Selected properties of commercial high-density hardboards

J. Dobbin McNatt
Gary Myers

Abstract

Information on the basic properties of hardboards is necessary for proper development of new end-use products. In this study, selected properties of 10 high-density hardboards from 6 manufacturing mills were determined. Results were compared with property requirements of the American National Standards Institute (ANSI) and with property values from a hardboard study in the 1960s. With few exceptions, property values exceeded the ANSI requirements and were within the range of those in the 1960s study.

For proper development of new end-use products, information on the basic properties of hardboards is necessary. Such information is also useful for explaining the performance of hardboard in current products. In the 1960s, the Forest Products Laboratory (FPL) conducted an extensive evaluation of 1/8- and 1/4-inch (3- and 6-mm) standard and tempered cardboards from 11 manufacturers. Portions of that study were published in 1970 and 1974 (5,6). Basic property information on 1/4- and 1/8-inch (3- and 6-mm) hardboards currently being manufactured is not available, although Biblis (3,4) published similar data for hardboard siding in 1989.

The objectives of this study were to compare property values of high-density hardboards produced today with those from the 1960s hardboard study and with property requirements of the American National Standards Institute (ANSI).

Selected property data for 1/8- and 1/4-inch (3- and 6-mm) high-density hardboards [59 to 68 pcf (941 to 1086 kg/m³)] produced at six manufacturing mills are presented.

Materials and methods

For this study, each mill furnished ten 2-foot-(6 10-mm) square hardboard samples, taken from 10 different 4-by-8-foot (1219- by 2438-mm) sheets. The six mills (labeled A to F) supplied 1/8-inch (3-mm) standard hardboard samples. Mills A and B supplied dry-process cardboards; the others supplied wet-process hardboards. Four mills (A,B,E,F) also furnished ten 1/4-inch (6-mm) hardboard samples. The 1/4-inch (6-mm) samples from mills A and F were tempered hardboard. Samples were cut from sheets selected during 1 week.

From each of the ten 2-foot- (610-mm-) square hardboard samples, 1 water absorption and thickness swelling specimen was cut. Two specimens, each of the following types, were also cut from each sample: static bending, tension parallel to surface, tension perpendicular to surface, and linear expansion. For static bending, tension, and linear expansion, one specimen was cut parallel to the machine direction, and the other, parallel to the cross-machine direction.

Specimens were conditioned to equilibrium moisture content (EMC) at 72°F (22°C) and 50 percent relative humidity (RH). In this study, the test methods in Part A of American Society for Testing and Materials (ASTM) Standard D 1037 (2) for wood-base fiber and particle panel materials were used to determine the following:

- Static bending: modulus of elasticity (MOE), modulus of rupture (MOR), EMC, and specific gravity (SG).
- Tensile strength parallel to surface.
- Tensile strength perpendicular to surface: internal bond (IB) strength.
- Linear variation with changes in MC: linear expansion (LE) between 50 and 90 percent RH.
- Water absorption and thickness swelling after 24-hour water-soak.

The authors are Research Forest Products Technologists, USDA Forest Service, Forest Products Lab., One Gifford Pinchot Dr., Madison, WI 53705-2398. This paper was received for publication in October 1992.

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Results and discussion

Property value results from this study are presented in Table 1. The values represent averages of both the machine and cross-machine directions. Table 1 also includes the requirements of the ANSI Standard for basic hardboard (1).

Average EMC for the 10 hardboards (A-F) at 50 percent RH ranged from 4.6 to 7.7 percent. (No obvious relationship existed between EMC and the hardboard process, treatment, or thickness.) The average EMC for all hardboards combined was about 6 percent. Average SG range was from 0.90 to 1.02, based on ovendry weight and dimensions at test. This converts to a density range of 59 to 68 pcf (910 to 1086 kg/m$^3$) at 50 percent RH.

Average MOE values for both thicknesses of standard and tempered hardboard ranged from 468,000 to 768,000 psi (3225 to 5295 MPa), and MOR values ranged from 4,560 to 8,060 psi (31 to 56 MPa). As expected, the 1/4-inch (6-mm) tempered hardboards (mills A and F) had higher MOE and MOR values than did the standard hardboards.

The range of average tensile strength values parallel to surface for all products was 3,280 to 5,450 psi (23 to 38 MPa). The 1/4-inch (6-mm) tempered hardboards were stronger in tension than were the 1/4-inch (6-mm) standard hardboards, but the 1/4-inch tempered hardboards had lower tensile strength than did two 1/8-inch (3-mm) standard hardboards. Average IB values, ranging from 180 to 510 psi (1.24 to 3.52 MPa), varied more than did any other properties. Coefficients of variation ranged from 9.5 to 31.5 percent for individual products.

Except for the specimens from mill B, LE values were ≤ 0.26 percent. Both the 1/8- and 1/4-inch (3- and 6-mm) specimens from mill B averaged about 0.45 percent. As expected, percentage weight increase and thickness swelling after a 24-hour water-soak were greater for the 1/8-inch (3-mm) specimens than for the 1/4-inch specimens (specimen E was the only exception). Also, the 1/4-inch (6-mm) tempered hardboards had lower values than did the standard hardboards.

With few exceptions, property values met the requirements, where specified, of the ANSI hardboard standard. The most obvious exception was the percentage weight increase after the 24-hour water-soak of 1/8-inch (3-mm) hardboard specimens from mills B and C (40.3% and 49.9%, respectively). The maximum weight percentage allowable in the ANSI standard is 35 percent. The 1/8-inch (3-mm) specimens from mill B had been sanded at the manufacturing mill. Sanding opens the hardboard surfaces and greatly increases the rate of water absorption.

It should be mentioned that values specified in the ANSI standard are based on the test procedures in Part B of ASTM Standard D 1037 (2). For static bending and IB strength, Part A test procedures, which are the basis for this study, are different than procedures in Part B.

In Part A, static bending specimens are 2 inches (50 mm) wide and 18 inches (457 mm) long. In Part B, static bending specimens are 2 inches (50 mm) wide, 18 inches (457 mm) long, and 2 inches (50 mm) thick. The minimum thickness for Part B specimens is 0.125 inches (3.18 mm), and the maximum thickness is 0.25 inches (6.35 mm). The maximum thickness for Part A specimens is 0.125 inches (3.18 mm).
(51 mm) wide for 1/8- and 1/4-inch (3- and 6-mm) specimens, and the span is 24 times the thickness. In Part B, all specimens are 3 inches (76 mm) wide, and the span for both thicknesses is 4 inches (102 mm).

However, a more significant procedure difference is in the rate of loading. For practical use by industry, the acceptance and specification test methods for hardboard in Part B of ASTM D 1037 use faster rates of loading than do those specified in Part A. In Part A, all static bending specimen sizes are loaded at a rate that produces a unit strain rate in the outer fibers of 0.005 in./in./min. [0.005 mm/mm/min.]. Thus, the loading rates are 0.06 in./min. (1.5 mm/min.) for 1/8-inch (3-mm) specimens and 0.12 in./min. (3 mm/min.) for 1/4-inch (6-mm) specimens. The allowable range of loading rates in Part B for both thicknesses is 0.5 to 1.0 in./min. (12 to 25 mm/min.). In Part A, the loading rates for 1/8- and 1/4-inch (3- and 6-mm) hardboard IB specimens are 0.01 in./min. (0.25 mm/min.) and 0.02 in./min. (0.50 mm/min.), respectively. The allowable range of rates in Part B is 0.125 to 0.175 in./min. (3.2 to 4.4 mm/min.) for both thicknesses. In other words, the rates of loading are considerably faster in Part B than in Part A. It is recognized that apparent strength increases about 6 to 10 percent for each tenfold decrease in time to failure (5, 7). Therefore, the MOE, MOR, and IB values in this study would further exceed those required in the ANSI standard if the specimens were tested by the procedures in ASTM D 1037, Part B.

As previously stated, the values in Table 1 are an average in both the machine and cross-machine direction. Table 2 gives the ratio of property values in the two machine directions. For all specimens, MOE, MOR, and tensile strength parallel to surface values were greater in the machine direction than in the cross-machine direction. This was a result of some alignment during formation of the fiber mat. For the same reason, LE was less in the machine direction than in the cross-machine direction. Several hardboard specimens had almost equal property values in the two directions. Others had property values that differed by about 15 percent. The ratios were not always consistent between the properties of a given specimen or even between the two thicknesses of material from the same mill. Overall, the 1/4-inch (6-mm) hardboard specimens were almost equal in the machine and cross-machine direction.

Property values in Table 1 were compared with those determined in the 1960s FPL study of commercial hardboards. Table 3 gives the range of hardboard property values from the 1960s study compared to values from this study. Note that 10 manufacturers of 1/4-inch (6-mm) hardboard were included, but only 3 manufacturers of 1/4-inch (6-mm) standard, 1/8-inch (3-mm) tempered, and 1/8-inch (3-mm) standard hardboards were included. The LE was determined for only 6 of the ten 1/4-in. (6-mm) hardboards. The water absorption and thickness swelling results could not be compared because different test procedures were used in this and the 1960s study.

Most property values determined in this study were within the range or exceeded the values from the 1960s study. The three exceptions were MOR and tensile strength of the 1/8-inch (3-mm) boards and tensile strength of the 1/4-inch (6-mm) boards.

Conclusions
Selected properties of 10 high-density hardboards from 6 manufacturing mills were evaluated. Property values were compared with ANSI Basic Hardboard Standard requirements and with property values of hardboard from a 1960s study at the Forest Products Laboratory. All mechanical property values met the ANSI requirements. However, three hardboard specimens exceeded the maximum allowable water absorp-

### Table 2. — Ratio of property values in machine and cross-machine direction.

<table>
<thead>
<tr>
<th>Manufacturer</th>
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<th>1/4</th>
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<tr>
<td>A</td>
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<tr>
<td>B</td>
<td>0.87</td>
<td>0.88</td>
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<tr>
<td>C</td>
<td>0.94</td>
<td>0.97</td>
</tr>
<tr>
<td>D</td>
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<td>0.98</td>
</tr>
<tr>
<td>F</td>
<td>0.98</td>
<td>0.96</td>
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</table>

**Table 3. — Range of hardboard property values from 1960s FPL study and from current study.**

<table>
<thead>
<tr>
<th>Hardboard</th>
<th>Modulus of elasticity</th>
<th>Modulus of rupture</th>
<th>Tensile strength parallel to surface</th>
<th>Internal bond strength</th>
<th>Linear expansion</th>
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</thead>
<tbody>
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<td>1/8</td>
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</tr>
<tr>
<td>Standard</td>
<td>(x10^3 psi)</td>
<td>(psi)</td>
<td>(psi)</td>
<td>(%)</td>
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</tr>
<tr>
<td>Standard</td>
<td>(x10^3 psi)</td>
<td>(psi)</td>
<td>(psi)</td>
<td>(%)</td>
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</tr>
<tr>
<td>Tempered</td>
<td>(x10^3 psi)</td>
<td>(psi)</td>
<td>(psi)</td>
<td>(%)</td>
<td>(%</td>
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</tbody>
</table>

*Range of current study values is in parentheses; 1 psi = 6.89 x 10^6 Pa.
Values are averages of 100 specimens, 3 manufacturers.
Values not determined.
Values are averages of 100 specimens, 10 manufacturers (6 manufacturers for linear expansion).
tion percentage, and one exceeded the maximum allowable thickness swelling percentage after a 24-hour water-soak. Except for MOR and tensile strength of two 1/8-inch (3-mm) hardboard specimens, property values of materials in this study matched those of hardboards evaluated at the Forest Products Laboratory in the 1960s study.

Literature cited