

# **INSULATING BOARDS FROM MILL WASTES, FOREST THINNINGS, AND CULL TREES**

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**UNITED STATES DEPARTMENT OF AGRICULTURE  
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**FOREST PRODUCTS LABORATORY**

**Madison 5, Wisconsin**

**In Cooperation with the University of Wisconsin**

# INSULATING BOARDS FROM MILL WASTES, FOREST

## THINNINGS, AND CULL TREES

By

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U. S. Department of Agriculture

### Introduction

Building boards of the insulating type are in growing demand for house construction. Besides their principal utility as thermal insulation for exterior walls and roofs, they are used as interior surfacing materials for walls, partitions, and ceilings, as a lath base for plaster, as sheathing, and for other purposes. Two factors, low material cost and a large sheet size that reduces fabrication costs, are primarily responsible for their increasing use.

Insulating boards may also be made of a variety of materials, such as cornstalks, flax straw, sugarcane fiber, cereal straw, palmetto and licorice roots, and banana stalks. Probably the largest source of raw material is wood fiber.

The purpose of this report is to present experimental laboratory information on the technical feasibility of utilizing various wood wastes ordinarily burned or otherwise disposed of at sawmills, woodworking plants, pulp and paper mills, and similar wood-using plants.

For many commercial purposes, insulating board is given finishing treatments of one kind or another. Large commercial enterprises devote much attention to special surface finishes, colors, beveling, drilling, kerfing, laminating, and other processing of the board for specialized uses after it comes from the drier. This report does not deal with such finishing processes, but is devoted entirely to technical aspects of producing the basic board materials.

Wood wastes have been utilized at different times by manufacturers of insulating boards. Often, however, these sources of raw material have not been sufficient to supply the manufacturers regularly and continuously as production expanded. Consequently, their use was generally discontinued. In addition, because special equipment was required for preparing the various kinds of waste materials, it was found to be more practical to operate large plants with pulp woods. A minimum of 100 tons of raw material per day is generally

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<sup>1</sup>Maintained at Madison 5, Wis., in cooperation with the University of Wisconsin.

required to supply the conventional type of board mill -- a quantity much in excess of the amount of waste usually obtainable from lumber-processing plants.

Wastes that have been investigated for making insulating boards include sawdust and such solid-wood wastes as slabs and edgings usually burned at sawmills; pulp-mill wastes consisting of a mixture of bark, chipper sawdust, and chip and pulp screenings; and low-density hardwoods, such as aspen, available as woods thinnings and sawmill waste. Research findings as to the potentialities of these materials and as to the possible types of insulating board they could be used for are reported here.

### Evaluation of Boards

The kinds of insulating board experimentally produced at the Forest Products Laboratory were evaluated in accordance with certain of the test requirements of Specification LLL-F-321b of the Federal Standard Stock Catalog. This specification sets up minimum strength and other properties for insulating board of five classes for procurement use by the departments and other establishments of the Federal Government. The five classes are: Class A, building board; Class B, lath (for plaster base); Class C, roof insulation board; Class D, interior boards (factory finished); and Class E, sheathing.

The results of this investigation indicate the marginal character of the products. Some of the insulating boards made from sawdust and chipped solid wood with hydrated binder pulps would meet requirements of these tests for all types of insulating boards; several other boards appear suitable for one or more types of boards. The most promising boards contained at least 15 percent of hydrated binder pulp. Satisfactory boards were also made by employing repulped old newspapers as the binder. The processing of the waste materials in an attrition mill resulted in boards superior to those made of unprocessed waste materials. Several boards made of unprocessed waste were, however, satisfactory for some types of insulating board when mixed with at least 25 percent of binder pulp and when the matted pulp was press-dried.

Woods thinnings and wood waste that accumulates in pulp mill wood yards were processed and made into test sheets having a range of properties that could be compared with the properties of test sheets made from pulps known to be satisfactory for some classes of insulating boards. Some of the test sheets were comparable in certain strength properties to those made from pulps of established usefulness for roof insulating boards and roofing felts.

It should be pointed out that, in general, most of the pulp mixtures made were too slow in water-drainage characteristics (freeness) for use on conventional board machines and would require modifications of the equipment.

## Boards from Processed Sawdust, Solid-wood Waste, and Mixtures

Insulating boards were made of sawdust and solid-wood waste (aspen chips) processed in an attrition mill to reduce the material to a fibrous state. Some boards were manufactured of 100 percent processed sawdust, some of 100 percent chipped and processed solid-wood waste, and some of either sawdust or solid-wood waste in mixture with a pulp binder. The various mixtures were formed into boards in a suction mold and dried in a hot press. Properties of the boards were determined according to certain of the tests set forth in Federal Specification LLL-F-321b.

### Materials

Materials used in making the insulating boards of processed waste included a sifted pine sawdust, aspen chips (used to represent solid-wood waste that might occur along with sawdust), aspen neutral sulfite semichemical pulp, repulped newspapers, rosin size, and alum. The sawdust passed through a 4-mesh screen and was retained on a 40-mesh screen.

The semichemical pulp used as a binder (digestion No. 1-50202N) was prepared with 14 pounds of sodium sulfite and 5.7 pounds of sodium bicarbonate per 100 pounds of moisture-free wood. This pulp was steamed for 1/2 hour, given an impregnation period of 1-1/2 hours at 120° C. (248° F.), and cooked for 2-1/4 hours at 160° C. (320° F.). The soft cooked chips were then passed through the attrition mill at a wide plate setting. This coarse fibrous material was hydrated in a beater to a gelatinous condition. The freeness of this pulp was 93 milliliters (Schopper-Riegler).

Old newspapers were beaten to a Schopper-Riegler freeness of 566 milliliters for use in some of the boards, either alone or in mixture with the sawdust and chipped waste.

### Method of Processing

Batches of the chips and sawdust were separately processed in a 36-inch disk-type attrition mill. Seven runs were made, three on air-dried chips and four on chips that had been soaked in hot water and left immersed about 16 hours. Various plate clearances were used, and the energy consumption and Oliver freeness, described later in this report, of each stock were determined.

The sawdust was soaked similarly and processed. Two runs were made with the plate clearance set at zero, but with the amount of shower water varied to bring about differences in the consistence of the stock passing through the mill. Determinations were made of the energy consumption in milling and of the Oliver freeness of the stocks.

Both the chip and the sawdust pulps were pressed to a moisture content of approximately 35 percent before storage.

## Board Formation

Insulating boards approximately 1/2 inch thick and 20 pounds per cubic foot in density were formed in an 18-inch-square suction mold. The calculated charges of pulp were dispersed in water by means of a motor-driven stirrer in a 30-gallon tank fitted with a 2-inch, quick-opening valve. Sufficient water was added to bring the consistence to 2 or to 4 percent. The suspension was then neutralized with a small amount of a 10 percent solution of sulfuric acid. Four percent of rosin size and then 4 percent of papermaker's alum were added. The pH (acidity) value of the stock at this stage was about 4. The stock was run into the mold restirred, and the water removed by applying a 15-inch vacuum.

The wet mat, approximately 1-1/2 inches thick, was removed and placed on a 16-mesh wire screen. It was placed between cauls and pressed in a slow-action press so that the spring-back thickness was about 5/8 inch.

Most of the pressed mats were air-dried, although some were dried in a 20-inch hot press. The air-dried mats were transferred to a frame and dried at 40° to 50° C. (104° to 122° F.) for approximately 24 hours. Stops were used in the hot press to obtain 1/2-inch boards. The temperature of the platens ranged from 173° to 180° C. (343° to 356° F.), and the time necessary to dry the mats was approximately 1 hour.

The stocks at 4 percent consistence possessed a high degree of fluidity and were handled as were those at 2 percent. The furnishes containing milled-chip pulps were not so fluid at 4 percent consistence as the others.

## Testing Procedure

In general, two boards were made of each furnish selected for test. One board provided three specimens for transverse breaking load and three specimens for tensile-strength determinations. The other board provided one water-absorption, one linear-expansion, and two water-permeability test specimens. The camber, if any, in the various air-dried specimens was removed by conditioning the test pieces to equilibrium at 97 percent relative humidity and redrying them under restraint at room temperature. The strength test specimens were then conditioned for at least 24 hours in a relative humidity of 65 percent and at a room temperature of 27° C. (80° F.). Tests made according to Federal Specification LLL-F-321b were for transverse breaking strength, tensile strength, water absorption, water permeability, and linear expansion.<sup>2</sup>

In Federal Specification LLL-F-321b strength in transverse bending is assumed to vary in direct proportion to the thickness (depth) of the specimen. In beams, however, the strength in bending actually varies as the square of the depth. The transverse-breaking-load values obtained from test were, therefore, adjusted to correspond to specimens 1/2 inch thick, on the basis that they varied as the square of the depth. Corrections were also

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<sup>2</sup>Deflection tests were not made.

made for density on the basis that strength varied as the square of the density. A common density of 20 pounds per cubic foot was used as a basis of comparison.

The formula<sup>3</sup> used was as follows:

$$\text{Corrected breaking load} = \frac{\text{Measured load (20)}^2 (0.5)^2}{(\text{Measured density in lb. per cu. ft.})^2 (\text{Measured thickness in inches})^2}$$

### Test Results

Twenty-two boards were made, 21 of which contained milled sawdust or milled simulated solid-wood waste. These materials constituted 85 to 100 percent of the various furnishes, except for board No. 636. Table 1 lists the composition of each board. Where used, pulp binders comprised 15 percent of the furnish. These boards were tested for transverse breaking load, tensile strength, water absorption, water permeability, and linear expansion.

Ten of the boards met or exceeded the requirements for building board (Class A) in transverse breaking load and in tensile strength. Two other boards practically met these qualifications. Three of these 12 were not tested for properties other than strength. The other 9 met specification requirements for water absorption and linear expansion, and 6 met the 14-pound transverse-breaking-load requirement for sheathing board (Class E).

Board No. 641 (table 1), which contained 85 percent of milled sawdust and 15 percent of hydrated pulp, practically met the requirements of the tests made for all types of insulating board. Two other boards, Nos. 627 and 629, which consisted 100 percent of processed soaked and processed air-dried aspen chips, respectively, met (or practically so) the requirements of the tests made for building board.

To determine the feasibility of using repulped newspapers in place of hydrated pulp, five boards were made using various amounts of this material. One, made entirely of repulped newspaper, gave the highest transverse breaking load and tensile strength. Another, containing 15 percent of this binder with milled air-dried aspen chips, also exceeded strength requirements for Class E boards. A third board, No. 657, met the strength requirements for Class A and B boards.

### Boards from Unprocessed Sawdust

To determine whether processing in an attrition mill could be dispensed with and thereby effect economy of equipment and in manufacturing costs, a series of boards was made of unprocessed sawdust. This material was used in

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<sup>3</sup>This formula was developed by the Armstrong Cork Company and confirmed by test data at this Laboratory.

admixture with binder pulps of various freenesses and in various quantities. Boards were formed in a suction mold after which some were press-dried and some air-dried. These boards were tested according to Specification LLL-F-321b also.

### Materials

Pine sawdust previously mentioned was used as the raw material. Some boards were also made with hydrated pulp binder (digestion No. 1-5202N), but in these tests the binder pulp was used at five different Schopper-Riegler freenesses, 885 (original stock), 630, 500, 280, and 93 milliliters. In addition, two boards were made with a binder pulp from a similar cook (digestion No. 1-5134N). This binder pulp, after passing through the attrition mill, was beaten for 4 hours to a Schopper-Riegler freeness of 75 milliliters.

### Board Formation

Furnishes for board formation were made in mixtures containing 15, 25, and 35 percent of hydrated binder pulp. The furnishes were prepared at consistences of 2, 4, and 8 percent (table 2). After formation, the mats were either press-dried or air-dried.

The Oliver freeness, a drainage-rate test, was determined for all 17 sawdust and pulp combinations made. To make this test, 150-gram samples, oven-dry basis, were charged to an Oliver leaf filter 9-1/2 inches in diameter. In each case, a volume of water was added to make up 1 1/4 quarts of stock (1.13 percent consistence), and the free water was removed under 10 inches of vacuum. The time of drainage was recorded in seconds. All the Oliver-leaf-filter mats so obtained were oven-dried and examined for segregation of sawdust and pulp and for potential flexural strength. In one case, Oliver-leaf-filter boards were made at 2.26, 4.52, and 7.42 percent consistence to determine the effect of this factor on the drainage rate, degree of segregation, and potential flexural strength.

The board stocks made at 8 percent consistence were difficult to stir and, when poured into the mold, had to be puddled like concrete. These furnishes were mixed in a bucket with a motor-driven stirrer having a special propeller capable of handling the heavy stock.

### Test Results

The boards made of unprocessed sawdust were, in general, less satisfactory than those made of processed waste. They varied widely in properties, as shown in table 2. Those that were press-dried were generally superior to those that were air-dried.

Strength of boards.--The flexural (transverse breaking) and the tensile strength of the boards made of unprocessed sawdust were found to increase in direct proportion to the degree of hydration of the pulp binder or to



the amount of binder used. In general, it appears that no less than 25 percent of highly beaten pulp is required to make a 1/2-inch board of a density of 20 pounds per cubic foot that will meet the flexural and tensile-strength requirements for building board (Class A). As shown in table 2, none of the boards made with 15 percent of pulp binder met these strength requirements.

The effects of the methods of drying the boards are also shown in table 2. The air-dried boards were uniformly weaker than the press-dried boards in both tensile and flexural strengths. Much of this difference, however, may be attributed to the lack of uniformity of the surface finish of the air-dried boards.

Moisture-exposure effects.--The results of moisture-permeability, water-absorption, and linear-expansion tests are also given in table 2. Only one-half of the boards met the moisture-permeability requirement for sheathing board (Class E). No specific correlation appears to exist between the water-permeability and water-absorption properties.

With one exception, board No. 618-3, all press-dried boards met the water-absorption test requirements for all types of insulating boards. Six of 10 air-dried boards failed to meet the water-absorption requirement of 7 percent for building and lath board, although all were below the 10 percent maximum allowed for roof insulating and interior board.

All of the press-dried boards met the linear-expansion requirements, but only two of the 10 air-dried boards qualified in this respect.

The failure of the air-dried boards to meet water-absorption and linear-expansion requirements is ascribed to the low temperature used in drying the, 40° to 50° C. (104° to 122° F.), which was insufficient to set the rosin size. The 174° C. (345° F.) platen temperature used with the press-dried boards, on the other hand, was ample for this purpose.

#### Manufacturing Limitations

The suitability of the various furnishes of unprocessed sawdust with a pulp binder for board manufacture on conventional commercial board machines was gaged by testing the drainage rate of the various furnishes by the Oliver method. The Oliver freeness of a stock suitable for running on commercial board machines is considered to be between 40 and 60 seconds. Of 15 board stocks tested, only 2 met these drainage-rate requirements. The others were either too slow or too fast. Neither of the two boards showed much promise as to appearance or strength. In both there was considerable segregation of sawdust from the binder.

Drainage time of the mats in the forming mold ranged from 0.8 to 7.2 minutes. The effect of the consistence of the furnish on drainage time was pronounced and corresponded to values obtained in the Oliver freeness tests of the furnishes.



In all cases in the laboratory, the mats were presqueezed in the forming mold to approximately the same moisture content, about 70 percent. Consequently, freeness of the pulp binder and the proportion of binder used did not appear to have any appreciable effect upon the drying time. In the case of laboratory press-dried boards, about 1 hour at 174° C. (345° F.) was required to bring the moisture content from 70 to 5 percent or less. This long drying time obviously precludes commercial acceptance of such a procedure. Air-dried boards required about 24 hours. It appears that the use of sawdust would in no way lessen the drying time and steam requirements for the conventional continuous-kiln process of drying insulating board.

#### Board Materials from Thinnings and Cull Trees

Exploratory investigations of the possibility of utilizing thinnings and cull trees of secondary species for insulating-board materials were limited to the production of pulps and test sheets. Insulating boards were not made. The suitability of the pulps was judged by comparing the properties of test sheets made from them with the properties of test sheets made from pulps suitable for insulating boards.

The raw material used in these tests was aspen, a low-density hardwood in potentially abundant supply as woods thinnings and sawmill waste. Aspen is a common second-growth species throughout New England and the Lake States.

#### Preparation of Material

The aspen raw material was obtained in a fiberized condition from a commercial source; that is, the wood, bark and all, had been prepared in a fiberizing machine by the supplier. This material was selected because it can be prepared from relatively small quantities of waste by a defiberizer that is capable of processing about a cord of wood an hour, and because it can be baled for shipment to a centralized converting mill.

Some of the fiberized material was either soaked in water for 24 hours and then steamed at 170° C. (328° F.) under pressure, or was digested in sodium carbonate solution under steam pressure at 180° C. (356° F.). It was then pulped in an attrition mill with fine-tooth plates to a freeness of approximately 500 milliliters (Canadian Standard) or 750 milliliters (Schopper-Riegler).

Another portion of the material, after being either soaked, steamed, digested in sodium carbonate, or given a mild cooking treatment in neutral sodium sulfite solution at 180° C. (356° F.) under steam pressure, was run through an attrition mill with coarse-tooth plates to produce pulps with a freeness of about 800 milliliters (Canadian Standard). The fibers were thus kept as coarse as possible in order to determine how strength developed in a test beater compared with that of pulps of about the same freeness treated in an attrition mill.

In the chemical digestions a quantity of chemical equal to 5 percent of the weight of the oven-dry wood was used in a liquor-to-wood volume ratio of 2.5 to 1. The maximum digestion temperature of 180° C. (356° F.) was reached in 1-1/4 hours.

The pulps so made were formed into test sheets either with or without further processing in a beater. These test sheets were evaluated for density and for bursting, tearing, and tensile strengths.

### Results of Tests

Test sheets made from fiberized aspen given a mild chemical digestion and passed through an attrition mill with fine-tooth plates were weaker than those produced from similar pulps milled with coarse-tooth plates. After being passed through an attrition mill with fine-tooth plates, the fiberized wood exhibited, under polarized light, compression failures that were points of weakness thought to be partly responsible for more fiber breakage, weaker pulp, and, finally, a weaker board. Coarser plates in the attrition mill did not cause so much fiber breakage, as they tended to brush the fibers apart.

The results of the strength tests are shown in table 3. These results were compared with those of test sheets made, in another study, from western hemlock slabwood chips cooked with dilute sodium sulfite solution and run through an attrition mill to a freeness of 600 milliliters (Canadian Standard). The sheets made from the hemlock pulp had a bursting strength of 0.07 point per pound per ream, a tearing strength of 0.87 gram per pound per ream, and a tensile strength of 138 pounds per square inch. Insulation boards made from this pulp met the strength, water-absorption, and linear-expansion requirements for roof insulating board and interior board.

These tests of aspen pulp were run primarily to determine whether pulp of sufficient freeness to be used on a conventional board machine would have strength properties suitable for insulating board. Table 3 shows that pulp of digestion No. 5270, run through an attrition mill with horizontal plates, was comparable in test-sheet properties with the hemlock sheets, even at freenesses of 720 and 550 milliliters (Canadian Standard), which are probably suitable for conventional-board-machine operation. At lower freenesses, this pulp could probably be used for board formation by the suction-mold method in forming boxes, as could several of the other pulps, notably digestion No. 5269. Many of the pulps were lacking only in tearing strength.

### Board Materials from Pulp-mill Wood Waste

To determine whether pulp-mill wood waste, such as occurs at barkers, chippers, chip screens, and pulp screens, can be made into pulps suitable for manufacture of insulating board, pulps were made from mixtures of these wastes, and sheets consisting of the pulps were tested for strength. The investigations were not carried to the point of making and testing

insulating boards, but strength properties of the test sheets were compared with those of sheets made from pulps used for insulating board.

The wastes that accumulate in relatively large quantities at pulp mills are usually burned for fuel or are permitted to rot. The raw material used in these tests was eastern hemlock waste collected at the barkers, chippers, chip screens, and pulp screens of a typical Wisconsin pulp mill. It consisted of about 50 percent inner bark, 28 percent outer bark, 4 percent chipper sawdust, and 18 percent chip and pulp screenings.

#### Preparation of Material

The waste was first run through a chipper to reduce large pieces to usable size. It was then either soaked in water for 24 hours, steamed at 170° C. (328° F.), digested in sodium carbonate solution at 180° C. (356° F.) or digested in neutral sodium sulfite solution at 180° C. (356° F.).

The water-soaked waste was run through an attrition mill with coarse-tooth plates. In the chemical digestions a quantity of chemical equal to 5 percent of the oven-dry waste was used, with the ratio of cooking liquor to pulp-mill waste being 2.5 to 1. The maximum digestion temperature of 180° C. (356° F.) was reached in 1-1/4 hours. The pressure was then relieved, and the waste was dumped into a screen-bottom drainer and washed thoroughly.

The cooked wastes were attrition milled and these pulps were made into test sheets of 340-pound ream weight either with or without further processing in a beater. The test sheets were evaluated for density and for bursting, tearing, and tensile strength.

#### Results of Tests

All of the pulps produced from pulp-mill waste were very weak. That from the sodium sulfite digestion was slightly stronger than the others, but the yield was lower than expected because of the loss of fine material through the 75-mesh screen of the drainer.

Different settings of the attrition-mill plates within a clearance range of 0.015 inch had little apparent effect on the strength-development characteristics of the pulps. Greater variations, however, produced a significant change in both freeness and strength properties. This is shown in table 4, where a change in plate clearance from 0.050 to 0.020 inch on digestion No. 5286 dropped the freeness from 800 to 720 milliliters (Canadian Standard) and, at the same time, increased the pulp strength so that a sheet could be formed.

The results of the strength tests (table 4) were compared with properties of test sheets made, in another study, from western hemlock slab wood, water-soaked and fiberized in an attrition mill. The hemlock sheets had a bursting strength of 0.03 point per pound per ream, a tearing strength of 0.39 gram per pound per ream, and a tensile strength of 59 pounds per square inch.

The pulp from which they were made had been formed into a board complying with the strength requirements for roof insulating board.

Pulp from pulp-mill waste digested with dilute sodium sulfite (digestion No. 5279) was made into test sheets comparable in bursting, tearing, and tensile strength with those made of the western hemlock pulp (table 4). At a freeness of 685 milliliters (Canadian Standard) this pulp appears suitable for formation of roof insulating boards on a commercial board machine. At the lower freenesses it is probably suitable for formation into roof insulating boards by the suction-mold process, although no board-forming experiments with this pulp were made.

The steam-cooked fiberized aspen pulp listed in table 3 (digestion No. 5267 run through an attrition mill with horizontal plates) also compares in test-sheet strength properties with the western hemlock pulp at the lower freenesses.

Where transportation costs from a mill to a converting plant are an important factor, economic use of such wastes may be affected by the somewhat low yields obtained. Table 4 shows that the yield of sodium sulfite pulp was 84 percent. This compares with the 91 percent yield of fiberized aspen pulp digested with sodium carbonate shown in table 3.

1. Older people are more likely to be employed and have a higher income than younger people.

Board No.	Form	Material	Milling data				Solvent analysis				Hard properties				Water absorption by weight % by volume	Blower efficiency																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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Classification Requirements for 1/2 inch Board		
Class A and Class B - Building and lath board	1212	14 7.0 14 5
Class K	1214	14 5 14 5

Energy-consumption data were obtained on extremely short runs, therefore they must be considered as exploratory only. (Data represent energy to the mill, not that actually absorbed by material.)

Density and thickness measurements for transverse-breaking-load specimens only.

connected to a density of 20 pounds per cubic foot and 1 1/2 inch thick. The density of the material is 100 pounds per cubic foot.

210-8721001 - 10-11-68

STATOR UNIT TO GENERATING UNIT WAS SHOWN ON 07 TO ALTHOUGH W OF DISTANCE

$$\text{Corrected load} = \frac{\text{measured load}}{(20)^2 (0.5)^2}$$

(normalized density)  $\rho$  measured throughout  $z$

4

Corrected to a density of 20 pounds per cubic foot on the assumption that the tensile strength

Aspen chips, shipment No. 2423, soaked in hot water and allowed to stand immersed overnight.

expended until now about \$50,000 to establish a permanent fund for the purpose of providing for the maintenance of the monument.

Amesbury, September 24, 1923.

shipment no. 2465. worked in hot water and allowed to stand immersed in water until shipment no. 2471.

1. The first step in the process is to identify the problem. This involves gathering information about the situation and the people involved.

ampere neutral sulfate marginal pump, digestion no. 1-5202K, hydrated in a beater to =

Blurred pine sawdust, analysis No. 2465.

Old newspaper repulped in a 5-pound-capacity beater to a Schopper-Riegler frequency of 566

Federal Specification for Fiberboard: Insulating 44-F-321b (December 17, 1942).

Submitted: 2002 November 14

 $\hat{y} = x_{\text{minimum allowable value}}$ 

Z M 84058 F

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Table 2.--Some properties of experimental 18- by 18-inch boards of unprocessed sawdust and hydrated binder pulp

Board No.	Sawdust amount	Pulp <sup>1</sup> amount	Consist: Means of drying or board stock	Board properties										Character of the board			
				Density <sup>2</sup> : Thickness <sup>2</sup> : breaking load <sup>2</sup> : Original: Adjusted: Original: Adjusted:	Tensile strength		Water permeability		Water absorption		Linear expansion		Warping		Surface		
Percent	Gr.	Percent	Percent	lb. per sq. ft.	lb.	lb.	lb. per sq. ft.	lb.	lb.	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
605	65	885	25	2	Air	17.2	0.576	2.8	2.9	28	42	18	31.2	7.6	0.40	Slight	Poor
608	65	530	25	2	Air	20.2	.563	11.1	8.6	133	131	20	27.5	7.3	.80	Considerable	Good
621	65	280	35	4	Hot press	22.7	.489	13.5	13.2	276	203	24	15.2	5.0	.24	None	Excellent
622	65	280	35	4	Hot press	23.6	.458	17.9	15.3	280	221	27	10.3	3.7	.18	None	Excellent
606	75	885	25	2	Air	17.0	.605	2.8	2.7	27	41	20	33.5	8.6	.40	Slight	Poor
609	75	530	25	2	Air	18.1	.623	7.1	5.6	69	88	20	33.2	9.7	.69	Slight	Fair
612	75	500	25	2	Air	20.5	.566	10.2	7.6	88	90	22	31.5	9.7	.75	Considerable	Good
615	75	280	25	2	Hot press	21.6	.588	11.7	8.8	134	121	22	11.6	3.9	.28	None	Excellent
619	75	93	25	8	Hot press	22.9	.487	15.2	12.3	196	166	18.5	13.5	4.3	.20	None	Excellent
626	75	75	25	4	Hot press	21.9	.471	16.7	15.7	278	213	25.5	13.5	4.3	.20	None	Excellent
620	85	500	15	4	Hot press	21.0	.505	6.1	5.4	66	67	16	20.4	6.2	.40	None	Excellent
616	85	280	15	2	Air	18.1	.605	4.9	4.1	57	71	17	15.1	5.1	.95	Considerable	Fair
602A-1	85	93	15	2	Hot press	20.0	.534	8.0	7.0	102	107	26.5	18.1	5.7	.31	None	Very good
602A-4	85	93	15	2	Hot press	20.1	.489	7.6	7.9	103	106	24	13.7	4.4	.50	None	Excellent
617-6	85	93	15	4	Hot press	21.6	.492	8.4	7.4	108	100	24	16.6	4.8	.30	None	Excellent
623-1	85	93	15	4	Hot press	21.2	.490	7.7	7.1	110	97	12	32.1	10.3	.35	None	Excellent
618-3	85	93	15	8	Hot press	20.8	.496	10.4	9.8	111	91	12	16.5	5.0	.35	None	Excellent
624-1	85	93	15	8	Hot press	21.0	.499	7.4	6.7	69	75	15	16.5	5.0	.35	None	Excellent
602A-2	85	93	15	2	Air	20.1	.584	8.2	5.9	74	90	22.5	17.2	8.1	.81	Considerable	Good
602A-6	85	93	15	2	Air	18.3	.500	6.9	8.3	93	96	17	28.5	4.7	.70	Considerable	Good
617-2	85	93	15	4	Air	18.4	.628	9.4	7.1	71	92	24.5	17.2	6.0	.70	Considerable	Good
618-5	85	93	15	8	Air	18.8	.588	8.1	6.6	59	65	15.5	22.3	5.7	.79	Considerable	Good
624-3	85	93	15	8	Air	17.3	.624	7.7	6.6	63	79	15.5	18.4	3.1	.26	None	Excellent
625	85	75	15	4	Hot press	20.4	.490	8.0	8.0	111	88	25	8.8	3.1	.26	None	Excellent

<sup>1</sup>Aspen neutral sulfite semichemical pulp digestion No. 1-5202N in all cases except for boards Nos. 625 and 626.

<sup>2</sup>Density and thickness values for transverse-breaking-load test specimens only.

<sup>3</sup>Corrected to a density of 20 pounds per cubic foot and 1/2-inch thickness by the formula:

$$\text{Corrected load} = \frac{\text{Measured load}}{\left( \frac{\text{Measured density}}{\text{Measured thickness}} \right)^2}$$

<sup>4</sup>Corrected to a density of 20 pounds per cubic foot on the assumption that the tensile strength varies as the square of the density.

<sup>5</sup>Aspen neutral sulfite semichemical pulp digestion No. 1-5134N.

**Table 3.--Digestion, milling, and test-sheet data on fiberized aspen wood compared with data on a Western hemlock pulp from which roof insulating board was made**

Cooking data										Test-sheet data									
Digestion					Attrition					Process					Tensile				
No.	Type of treatment	Total time	Maximum temperature	Yield	Type of plate	Time of clearing	Plate	Min. time	M.L.	Pts. per lb. per min.	Greenness	Bursting strength	Tearing strength	Density					
		Hr.	°C.	Percent		In.						lb. per sq. in.	lb. per sq. in.	Gm. per cc.					
	None				Vertical	0.015		0	625	0.04	0.21	106	106	0.28					
					cal			20	420	0.06	0.11	146	146	0.30					
								40	340	0.06	0.08	176	176	0.32					
								60	300	0.05	0.09	225	225	0.33					
	Water	24.0	25		Vertical	0.015		0	460	0.05	0.35	225	225	0.33					
	soaking				cal			20	350	0.06	0.18	182	182	0.31					
								40	325	0.06	0.12	194	194	0.32					
								60	280	0.07	0.15	276	276	0.34					
5267	Steam	1.25	170	74.9	Vertical	0.030		0	415	0.03	0.20	111	111	0.39					
	cooking				cal			20	380	0.04	0.25	195	195	0.38					
								40	320	0.04	0.25	199	199	0.39					
								60	300	0.05	0.24	338	338	0.44					
5270	Sodium	1.25	180	91.0	Vertical	0.030		0	820	0.08	0.08	66	66	0.24					
	carbonate				cal			20	760	0.07	0.18	238	238	0.27					
								40	450	0.07	0.21	349	349	0.29					
								60	350	0.07	0.21	349	349	0.29					
	Water	24.0	25		Horizontal	0.020		0	795	0.02	0.15	11	11	0.27					
	soaking				zental			20	635	0.02	0.14	41	41	0.34					
								40	420	0.02	0.24	122	122	0.34					
5267	Steam	1.25	170	74.9	Horizontal	0.015		0	790	0.03	0.28	41	41	0.37					
	cooking				zental			20	430	0.06	0.39	427	427	0.45					
								40	220	0.08	0.39	589	589	0.47					
5270	Sodium	1.25	180	91.0	Horizontal	0.015		0	720	0.06	0.58	190	190	0.32					
	carbonate				zental			20	550	0.11	0.80	497	497	0.38					
								40	340	0.18	0.91	800	800	0.38					
5269	Sodium	1.25	180	93.8	Horizontal	0.035		0	770	0.04	0.49	129	129	0.33					
	sulfite				zental			20	550	0.08	0.73	536	536	0.45					
								40	305	0.13	0.71	1,091	1,091	0.48					
Western hemlock	Sodium sulfite								600	0.07	0.87	138	138	0.29					



Table 4.--Cooking, milling, and test-sheet data on pulpmill waste compared with data on a Western hemlock pulp from which roof insulating board was made

Cooking data										Sheet test data						
Digestion No.	Type of treatment	Total time	Maxi- mum tem- perature	Yield: Milling data	Per- cent	Hours	°C.	Inch	Minutes	Ml.	Pts. per lb. ream		Bursting strength	Tearing strength	Tensile	Density
											lb. ream	Gm. per lb. ream				
.....	Water soaking	24.0	25	.....	.....	0.020	0	0	0	715	.....	Too weak to form sheets	.....	.....	.....	.....
							20		20	600	0.02	0.06	8	0.29		
							40		40	365	0.01	0.07	31	0.34		
							60		60	295	0.02	0.15	61	0.34		
5276	Steam cooking	1.25	180	75.8	.....	0.050	0	0	0	800	0.02	0.12	79	0.29		
							20		20	590	0.03	0.24	108	0.38		
						0.035	40		40	210	0.04	0.30	347	0.42		
							0		0	800	0.02	0.09	.....	0.31		
							20		20	480	0.03	0.29	135	0.38		
							40		40	215	0.05	0.30	347	0.41		
5286	Sodium carbonate	1.25	180	90.6	.....	0.050	0	0	0	800	.....	Too weak to form sheets	.....	.....	.....	.....
							20		20	700	0.02	0.22	65	0.32		
							40		40	400	0.03	0.35	164	0.38		
							60		60	135	0.04	0.40	409	0.43		
						0.020	0		0	720	0.03	0.20	31	0.32		
							20		20	430	0.04	0.23	279	0.43		
							40		40	215	0.05	0.28	450	0.44		
5279	Sodium sulfite	1.25	180	84.0	.....	0.015	0	0	0	685	0.03	0.39	134	0.34		
							20		20	430	0.06	0.45	254	0.40		
							40		40	215	0.07	0.48	746	0.46		
						0.010	0		0	670	0.04	0.38	139	0.35		
							20		20	370	0.06	0.39	358	0.41		
							40		40	170	0.07	0.37	634	0.44		
Western hemlock	Water soaking	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.03	0.39	59	.....	.....	.....