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IGNITION AND CHARRING TEMPERATURES OF WOOD

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IGNITION AND CHARRING TEMPERATURES OF WOOD

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A review of the technical literature reveals but a limited amount of data concerning minimum temperatures required to produce charring or ignition of wood. Results obtained by different investigators for ignition temperatures show wide discrepancies. As Brown (1)[2] has indicated, the different values reported may be due to the specific test conditions associated with the methods employed, and also to the different interpretations among investigators as to what constitutes "ignition temperature."

Available published reports (1), (2), (4), (5), and (7) on investigations of the ignition of wood usually deal with temperatures, size of material, and rate of air supply in the range that will cause ignition within a few minutes. No available publications relate to long exposures at the lower ranges of elevated temperature to which wood may often be subjected in actual use conditions.

The purpose of this report is to indicate the importance of time in the effects of heat upon wood rather than to present specific values for ignition temperatures or to recommend methods for determining such temperatures.

A previous investigation by R. E. Prince (7) demonstrated clearly that what he termed the "ignition temperature" for wood does not have a fixed value but is greatly influenced by the duration of exposure. In that work, oven-dry wood specimens 1-1/4 by 1-1/4 by 4 inches were exposed continuously to different temperatures maintained constant in an electrically heated apparatus. Record was made of the time that the specimens had to be kept at a specified temperature before the gases issuing from the specimens could be ignited by a pilot flame located about one-half inch above the test sample. The results reported for specimens of different species are shown in table 1.

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

[2] Numbers in parentheses refer to literature cited at the end of this report.

The data are somewhat erratic, especially at the lower temperatures, and they fail to show a consistent relation of ignition time to the specific gravity of the wood. It is probable that further, more comprehensive, testing may remove some of the apparent inconsistencies. Earlier studies, in which exposure was made at gradually increasing temperatures, showed that, as a general rule, a species of low specific gravity could be expected to ignite more readily than one of high specific gravity, provided that the specimens did not vary greatly in their content of resin or other extractive materials that would influence their behavior. It was also shown that ignition might either be hastened by the presence of flammable oils or resins, or be retarded by the presence of other extractives. Aside from these exceptional cases, specific gravity of the test piece was considered more important than species characteristics in influencing ignition when the size of the specimen, moisture content, and conditions of fire exposure were identical.

Some exploratory tests at the Forest Products Laboratory conducted more recently at a lower range of elevated temperature have demonstrated further the importance of time on the behavior of wood heated continuously. In these tests, small kiln-dried, hard maple motor wedges, about 1/8 by 1/4 by 3 inches which were to be used in a special motor for hot-air ducts, were subjected to temperatures ranging from 107° to 150° C. for various extended periods in electrically controlled drying ovens.

With prolonged exposure at all of the temperatures used there was a gradual darkening of the wood, accompanied by loss of weight and shrinkage in the transverse dimensions of the specimen. Chemical destruction of the specimens, as indicated by their loss of weight, was not associated with any one critical temperature. Instead, at each temperature of exposure, the specimens lost weight at a rather regular rate, and the rate became faster as the temperature was raised.

Samples which had been exposed to 107° C. for 1,050 days assumed a light chocolate shade. Those exposed to 120° C. for 1,235 days became appreciably embrittled, were of a dark chocolate color, and when moistened were strongly acid to litmus paper. Those exposed to 140° and 150° C. had the appearance and friability of charcoal even before they had lost 65 percent of their original air-dry weight at 6 to 8 percent moisture content, but none was ignited during its exposure.

A summary of weight losses and transverse shrinkage for different heating periods is given in table 2.

Although comparable data are unavailable, experience leads to the belief that other species would perform in much the same general manner as the maple used in these tests.

The fact that ignition did not occur at any time during this series of tests is no guarantee that it could not have done so if conditions more favorable for combustion had prevailed. In the lower range of temperature values, decomposition proceeded so slowly that the gaseous products evolved were dissipated in the surrounding air. In a confined space, however, the opportunity for escape of the gases and the heat accompanying oxidation would be lessened, and the danger of developing spontaneous ignition would be increased. This may account for the fires that have been reported to have started in wood in direct contact with low-pressure steam pipes or in wood heated at temperatures below that where the exothermic reaction normally becomes a factor (9). There are also indications from experience with wood in dry kilns, steam tunnels, and other places that long continued intermittent heating and exposure to damp conditions accelerate the decomposition of wood.

Little detailed information is available on the amounts and composition of the products formed at the temperatures and exposures described in table 2. Klar (3) reported that upon heating wood between 150° and 200° C., the composition in percent by volume of noncondensable gases is 68 percent carbon dioxide, 30.5 percent carbon monoxide, and 2 percent hydrocarbons. Murphy's investigation (6) of the thermal decomposition of paper below ignition temperatures also shows the evolution of gases to be a function of time and temperature.

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Table 1.--Effect of temperature and time of exposure upon the ignition of wood

Temperature of exposure	Duration of exposure before ignition[1]								
	Longleaf	Red oak	Tamarack	Western larch	Noble fir	Eastern hemlock	Redwood	Sitka spruce	Basswood
°C.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
180	14.3	20.0	29.9	30.8	......	....	28.5	40.0	......
200	11.8	13.3	14.5	25.0	....	13.3	18.5	19.6	14.5
225	8.7	8.1	9.0	17.0	15.8	7.2	10.4	8.3	9.6
250	6.0	4.7	6.0	9.5	9.3	4.0	6.0	5.3	6.0
300	2.3	1.6	2.3	3.5	2.3	2.2	1.9	2.1	1.6
350	1.4	1.2	.8	1.5	1.2	1.2	.8	1.0	1.2
430	.5	.5	.5	.5	.3	.3	.3	.3	.3
Reported average specific gravity of specimens	.70	.68	.60	.48	.46	.38	.35	.34	.31

[1]In general, the values shown represent the average of two tests.

Table 2.--Loss in weight and transverse shrinkage of hard maple specimens during oven heating

Duration of heating				Loss of weight[1]	Average transverse shrinkage (approximate)
at 107° C.	at 120° C.	at 140° C.	at 150° C.		
Days	Days	Days	Days	Percent	Percent
1,050	425	22	16	15	5.0
....	870	58	35	25	9.5
....	1,235	117	58	35	14.0
....	....	178	88	45	19.5
....	....	320	165	65	32.0

[1]Weight losses include 6 to 8 percent moisture that was in the wood at the start of the heating period.

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