HARDBOARD: PROCESSES, PROPERTIES, POTENTIALS

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Introduction

The term "hardboard," originally coined by the Masonite Corp. of Laurel, Miss., has now become generic and describes a cellulosic fibrous product made in one of three ways (wet, semidry, or dry processes), having a specific gravity from 0.8 to 1.2 and surfaces either wire marked on one side or smooth on two sides (S-2-S). The American Society for Testing Materials is now in the process of revising specifications for this product. The term "hardboard" is one of three constituting the category "wallboard." The other two are "insulating board" and "wallboard" (sheathing board). Semihardboard, with a specific gravity of 0.65 to 0.80, is a relatively new product.

Developments in the fiberboard field date from 1914 when the Minnesota and Ontario Paper Co. first developed a rigid insulating board. In 1926 Mason developed a process for the production of a hard-pressed fiberboard, hardboard. This process, which soon made its appearance in various parts of the world, was put into operation in Sweden in that country's first wallboard plant in 1929. Not many years later, Mason claimed that his process was used for 90 percent of the world's hardboard production, and it so continued until about 1946.

New and novel developments and greatly expanded production facilities on a world-wide scale in the hardboard field have characterized the past decade.

In a technical survey made in Germany after World War II (13), 2 J. N. McGovern of the U. S. Forest Products Laboratory found that a process similar to the Asplund process, which will be described later, was being used to make hardboard from wood waste. R. J. Schafer, in a report on a similar survey (16) on the manufacture of building materials from wood wastes, thoroughly covers synthetic-resin-molded wood-waste boards, lignin-bonded wood-waste boards, and sawdust-cement and wood-concrete.

Postwar interest in utilizing wood wastes has been evident both here and abroad. In the United States, the Asplund process and various combinations of cooking or of wood-softening pulping processes with attrition mills have been tried on a variety of wastes.

1 Maintained at Madison, Wis., in cooperation with the University of Wisconsin.
2 Underlined numbers in parentheses refer to Literature Cited at end of report.
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There has also been a great deal of interest shown in the utilization of sawdust and shavings and similar wood waste for the production of board materials by methods other than the well-known wet-forming processes, which are practically limited to the use of the coarser types of wood waste from which relatively undamaged fibers can be produced.

One of the earliest attempts along this line has been the production of cement-bonded boards for use where some structural strength and insulation are important. This process has found limited commercial application because of the inhibiting effect of the hemicelluloses and tannins of the wood on the setting of the concrete and of the tendency for absorbed water to freeze and thereby to crack the boards or blocks. Methods of controlling the setting rate of the cement have more recently been developed, but very close control in processing is necessary. One of the most successful wood-cement combinations has been the production of an acoustic tile material by using specially cut excelsior that is bonded with cement. This product has good fire resistance and, when properly set, good resistance to swelling and decay. In order to produce the best material, however, only specially cut wood wool or excelsior is usable, so that random sawdust and shavings are excluded.

Sawdust, shavings, and veneer clippings of relatively wide range of sizes are being used to produce dry-formed or resin-bonded boards of various specific gravities and of a range of properties making them suitable for special uses. One of the early developments along this line uses 10 to 15 percent of urea-formaldehyde resin binder and graded sawdust or shavings to obtain products that are finding use as subflooring for linoleum, house sheathing, and core stock for furniture and doors. A somewhat similar process, also using urea-formaldehyde resin binder, has been developed for the utilization of veneer clippings, which have been reduced to a suitable size, for the production of core stock. Two millwork companies are producing phenolic-resin-bonded sawdust board with 5 to 8 percent of resin. This material is being utilized very satisfactorily in the production of panels for millwork.

There are many other investigators who are approaching this problem from slightly different angles, including the semidry-formed process that is being developed in the Pacific Northwest. Such a utilization of wood waste promises to become of major importance. The dry and semidry processes appear to lend themselves to somewhat smaller plant sizes than have been generally considered economical for the more common wet-formed or pulp processes. For example, production of 15 to 30 tons per day of dry-formed boards appears to be practicable, as compared to the 50- to 100-ton daily capacity considered most practical for the wet-formed process. Furthermore, it is estimated that the dry-formed plant can be installed for approximately two-thirds the cost of the wet-formed plant, based on the tons-per-day capacity. It is also true, however, that the resin binders required in the dry-formed boards result in a more expensive product than the wet-formed material, but this can be balanced to some extent by the special properties that can be obtained by this method.

**Properties and Use Requirements**

Hardboard is often competitive in use with softwood plywood. It is cheaper, and, in general, where coverage is the essential feature of the use of the
material, it may be substituted directly. In some instances, as for bookcase
backings, relatively weak hardboards, such as sawdust-resin boards (dry-
formed) and laminated wallboard, are adequate. In order to use any hard-
board for panels of sandwich construction or stressed-skin construction
for walls, roofs, and floors of buildings, however, the mechanical and
physical properties of the board are important. The design of such struc-
tures is dependent on tensile and compressive strength, moduli of elas-
ticity, toughness, dimensional stability, nail-holding qualities, and
density of the materials used.

The requirements for hardboard of 1/8-inch thickness, as listed in Federal
Specification LLL-F-311, Fiberboard: Hard-pressed, structural (July 12,
1940), Federal Standard Stock Catalog, are given in the following tabulation:

<table>
<thead>
<tr>
<th>Material</th>
<th>Density (Lb. per cu. ft.)</th>
<th>Minimum modulus of rupture (P.s.i.)</th>
<th>Maximum water absorption (24-hour immersion) (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A (untreated)</td>
<td>60</td>
<td>6,000</td>
<td>20</td>
</tr>
<tr>
<td>Class B (treated)</td>
<td>60</td>
<td>10,000</td>
<td>12</td>
</tr>
</tbody>
</table>

Published information on production and properties of hardboard can be found
in references (8, 2, 14, 17, 18).

Commercial standards for hardboard are practically nonexistent. Hard-surface
boards of good appearance, good dimensional stability, and fair strength will
generally be suitable for commercial trade uses. Sawdust-resin boards of
relatively poor strength and dimensional stability but of hard and attractive
surface are acceptable for many uses today. As a rule the dry-formed boards
are superior to wet-formed boards in hardness and nail- and screw-holding
properties, which have made them particularly suitable for use as core stock.

**Raw Materials**

Generally speaking, the better the quality of fibers from most any species,
especially as to length, the better will be the board properties. This
does not mean that hardwoods, which have relatively short fibers, are not
acceptable material, as many of them produce strong boards alone or in
admixture with softwoods.

Freedom from bark and dirt obviously improves the quality of the product.
Some bark can be tolerated, and more can be used by facing the board with
bark-free stock. The latter procedure requires a special forming arrange-
ment.

Slabs and edgings generally are superior to shavings, sawdust, sander
dust, and similar mill wastes. The suitability of waste materials, how-
ever, can be determined in most cases only by evaluation trials. The
following generalization, based on information gathered at the U. S. Forest Products Laboratory and from various other sources, can be used as a rough guide.

For wet processes:

1. Sawdust is not a suitable raw material for wet-formed hardboard.
2. Shavings will produce at best a marginal board.
3. The incorporation of bark will lower the strength and detract from the appearance of the board. When the bark content is not in excess of 15 percent, the above factors may be disregarded, but regardless of any of these factors the bark content must be controlled to prevent a flaky, dusty wire-side surface.
4. Most woods and wood wastes, such as trim, edgings, slabs, and veneer scrap, are suitable raw material for hardboard. Considerable variation between various species has been observed, however.

For dry processes:

1. Sawdust and shavings are suitable raw materials for dry-formed boards.

Wet-forming Processes

Explosion (Masonite) Process

The Masonite wet process will be discussed in considerable detail, inasmuch as it is well known and differs from most of the other processes, as they do from each other, in the method of pulp production, sheet formation, and byproducts produced.

The Masonite process is an explosion pulping process developed about three decades ago in which a special instantaneous-relief digester, called a "gun," is used. Peeled wood is chipped, and the screened chips are conveyed to guns, which have a capacity of about 260 pounds each. Steam is admitted at a pressure of 400 pounds per square inch for about 15 seconds. After this condition is attained, high-pressure steam is added, and about 50 to 100 seconds from the initial addition of steam the pressure reaches about 1,000 pounds. The gun charge is then "blown" through a large pipe to a blow pit and cyclone. The exploded wood at this point is a fairly fluffy product with about a 50 percent moisture content. This stock is diluted with water, refined, and passed on to a large vacuum washer. The first wash water contains wood sugars and is sent to a byproduct plant.

The washed pulp is further refined and then screened before going to the hardboard-forming machine. A controlled amount of fiber fines is removed.
by the screening operation, and the effluent is sent to a Dorr thickener for recovery. It is necessary to remove the fines to control the freeness and consequent forming rate of the stock on the wire of the Fourdrinier-type forming machines. The headbox temperature of the stock going onto the forming wire is about 100° F.

The boards coming from the wet-press sections of the forming machine are automatically cut to 12-foot lengths and, by means of a large, adjustable tipple, are delivered to a 20-opening loading platform. When this platform is filled, the boards are simultaneously transferred by driven rolls into a similar press-loading platform. This rack is self-driven to a position at the end of one of several hot presses. Loading and unloading of the 20-opening, 4-by 12-foot hot presses is simultaneous. The wire screens on the bottom side of the board are in belt form and convey the wet mat into the press and dry board out of the press. The excess wire at each end of the press is wound on a mandrel.

A steam pressure of 260 pounds per square inch is used in the hot press, which has chrome-plated cauls. The pressing cycle for 1/8- to 5/16-inch hardboard is from 7 to 14 minutes. After the hot press is closed, the hydraulic pressure is raised to about 200 pounds per square inch for about 2 minutes, and then raised to 800 pounds per square inch for the balance of the cycle.

The boards are ejected into the unloading platform without cooling, placed edgewise in racks, and conveyed to a humidity chamber for conditioning to a moisture content of from 4 to 5 percent.

Boards that are to be processed for "tempered" Masonite are placed on a moving platform and conveyed through a heating chamber and a bath of hot tempering oil. This oil, which may contain as many as five components, is absorbed by the boards in amounts of 5 to 6 percent, board weight basis. After a short diffusion period the boards are placed edgewise in racks and transferred to a gas-fired kiln for 3 to 4 hours at 300° F.; the vapors from the oil are recirculated in the kiln. The boards are then humidified to a moisture content of from 4 to 5 percent. The tempering process is patented.

Board that is smooth on two sides (S-2-S) is produced by an 8-foot wet-forming machine and a 360-foot multideck Coe drier, much the same as insulating board is produced. The dry boards (2 percent moisture content) are pressed between chrome-plated cauls on both of the platens at 400 pounds per square inch and then "breathed" several times at short intervals until the gas and moisture no longer "whistle" as the press is opened. The hydraulic pressure is then raised to 1,300 pounds per square inch. The total cycle is only about 2 minutes. Some of the S-2-S boards are tempered and laminated to produce die stock.

One 4-foot machine operates at about 160 feet a minute for a 1/8-inch board or 60 feet a minute for a 1/4-inch board. This special type of Fourdrinier machine has a 7-foot-long suction box of high capacity but has a rather short wire. A top wire is also used and is carried through several presses.

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In the wood-sugar plant, the liquor (9 percent of solids) from the washer is evaporated to about 40 percent of solids and sold under the name of "Masonex." Some of this concentrate is sprayed onto a rapidly revolving disk, and the disbursed particles are flash-dried. The powdered sugar is separated in a cyclone and bagged. It was being sold for a nominal price of 4 cents per pound in 1947, when nearly 200 tons per day was available.

A Dorr thickener of 2-million-gallon capacity is used to gather the fiber and lignin fines in a sludge and thus separate them from the excess wash waters, which can be reused. The solid material is delivered by a sludge pump to a screen that separates the fiber fines. Some of these fines are flash-dried and bagged; some are added to the gas-fired furnace for fuel. The composition of the fines is about equal parts of lignin and fiber. The grit-like powder produced by drying the fines is sold under the name of "Benelex." Some is sold as a plastic molding compound under the name of "Benalloy." About 50 tons per day of fines are produced. In general, all the byproducts are produced as a waste-disposal proposition.

Southern yellow pine is the principal species used for Masonite. About one-fourth of the wood used, however, is hardwood. The southern gums are acceptable, while the oaks are undesirable. The oaks, when exploded, yield small pieces of wood that apparently carry through to the finished board. The hardwood is chipped, stored, and exploded separately, according to a slightly different cycle from that for softwood. It is blended as produced by discharging guns of hardwood and softwood into the same blow pits.

Articles on the Masonite process by Robert M. Boehm are found in references (2, 4).

Defibrator (Asplund) Process

The Asplund process was developed in Sweden about 20 years ago and is characterized by a special form of attrition mill, or "Defibrator." The Defibrator is a pressure vessel, equipped with an internal chip conveyor, an attrition mill, and automatic valves for feeding and discharging under pressure to implement a continuous process. It is generally made from stainless steel and is available in several sizes.

The special merit of the process seems to lie in the softening effect of high-temperature steam (125 to 175 pounds per square inch) on lignin, which permits the simultaneous separation of unbroken, whole fibers from the wood chips at the refiner end of the machine. The pulp is especially suited to the production of hardboard, as its drainage characteristics are excellent for forming and dewatering in a hot press.
A typical press cycle for nominal 1/8-inch board prepared from an acceptable hardboard stock and molded at a platen temperature of 185° C. would be as follows:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closing press</td>
<td>1-1/4</td>
</tr>
<tr>
<td>Dewatering</td>
<td>1</td>
</tr>
<tr>
<td>Drying</td>
<td>8-1/2</td>
</tr>
<tr>
<td>Board removal</td>
<td>1-1/4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

One of the most promising wet-forming processes is the Forest Fiber process. It utilizes the Asplund Defibrator, attrition mills, and a Fourdrinier former, followed by the usual hot press and conditioning equipment.

A rather complete description of plants and processes for the manufacture of wallboards in Sweden by Uno Lowgren (11) emphasizes the Asplund Defibrator process for reduction of chips to pulp form. An article by Halvar A. Lundberg (12) gives a description of the Masonite process as well as the Asplund process.

**Mechanized, Wet-batch (Chapman) Process**

Recently, Chapman Manufacturing Co. developed a small-scale forming process suited to plants having between 25 to 50 tons per day of wood or wood waste available for conversion to hardboard. A semicontinuous forming unit is used, followed by the usual hot-pressing equipment. The pulp can be prepared by any of the conventional methods.

The process is described in detail in reference (1).

**Dry (U. S. Gypsum) Process**

In the dry process steam or water cooking of chips at high temperatures (around 180° C.) produces the material for fiberizing in attrition mills, such as the Sprout Waldron and Bauer mills. It is refined to stock at a freeness suited to the wet-process forming equipment. The mat is formed at a low density similar to that of insulation boards, wet pressed to a degree, and dried in this condition in a Coe dryer. After it is dried the mat is heated in dielectric ovens, densified, and "cured" in a hot press at about 500° F. (260° C.). The surfaces are devoid of the usual backing-wire marks when the sheet is press-dried. It is then conditioned to equilibrium with the usual atmospheric moisture content by steaming in kilns. The product is a smooth-two-sides (S-2-S) board of high quality if clean, bark-free chips are used. A complete description of the process as it is operated at Kymi, Finland, and Greenville, Miss., is given in reference (10).
The dry-forming processes are relatively new and can be classed in two groups: dry-formed particle board, and semidry fibrous board.

**Dry-formed Particle Hardboard**

In the dry-formed particle hardboard process, planer mill wastes, such as shavings, edgings, and sawdust, are ground to size, and phenolic resin is added up to about 7 percent. The material is mixed and "dry-trayed" for thickness and dimensions. These trays are cured in a multiplaten hot press to a finished S-2-S hardboard. An example is "Prespine," which is being used in panels for doors and other products.

The equipment required for the production of a dry-formed board is relatively simple. If sawdust and shavings resulting from primary lumbering operations are to be used, provision should be made for drying these residues. Conventional inclined-drum or belt driers are suitable for the purpose. The sawdust, shavings, or veneer scrap must be sized or graded to prevent too wide distribution of particle size. This requires a relatively simple hammer mill and screening equipment. For the application of the binder to the wood waste, ribbon mixers or concrete mixers have been found suitable if liquid resins are used. If dry resins are used, a slightly more intensive type of mixing is generally employed for incorporating both the powdered resin and small amounts of water. Following the mixing, it is necessary to have an automatic or semiautomatic tray loader that is capable of loading the pans or trays with a uniform weight and thickness of the mixture of wood waste and resin. These pans or trays are then transferred through automatic loading devices to multiplaten hot presses, where the board is formed and the resins are set under heat (350° to 450° F.) and pressure (350 to 750 pounds per square inch), with the amount of pressure applied determining the specific gravity of the finished product.

**"Semidry" Processes**

Three semidry hardboard processes, sometimes called "wet-dry," have been developed in the United States. These processes are patented, and plants are being established to produce commercial quantities of semidry boards. It is estimated that these plants will cost from $10,000 to $20,000 per ton per day of product, compared to $20,000 to $40,000 for a conventional wet-process hardboard plant. The principal difference between the semidry and wet processes is that the pulp is felted with a minimum of water in the semidry processes.

Detailed information concerning the semidry processes may be available from the following concerns:

"Novoply," a wood-particle, three-ply board, has a low-density core consisting of fine wood slivers made from veneer scrap and outer face plies made of fine-quality shavings sliced from peeler-log cores by special machines. It is bonded by a special glue to give it superior mechanical and dimensional properties when compressed and cured in a hot press.

The core material is made by reducing dried chips to particles about 1/2 inch long and 1/16 inch thick in a hammer mill. The face material is sliced tangentially from the peeler cores by a rotary slicer to a thickness of about one one-thousandth of an inch. The core and face materials are then dry-formed in three plies on a metal plate and hot-pressed to 3/8-inch and 3/4-inch board.

"Novoply" is being manufactured by Shasta Plywood, Inc., Anderson, Calif., a subsidiary of the U. S. Plywood Corp. Two types are made, one faced with redwood material and the other with light-finish fir or pine material.

There are several other processes for hardboard, most of which have been developed in Europe and are being promoted in the United States and Canada. Several of these processes border on molded plastics and are generally much more costly than standard hardboards. These developments were recently reviewed in reference (15).

**Equipment**

The Downington Manufacturing Co., Downington, Pa., has made Fourdrinier sections for some of the large hardboard plants. This firm also recently made the continuous forming section for a small-scale plant at Forest Grove, Oreg. (2). An article by R. T. Depan, Downington Manufacturing Co., describing a small plant set-up for insulating and hardboard manufacture has been published (5).

**Hardboard Plants and Estimated Capacities (1951)**

The following tabulation gives the names, locations, and estimated capacities of hardboard plants in 1951:

<table>
<thead>
<tr>
<th>Plants</th>
<th>Location</th>
<th>Estimated production capacity per 24 hours (Sq. ft. of nominal 1/8-in. board)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants in United States:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masonite Corp.</td>
<td>Laurel, Miss.</td>
<td>2,190,000</td>
</tr>
<tr>
<td>Masonite Corp.</td>
<td>Ukiah, Calif.</td>
<td>1,215,000</td>
</tr>
<tr>
<td>U. S. Gypsum Co.</td>
<td>Greenville, Miss.</td>
<td>250,000</td>
</tr>
<tr>
<td>Forest Fiber Products Co.</td>
<td>Forest Groves, Oreg.</td>
<td>82,000</td>
</tr>
</tbody>
</table>

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Plants in United States (Contd.):

<table>
<thead>
<tr>
<th>Plants</th>
<th>Location</th>
<th>Estimated production capacity per 24 hours (Sq. ft. of nominal 1/8-in. board)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapman Manufacturing Co.</td>
<td>Corvallis, Oreg.</td>
<td>75,000</td>
</tr>
<tr>
<td>Superior Wood Products Co.</td>
<td>Duluth, Minn.</td>
<td>75,000</td>
</tr>
<tr>
<td>Oregon Lumber Co.</td>
<td>Dee, Oreg.</td>
<td>180,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total... 3,867,000</td>
</tr>
</tbody>
</table>

Plants in Canada:

<table>
<thead>
<tr>
<th>Plants</th>
<th>Location</th>
<th>Estimated production capacity per 24 hours (Sq. ft. of nominal 1/8-in. board)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masonite Corp. of Canada, Ltd.</td>
<td>Gatineau, Que.</td>
<td>125,000</td>
</tr>
<tr>
<td>Pacific Veneer and Plywood Div., Canadian Forest Products Ltd.</td>
<td>Westminster, B. C.</td>
<td>75,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total... 200,000</td>
</tr>
</tbody>
</table>

On the above basis Masonite produced 88 percent of the hardboard produced in the United States in 1951. A more complete list of hardboard plants, including those proposed and under construction (1951), together with production capacities for most foreign countries, will be found in reference (6).

Manufacturing Costs (1951)

All cost estimates following are based on information gained from various sources and are believed to be fairly representative for the conditions specified.

The following tabulation gives a comparison of costs for the various processes for making hardboard:

<table>
<thead>
<tr>
<th>Type of process</th>
<th>Board thickness (Inch)</th>
<th>Cost per 1,000 sq. ft. of board</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet, continuous felting:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explosion process</td>
<td>1/8</td>
<td>$23.62</td>
</tr>
<tr>
<td>Asplund process</td>
<td>1/8</td>
<td>21.70</td>
</tr>
<tr>
<td>Small Fourdrinier-Asplund process</td>
<td>1/8</td>
<td>25.00 - 30.00</td>
</tr>
<tr>
<td>Wet, continuous felting -- dry pressing:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Softboard-hardboard combination process</td>
<td>1/8</td>
<td>29.00</td>
</tr>
<tr>
<td>Wet, batch process:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deckle-box process</td>
<td>1/8</td>
<td>25.00 - 30.00</td>
</tr>
<tr>
<td>Deckle-box process</td>
<td>1/4</td>
<td>36.80</td>
</tr>
<tr>
<td>Dry, batch process:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granular-wood hardboard process</td>
<td>1/4</td>
<td>44.40</td>
</tr>
</tbody>
</table>

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Detailed Costs

The following distribution of costs on the explosion type of hardboard operations has been published (7).

<table>
<thead>
<tr>
<th>Distribution of costs</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages and salaries</td>
<td>26.0</td>
</tr>
<tr>
<td>Raw materials</td>
<td>25.9</td>
</tr>
<tr>
<td>Other materials and outside services</td>
<td>11.8</td>
</tr>
<tr>
<td>Taxes</td>
<td>11.8</td>
</tr>
<tr>
<td>Retained in the business</td>
<td>10.9</td>
</tr>
<tr>
<td>Transportation</td>
<td>7.9</td>
</tr>
<tr>
<td>Dividends</td>
<td>4.1</td>
</tr>
<tr>
<td>Depreciation</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Explosion Process Production Costs (1951)
(1/8-inch Hardboard)

(1) Wood cost:

Cost per cord of pulpwood (2,400 pounds, oven dry) = $10.00

Yield estimated at 75 percent = $2,400 x 0.75 = 1,800 pounds of stock

Trim loss = 10 percent = 180 pounds

Over-all yield per cord = 1,620 pounds;

\[
\text{Equivalent to } \frac{1,620}{0.73} \text{ or } 2,220 \text{ square feet}
\]

Cost per thousand square feet of board = \[
\left( \frac{1,000 \times 10.00}{2,220} \right) = \$4.50
\]

(2) Conversion-process costs:

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
<th>Cost per 1,000 sq. ft. of board</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>30 hp.-days per ton of board</td>
<td>$2.43</td>
</tr>
<tr>
<td>Steam†</td>
<td>3,750 pounds</td>
<td>2.62</td>
</tr>
<tr>
<td>Water</td>
<td>10,000 gallons</td>
<td>.50</td>
</tr>
<tr>
<td>Labor</td>
<td></td>
<td>5.00</td>
</tr>
<tr>
<td>Rosin size</td>
<td>8 pounds</td>
<td>.56</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$11.11</strong></td>
</tr>
</tbody>
</table>

†500 pounds for cooking, 3,000 pounds for press drying, 250 pounds for conditioning.

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(3) Other charges:

Assuming an investment of $10,000² per thousand square feet of board per day, other charges per thousand square feet of board are:

Maintenance cost = \( \frac{10,000 \times 0.05}{300} \) = $1.67

Property tax = \( \frac{10,000 \times 0.03}{300} \) = $1.00

Depreciation = \( \frac{10,000 \times 0.05}{300} \) = $1.67

Administrative expenses = \( \frac{10,000 \times 0.05}{300} \) = $1.67

Interest on investment = \( \frac{10,000 \times 0.06}{300} \) = $2.00

Total... $8.01

(4) Summary of costs:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost per 1,000 sq. ft. of board</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>$4.50</td>
</tr>
<tr>
<td>Conversion process cost</td>
<td>11.11</td>
</tr>
<tr>
<td>Other charges</td>
<td>8.01</td>
</tr>
<tr>
<td></td>
<td>Total... $23.62</td>
</tr>
</tbody>
</table>

Mechanized, Wet Batch Process Production Costs (1951)
(1/8-inch Hardboard)

(1) Wood cost:

Cost per cord of slabs (1,800 pounds, oven dry) = $3.00

Yield estimated at 90 percent = 1,800 x 0.90 = 1,620 pounds of stock

Trim loss = 10 percent = 160 pounds

Over-all yield per cord = 1,460 pounds;
sequivalent to \( \frac{1,460}{0.73} \) or 2,000 square feet

Cost per thousand square feet of board = \( \frac{1,000 \times 3.00}{2,000} \) = $1.50

²Present costs may be higher.

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(2) Conversion-process costs:

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
<th>Cost per 1,000 sq. ft. of board</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>25 hp.-days per ton of board</td>
<td>$2.03</td>
</tr>
<tr>
<td>Steam</td>
<td>4,600 pounds</td>
<td>3.22</td>
</tr>
<tr>
<td>Water</td>
<td>10,000 gallons</td>
<td>.50</td>
</tr>
<tr>
<td>Labor</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Resin</td>
<td>20 pounds</td>
<td>6.00</td>
</tr>
<tr>
<td>Size</td>
<td>9.6 pounds</td>
<td>1.34</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>$23.09</strong></td>
</tr>
</tbody>
</table>

(3) Other charges:

Assuming an investment of $5,000\(\frac{x}{300}\) per thousand square feet of board per day, other charges per thousand square feet of board are:

- Maintenance cost \(= (5,000 \times 0.05) = \$0.83\)
- Property tax \(= (5,000 \times 0.03) = \$0.50\)
- Depreciation \(= (5,000 \times 0.05) = \$0.83\)
- Administrative expenses \(= (5,000 \times 0.05) = \$0.83\)
- Interest on investment \(= (5,000 \times 0.06) = \$1.00\)

**(4) Summary of costs:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost per 1,000 sq. ft. of board</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>$1.50</td>
</tr>
<tr>
<td>Conversion process</td>
<td>23.09</td>
</tr>
<tr>
<td>Other charges</td>
<td>3.99</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$28.58</strong></td>
</tr>
</tbody>
</table>

\(6\) Without mechanized loading and unloading equipment.
Miscellaneous Economic Considerations

In general, a yield of about 85 percent by weight may be expected in the wet process, while in the dry processes there will be little, if any, loss. If the wet continuous system and round wood are used, 25 cords will produce about 55,000 square feet of 1/8-inch board.

Labor costs were about $3.85 per 1,000 square feet of 1/8-inch (3-millimeter) board in 1949. Administrative costs for a plant making 160,000 square feet a day of 1/8-inch board were estimated at $300 per day in 1949 in the United States.

Plant depreciation is usually figured at 5 percent and amortization at 6 percent in 10 years.
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(3) BOEHM, R. M.

(4) __________

(5) DEPAN, R. T.

(6) __________

(7) __________

(8) ELMENDORF, ARMIN

(9) __________

(10) LINZELL, H. K.

(11) LOWGREN, UNO

(12) LUNDBERG, H. A.

Rept. No. D1928
(13) McGOVERN, J. N.  

(14) NORTHEASTERN WOOD UTILIZATION COUNCIL  

(15) RISI, J.  

(16) SCHAFER, R. J.  

(17) SCHWARTZ, S. L. and BAIRD, P. K.  

(18) PEW, J. C., and SCHAFER, E. R.  