FIRE TESTS ON WOOD DOORS
Information Reviewed and Reaffirmed
April 1953

No. 1239

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison 5, Wisconsin
In Cooperation with the University of Wisconsin
FIRE TESTS ON WOOD DOORS

By

G. C. McNaughton, Engineer
and
T. J. Martin, Chemist

Forest Products Laboratory, Forest Service
U. S. Department of Agriculture

Wood doors, because of their low cost, light weight, and ready adaptability to various kinds of architectural treatment and finish have almost monopolized the door market for most buildings. Doors of other materials seldom are used, except where special requirements give them preference. In homes and other small buildings, the resistance of doors to fire is usually not taken into consideration, mainly because the rest of the structure and its contents are not designed to have high fire resistance and there is, therefore, no need to require it in the doors. In any structure designed for high fire resistance, or for preventing the rapid spread of fire from room to room, the fire resistance of the doors is very important. At first thought it may seem that wood doors cannot be successfully used where fire resistance is required, but this is far from the truth. Not only can wood doors be constructed with good fire resistance, but this feature can usually be accomplished without sacrificing their advantage in cost, weight, and appearance. The important requirement is that the door be designed, constructed, and hung with due regard for the degree of fire resistance required.

There is need for considerable research upon the various factors that influence the performance of a wood door exposed to fire, in order to establish the principles and the details of design and construction required to produce the different degrees of fire resistance that may be required. For example, it is not difficult to produce a door that will stand up against the standard fire exposure for a period of 15 minutes. Various flush doors now in use will meet this requirement. When the required resistance is raised to 1/2 or 3/4 of an hour, however, fewer of the doors now made will meet the test, and it becomes increasingly necessary to

---

1 Published in American Builder & Building Age, March 1940.
2 Maintained at Madison, Wis., in cooperation with the University of Wisconsin.
know the factors of design, construction, and treatment that govern performance, keeping in mind the necessity of avoiding a door that is unduly expensive. There are some doors on the market now that meet even more severe time requirements, and, no doubt, with better knowledge of the underlying principles, many more doors will be made in the future that will meet more exacting requirements.

In 1939, a brief study of the fire performance of several widely used types of flush wood doors was made by the Forest Products Laboratory in cooperation with the National Door Manufacturers Association, as a first step in what is hoped may later be expanded into a much more comprehensive investigation.

The 12 doors used in these experiments were of untreated, unfinished wood, 3 by 7 feet in size, by 1-3/4 inches thick, and were of 4 different types (3 doors of each type). They are illustrated in Figure 1 and described below.

**Type I.**—Solid core, made of ponderosa pine core blocks 7/8 to 1-1/2 inches wide, arranged parallel to the vertical edges of the door, glued together, using butt joints at sides and ends, with casein glue. On each side of the core, 1/16-inch birch crossband and face plies were glued with hot-press phenolic-resin glue.

**Type II.**—Solid core, made of ponderosa pine core blocks 1-1/4 inches wide glued (with butt joints) into stiles and rails, which were 5-1/2 inches wide and were assembled with dowels at each intersection. On each side of the core, 1/16-inch sap gum crossbands and birch faces were glued. Casein glue was used throughout the door.

**Type III.**—The core contained hollow, horizontal compartments, 2 inches wide, separated by ponderosa pine strips 3/8 inch thick. The stiles were of solid ponderosa pine, 2-1/2 inches wide and the rails 3-1/2 inches wide, of the same wood. The ends of the compartment strips were mortised into the stiles. A plywood panel of 3 plies of 1/16-inch birch veneer was applied to each side of the core. Casein glue was used throughout.

**Type IV.**—The core contained square cells separated on 2 inch-centers by 1/8 inch thick ponderosa pine strips; each cell was filled with a granulated type of mineral wood averaging approximately 1 lb. in weight per square foot of cell area. A plywood panel consisting of 1 ply of 1/16-inch basswood between 2 plies of 1/16-inch birch was applied to each side of the core. Casein glue was used throughout.

The doors were tested by hanging them in the large fire testing furnace at the Forest Products Laboratory and exposing one side to a gas fed fire of gradually increasing temperature, according to the standard time-temperature relations adopted by the American Society for Testing Materials for fire tests of Building Construction and Materials. (Designation C19-33). The temperatures to which doors are exposed in this test reach 1,000° F. at the end of the first 5 minutes, 1,550° F. at 30 minutes, and 1,700° F. at the end of 1 hour.
The test is ordinarily continued until the fire burns through or around the door, or until the temperature on the unexposed face of the door rises 250°F. higher than at the beginning of the test.

The doors were mounted in wood or metal door frames, with 5" x 5" full-mortise, butt hinges and a light-weight, mortise, case-lock with knobs and plates. The doors were hung with a clearance of 1/16 inch at the head jamb, 3/32 inch at both stile jambs, and 3/16 inch at the floor line and hinged so as to swing into the furnace.

Results of Tests

A summary of the results obtained with each of the 12 doors tested is given in Table 1 and is shown graphically in Figure 2. Photographs of one door of each type, after test, are shown in Figures 3 to 6.

Attention should be drawn to the fact that in fire resistance tests of doors, it is the entire assembly, rather than the door alone, which is subjected to test. Accordingly, details beyond the control of the door manufacturer, such as the magnitude of the clearances between door and frame, the type of frame, the integrity of the frame with the wall opening, the hinges, screws, and the type of lock employed, may be governing factors in the performance of the assembly. This was true in a number of the tests in this series, and the results obtained do not give a clear picture of the performance of the door itself unless the two aspects are considered separately.

Comparison of the inherent fire resistance on the four designs of door construction can best be made by neglecting, temporarily, the failures of the door assemblies in which the hardware or door frames were directly responsible. To assist in such a comparison, a definite effort was made to continue all of the tests until there resulted a type of failure due to the type of construction. There were several instances in which tests had to be terminated before an independent failure of the door occurred, as for example, when the door fastening became ineffective, or when failure of some other detail resulted in ignition of the unexposed face of the door under test.

As shown in Table 1, the doors of Type I and Type II did not burn through or show 250°F rise in temperature in less than 40 minutes. In the first test of each type, however, in which untreated wood frames were used, the test was discontinued before the 40 minute period expired, because of failure of the frame. It is to be noted, also, that when the frames were of more fire resistant material, failure took place by burning through near the hardware in 23 to 31 minutes. Thus the failure of frame or hardware in every case prevented the doors of Types I and II from showing the full fire resistance of which they were inherently capable.

Report No. 1239
Warping of the doors away from the door stop at the top and bottom became pronounced as the test proceeded. At the top of the latch stile, one door of Type I warped 1/2 inch away from the stop at the end of 20 minutes, but the 4 doors of Types I and II that were tested in fire resistant frames required over 30 minutes to warp the same amount.

The unfilled, hollow doors of Type III burned through in less than 10 minutes in each case. This exposure time was too short for failure of frame or hardware. The filled doors of Type IV gave much better performance than the unfilled doors, as would be expected, lasting 2 to 3 times as long, but they did not show as much inherent resistance as the solid wood doors. There was some tendency for the cell filling to fall out as the exposed face of the door burned and fell away, which permitted more rapid burning through at the affected spots. Better resistance would have been obtained with a type of filling that would remain firmly in place and also, probably, if the filling had been packed more densely.

In considering the results of these tests, the reader should note that the longest periods reported in Table I and Figure 2 do not represent the results that would have been obtained in an official acceptance test, for such tests are discontinued whether failure is due to hardware, frame, or other cause. The long periods reported for doors of Type I and Type II merely indicate the service that may be obtained if frame, hardware, and door are all properly designed for such endurance.

On more expensive, 1-3/4-inch thick, wood doors, especially built for fire resistance (some with treated wood cores), the Forest Products Laboratory conducted tests that extended over an hour, and it seems possible that wood doors of still higher fire resistance can be built, provided hardware and frames that will stand such long tests are used with them.
Table 1.—Fire resistance of door assemblies

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Type of Frame</th>
<th>Time</th>
<th>Separation at Top of Stile</th>
<th>Failure of Assembly due to</th>
<th>After Given Minutes</th>
<th>Frame Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-29: 1</td>
<td>Untreated wood</td>
<td>21.3</td>
<td>20</td>
<td>--</td>
<td>--</td>
<td>16.3</td>
</tr>
<tr>
<td>P-32: 2</td>
<td>Pressed steel</td>
<td>43.5</td>
<td>31</td>
<td>36</td>
<td>--</td>
<td>23.3</td>
</tr>
<tr>
<td>P-39: 3</td>
<td>&quot;Fireproofed&quot; wood</td>
<td>45.0</td>
<td>33</td>
<td>34</td>
<td>40</td>
<td>30.5</td>
</tr>
</tbody>
</table>

Type I Door -- Solid core -- Blocks in vertical strips

Type II Door -- Solid core -- Blocks forming stiles, rails, and panels

P-31: 1  | Untreated wood | 30.7 | --                        | --                        | --                  | 19.9         |
| P-33: 2  | Pressed steel  | 49.0 | 32                        | 39                        | 40                  | 30.7         |
| P-40: 3  | "Fireproofed" wood | 41.5 | 35                        | --                        | 36                  | 38.0         |

Type III Door -- Hollow core, unfilled

P-30: 1  | Untreated wood | 10.4 | No separation             | --                        | --                  | 9.8          |
| P-34: 2  | Untreated wood | 10.1 | No separation             | --                        | --                  | 9.4          |
| P-37: 3  | Untreated wood | 10.3 | No separation             | --                        | --                  | 9.8          |

Type IV Door -- Hollow core, filled with insulation

P-44: 1  | "Fireproofed" wood | 30.2 | 26                        | 27                        | 29                  | 22.0         |
| P-45: 2  | Pressed steel     | 22.3 | 19                        | 20                        | --                  | 29.0         |
| P-46: 3  | Pressed steel     | 35.6 | 25                        | 26                        | 28                  | 33.6         |

*Test discontinued at time indicated because fire reached unexposed face due to destruction of jamb or warping of door or both.*
Fig. 1. Details of construction of four types of doors tested.

Fig. 2. Results of fire tests on four types of flash doors.
Fig. 3. Unexposed face of solid door No. 2 of Type I, after 40 minutes in test. Note burning through at door latch and charring opposite a shrinkage check in the solid core.

Fig. 4. Unexposed face of solid door No. 2 of Type II, after 44 minutes in test; burned through at latch and at lower center, also burning at bottom edge and warping at top of latch stile.
Fig. 5. Unexposed face of hollow door No. 2 of Type III, after 10 minutes. Door burned through, but no warping and no failure at hardware.

Fig. 6. Unexposed face of filled door No. 3 of Type IV, after 30 minutes in test. Note general charring on lower portion of door, and warping at lower corner of latch stile.