# WHY THE DRYING TIME OF A KILN LOAD OF LUMBER IS AFFECTED BY AIR VELOCITY

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FOREST PRODUCTS LABORATORY
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UNITED STATES DEPARTMENT OF AGRICULTURE
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# WHY THE DRYING TIME OF A KILN LOAD OF LUMBER IS AFFECTED BY AIR VELOCITY[1]

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Only recently have there been any scientific studies made regarding the effect of air velocity on the drying rate of lumber in a dry kiln. Not more than 10 to 15 years ago, air velocities as low as 25 feet per minute were recommended by kiln engineers for slow-drying hardwoods, and velocities of 75 to 100 were considered very high. Studies[3] made at the Forest Products Laboratory during the past few years have indicated that the rates which might be called optimum from a drying time standpoint are much higher than these, ranging from approximately 500 to 800 feet per minute depending on the length of air travel, the drying schedule, and the drying rate of the lumber when in a green condition.

In addition to the collection of considerable empirical data, the studies have helped to clarify the reasons why air velocity affects drying time. When the conditioned air from the fans enters the load, it is uniform in temperature and relative humidity and, consequently, the entering air edges of the lumber dry at approximately their maximum rate. As the air progresses through the spaces between board surfaces, heat is used for evaporation and moisture in vapor form is added to the air. A gradation in temperature and relative humidity is immediately established, (1) transversely from the wood surface to the center of the air stream and, (2) longitudinally from the entering to the leaving-air side of the load.

## (1) Transverse gradation of temperature and relative humidity

The transverse gradation of temperature and relative humidity across the air stream is caused by more or less laminar flow which permits a stratification of low temperatures and high humidities next to the wood surface. Any means of breaking up this stratification by causing a greater turbulence of flow will result in greater efficiency of heat transfer and consequently faster and more uniform drying. Only by such complete mixing of the air as it progresses through the load can the maximum drying capacity of the conditioned air be obtained. Increased turbulence of flow can be caused by increases in air velocity or by introducing obstructions or interruptions in the air channel walls. This will be illustrated later by presenting some of the data collected.

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[1] Original report dated July 1941.

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

[3] Results in the drying of sugar maple given in Report No. 1264, obtainable from the Forest Products Laboratory, Madison 5, Wis.

(2) Longitudinal gradation of temperature and relative humidity

The average longitudinal gradation of temperature and relative humidity extending from the entering-air side to the leaving-air side of the load is dependent entirely on the amount of heat used from the total amount supplied and, therefore, is a function of air circulation and drying rate. Given any two, the third variable can be computed. All three of these can be measured satisfactorily, and the computations have been simplified by the construction of a chart[4] showing the amount of air needed to evaporate 1 pound of water for a 1° temperature drop across the load.

## Experiments Show the Effect of Space Piling and Increased Air Velocity on Drying Time

The first of two drying experiments on 1 by 8-inch northern red oak was made to show that greater turbulence of flow (and therefore greater transverse uniformity of air conditions) can be obtained by means of spaces between the edges of the boards. The spaces tend to break up the stratification of the air stream.

Three runs were made under the following constant drying conditions; temperature--115° F., relative humidity--85 percent, air velocity--260 feet per minute, sticker thickness--1 inch, width of pile--9 boards. The three runs differed only in the spacing of the boards. In one run, the boards were piled edge to edge, in the second the boards were spaced 1-1/2 inches apart, and in the third, groups of three boards were piled edge to edge leaving a 6-inch space between the third and fourth, and the sixth and seventh boards. The results showed (1) that the drying lag across the solid load took the more or less normal progressive shape, (2) that the average lag from board to board was considerably reduced by the 1-1/2 inch spacing, (3) that the effect of the 6-inch spaces was surprisingly large in respect to the drying rates of the fourth and seventh boards, and (4) that the average drying time of the entire load in drying from 80 to 40 percent moisture content was approximately the same whether eight 1-1/2-inch or two 6-inch spaces were used, but the solid pile took approximately 15 percent more time.

The second experiment was designed to show that increased turbulence of flow is caused also by increased air velocity thereby lessening the need for space piling. In this experiment, six groups were dried under the following constant drying conditions; temperature--115° F., relative humidity--80 percent, sticker thickness--1 inch, width of pile--9 boards. Three air velocities of 100, 300 and 600 feet per minute were used and each of these groups consisted of two runs one of which was solid piled (edge to edge) and the other was piled with 2-inch spaces between edges.

The results (shown graphically in figure 1) indicate (1) that such spacing of boards was very beneficial in respect to drying time at air velocities as low as 100 feet per minute, (2) that at 600 feet per minute the turbulence of flow caused by such a high velocity was not appreciably increased by the spacing of the boards and, as a result, such spacing was not beneficial for this velocity and possibly would not be beneficial for higher velocities, and (3) that, from a drying time standpoint, an optimum air velocity of at least 500 or 600 feet per minute is indicated for the early stages when kiln drying green 1-inch red oak.

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[4] Given in Report No. 1266, obtainable from the Forest Products Laboratory, Madison 5, Wis.

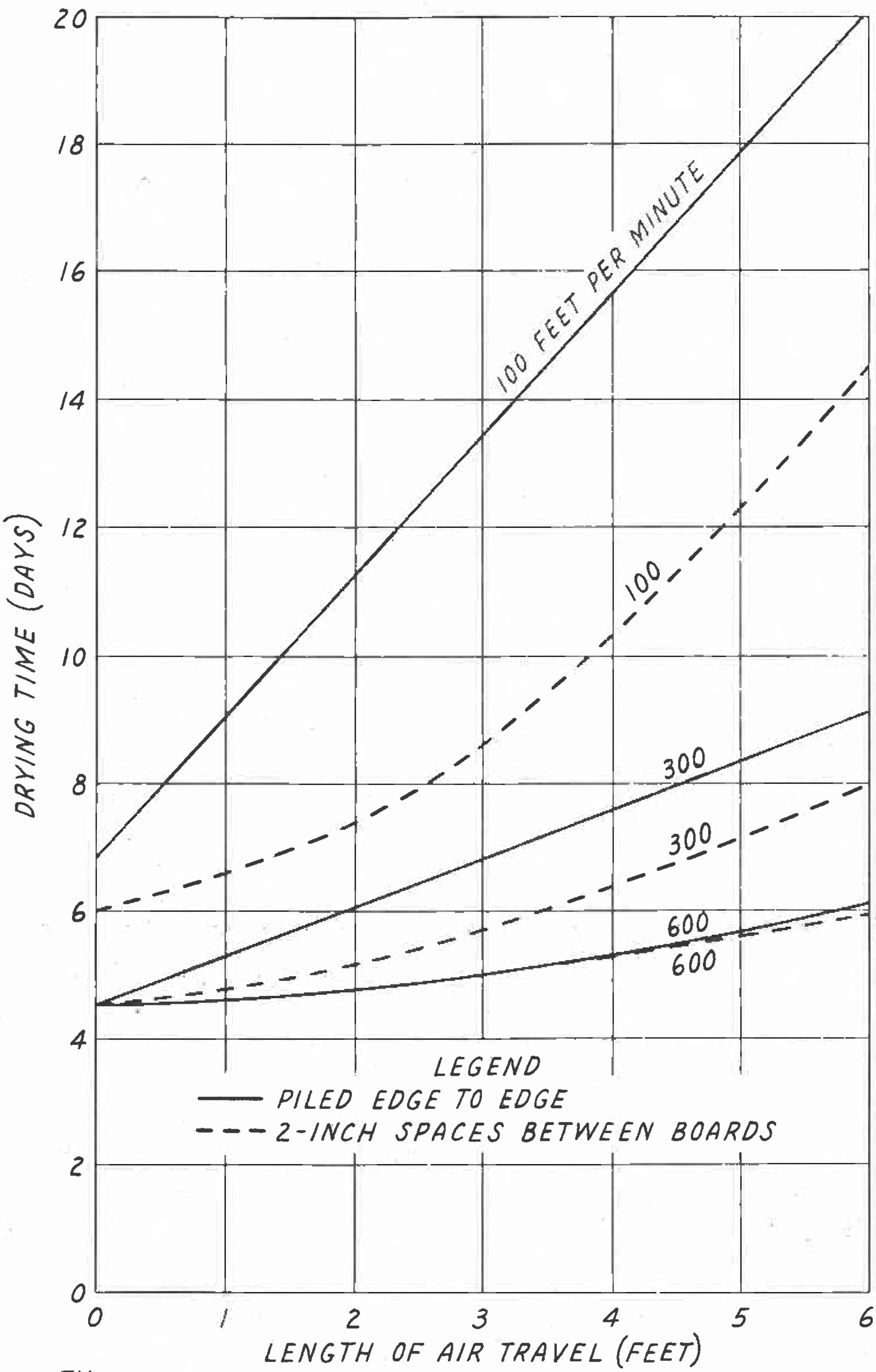


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Figure 1.--Effect of air velocity and space piling on drying time across a 6-foot wide pile of 1 by 8-inch northern red oak in drying from 80 to 40 percent moisture content under a temperature of 115° F., and a relative humidity of 80 percent.

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