Design for Code Acceptance

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Flame Spread Performance of Wood Products Used for Interior Finish

Wood and wood-based products are widely used as interior wall, ceiling, and floor surfaces in all types of buildings.

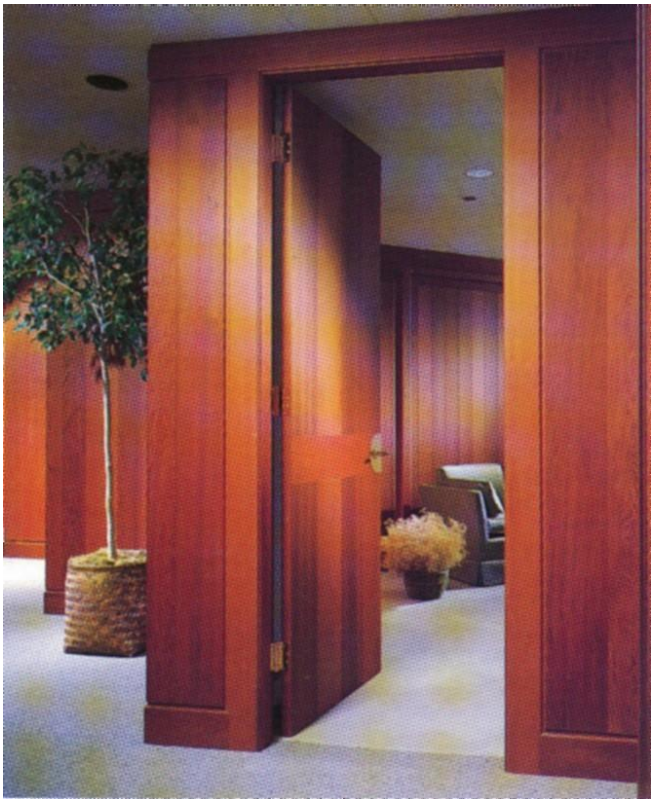
Appearance, acoustical qualities, and interior design versatility have made wood surfaces highly desired by architects, designers, and building occupants. This publication briefly describes building code flame spread regulations on products used in interior finish and presents performance data on a range of wood products.

Flame Spread Requirements

Most code requirements for wood interior finish materials are expressed in terms of flame spread index numbers. These values are determined in a standard fire test which evaluates the surface burning characteristics of a material. Different maximum flame spread indices are permitted depending upon building occupancy, location of the material in the building, and the presence of sprinklers. Flame spread indices in this publication are provided for wood materials that qualify for various building design requirements.

Test Method

The standard fire test used to evaluate flame spread characteristics of wood building materials in the United States is ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*.



The test procedure exposes candidate materials in a horizontal, rectangular tunnel that is 17-3/4" in width by 12" in height and 25' long. The tunnel is equipped with two gas burners at one end that direct a flame onto the surface of the test material under a controlled air flow. Flame spreads along the surface of the material as the test progresses. Distance of the flame travel and the rate at which the flame front advances during a 10-minute

exposure determine the calculated flame spread index (FSI).

To provide standard conditions for each test, the tunnel is calibrated such that the flame front reaches the end of the tunnel in approximately $5^1/_2$ minutes when tested on the wood calibrant (23/32" red oak flooring conditioned to an average moisture content of 7±0.5%), and to achieve an FSI of 0 when tested on $^1/_4$" fiber cement board. Flame spread indices for tested materials can range from 0 to over 1000.

At various times throughout the history of ASTM E84, changes have been made to the standard, affecting aspects such as test specimen conditioning and calculation procedures used to determine FSI values from raw data. Because of these changes, FSI values for particular products may change over time and it is not possible to directly calculate FSI values from some of the older ASTM E84 test data available; however, the classifications reported in these older test reports are deemed to be reasonable estimates.

Applicable Code Provisions

Section 803.1.2 of the 2018 *International Building Code* (IBC) defines classifications (Class A through Class C) for fire performance and smoke development. Each class corresponds to a specified range of FSI values, as shown in the following table:

Material Classification Based on FSI

Class	FSI Range
A	0-25
B	30-75
C	80-200

Table 803.13 of the IBC provides flame spread classification requirements for wall and ceiling finishes, based on occupancy, location, and presence of automatic sprinklers. Requirements for business and mercantile occupancy are as follows:

Flame Spread Class Requirement for Business and Mercantile Occupancy

Location	Non-Sprinklered	Sprinklered
Exit Stairway	A	B
Exit Corridor	B	C
Rooms	C	C

ASTM E84 makes mandatory reference to ASTM E2579 for wood specimen preparation and mounting, and ASTM E2404 for preparation and mounting of paper, polymeric, textile or wood veneer facings intended to be applied on-site over a wood substrate. As such, ASTM E2579 and ASTM E2404 are indirectly referenced by the IBC and would therefore be considered part of the code insofar as they do not conflict with the code. ASTM E2579 requires interior finish products with a factory-applied facing or veneer to be tested as manufactured. ASTM E2404 specifies a standard wood substrate to which facings or wood veneer specimens must be applied for testing if they are intended to be installed on-site over a wood substrate. Note that materials having a thickness less than 0.036 inch applied directly to the surface of walls or ceilings are exempted from testing under IBC Section 803.2.

Wood Products

Many interior finishes, including wood-based materials, are hygroscopic, and their moisture content can affect flame spread performance. Conditioning of test specimens can play an important role in determining the classification of a specimen. ASTM E84 requires test specimens to be equilibrated under specified conditions of temperature and relative humidity (73.4±5°F and 50 ±5% relative humidity), which are within commonly accepted comfort ranges for interior spaces. Under these specified conditions, sawn wood products equilibrate to a moisture content of approximately 8% to 10%, according to the US Forest Products Laboratory's *Wood Handbook—Wood as an Engineering Material.*

Lumber, plywood, and other wood-based materials typically fall into Class B or Class C when tested and evaluated in accordance with ASTM E84. If the wood product is homogeneous, flame spread may be considered nearly independent of material thickness at thicknesses greater than 1/2".

Flame spread indices for a number of species of lumber are listed in Table 1. Flame spread indices for plywood, oriented strand board (OSB), particleboard, and medium density fiberboard (MDF) are listed in Table 2. For products such as softwood and hardwood plywood, the arrangement and type of components may also influence surface flame spread. Some such products are described by face veneer species and core composition in Table 2. All ratings are based on the ASTM E84 test method.

As can be seen from the listed indices, *most tested wood products have a flame spread index less than 200,* making them acceptable under current building codes for a wide range of interior finish uses. Flame spread indices for a range of proprietary wood-based interior finish materials, such as factory-applied overlay-

finished products, are available from the manufacturer. Certification programs for these proprietary wood-based products typically consider the variability of the test method, material inputs, and production factors, to ensure ongoing compliance of certified product configurations. Ongoing certification of quality management systems and periodic testing are performed to identify potential changes in flame spread due to variations in production methods and materials. They account for the many possible configurations of face veneer species, veneer thickness, core types, suppliers, finishes, textures, and groove profiles from a manufacturer, all without testing every possible configuration. Compliance may be demonstrated through accredited third-party product labeling, listing programs, certification, or individual test reports.

Commercially available fire retardant treatments for wood and panel products can improve flame spread performance to Class A. Such products typically carry a label indicating their rating classification. Wood products utilizing a surface coating to achieve a Class A rating must be evaluated as a system.

A smoke-developed index was also measured for some of the wood products listed in Table 1 and Table 2. This index has a value of approximately 100 for the wood calibrant. None of the products tested and presented in this document have a smoke-developed index exceeding the code-specified limit of 450.

Table 1 Reported Flame Spread Indices of Solid Wood Products

Material[1]	ASTM E84 Flame Spread Index	Flame Spread Class	ASTM E84 Smoke Developed Index	Source[2]
Alder	80	C	165	HPVA T-14189 (2013)
Aspen	105	C	45	Exova 15-002-475(C1) (2015)
Birch, Yellow	NA[4]	C[4]	NA	UL527 (1971)
Cedar, Alaska	40	B	140	HPVA T-15591 (2017)
Cedar, Alaska Yellow	50	B	115	HPVA T-12704 (2008)
Cedar, Eastern White	40	B	200	HPVA T-15318 (2017)
Cedar, Incense	45	B	150	HPVA T-15204 (2016)
Cedar, Port Orford	60	B	150	HPVA T-12694 (2008)
Cedar, Western Red	45	B	125	HPVA T-15172 (2016)
Cottonwood	NA[4]	C[4]	NA	UL527 (1971)
Cypress	75	B	200	HPVA T-14530 (2014)
Douglas-fir	70	B	80	HPVA T-14253 (2013)
Fir, Balsam	45	B	105	HPVA T-15557 (2017)
Fir, White	40	B	80	HPVA T-15088 (2016)
Gum, Red	NA[4]	C[4]	NA	UL527 (1971)
Hem-Fir Species Group[3]	60	B	70	HPVA T-10602 (2001)
Hemlock, Eastern	35	B	175	HPVA T-15320 (2017)
Hemlock, Western	40	B	60	Exova 15-002-475(A1) (2015)
Maple (flooring)	NA[4]	C[4]	155	CWC FP-6 (1973)
Maple (rough sawn)	35	B	250	HPVA T-14573 (2014)
Oak, Red or White	NA[4]	C[4]	NA	UL527 (1971)
Pine, Eastern White	70	B	110	HPVA T-14186 (2013)
Pine, Idaho White	NA[4]	B[4]	125	HPVA T-592 (1974)
Pine, Jack	50	B	165	HPVA T-15556 (2017)
Pine, Lodgepole	75	B	140	HPVA T-15029 and T-15069 (2015)
Pine, Ponderosa	55	B	135	HPVA T-15067 (2016)
Pine, Red	115	C	65	Exova 15-002-475(B1) (2015)
Pine, Southern Yellow	70	B	165	HPVA T-14254 (2013)
Pine, Sugar	45	B	110	HPVA T-15068 (2016)
Pine, Western White	NA[4]	B[4]	NA	UL527 (1971)
Poplar, Yellow	125	C	125	HPVA T-14512 (2014)
Redwood	55	B	135	HPVA T-14185 and T-14243 (2013)
Spruce, Black	45	B	250	HPVA T-14053 (2013)
Spruce, Black (4" thick, 3 layers of cross laminations)	35	B	55	HPVA T-14054 (2013)
Spruce, Eastern Red	65	B	170	HPVA T-15034 (2015)
Spruce, Western White	45	B	120	HPVA T-15032 (2015)
Tamarack	35	B	90	HPVA T-15393 (2017)
Walnut	75	B	125	HPVA T-14526 (2014)

Table 1 Footnotes

[1].Thickness of material tested is one-inch nominal except where indicated.

[2] Sources: CWC – Canadian Wood Council; Exova – Exova Warringtonfire North America; HPVA – Hardwood Plywood Veneer Association; UL – Underwriters' Laboratories. Test report numbers and year of test are indicated. Where multiple reports are cited, tabulated FSI and SDI values represent the average of values from the respective test reports.

[3] The Hem-Fir Species Group represents six species: Californian Red Fir, Grand Fir, Noble Fir, Pacific Silver Fir, Western Hemlock, and White Fir. The reported flame spread index represents a product containing a mixture of these species. When lumber is from a single species refer to the specific species flame spread index.

[4] Flame spread index cannot be directly determined from the referenced source; however, the reported Flame Spread Class is deemed to be a reasonable estimate based on changes to the analysis method of test results as reported within the referenced source.

Table 2 Reported Flame Spread Indices of Wood Panels

Material	ASTM E84 Flame Spread Index	Flame Spread Class	ASTM E84 Smoke Developed Index	Source[1]
ORIENTED STRAND BOARD (Exterior Glue) [2]				
5/16"	127-138	C	155-171	APA (1985)
3/8"	100	C	95	HPVA T-15116 (2016)
7/16"	115-155	C	75-130	APA 8901-8 (1989)
15/32"	100	C	80	HPVA T-15117 (2016)
1/2"	75-172	C	109-194	APA (1985)
19/32"	175	C	95	HPVA T-14312 (2013)
23/32"	100	C	60	HPVA T-15118 (2016)
3/4"	147-158	C	111	APA (1985)
1-1/8"	110	C	115	HPVA T-15298 (2016)
SOFTWOOD PLYWOOD (Exterior Glue) [3]				
1/4"	NA[5]	C[5]	55-200	UL R6829 (1973)
3/8"	NA[5]	C[5]	22-144	UL R6829 (1973)
1/2"	NA[5]	C[5]	55	UL R6829 (1973)
19/32"	95	C	50	HPVA T-14311 (2013)
5/8"	NA[5]	C[5]	50-85	UL R6829 (1973)
1/4" Douglas-fir Plywood	85	C	70	HPVA T-15293 (2016)
3/8" Douglas-fir Plywood	65	B	60	HPVA T-15295 (2016)
15/32" Douglas-fir Plywood	40	B	50	HPVA T-15114 (2016)
23/32" Douglas-fir Plywood	35	B	55	HPVA T-15294 (2016)
11/32" Southern Pine Plywood	75	B	115	HPVA T-15113 (2016)
15/32" Southern Pine Plywood	95	C	135	HPVA T-15297 (2016)
23/32" Southern Pine Plywood	65	B	175	HPVA T-15296 (2016)
HARDWOOD PLYWOOD [4]				
Ash 3/4" – Particleboard Core	135	C	80	HPVA T-9344 (1995)
Birch 1/4" – MDF Core	120	C	200	HPVA T-14750 (2015)
Birch 1/4" – Douglas Fir Veneer Core	115	C	40	HPVA T-14911 (2015)
Birch 1/4" – Fuma Veneer Core	125	C	15	HPVA T-9665 (1996)
Birch 1/4" – High Density Veneer Core	165	C	65	HPVA T-9234 (1995)
Birch 1/4" – Poplar Veneer Core	110	C	15	HPVA T-14697 (2015)
Birch 3/4" – Combination Core	90	C	120	HPVA T-14691 (2015)
Birch 3/4" – High Density Veneer Core	115	C	50	HPVA T-9317 (1995)
Birch 3/4" – Particleboard Core	125	C	100	HPVA T-9431 (1995)
Birch 3/4" – MDF Core	120	C	110	HPVA T-14917 (2015)
Birch 3/4" – Aspen Veneer Core	135	C	70	HPVA T-14700 (2015)
Birch 3/4" – Baltic Birch Veneer Core	120	C	70	HPVA T-14694 (2015)
Birch 3/4" – Douglas Fir Veneer Core	70	B	55	HPVA T-14704 (2015)
Birch 3/4" – Poplar Veneer Core	95	C	140	HPVA T-14689 (2015)
Birch 3/4" – Russian Birch Veneer Core	110	C	70	HPVA T-14764 (2015)
Mahogany 3/4" – High Density Veneer Core	105	C	90	HPVA T-9354 (1995)
Maple 1/4" – Douglas Fir Veneer Core	130	C	45	HPVA T-14910 (2015)
Maple 1/4" – Poplar Veneer Core	170	C	55	HPVA T-14695 (2015)
Maple 3/4" – Combination Core	100	C	85	HPVA T-14706 (2015)
Maple 3/4" – MDF Core	130	C	70	HPVA T-14763 (2015)
Maple 3/4" – Particleboard Core	85	C	75	HPVA T-14912 (2015)
Maple 3/4" – Aspen Veneer Core	180	C	75	HPVA T-14699 (2015)
Maple 3/4" – Baltic Birch Veneer Core	125	C	70	HPVA T-14693 (2015)

Table 2 Reported Flame Spread Indices of Wood Panels(continued)

Maple 3/4" – Douglas Fir Veneer Core	95	C	50	HPVA T-14703 (2015)
Maple 3/4" – Poplar Veneer Core	150	C	60	HPVA T-14702 (2015)
Maple 3/4" – Russian Birch Veneer Core	120	C	50	HPVA T-14752 (2015)
Oak 1/4" – High Density Veneer Core	155	C	65	HPVA T-9237 (1995)
Oak 1/4" – Fuma Veneer Core	60	B	50	HPVA T-14698 (2015)
Oak 1/4" – Poplar Veneer Core	140	C	60	HPVA T-14696 (2015)
Oak 3/4" – Medium Density Fiberboard Core	100	C	85	HPVA T-14916 (2015)
Oak 3/4" – Combination Core	90	C	155	HPVA T-14690 (2015)
Oak 3/4" – Particleboard Core	80	C	80	HPVA T-14914 (2015)
Oak 3/4" – Aspen Veneer Core	160	C	75	HPVA T-14701 (2015)
Oak 3/4" – Baltic Birch Veneer Core	105	C	80	HPVA T-14692 (2015)
Oak 3/4" – Douglas Fir Veneer Core	60	B	65	HPVA T-14762 (2015)
Oak 3/4" – Russian Birch Veneer Core	95	C	110	HPVA T-14751 (2015)
Walnut 3/4"	NA[5]	C[5]	NA	HUD (1973)
PARTICLEBOARD				
1/3" (No Added Formaldehyde)	130	C	135	HPVA T-14387 (2014)
3/8"	150	C	65	HPVA T-14350 (2014)
1/2"	125	C	125	HPVA T-14376 (2014)
3/4"	95	C	130	HPVA T-14296 (2014)
3/4"	135	C	80	HPVA T-14351 (2014)
3/4" Birch Particle Board	80	C	95	HPVA T-14913 (2016)
3/4" (Floor Underlayment)	110	C	80	HPVA T-14315 (2013)
1" (No Added Formaldehyde)	105	C	145	HPVA T-14386 (2014)
MEDIUM DENSITY FIBERBOARD (MDF)				
7/32"	125	C	200	HPVA T-14370 (2014)
5/8"	120	C	250	HPVA T-9567 (1996)
3/4"	120	C	170	HPVA T-14372 (2014)
6mm (No Added Formaldehyde)	135	C	200	HPVA T-14369 (2014)
1/4"	135	C	300	HPVA T-14371 (2014)
HARDBOARD				
0.118" Tempered Hardboard	155	C	150	HPVA T-14313 (2013)
0.386" Engineered Wood Siding	95	C	50	HPVA T-14297 (2013)

Table 2 Footnotes

[1] Sources: APA – American Plywood Association; DOC – US Department of Commerce; HPVA – Hardwood Plywood Veneer Association; HUD – US Department of Housing and Urban Development Manual of Acceptable Practices to the HUD Minimum Property Standards; UL – Underwriters' Laboratories. Test report numbers and year of test are indicated.

[2] Values reported for oriented strand board (OSB) are derived from multiple tests performed on panels comprised of a variety of strand species, including aspen, Douglas-fir southern pine, and mixed softwood species.

[3] Flame spread classes and Smoke-Developed Indices reported for softwood plywood are derived from multiple tests performed on panels comprised of a variety of veneer species, including Douglas-fir, hemlock, southern pine and cedar.

[4] Flame spread classes and Smoke-Developed Indices reported for hardwood plywood are derived from multiple tests performed on panels comprised of a variety of face veneer species, core species and adhesive systems.

[5] Flame spread index cannot be directly determined from the referenced source; however, the reported Flame Spread Class is deemed to be a reasonable estimate based on changes to the analysis method of test results as reported within the referenced source.

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