, as shown in Table 4. Panels of 5 of these descriptions were pressed in the APA laboratory for convenience.* Panels of the other 28 descriptions were made in Association member mills. All panels were 4 ft x 8 ft size, and all were manufactured using normal production techniques and pressing schedules.

*These descriptions involved variables which, although allowed under Product Standard PS 1, were not in production at the time required. They included intermediate and interior-hot-press glue.

Phase I

Species/Density Groups

Phase I panels were of 3-ply construction, 3/8-in. sanded A-D grade Interior plywood with exterior glue, conforming to Product Standard PS 1. These panels were constructed with 1/8-in. A-grade face, 1/8-in. D-grade back and 3/16-in. D-grade core, thus allowing for compression during pressing and for full sanding

Details of Manufacture

The exterior phenolic resin used contained 25 to 32 percent resin solids with the lower resin solids typical of adhesive formulations for West Coast species and the higher resin solids for southern pine. Glue spreads of 70 to 75 lbs per 1000 sq. ft double glueline were used for the 3/16-in. Douglas-fir and hemlock core and somewhat lower spreads for cedar core, with an 80-lb spread for the southern pine. Panels were pressed at temperatures of 285°F for Douglas-fir and hemlock, 270°F for cedar, and 300°F for southern pine. Pressure was 175 psi for all species except cedar, which was pressed at 150 psi.

Nine combinations of the three western species were made up in 3-ply constructions as listed below, plus the one southern pine species.

Face and back	**Inner Ply (Core)**
Southern pine	Southern pine
Douglas-fir	Douglas-fir
Douglas-fir	Hemlock
Douglas-fir	Cedar
Hemlock	Douglas-fir
Hemlock	Hemlock
Hemlock	Cedar
Cedar	Douglas-fir
Cedar	Hemlock
Cedar	Cedar

Phase II

Because the first phase showed that panels containing high-specific-gravity outer plies and lower-specific-gravity inner plies were the most severe case, most panels in the second phase were constructed in this manner. However, several panels containing all Group 1 plies were also tested to represent a far more common condition.

Glueline types in Phase II were tested using 1/4-in. sanded A-D panels made with Douglas-fir outer plies and cedar core. These panels were constructed of 1/10-in. veneers in all three plies and sanded to 1/4 in.

Details of Manufacture

The exterior phenolic resin contained 25 to 32 percent resin solids, and was typical of exterior gluelines produced in the industry. The intermediate glueline tested was an extended resin mix containing 17 percent phenolic resin solids. The interior hot-press blood protein glue was a typical mix used within the plywood industry, and contained about 1 percent phenolic resin based on total mix weight. The interior cold-press protein glue was a straight blood mix. The exterior and intermediate glueline pressing conditions were similar to those listed above except that a spread rate of 58 lbs of glue per 1000 sq. ft double glueline was used on the 1/10-in. cedar core veneer. Panels containing interior hot-press protein had glue spread at a rate of 75 lbs, press temperature 260°F and pressure 175 psi. Cold-press panels had about 130 lbs of glue per 1000 sq. ft double glueline and were pressed at 175 psi at room temperature. In addition to the constructions noted above, 1/4-in. all-southern-pine sanded panels made with exterior glue were included, as were 3/8-in. intermediate-glueline sanded panels containing Douglas-fir outer plies and cedar core.

Panel Thicknesses

To test the effect of panel thickness, 3/8-in., 1/2-in., and 5/8-in., Douglas-fir-cedar sanded panels of A-D grade with exterior glue were included, as well as the 1/4-in. panels discussed above. Pressing conditions were similar to those discussed above for the species mix.

Surfaces

In Phase II, a repeat test was made for comparison with Phase I results, using sanded 3/8-in. A-D with exterior glue and all plies of Douglas-fir. Other constructions tested were Medium Density Overlay one-side and 60/60 High Density Overlay two-sides on exterior panels of all Douglas-fir. Also tested were various APA Rated Siding-303 plywood face textures, including Texture 1-11 pattern, with 1/4-in. deep by 3/8-in. wide grooves spaced 4 inches on center; rough sawn surface; rough sawn surface and grooved with 1/16-in. deep by 3/8-in. wide grooves spaced 4 inches on center; and brushed surface. The Texture 1-11 siding panels were of 5/8-in. construction of Exterior C-C Plugged grade, one having all plies of Douglas-fir, another having all plies of southern pine. The Decorative constructions were Exterior C-C Plugged of 5/16-in. average thickness having Douglas-fir outer plies and cedar core, in one series. (The APA 303 Siding Manufacturing Specification does not permit Group 4 core in panels thinner than 3/8-in.) All plies were of Douglas-fir in another series, qualifying the panels as APA Rated Siding-303.

Finishes

Although non-proprietary materials are normally tested without any finish, three finishes were applied to Douglas-fir-cedar panels to obtain an indication of the effect of finish on performance.

Sanded 3/8-in. A-D panels with exterior glue were finished with one coat of acrylic latex wood primer and one top coat of acrylic latex house paint, brush applied. Two rough sawn Decorative panels were finished, one with brush-applied semitransparent latex emulsion stain, the other with opaque linseed-oil-based stain in a one-coat application. The finishes were cured for two weeks at low relative humidity and 90° F temperature at the laboratory following finish application.

SAMPLES

Test samples were cut at the Association laboratory. Each fire-test sample contained three 20.5-in.-wide by 96-in.-long pieces. Two fire-test sections could be cut from each 4-ft by 8-ft plywood panel with the remaining 7-in. by 96-in. material used for supplementary testing of specific gravity and glue bond durability. All fire-test panels were well wrapped for dry shipment to Underwriters' Laboratories, Inc. where they were placed in a dry storage room in the original packages. Prior to testing, the fire-test panels were removed from the packages and placed in the UL conditioning racks for several days. All panels were tested in their natural state without fire-retardant treatment.

TEST METHODS

Fire Hazard

Tests for fire-hazard classification were conducted at Underwriters' Laboratories, Inc., Santa Clara, California, in their 25-ft tunnel. The three test sections of each test sample were placed end-to-end in the tunnel and the tests were conducted in accordance with Underwriters' Laboratories, Inc. Standard UL 723, Test Method for Fire-Hazard Classification of Building Materials (ASTM E 84-70, Standard Test Method for Surface Burning Characteristics of Building Materials). Normally, only one test was conducted for each panel type. Extra panels were available for additional confirming tests in case of discrepancies, however, and in several cases, three tests were run.

RESULTS

Fire Hazard

The UL test report is included as Appendix 1. Table 4 summarizes test results, rearranged from the UL report for convenient comparison. Test results in Table 4, for individual and average values, are rounded to the nearest five points, as is customary. Flame spread index values were calculated by the then current ASTM E 84-70 formulas, and discussion in this report is based on those values or their average when more than one test was run. Also given are flame spread index values calculated by the method used in the current edition of ASTM E 84; see note in Appendix, page A1. Smoke-developed index values also were calculated by ASTM E 84 methods.

Fuel-contributed values, included in the UL report, have been omitted from Table 4 and the following discussion. Determination of fuel-contributed values has been discontinued since 1977 when evaluating products by ASTM E 84.

Supplementary Tests

Results of the supplementary tests are summarized in Table 5. All panel thicknesses were within tolerance requirements. Apparent specific gravity of the plywood was based on oven-dry volume and weight, rather than green volume and oven-dry weight, as was done for the plain wood. This difference in method, plus addition of gluelines and compression during pressing, as well as the mixing of species, resulted in panel gravity values different from those of the wood. Glue bond tests generally were well within Product Standard requirements, although rough veneer reduced values in a few cases. Heat-durability tests based on PS 1, paragraph 4.5.4, were performed on all panels, although they are required only for fully Exterior plywood. They showed no glueline delamination under the Bunsen burner flame on any exterior, intermediate, or interior hot-press glueline; as expected, delamination occurred on panels made with interior cold-press glues.

TABLE 4

FIRE HAZARD CLASSIFICATION OF CONSTRUCTION PLYWOOD PANELS

	Panel Description							ASTM E 84 Flame Spread		ASTM E 84
						Species				
Test Number	Thickness (in.)	Grade	Glue Type	Surface	Finish	Face & Back	Inner Plies	1970 Method	Current Method	Smoke Devel.
Phase I – Species/Density Groups										
1	3/8	A-D	Exterior	Sanded	None	So. pine	So. pine	115	105	70
2	3/8	A-D	Exterior	Sanded	None	So. pine	So. pine	100	100	100
Avg.								105	105	85
3	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Doug.-fir	100	110	45
4	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Hemlock	105	125	40
5	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	170	150	35
6	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	170	140	60
7	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	165	140	110
Avg.								170	145	70
8	3/8	A-D	Exterior	Sanded	None	Hemlock	Doug.-fir	85	75	25
9	3/8	A-D	Exterior	Sanded	None	Hemlock	Hemlock	85	80	40
10	3/8	A-D	Exterior	Sanded	None	Hemlock	Cedar	85	120	35
11	3/8	A-D	Exterior	Sanded	None	Hemlock	Cedar	190	160	45
12	3/8	A-D	Exterior	Sanded	None	Hemlock	Cedar	120	140	65
Avg.								130	140	50
13	3/8	A-D	Exterior	Sanded	None	Cedar	Doug.-fir	90	70	45
14	3/8	A-D	Exterior	Sanded	None	Cedar	Hemlock	90	90	100
15	3/8	A-D	Exterior	Sanded	None	Cedar	Cedar	85	95	145
16	3/8	A-D	Exterior	Sanded	None	Cedar	Cedar	75	90	110
Avg.								80	90	130
Phase II – Glue Type, Panel Thickness, Surface, Finish										
17	1/4	A-D	Exterior	Sanded	None	So. pine	So. pine	150	110	200
18	1/4	A-D	Exterior	Sanded	None	So. pine	So. pine	125	95	105
19	1/4	A-D	Exterior	Sanded	None	So. pine	So. pine	130	110	90
Avg.								135	105	130
20	1/4	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	170	150	55
21	1/4	A-D	Intermediate	Sanded	None	Doug.-fir	Cedar	185	155	55
22	1/4	A-D	Interior hot press protein	Sanded	None	Doug.-fir	Cedar	160	150	50
23	1/4	A-D	Interior cold press protein	Sanded	None	Doug.-fir	Cedar	230	190	70
24	1/4	A-D	Interior cold press protein	Sanded	None	Doug.-fir	Cedar	140	160	90
25	1/4	A-D	Interior cold press protein	Sanded	None	Doug.-fir	Cedar	235	185	105
Avg.								200	180	90
26	3/8	A-D	Intermediate	Sanded	None	Doug.-fir	Cedar	175	170	60
27	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	170	145	60

TABLE 4

FIRE HAZARD CLASSIFICATION OF CONSTRUCTION PLYWOOD PANELS *(Continued)*

Test Number	Panel Description: Thickness (in.)	Grade	Glue Type	Surface	Finish	Species: Face & Back	Species: Inner Plies	ASTM E 84 Flame Spread: 1970 Method	ASTM E 84 Flame Spread: Current Method	ASTM E 84 Smoke Devel.
Phase II – Glue Type, Panel Thickness, Surface, Finish										
28	3/8	A-D	Exterior	Sanded	Acrylic latex paint	Doug.-fir	Cedar	170	165	55
29	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Doug.-fir	90	95	45
30	3/8	A-C	Exterior	MDO	None	Doug.-fir	Doug.-fir	110	110	65
31	3/8	A-A	Exterior	HDO	None	Doug.-fir	Doug.-fir	90	110	60
32	1/2	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	150	130	55
33	5/8	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	140	130	50
34	5/8	C-C Pl.	Exterior	303 Siding, Texture 1-11	None	Doug.-fir	Doug.-fir	95	95	50
35	5/8	C-C Pl.	Exterior	303 Siding Texture 1-11	None	So. pine	So. pine	95	90	85
36	5/16	C-C Pl.	Exterior	Decorative, rough sawn	None	Doug.-fir	Cedar	170	140	55
37	5/16	C-C Pl.	Exterior	Decorative, rough sawn	Semitransparent latex stain	Doug.-fir	Cedar	230	185	60
38	5/16	C-C Pl.	Exterior	Decorative, rough sawn	Semitransparent latex stain	Doug.-fir	Cedar	220	185	95
39	5/16	C-C Pl.	Exterior	Decorative, rough sawn	Semitransparent latex stain	Doug.-fir	Cedar	215	185	55
Avg.								220	185	70
40	5/16	C-C Pl.	Exterior	Decorative, rough sawn	Opaque oil stain	Doug.-fir	Cedar	200	190	50
41	5/16	C-C Pl.	Exterior	Decorative, rough sawn & channel grooved	None	Doug.-fir	Cedar	190	155	60
42	5/16	C-C Pl.	Exterior	Decorative, brushed	None	Doug.-fir	Cedar	150	135	50
43	5/16	C-C Pl.	Exterior	303 Siding, rough sawn	None	Doug.-fir	Doug.-fir	95	115	40
44	5/16	C-C Pl.	Exterior	303 Siding, rough sawn & channel grooved	None	Doug.-fir	Doug.-fir	120	130	55
45	5/16	C-C Pl.	Exterior	303 Siding, brushed	None	Doug.-fir	Doug.-fir	100	115	50

TABLE 5

SUPPLEMENTARY PANEL – TEST DATA

Test Number	Panel Description							Thickness (in.es)[1]	Apparent Panel Specific Gravity[1]	Glue Bond % Wood Failure[1]
	Thickness (in.)	Grade	Glue Type	Surface	Finish	Species: Face & Back	Species: Inner Plies			
Phase I – Species/Density Groups										
1	3/8	A-D	Exterior	Sanded	None	So. pine	So. pine	0.37	0.66	97
2	3/8	A-D	Exterior	Sanded	None	So. pine	So. pine	0.37	0.67	87
Avg.								0.37	0.67	92
3	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Doug.-fir	0.38	0.55	98
4	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Hemlock	0.39	0.51	94
5	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	0.39	0.45	74[2]
6	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	0.39	0.45	77[2]
7	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	0.38	0.45	67[2]
Avg.								0.39	0.45	73
8	3/8	A-D	Exterior	Sanded	None	Hemlock	Doug.-fir	0.38	0.52	96
9	3/8	A-D	Exterior	Sanded	None	Hemlock	Hemlock	0.38	0.47	78[2]
10	3/8	A-D	Exterior	Sanded	None	Hemlock	Cedar	0.38	0.41	94
11	3/8	A-D	Exterior	Sanded	None	Hemlock	Cedar	0.38	0.41	96
12	3/8	A-D	Exterior	Sanded	None	Hemlock	Cedar	0.39	0.41	90
Avg.								0.38	0.41	93
13	3/8	A-D	Exterior	Sanded	None	Cedar	Doug.-fir	0.38	0.43	97
14	3/8	A-D	Exterior	Sanded	None	Cedar	Hemlock	0.38	0.40	93
15	3/8	A-D	Exterior	Sanded	None	Cedar	Cedar	0.38	0.34	96
16	3/8	A-D	Exterior	Sanded	None	Cedar	Cedar	0.38	0.34	96
Avg.								0.38	0.34	96
Phase II – Glue Type, Panel Thickness, Surface										
17	1/4	A-D	Exterior	Sanded	None	So. pine	So. pine	0.25	0.65	86
18	1/4	A-D	Exterior	Sanded	None	So. pine	So. pine	0.24	0.64	87
19	1/4	A-D	Exterior	Sanded	None	So. pine	So. pine	0.25	0.65	89
Avg.								0.25	0.65	87
20	1/4	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	0.26	0.51	96
21	1/4	A-D	Intermediate	Sanded	None	Doug.-fir	Cedar	0.25	0.50	96
22	1/4	A-D	Interior hot press protein	Sanded	None	Doug.-fir	Cedar	0.25	0.49	NF[3]
23	1/4	A-D	Interior cold press protein	Sanded	None	Doug.-fir	Cedar	0.25	0.46	NF[3]
24	1/4	A-D	Interior cold press protein	Sanded	None	Doug.-fir	Cedar	0.26	0.47	NF[3]
25	1/4	A-D	Interior cold press protein	Sanded	None	Doug.-fir	Cedar	0.26	0.46	NF[3]
Avg.								0.26	0.46	NF
26	3/8	A-D	Intermediate	Sanded	None	Doug.-fir	Cedar	0.38	0.45	91
27	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	0.38	0.47	87

TABLE 5

SUPPLEMENTARY PANEL – TEST DATA *(Continued)*

Test Number	Panel Description: Thickness (in.)	Grade	Glue Type	Surface	Finish	Species: Face & Back	Species: Inner Plies	Thickness (in.)[1]	Apparent Panel Specific Gravity[1]	Glue Bond % Wood Failure[1]
Phase II – Glue Type, Panel Thickness, Surface										
28	3/8	A-D	Exterior	Sanded	Acrylic latex paint	Doug.-fir	Cedar	0.39	0.46	96
29	3/8	A-D	Exterior	Sanded	None	Doug.-fir	Doug.-fir	0.38	0.55	98
30	3/8	A-C	Exterior	MDO	None	Doug.-fir	Doug.-fir	0.40	0.55	98
31	3/8	A-A	Exterior	HDO	None	Doug.-fir	Doug.-fir	0.40	0.58	94
32	1/2	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	0.51	0.44	85
33	5/8	A-D	Exterior	Sanded	None	Doug.-fir	Cedar	0.61	0.43	85
34	5/8	C-C Pl.	Exterior	303 Siding, Texture 1-11	None	Doug.-fir	Doug.-fir	0.60	0.55	89
35	5/8	C-C Pl.	Exterior	303 Siding, Texture 1-11	None	So. pine	So. pine	0.64	0.66	98
36	5/16	C-C Pl.	Exterior	Decorative, rough sawn	None	Doug.-fir	Cedar	0.33	0.47	95
37	5/16	C-C Pl.	Exterior	Decorative, rough sawn	Semi-transparent latex stain	Doug.-fir	Cedar	0.33	0.47	98
38	5/16	C-C Pl.	Exterior	Decorative, rough sawn	Semi-transparent latex stain	Doug.-fir	Cedar	0.33	0.45	95
39	5/16	C-C Pl.	Exterior	Decorative, rough sawn	Semi-transparent latex stain	Doug.-fir	Cedar	0.33	0.49	90
Avg.								0.33	0.47	94
40	5/16	C-C Pl.	Exterior	Decorative, rough sawn	Opaque oil stain	Doug.-fir	Cedar	0.33	0.49	94
41	5/16	C-C Pl.	Exterior	Decorative, rough sawn & channel grooved	None	Doug.-fir	Cedar	0.33	0.48	96
42	5/16	C-C Pl.	Exterior	Decorative, brushed	None	Doug.-fir	Cedar	0.33	0.48	94
43	5/16	C-C Pl.	Exterior	303 Siding, rough sawn	None	Doug.-fir	Doug.-fir	0.33	0.54	88
44	5/16	C-C Pl.	Exterior	303 Siding, rough sawn & channel grooved	None	Doug.-fir	Doug.-fir	0.33	0.53	94
45	5/16	C-C Pl.	Exterior	303 Siding, brushed	None	Doug.-fir	Doug.-fir	0.33	0.54	98

1. Average of 3 tests.
2. Lower bond durability resulted from rough veneer.
3. NF = No failure in the PS 1 interior glueline test.
4. Pl. = Plugged

DISCUSSION

Flame Spread Index – Phase I

Species/Density Groups

In the first phase of testing, individual flame spread index values fell between 73 and 187. Within panels containing all plies of the same species, the highest-specific-gravity species produced the highest flame spread, and as specific gravity decreased, the average flame spread values also decreased, being 105, 100, 85 and 80, respectively, for southern pine, Douglas-fir, hemlock and cedar, for which the panel specific gravities were 0.67, 0.55, 0.47 and 0.34, respectively.

In panels with low-density faces, density of inner plies seemed to have no effect on flame spread. In panels with denser faces, however, use of low-density inner plies yielded a higher flame spread value. For example, while the all-cedar panels averaged 80, and cedar-Douglas-fir tested at 90, an all-Douglas-fir panel rated 100, hemlock-cedar panels averaged 130, and the Doug]as-fir-cedar panels averaged 170. (Where two species, hyphenated, are shown, the first represents face species; the second, inner plies.)

The production statistics given in Table 2 establish that Group 1 (represented by Douglas-fir and southern pine) is the most common species group, and that Groups 2 and 3 (represented in these tests by hemlock) are the next most common, while Groups 4 and 5 (represented by cedar) are the least common. The table shows that Groups 4 and 5 constitute about one percent of plywood produced under PS 1. Actually only a minor fraction of this amount is used as inner plies in panels having Group 1, 2 or 3 faces. (The major use of cedar is as faces in panels, which results in low flame-spread numbers as shown in Phase I testing.) Nevertheless, Group 4 inner plies are permissible under the Product Standard, so that in subsequent testing in the second phase of this project, most of the specimens were made with the unusual species combination of Douglas-fir outer plies and cedar inner plies, so as to test the least favorable species combination theoretically possible. (Because of its geographical isolation, southern pine is not combined with cedar, and so was not tested with cedar inner plies.)

The APA 303 Siding Manufacturing Specification precludes use of Group 4 inner plies in 5/16-in. 3-ply APA Rated Siding-303 panels. Such panels are classified as Decorative. Thus, 5/16-in. Decorative panels earned flame spread values from 150 to 190, while 5/16-in. 303 panels rated only from 95 to 120. However, 3/8-in. 303 panels *may* use Group 4 inner plies, and thus theoretically could actually develop higher flame spread values than the 5/16-in. 303 panels.

Since the use of Group 4 inner plies with Group 1 faces is, to say the least, extraordinarily rare, it is apparent that the 170 flame spread value for panels with Group 1 face and Group 4 inner plies is not representative of the great mass of production under PS-I. For example, values for southern pine are 105; for Douglas-fir, 100; for Douglas-fir-hemlock, 105; for all-hemlock, 85; and for hemlock-Douglas-fir, 85. In other words, a value of 105 could be taken as the high value for the common combinations of Group 1, 2 and 3 species. Compared with the Douglas-fir-cedar panel, there is a 65 point "correction factor" that could be applied to the other Phase II test panels. This "corrected figure" would more closely represent the performance of the usual production panels.

Flame Spread Index – Phase II

Glue Types

The effect of several glue types was tested with 1/4-in. sanded Douglas-fir-cedar plywood, with flame spread values ranging from 160 to 185 for exterior, intermediate and interior-hot-press adhesives.

The intermediate glueline was also tested in 3/8-in. sanded Douglas-fir-cedar panels, resulting in a value of 175, compared to 170 for the equivalent 3/8-in. panel with exterior glue.

Interior-cold-press glue produced higher flame spread values, with a three-test average of 200. If they had not been made with Group 4 inner plies, and if the 65 point "correction factor" were applied to these cold-press results, their average value probably would rate well down on the scale at about 135. Furthermore, since production of cold-press glue is a fraction of 1% of production (Table 3), the likelihood of combining Group 1 faces with Group 4 core in a cold-press panel is extremely remote.

Thicknesses

The effect of plywood thickness was tested in Douglas-fir-cedar panels with exterior glue, ranging from the thinnest standard panel, 1/4-in., up to 5/8-in. A decrease in flame spread value with an increase in thickness was noted. Although the 1/4-in. and 3/8-in. panels both had a 170 value, the 1/2-in. had a 150 value and the 5/8-in. had a 140 value. Also included were 1/4-in. panels of all-southern-pine which had a three-panel average of 135, which compares with 105 for the 3/8-in. southern pine two-panel average in the first phase.

Surfaces

Medium Density Overlay panels and 60/60 High Density Overlay panels of 3/8-in. thickness, with all Douglas-fir plies, had flame spread values comparable to the sanded all-Douglas-fir plywood, all ranging around 100.

In analyzing the effect of surface texture on flame spread, it can be concluded that neither rough sawing nor brushing has any significant effect compared to a sanded surface. However, 3/8-in. x 1/16-in. grooves are evidently a factor since the combination of rough sawing and grooving added 20 to 25 points to the flame spread value.

In the Douglas-fir-cedar panels, a flame spread value of 170 was obtained both for 1/4-in. and 3/8-in. sanded; for 5/16-in. rough sawn it was 170; for brushed it was 150; and for rough sawn and grooved it was 190. This first comparison would appear to indicate some benefit from brushing. However, in comparing these surfaces in panels containing all Douglas-fir plies, the 3/8-in. sanded panels had a value of 90 in one case and 100 in the other, and values of 95 for 5/16-in. rough sawn, 100 for brushed, and 120 for rough sawn and grooved. This second comparison indicates a higher flame spread value for panels with both rough sawing and grooving, but shows no effect for rough sawing alone or for brushing.

The effect of grooving may also be deduced from the tests on Texture 1-11. For example, the 5/8-in.-thick Texture 1-11 panel of all-Douglas-fir had a flame spread value of 95. Comparing 3/8-in. versus 5/8-in.-thick panels of Douglas-fir-cedar gives a correction factor of 30 (170 for 3/8-in. less 140 for 5/8-in.) for thickness. Adding 30 to 95 results in a 125 value for a hypothetical panel 3/8-in. thick with grooves 3/8-in. wide x 1/4-in. deep. This 125 can be compared to the values of 90 and 100 for 3/8-in. sanded panels. The indication again is that the grooves have an appreciable effect.

Finishes

The 3/8-in. sanded panels with an acrylic-latex paint finish had the same flame spread value, 170, as that of the matching sanded unfinished panel. An opaque oil stain increased the flame spread value of a 5/16-in. rough sawn Decorative panel from 170 to 200. A semitransparent latex stain on the same panel type increased the average value to 220. If the 65-point correction factor were applied, as discussed earlier, for panels without the Group 4 inner plies, these finishing samples would have rated well down on the scale. It is also possible that further curing or weathering of the stain finishes would have produced lower flame spread values.

Smoke Developed Index

Average values for smoke development index ranged from 25 to 130. Except for the average of one all-southern pine and one all-cedar test which only went to 130, none of the average smoke-developed values exceeded 100, and the average of all 45 tests was 65. Thus, it can be seen that smoke developed, indeed, was quite low.

SYNOPSIS

1. Flame spread index values of untreated, unfinished plywood of density classes representative of Group 1, Group 2 and 3, Group 4 and 5 species under PS 1 ranged from 75 to 200. This range includes mixed-species panels.
2. Thin (1/4-in.) mixed-species sanded plywood panels containing exterior, intermediate and interior glues had average flame spread index values of 200 or less.
3. Sanded plywood constructions from 1/4-in. to 5/8-in. in thickness showed a small decrease in flame spread with increase in panel thickness.
4. Minimum thickness (5/16-in.) unfinished Decorative panels with rough sawn, rough sawn and channel grooved, and brushed surface textures had flame spread index values ranging from 150 to 190. Minimum thickness APA Rated Siding-303 plywood panels yielded values from 95 to 120. APA Rated Siding-303 plywood Texture 1-11 pattern also rated 95.
5. Exterior stains appeared to contribute about 30 to 50 points to flame spread, but latex paint added nothing.
6. Smoke developed index averaged 65 for all 45 specimens, with a range of 25 to 200 for individual tests.

CONCLUSION

Plywood in this study was selected from the constructions that would develop the highest flame spread index values. All of the unfinished plywood, based on the average of one or more specimens for each description, had flame spread index values of 200 or less, with most categories considerably lower.

APPENDIX

Underwriters' Laboratories Report

NOTE: Flame spread index values in Table A1, pages A8 - A10 of the Underwriters' Laboratories Report in the column headed "Current ASTM E 84 Form" are calculated identically with those given Table 4 of the APA report in the column headed "ASTM E 84 Flame Spread - 1970 Method."

Values shown in Table 1 of the UL report in the column headed "Proposed GWL Form" are obsolete, as the calculation method has been revised. The revised formula is given in the current edition of ASTM E 84, "Standard Test Method for Surface Burning Characteristics of Building Materials," and values calculated with that formula are given in Table 4 of the APA report in the column headed "ASTM E 84 Flame Spread - Current Method."

UNDERWRITERS' LABORATORIES, INC.
1655 SCOTT BLVD. SANTA CLARA, CALIFORNIA 95050

an independent, not-for-profit organization testing for public safety

R6829
72SC3289

Santa Clara, California
December 21, 1973

American Plywood Association
1119 A Street
Tacoma, Washington 98401

Attention: Mr. J. M. Hess

Gentlemen:

The attached report covers the work anticipated under the above assignment and application number. As noted in the report, the information other than the fire hazard classification data is being retained for use by those who may seek to have their products classified by Underwriters Laboratories, Inc.

With this letter we are closing the assignment. Should you have any questions, or if we can be of further assistance, please contact us.

Very truly yours,

A. A. BRIBER
Engineering Group Leader
Fire Protection Department

AAB:Jt

Enclosures

FILE R6829

PROJECT 72SC3289

December 17, 1973

Report

on

Untreated Plywood

American Plywood Association

Tacoma, Washington 98401

American Plywood Association
File R6829 *Page 1 Issued: 12-17-73
72SC3289 Revised: 4-30-74

DESCRIPTION

Product Covered:

Untreated softwood plywood of different thicknesses (1/4 to 5/8 inch) surface finish, softwood veneer combinations, glue-line type, with and without an overlay conforming with US Product Standard PS 1-66.

General – All the test specimens used in this investigation were selected by representatives of American Plywood Association from Member company mills and shipped to the Tacoma, Washington Laboratories of the Association. At Tacoma, the specimens were sorted, identified with respect to construction, species of veneer and density, and cut to the size for the tunnel testing.

The tunnel test samples were shipped to Underwriter's Laboratories Inc., Santa Clara office for tunnel test. In addition to the tunnel tests, delamination tests, boil tests and small scale fire tests were conducted for use in follow-up investigations. This additional information is held on file for future use.

Phase 1

The investigation was conducted in two phases. The first phase was concerned primarily with density and species grouping. Based on the assumption that the fire hazard classification would be affected by density, and type of veneer different combinations of face, and inner plies were tested. The face and core identification is as follows:

Species Combinations	Code
Douglas-fir, face and core	DD
Douglas-fir, faces and hemlock core	DH
Douglas-fir, faces and cedar core	DC
Hemlock faces and hemlock core	HH
Hemlock faces and Douglas-fir core	HD
Hemlock faces & cedar core	HC
Cedar faces & cedar core	CC
Cedar faces & Douglas-fir core	CD
Cedar faces & Hemlock core	CH
Southern pine faces & southern pine core	SS

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All specimens tested under Phase I were 3 ply softwood plywood conforming to Product Standard PS-I-66 uncoated, sanded in one thickness of nominal 3/8 inches with an exterior glue.

Phase II

The purpose of the second phase in this investigation was to determine the effect of glue-line type, surface texture, and panel thickness on the fire hazard classification of the plywood.

Glue Line – The effect of the glue-type was determined on 1/4 in. sanded panels having Douglas fir face plies and Cedar Cores, with interior cold-press, interior hot-press, intermediate (also 3/8 in. with intermediate glue line), and exterior glue-line types. In addition 1/4 in. sanded panels with exterior glue containing all Southern Pine plies were tested.

Surface Finish – Nominal 1/4 in. thick plywood containing either all plies of Southern Pine or an outer ply of Douglas fir and an inner p]y of cedar was tested with a sanded finish.

Nominal 3/8 in. thick plywood containing outer plies of Douglas fir and inner plies of either cedar or Douglas fir was tested with either a sanded or sanded and latex painted finish.

Panels known as "303 siding" containing Douglas fir outer plies and inner plies of Douglas fir or cedar were tested with three basic surface finishes (rough-sawn, rough-sawn and grooved, and brushed). Some panels in addition to the basic surface finishes were tested with either a latex or an oil stain coating finish.

Panels nominally 5/8 in. thick were tested with and without a surface finish known as Texture 1-11.

To test the effect of overlays on the hazard classification of softwood plywood, tests were conducted on 3/8 in. sanded Douglas fir panels from Phase I with 60-60 high density overlay on both sides and also with medium density overlay on one side only.

Thickness – In addition to the 1/4 in. and 3/8 in. sanded constructions, 1/2 in. and 5/8 in. panels containing Douglas fir outer plies and cedar cores were tested to determine the effect of thickness on flame spread classifications.

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American Plywood Association
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The glue-line and surface texture identification is as follows:

*	EXT-S	Exterior type glue-line, sanded faces
*	IMG-S	Intermediate type glue-line, sanded faces
*	IHP-S	Interior type glue-line, Hot-pressed, sanded faces
*	ICP-S	Interior type glue-line, Cold-pressed, sanded faces
	S-ALP	Sanded faces, Acrylic Latex Paint
	MDO	Medium Density Overlay
	HDO	High Density Overlay
	T-11	Texture 1-11
	R	Rough-sawn
	R-LS	Rough-sawn, Latex Stained
*	R-OS	Rough-sawn, Oil Stained
	B	Brushed
	RG	Rough-sawn, grooved

HFH:AAB:jt

American Plywood Association
File R6829
Z2SC3289 T1-1 12-17-73

TEST RECORD NO. 1

Fire Hazard Classification Test:

Samples

The test samples consisted of untreated softwood plywood of various thicknesses (1/4 inch to 5/8 inch), having various surface textures, glue-types, and softwood veneer combinations with and without an overlay, conforming with U.S. Product Standards PS-I-66.

Each test sample consisted of three sections, each section measured 20-1/2 inches in width by 96 inches in length. These sections were placed end-to-end in the tunnel to form a continuous 24 foot test surface. A 20-1/2 inch by 12 inch asbestos cement board was placed upstream of the burner to complete the 25 foot length of the standard tunnel.

Method

The tests were conducted in accordance with Underwriters' Laboratories, Inc. Standard Test Method for Fire Hazard Classification of Building Materials (UL 723).

Results

The flame spread value was calculated both by the existing method and by the proposed GWL method (G. Williams-Leir Equivalent Flame Front Concept).

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PHASE I

TABLE I

Sample Description Code	Specific Gravity Range+	Calculated Value for Flame Spread by Current ASTM E-84 Formulae	Calculated Value for Flame Spread Class. by Proposed GWL++ Form.	Calculated Value For Fuel Contributed	Calculated Value for Smoke Contributed
Untreated Red Oak		100	–	I00	100
Asbestos		0	–	0	0
Southern Pine Faces and Core Plywood:					
SS-1	.649–.676	115.8	115.8	111.1	67.8
SS-2	.666–.671	98.5	110.1	112.9	100.6
Douglas Fir Faced Plywood:					
DD-2	.537–.558	100.6	121.4	110.0	42.8
DH-2	.488–.539	105.8	136.3	101.8	42.4
DC-1	.445–.462	171.0	162.5	121.0	35.3
DC-2	.435–.468	171.0	155.2	102.9	58.9
DC-3	.435–.462	165.0	155.4	95.4	110.1
Hemlock Faced Plywood:					
HH-2	.463–.496	86.7	86.9	82.4	40.2
HD-2	.516–.524	83.7	79.6	67.2	22.8
HC-1	.410–.415	84.4+++	128.6	76.1	36.1
HC-2	.410–.414	187.5+++	172.4	102.9	46.6
HC-3	.408–. 415	117.9+++	154.1	80.7	63.1
Cedar Faced plywood:					
CC-1	.340–.353	85.1	103.6	70.3	144.1
CC-2	.339–.347	73.3	97.8	63.9	111.5
CD-2	.420–.445	87.5	77.2	67.6	46.6
CH-2	.379–.433	87.9	100.4	61.4	100.8

+ – Specific gravity based on oven dry volume and oven dry weights.

++ – See Figure 1 for Illustration on calculation

+++ – Wide variation in test results on HC-1, HC-2 and HC-3 caused by delamination of the plywood during test.

Observation of the test samples after testing raised a question about the integrity of the glue-bond between the Hemlock face and the Cedar core.

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PHASE II

TABLE 1

Sample Thickness and Code Description	Glue Type	Surface, Face Types	Calculated Value for Flame Spread by Current ASTM E-84 Form	Calculated Value for Flame Spread Class. by Proposed GWL Form	Calculated Value for Fuel Contributed	Calculated Value for Smoke Development
1/4 SS-S	Exterior	Sanded A-D	148.0	122.7	133.8	198.2
1/4 SS-S	Exterior	Sanded A-D	124.5	102.8	111.9	105.2
1/4 SS-S	Exterior	Sanded A-D	132.0	120.9	110.6	91.2
1/4 DC-EXT-S	Exterior	Sanded A-D	169.2	162.4	104.2	55.0
1/4 DC-IMG-S	Intermediate glueline	Sanded A-D	183.3	168.9	98.1	56.7
1/4 DC-IHP-S	Interior hot-press	Sanded A-D	157.1	165.0	94.5	51.6
1/4 DC-IPC-S	Interior cold-press	Sanded A-D	227.6	207.0	139.8	67.8
1/4 DC-ICP-S	Interior cold-press	Sanded A-D	140.4	177.5	116.1	90.7
1/4 DC-ICP-S	Interior cold-press	Sanded A-D	235.7	203.9	114.8	106.0
3/8 DC-IMG-S	Intermediate glueline	Sanded A-D	175.5	186.2	101.0	61.8
3/8 DC-S	Exterior	Sanded A-D	169.2	145.9	101.8	60.5
3/8 DC-S-ALP	Exterior	Sanded Latex Painted A-D	169.2	181.8	115.9	57.2
3/8 DD-S	Exterior	Sanded A-D	92.3	105.1	90.4	45.7
3/8 DD-MDO	Exterior	Medium Density Overlay one side	110.0	121.9	97.6	66.5
3/8 DD-HDO	Exterior	High Density Overlay 60/60 2 sides A-A	92.3	122.6	90.7	61.8
1/2 DC-S	Exterior	Sanded A-D	151.4	140.7	123.5	56.3
5/8 DC-S	Exterior	Sanded A-D	140.4	124.4	115.5	52.4

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American Plywood Association
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PHASE II

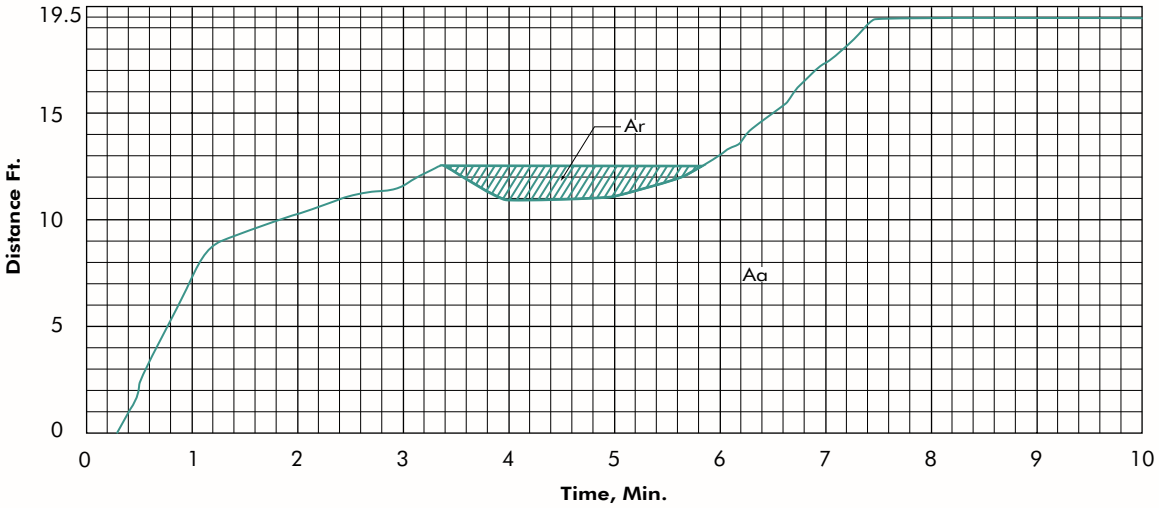
TABLE 1 *(Continued)*

Sample Thickness and Code Description	Glue Type	Surface, Face Types	Calculated Value for Flame Spread by Current ASTM E-84 Form	Calculated Value for Flame Spread Class. by Proposed GWL Form	Calculated Value for Fuel Contributed	Calculated Value for Smoke Development
5/8 DD-T-11	Exterior	Texture 1-11 C Plg-C	93.4	104.9	86.3	50.4
5/8 SS-T-11	Exterior	Texture 1-11 C Plg-C	95.8	98.4	86.2	85.6
303 DC-R	Exterior	Rough sawn C Plg-C	169.2	150.8	108.7	55.4
303 DC-R-LS	Exterior	Rough sawn Latex stained C Plg-C	227.7	205.0	123.3	58.4
303 DC-R-LS	Exterior	Rough sawn Latex stained C Plg-C	220.0	200.8	127.0	96.7
303 DC-R-LS	Exterior	Rough sawn Latex stained C Plg-C	215.6	201.9	120.5	55.0
303 DC-R-OS	Exterior	Rough sawn Oil stained C Plg-C	200.0	208.2	122.1	48.6
303 DC-RG	Exterior	Rough sawn and grooved C Plg-C	188.6	168.0	112.9	60.5
303 DC-B	Exterior	Brushed C Plg-C	150.0	146.4	109.6	50.8
303 DD-R	Exterior	Rough sawn C Plg-C	97.4	124.4	95.5	41.5
303 DD-RG	Exterior	Rough sawn and grooved C Plg-C	122.2	144.7	110.5	54.6
303 DD-B	Exterior	Brushed C Plg-C	101.5	123.8	97.5	50.0

HFH:AAB:ef

FIGURE 1

FLAME SPREAD CALCULATED BY G. WILLIAMS – LEIR CONCEPT



Test No. 3
Sample HH-2
File Reg. R6863
Figure 1

Ar = Ratchet Area, Ar
Aa = Area under Actual Frame Front
A = Ar ÷ Aa (Total Area)

Flame Spread = 5362/195 = A

FS = 5362/195 – 133.30
FS = 5362/61.70
FS = 86.9

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CONCLUSIONS

The following conclusions represent the judgement of Underwriters' Laboratories, Inc., based upon the results of the examination and tests presented in this report as they relate to established principles and previously recorded data.

Classification:

Plywood meeting the specifications developed as a result of this investigation will be eligible to meet the classification requirements of Untreated Plywood of Underwriters' Laboratories. The classification established will depend upon the type and specific gravity of the face and core plies as well as the surface finish, thickness and type of glue-line used.

Reviewed by:

A. A. BRIBER
Engineering Group Leader
Fire Protection Department

HFH/sdm

Report by,

H. F. HANSEN
Engineering Assistant
Fire Protection Department

APA RESEARCH AND TESTING

APA – The Engineered Wood Association's 37,000-square-foot Research Center in Tacoma, Washington is the most sophisticated facility for basic panel research and testing in the world. The center is staffed with an experienced corps of engineers, wood scientists, and wood product technicians. Their research and development assignments directly or indirectly benefit all specifiers and users of engineered wood products.

We have field representatives in many major U.S. cities and in Canada who can help answer questions involving APA trademarked products. For additional assistance in specifying engineered wood products, contact us:

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Revised May 1997

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