EXPERIMENTS ON THE PRODUCTION OF INSULATING BOARD AND HARDBOARD FROM WESTERN SAWMILL AND LOGGING WASTE

August 1947

No. R1680

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison, Wisconsin
In Cooperation with the University of Wisconsin

EXPERIMENTS ON THE PRODUCTION OF INSULATING BOARD AND HARDBOARD FROM WESTERN SAWMILL AND LOGGING WASTE[1] [2]

By

S. L. SCHWARTZ, Engineer
J. C. PEW, Engineer
E. R. SCHAFER, Engineer

Forest Products Laboratory,[3] Forest Service
U. S. Department of Agriculture

Abstract

Insulating-board and hardboard experiments were made on eight types of western sawmill, veneer-mill, and logging wastes. Western hemlock slab-and-edging waste was subjected to six softening treatments, including water, steam, sodium sulfite, caustic soda, and lime. Because of quality of product, considered in relation to simplicity of treatment, a steaming treatment of 1/2 hour to 180° C. and 1/4 hour at 180° C. was used for the other wastes.

Acceptable insulating boards and hardboards were obtained from Western hemlock slabs and edgings, and from veneer wastes and white fir logging waste. Less promising results were obtained from the Western hemlock planer ends, apparently because of the bruised condition of the hogged material. Boards produced from the Douglas-fir wastes were of marginal or submarginal quality, especially those made from the hogged planer ends. The Douglas-fir planer shavings, a finely divided type, when used alone, were wholly unsuited for the purpose. It is possible that better results might be obtained from the Douglas-fir wastes by use of other cooking and manufacturing methods.

---

[1] Presented at the annual meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., February 23-27, 1947.

[2] Acknowledgment is made to the Simpson Logging Company, Shelton, Wash., for its cooperation in this work.

[3] Maintained at Madison 5, Wis., in cooperation with the University of Wisconsin.

Introduction

This report describes experiments on sawmill and logging wastes from western woods for the production of insulating boards and hardboards. The work included a limited investigation of several procedures for the preparation of the coarse-fibered pulps, and the determination of the suitability of several species and forms of waste for these products.

Eight samples of sawmill and logging wastes and three mixtures of equal parts by weight of some of the wastes, as given in the following list, were tested.

1. Western hemlock slabs and edgings.
2. Western hemlock hogged planer ends.
3. Western hemlock hogged veneer waste.
4. Douglas-fir, old growth, slabs and edgings.
5. Douglas-fir, old growth, hogged planer ends.
6. Douglas-fir, old growth, hogged veneer waste.
7. Douglas-fir, old growth, planer shavings.
8. White fir cordwood (logging waste).
9. Mixture of Douglas-fir, old-growth, slabs and edgings and Western hemlock slabs and edgings.
10. Mixture of Douglas-fir, old-growth, slabs and edgings and Douglas-fir, second-growth, cordwood (logging waste).
11. Mixture of Douglas-fir, old-growth, slabs and edgings and white fir cordwood.

Equipment and Procedure

Cooking and Milling

The wood wastes, either as received or later converted to chip form, were treated, or softened, by soaking in water or by some cooking procedure and then pulped in a 36-inch Bauer mill. One of the wastes, Western hemlock slabs and edgings, was selected for a variety of treatments as follows:

1. Soaking in water.
2. Steaming at elevated temperatures and pressures.

3. Digesting in water at elevated temperatures and pressures.

4. Digesting in neutral sodium-sulfite solution at elevated temperatures and pressures.

5. Digesting in caustic-soda solution at elevated temperatures and pressures.

6. Digesting with lime and water at elevated temperatures and pressures.

Five-eighths-inch chips were prepared from the Western hemlock slabs and edgings. For the experiments involving water-soaked chips, a quantity of the chips were soaked in water at room temperature for 24 hours and then divided into lots of 10 pounds each (oven-dry equivalent) for milling. At first, the chemical, steam, and water-cooking treatments were conducted in a 1.5-cubic-foot stainless-steel-lined rotary digester, and the charge of chips in each case was, on an oven-dry basis, approximately 12.5 pounds. In each type of treatment, several such digestions were made in order to arrive at appropriate cooking and milling conditions. Later, selected procedures were followed by cooking in a 13-cubic-foot digester, using 50 pounds or more (oven-dry basis) of chips and subdividing the cooked chips into portions for milling trials.

In conducting the smaller digestions, yields were determined by sampling the softened chips after they had been soaked overnight in hot water. This procedure gave unreliable results, because, even after the long soaking period, the chips contained considerable soluble matter. Consequently, in making the larger digestions, the yields were determined by processing a sample of each run in a 10-pound size beater and determining the resulting amount of washed stock.

The other wastes were digested by a single process only; that is, steaming at an elevated temperature and pressure. A schedule of 1/2 hour to a maximum temperature of 180° C. and 1/4 hour at that temperature was used. The cooks were made in the larger digester, and yields determined by fiberizing a sample of the chips in the beater as explained previously.

Except for the soaking process the treated chips were milled, using B-980 plates run in a counter-clockwise (cutting) direction. In the experiments with soaked wood, it was found preferable to reverse the direction of rotation in order to secure a brushing action. The resulting pulps were collected in a screen box, and a preliminary Oliver freeness was determined on the stock in this state. The pulps were then pressed to remove excess water, the dryness determined, and the Oliver freeness checked, using accurately measured samples. The Oliver freeness of a stock suitable for running on existent commercial board machines should be between 40 and 60 seconds. It was found difficult, even with repeated trials, to mill small runs within these limits. Consequently, the mixing of free and slow pulps to obtain a suitable freeness was resorted to in several instances. When this practice was used, the component pulps selected usually had been milled so as to be reasonably close to this desired freeness range.

Insulating Boards

Insulating boards of approximately 1/2-inch thickness and 17-pounds-per-cubic-foot density were formed in an 18-inch-square improvised suction mold. The charge of pulp was dispersed in water by means of an electric stirrer in a 30-gallon tank fitted with a 2-inch, quick-opening valve. Sufficient water was added to bring the consistency to 1 percent. The suspension was then neutralized with a small amount of 10 percent solution of sulfuric acid. This was done to overcome the high alkalinity of the local water supply, which sometimes interferes in the sizing operation. Four percent rosin size and then 4 percent papermakers alum were added. The pH of the stock at this stage was approximately 5. At this point the agitation was discontinued and the stock run into the mold. The stock was stirred in the mold; the suction was then applied, and the mat sucked as dry as possible.

The wet mat, approximately 1-1/2 inches thick, was removed, placed between sheet-metal cauls, and pressed in a hydraulic press so that the springback thickness was approximately 5/8 inch. This control was obtained by the use of stops between the press platens. The stops varied from 5/16 inch to 1/2 inch, depending on the nature of the stock.

The pressed mats were then transferred to a drying frame and dried 14 to 16 hours, or longer if necessary, in a forced-circulation oven at 45° to 65° C. The finished boards were cut into test specimens.

Hardboards

The wet mats of rosin-sized pulp for the approximately 1/8 inch thick hardboards were formed in an improvised 13 inch square suction mold. The charge of pulp was sufficient to produce a board of a density of 60 pounds per cubic foot. The forming procedure used was similar to that used in making insulating boards.

These mats, approximately 1-1/2 inches thick, were placed on 16-mesh galvanized-wire screen that was moistened with a lubricant, such as N-butyl stearate or Montan wax. The screen and mat were then placed in a 15-inch-square galvanized-iron tray, covered with a 14-inch-square stainless-steel caul, also coated with a lubricant, and pressed in a 14- by 14-inch, steam-heated, 125-ton-capacity press.

The pressing schedules used entailed three stages: (1) in which the excess water was pressed out and the press platens brought up to temperature; (2) in which the pressure was lowered to allow the mat to expand, thereby insuring uniform drying throughout; and (3) in which sufficient pressure was applied to bring the density of the board up to the desired 60 pounds per cubic foot.

In the first stage, a pressure of 500 to 600 pounds per square inch was gradually applied to the mats to squeeze out the excess water. This pressure was maintained for 2 minutes while the steam was on and the platens were heated to 185° C.

The second stage, which lasted for 1-1/2 to 6 minutes depending on the material employed, was initiated by reducing the pressure on the pulp mat to 100 pounds per square inch or less. The platen temperature during this stage rose from 185° C. at the start to 190° C., where it was held until the pressing was completed. The reduced pressure was maintained until the pressed mats were nearly dry. This point in the drying schedule could be determined in one of two ways. In most instances the time when no escaping vapor from the pressed mats was visible, was taken as the end point. If satisfactory results were not obtained in the first boards formed, the period was shortened or lengthened as required for subsequent panels. A much more satisfactory indication of the termination of the second stage was obtained by a thermocouple in the mat. The temperatures of the pressed mats were found to reach a constant value slightly above the boiling point of water. This temperature was maintained until the mats were nearly dry. The temperatures of the mats would then rapidly rise to the temperature of the heated platens. The second stage was terminated when the temperature of the mats began to increase rapidly.

The third stage consisted of raising the pressure again to 500 or 600 pounds per square inch. This higher pressure was maintained until the summation of periods was 10 minutes. In some cases the third stage undoubtedly could have been shortened, thus reducing the total time to less than 10 minutes. Although in the experiments some boards were removed from the press hot and others after cooling, it was evident that cooling of the press was not required.

Methods of Testing

Freeness of Pulps

The "Oliver" freeness, a drainage-rate test, was determined on all pulps as discharged from the mill. As a preliminary freeness test for use as a control of the milling, a batch of stock was added to a 9-1/2-inch-diameter Oliver leaf filter and sucked free of the excess water. A 720-gram portion of this wet material was recharged to the filter and diluted to a volume of 14 quarts. The free water was removed from the dispersed stock under a vacuum of 10 inches, and the time of drainage was recorded in seconds.

The value selected for operational purposes, however, was made with a known weight of pulp. The pulps from the mill were pressed to a dryness of 20 to 30 percent and the moisture content determined. From these pressed pulps of known dryness, 150-gram samples (oven-dry basis) were charged to the Oliver filter for freeness determinations. In each case a volume of water was added to make up to 14 quarts of stock and the free water removed under 10 inches of vacuum. The time of drainage was recorded in seconds.

Pulp-sheet Tests

Insulating-board pulps can be evaluated to some degree by various tests on pulp sheets. One investigator has found this procedure to be more suitable than most small-scale board tests. In this work pulp sheets of 340-pound ream weight (25x40-500) were tested according to TAPPI standards for bursting, tearing, and tensile strengths, and for density. The brightness was measured with the Hunter reflectometer calibrated according to TAPPI method T-217 Sm-42.

Insulating-board Tests

Two insulating boards were made of each pulp selected for test. One board furnished three specimens for transverse-breaking load and three specimens for tensile-strength determinations. The other board furnished one water-adsorption and one expansivity-test specimen. The camber, if any, in the various test specimens was removed by conditioning the test pieces in a relative humidity of 97 percent and redrying under restraint at normal room conditions. The strength-test specimens were then conditioned for at least 24 hours in a relative humidity of 65 percent and temperature of 75° F. Tests were made according to A.S.T.M. emergency specifications, designation ES-19, August 24, 1942.

Hardboard Tests

Two hardboards were made of each pulp selected for test. One board furnished three specimens for the modulus-of-rupture determination and the other furnished one 12 inch square water-adsorption sample. Tests were made according to Federal specification LLL-F311, July 12, 1940.

Discussion of Results

Insulating Boards and Hardboards from Western Hemlock Slabwood

The conditions used in the various treating processes and the results of the subsequent milling treatment of Western hemlock slabs and edgings are given in tables 1 and 2. Only two of the insulating boards met the specification in regard to the corrected transverse-breaking load. These were produced from milled water-cooked chips (test No. 276) and from milled steamed chips (test No. 283). Of all the methods of treatment, however, only the milled water-soaked chips (test No. 256) gave a very low result for this property. Since it cannot be considered that optimum conditions of cooking, milling, sizing, and forming were arrived at in all cases, it is probable that several of the processes, other than steam or water, would be suitable for the production of boards of adequate strength if given more study. Furthermore, it has been noted by others that boards made in a laboratory mold usually have poorer transverse strength than corresponding material made on commercial machines. The strengths obtained are believed, however, to be more or less relative insofar as the different treating methods are concerned. The tensile strengths of all insulating boards met specifications except for those made of pulps produced from soaked chips and lime-cooked chips.

The pulp-sheet-test data obtained on the various board-pulp stocks were found to be indicative of the quality of insulating boards that could be produced from them. In general, the higher the pulp-sheet strength, the stronger the board; and the higher the pulp-sheet brightness, the lighter the color of the board.

None of the Western hemlock hardboards met the Federal specifications for modulus of rupture, though two of them (water cook, test No. 285, and steam cook, test No. 273) approximated that of the commercial sample B. As with the insulating boards, the strengths obtained cannot be considered as optimum values. The use of high pressing temperatures is said to favor hardboard quality, but the presses available were not equipped to investigate this variable.

The results of various treating methods used on Western hemlock slabwood may be summed up as follows:

1. Boards produced from the milled, uncooked wood are likely to be, at best, marginal in strength properties.

2. For simplicity of process and strength of product, steaming appears to have an advantage over the other cooking processes. Steaming appears particularly advantageous for hardboards. Due to the organic acids evolved, precautions against corrosion might be required.

3. For these products, water cooking has no special advantage over steaming and would be more costly.

4. Cooking with 5 percent caustic soda (based on wood charged) would be satisfactory for insulating board, though a higher energy consumption in milling is indicated. The only advantage of the caustic-soda treatment over steaming is that ordinary steel digesters could be used. The results obtained by cooking with 2 percent of caustic soda indicate this to be an insufficient amount of chemical.

5. Four and 2 tenths percent of sodium sulfite and 0.8 percent of sodium bicarbonate (calculated as carbonate), based on wood charged, appear to be insufficient amounts of these chemicals to insure a good margin of strength with this type of digestion, but 7 to 8 percent of total chemicals should suffice. The energy consumed in milling

the stock was very high. Neutral sulfite liquors, however, have the advantages of being non-corrosive to ordinary steel and of producing relatively light-colored boards.

6. More than 2 percent of lime and longer cooking time than with the other cooking processes are indicated for this type of cook.

Comparison of Insulating Board and Hardboard Made from Steamed Western Hemlock, Douglas-fir, and White Fir Wastes

The milling conditions and data on insulating board and hardboard made from the various wood wastes steamed for 15 minutes at 180° C. are given in tables 3 and 4. On the basis of transverse-breaking loads corrected to 1/2 inch thick boards of a density of 17 pounds per cubic foot, the Western hemlock slabwood and hogged veneer produced satisfactory insulating boards. The strength of the board made from hogged planer ends was, on the other hand, somewhat low, and the energy used in milling was lower than with the other hemlock wastes. Modifying milling conditions so as to increase the energy would probably have improved the strength, but very likely it would also have yielded a pulp with too high an Oliver freeness. This waste material appeared to have been severely crushed in the hogging operation. The subjection of wood to high stresses prior to cooking by the acid-sulfite process has been shown to increase the susceptibility of the cellulose to chemical degradation[4]. A similar effect may have occurred here, since steaming is essentially an acid cook. The hogged veneer waste did not have this severely bruised appearance and gave satisfactory results.

The Douglas-fir in all forms gave low-strength boards. This may be due to the nature of the fiber or to the fact that this species contains considerable "extraneous" matter. The hogged planer ends gave particularly poor results. The planer shavings resulted in a sawdust-like product practically devoid of felting characteristics. This product after milling was, however, very free. Even at zero mill setting, that is, with the plates practically rubbing each other, the energy consumed was only 4 horse-power days per ton of pulp. Possibly better results could be obtained with these shavings by using other types of plates than the B-980, but it is probable that a poor product would be obtained at best. Improved results with the other forms of Douglas-fir waste might have been realized by modifying milling conditions. It is also possible that a cooking procedure other than steaming (neutral sulfite, for example) might have been more advantageous for all of the Douglas-fir wastes.

---

[4] "The Effect of Chipping on the Suitability of Wood for Sulfite Pulping," by H. Green and F. H. Yorston, Pulp and Paper Magazine of Canada, Vol. 41, No. 2: 123 Feb. 1940.

The yields of pulp obtained from the Douglas-fir wastes were several percent lower than those from the hemlock, due, presumably, to the high content of water-soluble, extraneous matter in the fir. This extraneous matter was probably responsible for the rather pronounced foaming tendencies noted with the Douglas-fir pulps. Washing of the pulps is suggested as a means of obviating foaming difficulty.

The white fir cordwood produced insulating board with satisfactory strengths when used either alone or in a 50-50 mixture with Douglas-fir slabs and edgings. The 50-50 mixture of Douglas-fir slabs and edgings with Western hemlock slabs and edgings, though slightly weaker, was promising.

The linear expansion with humidity changes was high for all of the insulating boards and, in general, exceeded the specification limitation. The reason for this is not known, but it is thought to be due to sizing or fiber formation rather than to species or to the cooking procedure.

None of the experimental hardboards met the strength required by the Government specifications; but the Western hemlock slabs and edgings, the Western hemlock hogged veneer, and the white fir cordwood would undoubtedly prove satisfactory with improved procedures.

Conclusions

It is concluded that Western hemlock mill and logging wastes can be converted into acceptable insulating board and hardboard provided the waste is not too finely divided nor crushed excessively in preparing it for processing. For strength of product and simplicity of treatment, steaming appears to be a satisfactory method of softening prior to milling. By the steaming method, white fir is as suitable as Western hemlock, but Douglas-fir alone gives definitely inferior boards. It is possible, however, that Douglas-fir, especially the chipped slabwood and cordwood, could be used as a portion of the furnish. It is also possible that more favorable results could be obtained from Douglas-fir by use of other cooking and manufacturing methods.

Table 1.--Insulating and hard-pressed fiberboard made from Western hemlock slabwood

Type of treatment[1]	Digestion No.	Milling data[2]: Bauer run No.	Milling data: Energy consumed[6]	Milling data: Freeness (Oliver)[7]	Sheet test data[3]: Bursting strength	Sheet test data: Tearing strength	Sheet test data: Tensile strength	Sheet test data: Density	Sheet test data: Brightness (Hunter)[1]	Insulating board data[4]: Test No.	Insulating board data: Thickness	Insulating board data: Density	Flexure: Breaking load	Flexure: Deflection at 12 pounds	Flexure: Breaking load (corrected)[8]	Insulating board data: Tensile strength	Insulating board data: Linear expansion	Insulating board data: Water absorption	Hard board data[5]: Test No.	Hard board data: Density	Hard board data: Thickness	Hard board data: Modulus of rupture	Hard board data: Water absorption
			No. days per ton	Seconds	Pts. per lb. per ream	Gm. per lb. per ream	Lb. per sq. in.	Gm. per cc.			Inch	Lb. per cu. ft.	Lb.	Inch	Lb.	Lb. per sq. in.	Percent	Percent		Lb. per cu. ft.	Inch	Lb. per sq. in.	Percent
Water soaked	....	176	29	50	0.03	0.39	59	0.24	32.7	256	0.52	17.1	8.2	....	7.5	104	0.30	5.7	263	60	0.139	3,460	22.3
Water soak Water soak	7 11	164 165	39 24	67 35	[9].13	1.08	281	.24	15.8	255	.56	15.6	12.3	0.71	11.6	173	.45	5.7	....	....	....	....	....
Water cook	27	208	33	53	.16	1.65	415	.27	13.5	276	.48	18.6	15.0	.51	13.6	295	.60	4.2	285	61	.136	5,190	15.1
Steam	26	204	29	46	.14	1.34	445	.30	15.2	275	.49	17.7	12.4	.84	11.9	261	.50	4.1	273	60	.129	5,120	16.1
Steam	28	214 215	43 29	83 34	[9].11	1.04	290	.29	19.7	283	.52	16.7	14.2	.41	13.6	239	.50	5.6	284	62	.134	4,220	20.7
Caustic soda	23	190	39	49	.04	.52	124	.26	25.8	....	....	....	....	....	....	....	....	....	267	60	.142	3,310	....
Caustic soda	25	200	52	60	.12	.90	318	.29	20.1	274	.51	17.6	12.7	.64	11.4	211	.40	4.6	269	61	.138	3,920	21.8
Neutral sulfite	19	186	65	48	.07	.87	138	.22	26.4	268	.53	16.9	11.5	....	10.4	190	.40	4.7	265	61	.131	4,220	20.1
Lime	22	188	45	54	.05	.69	144	.25	19.5	269	.53	16.7	11.8	....	10.9	157	.45	4.1	266	61	.138	4,260	19.3
Commercial boards[10]																							
A										251	.510	19.2	16.6	.31	12.5	266	.10	5.0	....	....	....	....	....
B										277	.510	22.0	15.7	.18	9.0	152	.08	6.0	272	60	.140	5,310	11.0
C										278	.500	18.8	15.9	.34	13.0	238	.23	8.6	....	....	....	....	....
D										279	.475	16.8	14.6	.31	13.3	229	.20	8.5	....	....	....	....	....
E										280	.485	17.9	11.1	....	10.7	219	.15	11.1	....	....	....	....	....
Specification requirements																							
Federal specifications LLL-F321b, Dec. 17, 1942, Fiberboard; Insulating, Class A building board										....	.500 ±.0625	....	[11]12.0	[12].85	....	[11]150	[12].5	[12]7.0	....	....	....	....	....
A.S.T.M. Emergency specifications, Designation ES-19, Aug. 24, 1942, Class A building board										....	....	....	[11]12.0	[12].85	....	[11]175	[12].5	[12]7.0	....	....	....	....	....
Federal specification LLL-F311, Fiberboard, Hard-pressed, Structural										....	....	....	....	....	....	....	....	....	....	[11]60	.125 ±.0156	[11]6,000	[12]20.0

[1]See table 2 for cooking data.

[2]B-980 plates run in a counter-clockwise direction (cutting) for all tests except Bauer run No. 176 in which they were run in a clockwise (brushing) direction.

[3]Made on sheets weighing approximately 20 grams for 64 square inches. (340 pounds ream weight (25 x 40 - 500)).

[4]Tests made according to A.S.T.M. Emergency specifications, Designation ES-19, Aug. 24, 1942. The boards contained 4 percent rosin size.

[5]Tests made according to Federal specifications LLL-F311, July 12, 1940. The boards contained 4 percent rosin size.

[6]Based on oven-dry chips charged and energy input to Bauer mill motors. Figures, though relative, are probably higher than would be obtained in continuous operation.

[7]Calibrated according to TAPPI Method T-217 sm-42.

[8]Corrected to density of 17 pounds per cubic foot (708 pounds per 1,000 square feet) and 1/2 inch thickness by the empirical formula, Corrected load = $\frac{\text{measured load} \times 17^2 \times 0.5^2}{(\text{measured density})^2 \times (\text{measured thickness})^2}$

[9]A mixture of equal parts of the pulps from the two Bauer mill runs.

[10]Based on material obtained at local lumber yards.

[11]Minimum.

[12]Maximum.

W 71096 F

Table 2.--Cooking conditions used in treating Western hemlock slabs and edgings

No.	Type	Amount of wood (moisture-free) treated	Amount of chemical per 100 pounds moisture-free wood	Volume of liquor per 100 pounds moisture-free wood	Duration of cooking: Time to 120° C.	Time at 120° C.	Time to maximum temperature	Time at maximum temperature	Total time	Maximum temperature	Chemical consumed	Yield: Chips cooked	Fiberized chips
		Lb.	Lb.	Gal.	Min.	Min.	Min.	Min.	Min.	° C.	Percent	Percent	Percent
7	Water cook	12.4	....	64.5	....	....	35	15	50	180	....	89.5	....
11	Water cook	12.6	....	63.5	....	....	30	15	45	180	....	87.3	....
27	Water cook	53.8	....	59.2	....	....	60	5	65	178	....	82.0	77.0
26	Steam	52.5	....	....	....	....	30	15	45	180	....	89.0	83.0
28	Steam	59.9	....	....	....	....	15	0	15	178	....	92.7	85.9
23	Caustic soda	12.5	2	30.0	25	35	25	35	60	120	100.0	[1]95.7	....
25	Caustic soda	50.0	5	30.0	15	30	60	0	60	150	98.0	[2]90.0	85.0
19	Neutral sulfite	12.5	[3]5	30.0	15	[4]30	63	0	63	180	83.0	[5]93.0	....
22	Lime	12.5	2	30.0	15	30	60	0	60	180	....	[6]97.0	....

[1] Chips were not markedly darkened.

[2] Chips were of a light brown color.

[3] Ratio of sodium sulfite to sodium bicarbonate (calculated as sodium carbonate) 5.25:1.

[4] In this cook, the temperature was approximately 125° C.

[5] Approximately half of the chips were completely penetrated; the others had light brown centers.

[6] Chips were not entirely free of lime deposits and were not greatly darkened by the cooking treatment. The pH of the spent liquor was 5.8.

Z M 71097 F

Table 3.--Insulating and hard-pressed fiberboards made from Western hemlock, Douglas-fir, and white fir sawmill and logging wastes

Type of waste material	Cooking data[1]: Digestion No.	Cooking data[1]: Pulp yield[6]	Milling data[2]: Bauer run No.	Milling data[2]: Energy consumed[7]	Milling data[2]: Freeness (Oliver)[8]	Sheet test data[3]: Bursting strength	Sheet test data[3]: Tearing strength	Sheet test data[3]: Tensile strength	Sheet test data[3]: Density	Sheet test data[3]: Brightness (Hunter)[8]	Insulating board data[4]: Test No.	Insulating board data[4]: Thickness	Insulating board data[4]: Density	Insulating board data[4]: Flexure: Breaking load	Insulating board data[4]: Flexure: Deflection at 12 pounds	Insulating board data[4]: Flexure: Breaking load (corrected)[9]	Insulating board data[4]: Tensile strength	Insulating board data[4]: Linear expansion	Insulating board data[4]: Water absorption	Hard board data[5]: Test No.	Hard board data[5]: Density	Hard board data[5]: Thickness	Hard board data[5]: Modulus of rupture	Hard board data[5]: Water absorption
		Percent		Hp. days per ton	Seconds	Pts. per lb. per ream	Gm. per lb. per ream	Lb. per sq. in.	Gm. per cc.			In.	Lb. per cu. ft.	Lb.	In.	Lb.	Lb. per sq. in.	Percent	Percent		Lb. per cu. ft.	In.	Lb. per sq. in.	Percent
Western hemlock slabs and edgings	26	83.0	204	31	46	0.14	1.34	445	0.30	15.2	275	0.49	17.7	12.4	0.64	11.9	261	0.50	4.1	273	60	0.129	5,120	16.1
Western hemlock planer hogged ends	36	81.0	243-244	21	51	.09	.94	221	.31	14.5	317	.55	16.4	11.4	....	10.1	154	.65	4.9	319	63	.144	3,770	14.6
Western hemlock hogged veneer	37	81.2	248	[10]35	56	.18	1.52	424	.28	18.4	321	.50	18.1	15.9	.42	14.0	326	.55	4.4	322	64	.143	4,800	14.1
Western hemlock hogged veneer	37	81.2	248-249	[10]31	43	.15	1.53	460	.31	17.2	323	.54	17.4	17.5	.50	14.3	295	.45	4.4	324	63	.143	4,250	14.0
Douglas-fir, old growth, slabs and edgings	30	76.9	230	23	50	.08	.78	237	.31	14.4	306	.50	18.2	10.4	....	9.1	159	.65	4.9	309	57	.154	2,750	14.3
Douglas-fir, old growth, planer hogged ends	35	78.8	241-242	17	49	.04	.45	68	.28	12.0	316	.50	17.9	6.0	....	5.4	98	.60	4.3	318	62	.147	2,110	16.5
Douglas-fir, old growth, hogged veneer	39	77.9	253	[10]16	54	.05	.41	131	.30	12.6	325	.51	16.9	8.2	....	8.0	124	.60	4.8	326	62	.144	2,880	15.4
Douglas-fir, old growth, planer shavings	38	[11]81.4	246	4	30	Material discarded as unsuitable for board stock																		
White fir cordwood	32	82.8	233-234	28	50	.18	1.60	507	.34	19.9	308	.45	19.9	14.2	.52	12.8	330	.60	4.9	311	64	.139	4,760	17.2
Mixture of Douglas-fir, old growth, slabs and edgings, and Western hemlock slabs and edgings[12]	31	82.3	231-232	28	45	.10	.93	309	.33	15.4	307	.51	16.8	11.3	....	11.1	196	.55	5.0	310	62	.146	3,530	13.4
Mixture of Douglas-fir, old growth, slabs and edgings, and Douglas-fir cordwood, second growth[12]	33	77.4	236-237	22	47	.09	.92	232	.31	14.6	315	.49	18.1	10.5	....	9.9	202	.65	5.2	312	62	.147	2,970	15.5
Mixture of Douglas-fir, old growth, slabs and edgings, and white fir cordwood[12]	34	81.2	238-240	23	53	.13	1.10	236	.29	16.1	314	.49	17.8	12.8	.64	12.1	224	.55	4.9	313	62	.148	3,580	15.5

[1] Chips digested with steam on a schedule of 1/2 hour to 180° C. and 1/4 hour at 180° C.

[2] See table 4 for detailed milling data.

[3] Tests made on sheets weighing approximately 20 grams per 64 square inches (340 pounds ream weight (25 x 40 - 500)).

[4] Tests made according to A.S.T.M. Emergency specifications, Designation ES-19, Aug. 24, 1942. The boards contained 4 percent rosin size. See table 1 for specification requirements.

[5] Tests made according to Federal specifications LLL-F311, July 12, 1940. The boards contained 4 percent rosin size. See table 1 for specification requirements.

[6] A small proportionate amount of the treated chips were processed in a beater for yield determinations.

[7] Based on pulp yield and energy input to Bauer mill motors. Figures, though relative, are probably higher than would be obtained in continuous operation.

[8] Calibrated according to TAPPI Method T-217 m-42.

[9] Corrected to 17 pounds per cubic foot density (708 lbs. per 1,000 sq. ft.) and 1/2 inch thickness. See table 1, footnote 7.

[10] Cooked material processed twice. The large veneer strips were first run through Bauer mill with the plates at a relatively large setting. The additional energy required was not recorded.

[11] Yield figure undoubtedly high. Pulp washed and pressed but not beaten.

[12] Equal parts by weight.

Z M 71098 F

Table 4.—Mill processing data for the steamed Western hemlock, Douglas-fir, and white fir wood wastes

Cook No.	Mill run no.	Plate[1] setting	Freeness (Oliver)	Energy consumed	Proportion of mixtures	Energy consumed for pulp stock used
		1/1,000 inch	Sec.	Hp. days per ton of pulp	Parts	Hp. days per ton of pulp
26	204	22.5	46	31.0	....	31
36	243	20	73	22.9	1	21
	244	30	37	19.4	1	....
37	248	20	56	34.9	....	35
37	248	20	56	34.9	4	31
	249	30	29	15.7	1	....
30	230	20	50	22.6	....	23
35	241	20	80	20.0	1	17
	242	30	33	13.6	1	....
39	252	50	....	....	....	....
	253	20	54	16.1	....	16
38	246	0	30	4.4	....	4
32	233	20	67	31.4	1	28
	234	30	36	24.6	1	....
31	231	20	60	31.4	3	28
	232	30	28	17.7	1	....
33	236	20	136	35.6	1	22
	237	30	36	17.8	3	....
34	238	20	195	37.8	1	23
	240	30	40	18.9	4	....

[1]B-980 plates run in a counterclockwise (cutting) direction.