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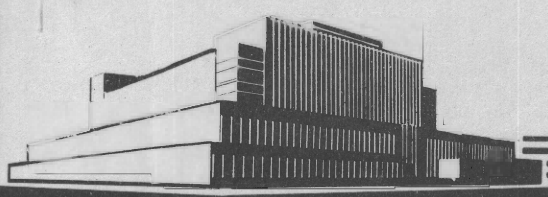

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

CHEMICAL PULPING AND WALLBOARD EXPERIMENTS WITH SUNDRI (HERITIERA MINOR) WOOD

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Summary

Kraft, neutral sulfite semichemical, and cold soda pulps from sundri (Heritiera minor) wood from East Pakistan were prepared and evaluated, and the suitability of low-chemical cold soda and steam-cooked pulps for making hardboards was determined. Experiments also were conducted to determine the feasibility of making medium-density and insulation boards from steam-cooked pulps by press-drying.

The strength of the kraft, neutral sulfite semichemical, and cold soda pulps compared favorably with that of pulps from such North American broad-leaved species as aspen. The tearing strength of the sundri kraft pulp was higher than that of most hardwood kraft pulps. The strength properties were better than those obtained from gewa, another hardwood species from East Pakistan.

Sundri chips, softened by cold soda impregnation (2 to 3 percent on wood) and reduced to high-yield pulp in an attrition mill, were used for making hardboards. Heat-treated hardboards, containing 1 percent phenolic resin, were of good flexural strength and fairly resistant to water. Hardboards with better water resistance can be expected from freshly cut wood than from the stored wood used in these experiments. The hardboards made with defibrated pulps possessed good water absorption characteristics.

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

Report No. 2253

Introduction

Sundri, Heritiera minor, a high-density hardwood that is abundant in a large forested area in the coastal region of East Pakistan is available for utilization.

As part of a project sponsored by the International Cooperation Administration, this study was undertaken at the Forest Products Laboratory to evaluate sundri for the manufacture of pulps that might be suitable for newsprint paper, nine-point paperboard, book paper, and hardboard.

This report presents data on papermaking pulps made from bark-free sundri wood chips by the kraft, neutral sulfite semichemical, and cold soda processes, and experiments on the manufacture of hardboards from coarse fibers prepared by the cold soda and defibrator processes.

Materials

Wood

In the moist and swampy lands of the Sunderbans, sundri grows as a weed tree to 50 feet in height and 22 inches in diameter. Although trees 6 to 8 inches in diameter predominate, those with 14- to 16-inch diameters are not uncommon. The trees are fairly straight. The bark is smooth, gray in color, easy to remove, and constitutes approximately 10 percent of the wood by volume. The reddish-brown wood turns darker after it has been chipped and stored. Its density varies from 60 to 70 pounds per cubic foot. The short, thin fibers of the wood have an average length of 1 millimeter and a thickness of 20 microns.

Several cords of sundri bolts were shipped to the United States and converted to chips on the West Coast before they were sent to the Forest Products Laboratory in May 1961. The moist (36 percent moisture content) chips were bark free, slightly moldy, 3/4 to 1 inch long, and 1/4 inch thick.

The results of a chemical analysis of the chips, determined by TAPPI Standard methods are as follows:

Constituents	Percent
Lignin	23.5
Holocellulose	71.8
Total pentosans	16.5
Solubility in:	
Hot water	3.4
1 percent NaOH	23.0
Alcohol-benzene	4.0

Chemicals Used for Boardmaking

The chemicals used for making the hardboards, medium-density and insulation boards included a size emulsion of 10 percent refined paraffin wax; a beater-dispersible phenolic resin, of 50 percent solids content; a 10 percent solution of papermakers' alum; a 10 percent solution of ferric sulfate; and a 10 percent solution of sulfuric acid.

Pulping Experiments

Kraft Pulping

A stainless steel laboratory-model rotating digester with a capacity of 0.8 cubic foot and heated by indirect steam was used for pulping the wood chips by the kraft process. The digester charge was 5.95 pounds of chips (moisture-free basis). The cooking conditions are given in table 1.

At the end of the digestions, the steam was shut off and the black liquor drained as quickly as possible. After the internal pressure had been reduced to atmospheric pressure, the cover was removed and the cooked chips were dumped into a screen box that was equipped with 75-mesh wire screen. The cooked chips were then disintegrated in a tank by an electric stirrer. The pulps were washed until the wash water was clear; passed through a screen with 0.012-inch-wide slits; put into a canvas bag, and pressed in a hydraulic press. They were then shredded, weighed, and sampled for moisture content, strength tests, and yield determinations.

Neutral Sulfite Semichemical Pulping

Three neutral sulfite semichemical pulps were made in a stainless steel stationary digester of 0.8 cubic foot capacity. The cooking liquor consisted of sodium sulfite and sodium carbonate or sodium bicarbonate. One pulp was made with 16 percent total chemical for nine-point paperboard, and two pulps were made for bleaching using 20 and 22 percent total chemical. The liquor, heated to 140° C. in a digester similar to that used for the digestions, was forced into the evacuated digester containing the chips. At the end of each cook the liquor was drained and the chips washed for 10 minutes, while they were inside the digester. They were then milled in an 8-inch disk mill to a freeness (Canadian Standard) of about 700 millimeters. After milling, the pulp was washed in a screen box for 5 minutes, then screened, pressed to damp dryness, shredded, weighed, and sampled for moisture content and yield determination. The pulping conditions and pulp yields are given in table 2.

Cold Soda Pulping

Experiments with cold soda impregnation were conducted in the same digesters in which the kraft cooking was done. Cold caustic soda liquor was forced in from another digester, and the chips (5.95 pounds, moisture-free basis) were allowed to soak for a half hour at room temperature and under a hydrostatic pressure of 150 pounds per square inch. The liquor was then drained and the chips were allowed to stand for an hour before they were processed, without washing, in an 8-inch single-rotating disk mill that was fitted with leveled, radial serrated plates.

Two of the cooks were made with 6.9 and 3.33 percent sodium hydroxide for groundwood-type pulps. The other two were made with 2.8 and 2.1 percent alkali, and were used for hardboards.

The first two pulps required centrifugal cleaning in a 3-inch cleaner before bleaching because they contained many shives. Yield and cooking data are given in table 3.

Defibrator Pulp

Sundri wood chips were fiberized in a stainless steel, laboratory-model defibrator, which has a capacity of approximately 1 pound of low-density wood chips, moisture-free basis. Two pounds of sundri wood chips were used for each charge because of the high density of the wood.

In each defibration run, the charge of chips was presteamed and then milled at the same steam pressure. Each run was terminated by shutting off the steam and the motor of the defibrator and releasing the steam to the attached cyclone. The conditions of defibration, pulp yield, and freeness data are given in table 4.

The coarse and free-draining pulps produced by this process needed fiberizing in a disk mill, so they were fed into the mill with relatively large amounts of softened water at 50° C. The refined pulps were collected in an 80-mesh screen box.

The freeness of the stocks was determined in a defibrator freeness tester. This value is reported in seconds as the drainage time required for the water in a 10-liter sample of fiber suspension (128 grams of ovendry pulp per 10 liters) to pass through a screen, and 10 liters of air to pass through the pulp mat formed on the screen. The desired number of mats suitable for the preparation of 1/8-inch hardboards and 1/2-inch insulation boards were then prepared using 128 grams pulp for each mat. For the medium-density boards, 260 grams of pulp were required to produce a board approximately 1/2 inch thick. The data for the hardboards are given in tables 5 and 6 and those for the medium-density and insulation boards in table 7.

The pulps selected for the preparation of hardboard evaluations were analyzed in a Bauer pulp classifier, using 10-, 14-, 48-, and 200-mesh screens (table 8).

Bleaching of Pulps for Newsprint and Book Papers

Multistage bleaching processes for the neutral sulfite semichemical and kraft pulps were the conventional three-stage sequence of chlorination, alkaline extraction, and hypochlorite oxidation. When 0.76 percent chlorine dioxide was used instead of 2 percent calcium hypochlorite as available chlorine in bleaching the kraft pulp (cook 4233), a one-point lower brightness resulted. A fourth stage of bleaching with 0.5 percent chlorine dioxide following the chlorine, sodium hydroxide, and calcium hypochlorite treatments gave better results for the kraft pulps (cooks 4237 and 4238).

In bleaching cold soda pulps, calcium hypochlorite was used in the first stage, followed by alkaline extraction and hydrogen peroxide oxidation. Attempts to bleach the cold soda pulps by a two-stage bleaching process, comprised of 1.5 percent hydrogen peroxide and 1.5 percent sodium hydrosulfite, proved unsatisfactory.

The total chlorine requirement of the kraft pulps was estimated from the permanganate numbers. The Tingle number[2, 3] was used for estimating the chlorine number of the neutral sulfite semichemical pulps. All bleaching experiments were carried out according to standard procedures.

The amount of chemicals, bleaching conditions, and pulp brightnesses are given in table 9.

Preparation of Wallboards

The pulp mats were formed in a defibrator freeness tester. These mats were 8-1/2 inches in diameter and contained sufficient pulp to make either a nominal 1/8-inch-thick screenback hardboard or a 1/2-inch-thick insulation or medium-density board. The pulp charge was dispersed in softened water at about 2 percent consistence (3 percent consistence for medium-density boards). The wax size or phenolic resin, or both, was added to the pulp slurry. Sulfuric acid and alum or ferric sulfate were added to fix any natural resinous and other constituents of the pulp, the size, and phenolic resin, and to accelerate heat treatment. This was accomplished at a pH of 4 to 4.5.

All the mats were cold pressed to a moisture content of approximately 65 percent, and then hot pressed between stainless steel cauls that had been coated with silicone to ease their release.

The hardboards were hot pressed at 190° C. at a maximum pressure of 500 pounds per square inch for 6 minutes. The pressing schedule consisted of an initial period of 2 minutes at maximum pressure, a 1-minute breathing period at a pressure of 100 pounds per square inch, and a final period of 3 minutes at maximum pressure. For the medium-density boards the pressure was limited to 50 pounds per square inch for periods in excess of 20 minutes. For insulation boards a pressure of 5 pounds per square inch or less was used.

Boards that were heat treated were baked for 3 hours at 165° C.

Results and Discussion

Test Methods

For paper and paperboard pulps.--The kraft and semichemical pulps were processed in a test beater and handsheets were made and tested according to TAPPI Standards except for flat crush tests. For these tests, procedures

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[2]Tingle, A. The Determination of the "Bromine Figure" or "Chlorine Factor" of Pulp and the Utilization of These Quantities in Bleaching. J. Ind. Eng. Chem., 14, 1922.

[3]Tingle, A. Estimating Bleach Requirement for Pulp. Paper 29: No. 18, 1922.

recommended by the manufacturer of a corrugating medium fluter were followed. The handsheets from cold soda pulps were prepared without additional mechanical processing. The strength properties for the sulfate, neutral sulfite semichemical, and cold soda pulps are given in tables 10 and 11.

For boards. --Each hardboard that was tested furnished three 5- by 2-inch test specimens, two for flexural strength tests, and one for water absorption and thickness change. The specimens were tested for modulus of rupture according to the ASTM Standard D1037-58T, and this value was adjusted to a specific gravity of 1.0. This adjustment was made on the basis that the flexural strength varies as the square of the density. The water absorption samples were smaller than specified, but exploratory tests have shown that the smaller samples gave satisfactory results for nominal 1/8-inch hardboard.

Hardboards

Cold soda pulps of 91 percent yield were made using caustic impregnations of 2.1 percent (ovendry basis). Those with 94 percent yields had caustic impregnations of 2.8 percent. The caustic-impregnated chips readily fiberized in the 8-inch single-rotating disk mill. Heat-treated hardboards of good strength were made from this stock, but they were decidedly deficient in water resistance. Even the heat-treated boards containing 1 percent phenolic resin did not quite meet the S-1-S, class 1 specification of the U.S. Hardboard Association (tables 5 and 6).

The wood used for these boards, though reasonably sound, was moldy. For this reason, defibrator pulps of 88 and 86 percent yield (cooks 135 and 136) were made from this material so that a comparison could be made between the hardboards from these pulps and those from the defibrated pulp previously made while the wood was still fresh (cook 127).

Boards made from the defibrated pulp (cook 127, 86 percent yield) that was prepared from mold-free chips were more water resistant than those made from the moldy wood. Heat-treated boards, with and without 1 percent phenolic resin, were strong and quite water resistant. The 1 percent phenolic resin board met the U.S. Hardboard Association specification for class 1, S-1-S hardboard. The water absorption of the heat-treated nonresin board was only 2 percent higher than the specification allowance.

If one can attribute the high-water absorption of hardboards made from defibrated pulp of cook 135 to the moldy state of the wood, the high-water absorption of cold soda pulp boards can be attributed to the condition of the wood also. On this basis, it appears that heat-treated cold soda pulp

hardboards containing 1 percent phenolic resin would meet the specification for S-1-S, class 1 of the U.S. Hardboard Association.

Heat treatment had a very beneficial effect on the flexural strength and water resistance of all boards. Paraffin sizing in addition to phenolic resin was not as desirable as heat treatment because it reduced flexural strength and did not impart sufficient water repellency.

Medium-Density and Insulation Boards

Medium-density boards, made with or without the chemical additives and molded at a pressure of 50 pounds per square inch and temperatures between 190° and 212° C., were without defects only when the hot-pressing cycle was 23 minutes or more. When the time was reduced to 22 minutes or less, a soft centerline was evident. This indicated the center of the board was not quite dry and had a plane of weakness which ultimately might give rise to delamination (table 7). These medium-density boards, even with 5 percent phenolic resin, retained their fibrous appearance.

Insulation boards of adequate density could not be made using a pressure of more than 5 pounds per square inch and therefore would require a lengthy pressing cycle; hence the procedure was considered impractical.

No tests were made on insulation boards.

Pulping, Bleaching, and Pulp Strength

Kraft pulps. -- For making bleachable pulp, 14 and 16 percent of total cooking chemical was used for two sulfate digestions. Cooking for 1-1/2 hours at maximum temperature produced a 46 percent pulp yield when 14 percent of cooking chemical was used, and a 44 percent yield was obtained when using 16 percent of the cooking chemical. By decreasing the cooking time at maximum temperature from 1-1/2 hours to 1 hour, a rise of about 1 percent age point in pulp yield was obtained, and the permanganate number was increased from 14.3 to 14.9. The strength properties of both the bleached and unbleached pulps were very good (table 10). By means of a four-stage bleaching process the pulps were bleached to 85 percent (G.E. equivalent) brightness and could be used in book papers.

Neutral sulfite semichemical pulp. --The neutral sulfite process, employing sodium sulfite as the pulping agent and sodium bicarbonate or sodium carbonate as the buffering agent, was used to make semichemical pulp. The cooking of the chips continued until the concentration of sodium sulfite in the liquor (which was sampled periodically) had fallen to 10 grams per liter.

Cooking chemicals of 16, 20, and 22 percent were used for three different cooks. The permanganate number increased from 40.6 to 46 when the cooking chemicals were decreased from 22 to 16 percent, and the pulp yield increased by 5 percentage points (table 2).

The dark pulp could be bleached to newsprint quality by a three-stage bleaching process. Bleaching decidedly increased the strength properties of the pulps, which is typical of neutral sulfite semichemical pulps (table 11).

The suitability of unbleached neutral sulfite semichemical pulp made with a comparatively lesser amount of chemical (1840Y) was evaluated for the manufacture of corrugating medium. The nine-point handsheets were made and tested for rigidity, which was adequate for the manufacture of corrugating medium. The other strength properties of these pulp sheets were good also.

Cold soda pulps. --Groundwood-type pulps made by the cold soda process were obtained in yields of 85 percent by using 7 percent alkali consumption, and 90 percent by using 3 percent alkali. The pulps required cleaning centrifugally to remove the shives before bleaching. Low-chemical cold soda pulps were poor in strength and hard to bleach. Pulps with 7 percent alkali consumption, after being cleaned, could be bleached to 72 percent brightness and showed an improvement in strength properties (table 11). A blend of this pulp and long-fibered kraft pulp should be suitable for newsprint.

Conclusions

(1) Sundri wood can be easily reduced to a strong pulp by the kraft process. The unbleached pulps have unusually good tearing resistance, higher than that of the kraft pulps from the broad-leaved trees of the temperate zone in North America. It should be suitable for the manufacture of brown paper in a mixture with long-fibered pulps. The bleached kraft pulps have exceptionally good strength also.

(2) The semibleached neutral sulfite semichemical pulps have strength properties that are nearly similar to bleached kraft pulps from North American coniferous woods and can be used in many grades of coated printing papers, boards, and newsprint.

(3) The fully bleached neutral sulfite pulps from sundri alone, or in mixtures with some long-fibered pulps, are expected to be suitable for the manufacture of many grades of printing and writing papers and boards.

(4) Cold soda pulps from sundri are not easy to bleach; they do not respond to the usual brightening agents, such as peroxide or hydrosulfite. Hypochlorite bleaching of the pulps results in some yield loss, but the resulting pulps may find use as a groundwood substitute in printing papers and newsprint.

(5) By the proper choice of processing and manufacturing conditions and by using additives, both low-chemical cold soda and steam-cooked defibrated pulps from sundri can be used for making screenback hardboard.

(6) The production of medium-density boards and insulation boards by press-drying appears to be impractical because of the difficulty in finding the right combination of the temperatures and time in the press. The use of phenolic resin as a binder in the medium-density board is not technically feasible because of the low pressure in the press.

Table 1.--Kraft pulping[1] of sundri

Digestion No.	Chemicals charged[2]		Maximum temperature	Time to maximum temperature	Time at maximum temperature	Original freeness	Black liquor analysis			Total yield[2]	Screenings[2]	Permanganate number
	NaOH	Na_2S					NaOH as Na_2O	Na_2S as Na_2O	Specific gravity at 15° C.			
	Percent	Percent	°C.	Min.	Min.	Ml.	G. per l.	G. per l.		Percent	Percent	
4233	10.5	3.5	170	75	90	720	0.47	3.41	1.075	46.1	2.56	14.3
4237	12	4	170	75	90	680	2.25	4.96	1.082	44.4	.74	14.1
4238	10.5	3.5	170	75	60	730	1.02	2.69	1.080	47.3	3.5	14.9

[1]Constant cooking conditions used 25 percent sulfidity and 4:1 liquor-to-wood ratio.

[2]Moisture-free wood basis.

Table 2.--Data on neutral sulfite semichemical pulping of sundri

Digestion No.	Chemicals[1]		Maximum temperature	Time to maximum temperature	Time at maximum temperature	Spent liquor	Total yield[2]	Permanganate number
	Na_2SO_3	Na_2CO_3				Na_2SO_3		
	Percent	Percent	°C.	Min.	Min.	G. per l.	Percent	
1840y	12	4	170	90	90	9.4	64	46
1810y	14	[3]6	170	90	113	9.7	64	42
1841y	18	4	170	90	225	10	59	40.6

[1]Liquor-to-wood ratio was 11:2.

[2]Moisture-free basis.

[3]Sodium bicarbonate used instead of sodium carbonate.

Table 3.--Data on the preparation of cold soda pulps from sundri wood chips

Cook No.	Material charged[1]	Volume of liquor	Concentration of alkali	Cooking temperature	Maximum pressure	Treating time	Chemical retained	Pulp yield[1]	Disk milling: Plate clearance	Disk milling: Defibrator freeness	Freeness (Canadian Standard)	Stock pH
	Lb.	Gal.	G. per l.	°C.	P.s.i.	Min.	Percent	Percent	1/1000 in.	Sec.	Cc.	
4274x	5.95	5.5	20	33	150	30	2.8	92	20	103	.....	7.3
4291x	5.95	5.5	15	23	150	30	2.1	94.6	-40	44	.....	7.4
4262x	5.95	5.5	50	30	150	30	6.9	85	[2]3	.....	300	.....
4263x	5.95	5.5	25	30	150	30	3.33	90	[2]1.5	.....	155	.....

[1] Moisture-free wood basis.

[2] First milling at 0.020-inch plate clearance. In the second milling, a 2 percent slurry was used.

Table 4.--Data on the preparation of defibrator stocks from sundri wood chips

Defibrator No.	Time in defibrator[1]		Pulp yield[2]	Defibrator freeness	
	Steaming	Milling		Before refining	After refining
	Min.	Min.	Percent	Seconds	Seconds
135 (unbarked wood)	3	2	86	13	40
136 (barked wood)	2	1.5	88	12	30

[1] Steaming and milling pressure was 175 pounds per square inch.

[2] Moisture-free basis.

Table 5.--A comparison of unsized sundri hardboards made from cold soda and defibrated pulps

Board No.	Cook No.	Amount of NaOH	Yield[1]	Defibrator freeness	Chemicals added to pulp: Alum	Chemicals added to pulp: Ferric sulfate	Heat treatment	Board properties: Specific gravity at test	Board properties: Adjusted modulus of rupture	Board properties: Increase in modulus of rupture over control	Board properties: Water absorption	Board properties: Thickness change	Board properties: Springback
		Percent	Percent	Sec.	Percent	Percent			P.s.i.	Percent	Percent	Percent	Percent
COLD SODA PULPS													
2951	4274x	2.8	92	103	0	0	No	0.95	4,400	Control	92	54	25
2966	4274x	2.8	92	100	0	0	Yes	.91	6,200	41	35	24	8
2952	4274x	2.8	92	103	2	0	Yes	.92	5,100	16	26	22	7
2956	4274x	2.8	92	121	0	1	Yes	.93	5,900	34	29	22	7
2957	4291x	2.1	94.6	42	0	0	No	.93	4,600	Control	100	53	24
2967	4291x	2.1	94.6	38	0	0	Yes	.91	6,200	35	35	27	8
2958	4291x	2.1	94.6	40	2	0	Yes	.91	5,200	13	26	23	8
2959	4291x	2.1	94.6	38	0	1	Yes	.90	6,000	30	30	21	7
DEFIBRATED PULPS													
2972[2]	136	0	88	30	0	0	No	.93	6,100	Control	103	76	35
2973	136	0	88	30	0	0	Yes	.95	8,400	38	35	29	10
2974	136	0	88	29	2	0	Yes	.88	7,400	21	25	26	8
2976[2]	136	0	88	30	0	0	Yes	.91	8,700	43	27	24	7
2968	135	0	86	39	0	0	No	.90	6,100	Control	97	61	26
2969	135	0	86	41	0	0	Yes	.94	8,800	44	32	26	20
2970	135	0	86	38	2	0	Yes	.95	7,000	15	25	25	8
2696	127	0	86	31	0	0	No	.98	5,700	Control	63	49	15
2697	127	0	86	31	0	0	Yes	.95	7,800	37	22	19	3

[1] Moisture-free basis.

[2] The pH of board No. 2972 was 7.1, whereas that of board No. 2976 was adjusted to 4.0 by the addition of dilute sulfuric acid.

Table 6.--A comparison of sundri hardboards made from cold soda and defibrated pulps

Board No.	Pulp used: Cook No.	Pulp used: Type	Pulp used: Amount of NaOH	Yield[1]	Defibrator freeness	Chemicals added to pulp: Phenolic resin	Chemicals added to pulp: Paraffin size	Chemicals added to pulp: Alum	Chemicals added to pulp: Ferric sulfate	Heat treatment	Board properties: Specific gravity at test	Board properties: Adjusted modulus of rupture	Board properties: Increase in modulus of rupture over control	Board properties: Water absorption	Board properties: Thickness change	Board properties: Springback
			Percent	Percent	Sec.	Percent	Percent	Percent	Percent			P.s.i.	Percent	Percent	Percent	Percent
PHENOLIC RESIN BOARDS																
2954	4274x	Cold soda	2.8	92	110	1	0	2	0	Yes	0.92	6,100	38	22	19	5
2955	4274x	..do...	2.8	92	122	1	0	0	1	Yes	.92	6,700	52	24	17	4
2963	4274x	..do...	2.8	92	103	1	0	2	0	No						
2960	4291x	..do...	2.1	94.6	45	1	0	2	0	Yes	.93	6,100	33	28	19	5
2961	4291x	..do...	2.1	94.6	40	1	0	2	0	No						
2962	4291x	..do...	2.1	94.6	45	1	0	0	1	Yes	.92	7,100	54	25	18	5
2975	136	Defibrated	0	88	29	1	0	2	0	Yes	.91	9,500	56	19	19	4
2971	135	..do...	0	86	39	1	0	2	0	Yes	.99	7,800	28	21	22	6
2706	127	..do...	0	86	31	1	0	2	0	No	.94	6,800	19	28	21	7
2707	127	..do...	0	86	31	1	0	2	0	Yes	.94	7,900	39	18	16	5
PHENOLIC RESIN, PARAFFIN-SIZED BOARDS																
2964	4274x	Cold soda	2.8	92	123	1	1	2	0	No	.93	5,200	18	28	23	8
2965	4291x	..do...	2.1	94.6	41	1	1	2	0	No	.93	5,000	9	27	24	8
2710	127	Defibrated	0	86	31	1	1	2	0	No	.95	5,900	4	20	19	7
2711	127	..do...	0	86	31	1	1	2	0	Yes	.96	6,100	7	20	18	5

[1] Moisture-free basis.

Table 7.--Hot-pressing experiments with medium-density and insulation boards from sundri defibrated pulps

Board No.	Cold pressing			Hot pressing					Board data		
	Mat weight	Moisture content	Thickness	Time	Temperature	Pressure	Board weight	Moisture content	Specific gravity	Thickness	Remarks[1]
	G.	Percent	In.	Min.	°C.	P.s.i.	G.	Percent		In.	
MEDIUM-DENSITY BOARDS (NO CHEMICALS)											
2776				20	190	50	266				Delaminated
2777				30	190	50	261	0.0	0.64	0.41	Satisfactory
2778				25	190	50	271	1.8	.67	.42	Do.
2789	618		1.45	20	207	50	299				Delaminated
2790-3	504	53	1.40	21	212	50	248	4.0	.58	.43	Soft centerline
2788	671		1.50	22	212	50	306				Delaminated
2790-2	504	53	1.40	23	212	50	234	.2	.63	.39	Satisfactory
2790-1	606	57	1.50	25	207	50	261	.0	.62	.34	Do.
MEDIUM-DENSITY BOARDS (5 PERCENT PHENOLIC RESIN, 1 PERCENT PARACOL, AND 4 PERCENT ALUM)											
2805[2]	597	56	1.6	20	212	50	282	7.6		.48	1/16-inch soft center
2794	587	56	1.6	20	212	50	276	6.0	.63	.45	Centerline
2804[2]	572	54	1.5	21-1/2	212	50	275	5.0		.47	Do.
2795[2]	586	55	1.6	22	212	50	270	3.3	.62	.45	Faint centerline
2800	587	54	1.6	22	212	50	275	2.9	.62	.45	Satisfactory
2806[2]	605	57	1.6	23	212	50	263	3.0		.47	Do.
2799	622	56	1.5	23	212	50	287	4.2	.65	.47	Do.
2798	611	55	1.5	23	212	50	283	3.2	.63	.46	Do.
2796	548		1.5	23	212	50	250	.0			Do.
2801	608	55	1.6	24	212	50	281	2.1	.63	.46	Do.
2797	564		1.5	24	212	50	250	.0			Do.
2807	595	56	1.6	25	212	50	263	.8		.45	Do.
INSULATION BOARDS (NO CHEMICALS)											
2791	328	62	.6	20	212	5	131	5.0	.33	.40	Soft center
2792	302	59	.7	20	212	2-1/2	183	33.0	.18	.73	Do.
2793	307	62	.6	20	212	3-3/4	138	14.0	.24	.53	Do.

[1] Reference to soft center or centerline indicates portion of board that was wet when removed from the press. This portion of the mat was never thoroughly consolidated and was undoubtedly a weak area. A centerline (a thin area) represents a plane of weakness.

[2] Defibrator run No. 129. All others made from pulp of defibrator run No. 128.

Table 8.--Screen classification of sundri pulps made by various processes

Pulp		Defibrator freeness	Screen analysis (Bauer Classifier)				
			Retained on--				Passing 200-mesh[1]
Type	Cook No.		10-mesh[2]	14-mesh[3]	48-mesh[3]	200-mesh[4]	
		Sec.	Percent	Percent	Percent	Percent	Percent
Cold soda	4274x	103	2.4	4.3	43.1	23.7	26.5
Do.....	4291x	44	6.4	6.9	35.0	23.7	28.0
Defibrated	127	31	1.3	2.5	32.7	29.4	34.1
Do.....	135	40	.5	.5	49.0	22.2	27.8

[1] Fibers, fiber fragments, debris, ray cells, and other parenchyma cells.

[2] Fiber bundles.

[3] Individual fibers.

[4] Individual fibers and a few vessel cells.

Table 9.--Bleaching conditions for sundri pulps

Item	Kraft	Neutral sulfite semichemical	Cold soda				
			Bleach No. 1	Bleach No. 2	Bleach No. 1	Bleach No. 2	Bleach No. 3
Digestion No.	4233	4237	4238	1810y	1841y	4262x	4262x	4263x	4263x	4263x
Permanganate number	14.3	14.1	14.9	42	40.6					
Chlorination (2 to 3 percent consistence, 60 to 90 minutes at 25° C.):										
Amount applied.....percent[1]	4.5	4.5	4.5	8	8					
Amount consumed.....percent[1]	4.05	3.42	4.28	7.94	7.92					
Extraction with caustic soda (10 percent consistence, 60 minutes at 70° C.):										
Amount applied.....percent[1]	1.5	2	1.5	2	3				2.0	2.0
Initial pH	8.7	11.8	11.2	11.3	12				12.4	12.0
Final pH	7.7	11.4	10.9	10.9	8.9				10.5	10.2
Calcium hypochlorite treatment (10 percent consistence, 2 to 5 hours at 37° C.):										
Amount applied.....percent[1]	2	1.5	1.5	2	2	12	12		10	12
Amount consumed.....percent[1]	1.42	1.28	1.49	1.93	1.95	11.98	11.6		9.9	11.5
Initial pH	9.5	9.1	9.8	11.7	9.8	11.3	10.8		10.5	11.4
Final pH	8.7	7.6	8.2	10.9	8.3	11.0	9.9		9.5	9.3
Chlorine dioxide treatment (10 percent consistence, initial pH 6, 120 minutes at 70° C.):										
Amount applied.....percent[1]	0.5	0.5								
Amount consumed.....percent[1]	0.48	0.485								
Final pH	3.1	3.2								
Hydrogen peroxide oxidation[2] (13 percent consistence, 60 to 135 minutes at 70° C.):										
Amount applied.....percent[1]						1.0	1.5	1.0	1.0	
Amount consumed.....percent[1]						0.86	1.498	0.91	0.90	
Initial pH						10.5	10.8	10.9	10.9	
Final pH						9.6	9.8	10.1	10.1	
Sodium hydrosulfite treatment[3] (3 percent consistence, 60 minutes at 70° C.):										
Amount applied.....percent[1]							1.5			
Amount consumed.....percent[1]							1.44			
Initial pH							5.7			
Final pH							6.1			
Bleaching yield.....percent[4]	96.5	97	95	86	88	85.0		83		
Net bleached yield....percent[4]	44	42.9	44.9	55	52	72.2		74.8		
Brightness	82	85	85	50	77	55.1	73	36.6	60.3	64

[1] Based on weight of moisture-free unbleached pulp. The percent of calcium hypochlorite refers to available chlorine.

[2] Bleach liquor also contained 0.05 percent magnesium sulfate, 4 percent sodium silicate, and 1.6 percent sodium hydroxide.

[3] Bleach liquor contained 0.5 percent trisodium polyphosphate.

[4] Based on weight of moisture-free wood.

Table 10.--Properties[1] of sundri kraft pulps

Digestion No.	Condition of pulp	Total yield[2]	Beating time	Freeness (Canadian Standard)	Burst factor	Tear factor	Folding endurance (M.I.T.)	Breaking length	Density
		Percent	Min.	Cc.			Double folds	M.	G. per cc.
4233	Unbleached	46.1	0	720	.....	49.2	.....	1,585	0.33
			15	550	31.4	138.6	30	6,440	.45
			25	390	50.5	130.8	143.4	7,980	.51
			35	220	58.5	136.5	292.6	9,260	.57
4233	Bleached	44	0	700	15.1	131	4.4	3,440	.55
			10	450	29.6	141	82	5,080	.63
			15	250	53.8	99.4	257.6	8,483	.7
4237	Unbleached	44.4	0	720	11	109	.....	2,620	.37
			15	500	52	194	285	7,580	.56
			25	245	66	123	800	9,280	.64
4237	Bleached	42.9	0	680	10	94	5	2,660	.44
			10	500	33	116	37	6,230	.55
			17-1/2	330	47	112	74	7,440	.62
			22-1/2	200	48	106	76	7,760	.66
4238	Unbleached	47.3	20	555	49	161	118	8,070	.51
			30	420	64	144	344	9,600	.50
			45	240	78	130	899	9,750	.62
4238	Bleached	44.9	25	540	52	109	182	8,680	.58
			35	420	61	107	277	9,240	.57
			55	220	65	93	503	9,850	.62

[1]Tested by TAPPI Standards.

[2]Moisture-free basis.

Table 11.--Properties[1] of sundri neutral sulfite semichemical and cold soda pulps

Digestion No.	Condition of pulp	Total yield[2]	Beating time	Freeness (Canadian Standard)	Burst factor	Tear factor	Folding endurance (M.I.T.)	Breaking length	Density
		Percent	Min.	Cc.			Double folds	M.	G. per cc.
NEUTRAL SULFITE SEMICHEMICAL PULPS									
1810y	Unbleached	64	40	500	32	96	25	6,000	0.44
			50	390	40	94	80	7,000	.49
			60	285	44	76	139	6,860	.49
1810y	Bleached	55	25	520	50	132	129	7,680	.48
			35	410	64	159	476	9,750	.47
			45	280	73	135	594	9,760	.55
1840y[3]	Unbleached	64	15	630	14	76	4	3,240	.40
			35	540	29	108	26	5,360	.49
			55	325	44	100	85	6,920	.54
1841y	Unbleached	59	0	730	14	76	4	3,185	.46
			10	640	23	104	11	5,210	.48
			30	430	44	99	94	7,400	.55
			43	220	56	112	275	8,930	.59
1841y	Bleached	52	10	465	63	154	281	9,330	.54
			25	200	82	135	447	11,930	.66
COLD SODA PULPS									
4262	Bleached	72.2	.....	300	24	94	21	3,200	.58
4263	Unbleached	90	.....	155	4.1	24	.....	1,090	.42
4263x	Bleached	74.8	.....	45	7.4	36	.....	1,706	.41

[1] Tested by TAPPI Standards.

[2] Moisture-free basis.

[3] At 220 Canadian Standard freeness and 0.56 density, a 26-pound 1,000 sq. ft. handsheet had a flat crush (Concora) of 75.6 pounds and a ring crush of 61 pounds for a specimen 6 inches long and 1/2 inch wide.

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