PULPING OF NORTHERN WHITECEDAR AND TAMARACK

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PULPING OF NORTHERN WHITECEDAR AND TAMARACK[1]

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Summary

Groundwood, sulfate, and sulfite pulping experiments were made on samples of northern whitecedar and tamarack from northern Wisconsin, representative of material available for pulpwood.

Groundwood pulp obtained from the cedar was comparable in strength properties with that made from spruce. However, its yellowish-brown color, which apparently was caused by a high percentage of dark-colored heartwood, did not respond to the normal treatment with bleaching chemicals. Unbleached-cedar groundwood could be used in darker colored paper and board, but it appeared that bleaching it for use in white paper would not be practicable.

The cedar required longer cooking by the sulfite process, and the yield of pulp was 2 to 3 percent lower than that of spruce. The strength value of the unbleached pulp was high. The yield of sulfate pulp obtained from the cedar was 3 or 4 percent lower than that obtained from jack pine of similar grade, but its strength was equal to that of jack pine.

The tamarack groundwood pulp was similar to southern pine groundwood pulp, except that its color was darker. The pulp was easily brightened to the level required for newsprint by bleaching it with peroxide or hydrosulfite in a single-stage treatment.

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

Like the cedar, the tamarack required longer cooking and gave a slightly lower yield by the sulfite process than did spruce. Its strength was much lower than that of spruce. Tamarack sulfate pulp was found to be about like jack pine sulfate pulp, with generally higher tearing resistance. Though yields on a weight basis by both chemical processes were relatively low, this wood will give high yields per cord because of its high density.

Introduction

Northern whitecedar and tamarack have been used for pulp manufacture in the Lake States for many years, but only in small quantities because of the availability of other softwoods with generally better pulping qualities. Because of heavy cutting for lumber and pulp and inadequate regrowth, the decline in the supply of the better conifers has now become a matter of much concern. The cedar and tamarack swamps have been cut less heavily, and so these woods are increasing in volume. More use of them could relieve the drain on other softwoods, as well as be a help in improving forest management, especially in areas where they grow in mixed stands with other softwoods.

This report deals with the pulping of these two woods by the groundwood, sulfate, and sulfite processes, and the kinds of paper in which they can be used.

Test Material

Approximately 1 cord of each of the two woods was shipped to the Forest Products Laboratory by the Lake States Forest Experiment Station. The trees had been cut in the vicinity of Wausau, Wis., and the bark removed from the 8-foot logs before shipment. The wood was practically air dry when received. The moisture content ranged from 15 to 20 percent (based on the weight of the wood and moisture).

Northern Whitecedar (*Thuja occidentalis*)

The physical characteristics and chemical constituents of the northern whitecedar sample are given in table 1. The average density of 19.1 pounds per cubic foot (based on the weight of the moisture-free wood and its volume when green) is lower than that of any of the coniferous woods now used for pulping. The sample contained a large amount of heartwood, an important factor in determining the quality of the wood for groundwood pulping.

Tamarack (*Larix laricina*)

The data on tamarack from this sample are in table 1. In contrast to the cedar, the density of this wood was 30.6 pounds per cubic foot, much higher than most of the northern softwoods used for pulping. In average age, number of rings per inch, and volume of heartwood, the tamarack was much lower than the cedar.

Experimental Procedures

Groundwood Pulping

The experimental grinder used for these tests has 3 pockets, each 16 inches wide, and takes blocks of wood 6 inches long. The pulpstone is 54 inches in diameter and 8 inches in width. A sandstone was used. The nearly air-dry wood was impregnated with cold water under air pressure before it was ground. About 50 pounds of wood (estimated moisture-free weight) were ground in each experiment.

Sulfate Pulping

The sulfate digestions were made in a stainless-steel, tumbling autoclave of 0.8-cubic-foot capacity and equipped with a steam-heated jacket. The digester was charged with 5 pounds of chips (estimated moisture-free weight) and 2.4 gallons of cooking liquor. After a digestion was completed, the chips were emptied from the autoclave into a drain box, then defibered in water in a tank equipped with an electric stirrer.

Sulfite Pulping

Sulfite pulping experiments like the sulfate pulping tests were made in tumbling, 0.8-cubic-foot digesters with indirect heating. The same volumes of liquor and of chips were used in all digestions. Therefore, the ratio of gallons of liquor to pounds of wood was greater for the cedar wood than for the tamarack because of its lower density. Because both the cedar and tamarack were nearly air dry, the chips were lightly steamed in the digester before the cooking liquor was introduced, to increase their moisture content and so help the diffusion of the chemicals into the wood.

Screening

All pulps were screened on a diaphragm-plate screen. The plate used for the sulfate pulps had slots 0.012 inch wide (12-cut), and the plate used for the groundwood and sulfite pulps had slots C.008 inch wide (8-cut). Inasmuch as the digesters were emptied by dumping the contents instead of blowing them out, the first screenings of the sulfite pulps were mildly stirred in water by mechanical means to simulate the action that might occur if they were blown and "pumped to the screen." They were then rescreened. In the tabulation of the data, "hard" screenings are those retained on the plate in the second screening, and "soft" screenings are those which passed the plate in the second screening.

Bleaching

Small-scale bleaching tests were made to determine the response of the cedar and tamarack groundwood pulps to one-stage treatments with peroxide, hydrosulfite, and hypochlorite. The dosage of chemicals and other experimental details are included in the tabulated data.

Testing

Standard TAPPI pulp testing procedures were followed. The only test made for which there is no standard is the Bauer-McNett screen classification test used on the groundwood pulps.

Pulping of Northern Whitecedar

Groundwood Pulping

The data for three groundwood pulping experiments are given in table 2. The pulps ranged in Canadian Standard freeness from 43 to 140 milliliters, within which groundwood for use in printing papers, such as book and newsprint, is manufactured. The strength of the pulps was as high or higher than that of typical commercial pulps of the same freeness. The data indicate that the amount of energy consumed would be comparable to that consumed in commercial practice. Because of the high proportion (67 percent) of dark-colored heartwood in the wood, the color of the groundwood was yellowish brown and the brightness in the low range of 36 to 39 percent.

Bleaching experiments on the cedar groundwood pulp are summarized in table 3. The response to bleaching was not good. Calcium hypochlorite and hydrogen peroxide were better than sodium hydrosulfite for bleaching, but the brightness obtained with the normally used amounts of these chemicals was only 52 percent.

The experiments indicated that unbleached cedar groundwood pulp could be used in large amounts in papers and boards where color is unimportant and perhaps mixed in small amounts with other groundwood in lighter colored papers, but that it would not be practical to bleach it for use in white papers.

Sulfate Pulping

The sulfate pulping experiments made on the northern whitecedar consisted of a series of digestions made with from 17.5 percent to 30 percent of total chemical, based on the weight of the wood. A constant sulfidity of 25.5 percent was maintained in the cooking liquor. The cooking conditions are given in table 4.

The yield of moisture-free screened pulp decreased from 46.6 to 39.1 percent of the weight of the moisture-free wood as the amount of chemical was increased. Similarly, the amount of screenings decreased from 2.8 to 0.1 percent. The screenings appeared to be mostly the remains of small knots.

Handsheets made from the pulps were relatively light colored compared with most kraft pulps. Judged by the permanganate numbers, cedar pulped to about 40 percent yield with 28 to 30 percent of total chemical would be fairly easy to bleach. One digestion (No. 3453) was cooked an additional hour in an effort to lower the permanganate number. The longer cook did reduce the permanganate number, which indicated a reduction in the amount of bleaching chemical that would be required without reducing the yield of unbleached pulp.

As noted in table 5, the cedar pulps required more beating time to reach the same freeness level than did the commercial jack pine sulfate pulp used for comparison. The cedar pulps had slightly greater tearing resistance and tensile strength, about the same bursting strength, and almost two times as much folding endurance as did the jack pine pulp. The slight strength superiority of the cedar pulp could be due to its higher sheet density.

Sulfite Pulping

The northern whitecedar was cooked by the calcium-base sulfite process. Conditions known to be suitable for pulping spruce were used, and are included in table 6.

Compared with black spruce cooked under similar conditions, the cedar cooked more slowly, and required perhaps 2 hours longer than the pulps cooked for easier bleaching. The yields of pulp were several percent lower than those of spruce cooked similarly. The best unbleached cedar pulps were strong, though not as strong as the best spruce sulfite pulp (table 7). Their brightness was also lower than that of spruce. The lower strength values of pulp No. 1430Y, which had been cooked for 8 hours, are believed to be the result of overcooking.

Pulping of Tamarack

Groundwood Pulping

A dull stone surface was used in the first two groundwood pulping experiments on tamarack (grinder runs Nos. 1147 and 1148, table 2). The pulp made at the lower grinding pressure (run No. 1148) was lower in freeness than most commercial groundwood pulps, while the pulp made at a higher pressure (run No. 1147) was slightly higher in freeness and within the range of commercial practice. Its strength was average. The stone surface was burred lightly, and another pulp (run No. 1159) was made which had still higher freeness but its strength was lowered a little. The consumption of energy was reasonable for all the pulps.

The brightness of the tamarack groundwood was below or near the lower limit of the range of groundwood pulps used for making newsprint, but it responded readily to bleaching with peroxide or hydrosulfite in single-stage treatments. Grinder run No. 1160 was made under conditions duplicating run No. 1159 to obtain fresh pulp for bleaching tests. The details of the bleaching experiments are given in table 3.

Sulfate Pulping

An increase in the amount of sulfate pulping chemicals from 17.5 percent to 27.5 percent of the weight of the wood caused the yield of tamarack pulp to decrease from 48.4 percent to 40.7 percent (table 4). The lowest percentage of chemicals gave inadequate pulping, as shown by the high amount of screenings, 7.4 percent, and the high permanganate number, 34.9. Kraft-type pulp of satisfactory quality and the highest yield of screened pulp (44.6 percent) in the series was obtained with 20 percent of chemicals. A pulp suitable for bleaching was made with total chemicals equivalent to 25 percent of the weight of the wood; the yield of screened pulp was 41.7 percent, and the permanganate number was 19.4. The yields of pulp, based on weight of moisture-free materials, were a little lower than those obtained from similarly cooked jack pine, but on a basis of pounds of pulp per cord or cubic foot they were appreciably higher because of the higher density of the tamarack.

The outstanding strength characteristic of the tamarack sulfate pulps was their tearing resistance (table 5). The tearing resistance was higher than that of jack pine and lower than that of southern pine. The kraft type of tamarack pulp had the best bursting strength and breaking length, whereas the bleaching-grade pulp had the best tearing resistance and folding endurance. The bursting strength of the kraft-type tamarack pulp was about equal to that of a similar grade of jack pine pulp. It could be used in making high-grade wrapping paper and, if mixed with jack pine pulp, would improve the tearing strength as compared to paper made with jack pine pulp alone.

Because of similar pulping characteristics, tamarack and jack pine could be cooked together provided proper adjustments are made for the change in weight of wood in the digester caused by the difference in their densities.

In comparison with tests made on samples of western larch (*Larix occidentalis*), this sample of tamarack required more chemical for pulping, gave lower yields, and produced pulps that were a little higher in bursting strength and a little lower in tearing resistance.

Sulfite Pulping

The tamarack, like the cedar, required more time than black spruce to obtain an easy bleaching sulfite pulp, and the yields were several percent lower (table 6). The strength of the tamarack sulfite pulps was lower than that of the cedar sulfite, as well as that of black spruce sulfite (table 7). The color of the tamarack pulp was darker than that of spruce sulfite and similar to that of the cedar pulp. Tamarack sulfite pulps with the higher permanganate numbers were dirty.

Table 1.--Physical tests and chemical analysis on northern whitecedar and tamarack from Wisconsin

Species	Northern whitecedar	Tamarack
Shipment No	4324	4325
Physical tests:[1]		
Diameter........inches	6.4	4.7
Age........years	93	43
Rate of growth........rings per inch	28.9	19.1
Specific gravity[2]	.306	.491
Density[2]........lb. per cu. ft.	19.1	30.6
Heartwood (diameter)........inches	5.2	[3]3.3
(volume)........percent	66.7	24.9
Chemical analysis:[4]		
Lignin........percent	29.8	25.8
Holocellulose........percent	58.9	60.4
Alpha-cellulose........percent	43.6	43.3
Pentosans........percent	13.6	8.6
Solubility in:		
Alcohol-benzene........percent	6.0	3.6
Ether........percent	1.4	1.5
1 percent sodium hydroxide..percent	12.9	18.2
Hot water........percent	5.3	10.1
Ash........percent	.5	.3

[1] Physical tests made on disks cut from 19 cedar logs and 50 tamarack logs. Average values include all logs in the samples unless otherwise noted.

[2] Moisture-free weight and green volume.

[3] Average for the 25 logs that contained heartwood.

[4] Chemical analysis made on samples of chips used for chemical pulping. Percentages based on moisture-free wood.

Table 2.--Groundwood pulping of northern whitecedar and tamarack

Run No.	Grinding data[1]: Pressure of wood on stone	Grinding data[1]: Grinding rate	Grinding data[1]: Energy consumed[4]	Properties of pulp suspension: Canadian Standard freeness	Screen analysis: Retained on 28-mesh	Retained between 28- and 48-mesh	Retained between 48- and 100-mesh	Retained between 100- and 200-mesh	Passing 200-mesh	Fiber length index[5]	Properties of pulp test sheets[2]: Bursting strength	Tearing resistance	Breaking length	Density	Brightness: Unbleached	Brightness: Bleached
	Lb. per sq. in.	Tons[3]	Hp.-days	Ml.	Percent	Percent	Percent	Percent	Percent		Pts. per lb. per ream	Gm. per lb. per ream	Meters	Gm. per cc.	Percent	Percent
							NORTHERN WHITECEDAR									
1144	20	0.84	95	43	8.5	17.8	18.3	12.9	42.5	0.071	0.35	0.64	3,710	0.48	39	....
1145	27	1.17	73	95	9.7	17.2	18.5	13.4	41.2	.072	.27	.62	2,950	.40	36	52
1146	35	2.12	61	140	11.4	19.2	18.7	13.2	37.5	.078	.23	.56	2,520	.36	37	....
							TAMARACK									
1148	30	1.39	64	25	5.7	15.6	18.6	15.4	44.7	.067	.21	.49	2,630	.42	40	....
1147	40	1.96	58	40	5.5	16.7	20.9	15.9	41.0	.071	.21	.54	2,910	.43	42	....
1159	40	3.11	43	70	6.5	17.1	22.8	17.2	36.4	.077	.16	.47	1,960	.40	41	....
1160	40	2.54	50	....	....	....	....	....	....	....	....	....	....	....	45	60
							TYPICAL GROUNDWOOD PULPS FROM COMMONLY USED WOODS									
Spruce-aspen[6]			....	60	4.6	16.6	24.9	16.5	37.4	.075	.26	.48	3,200	.44	63	....
Spruce-aspen[7]			....	140	9.3	19.7	24.2	16.3	30.5	.087	.17	.43	2,070	.39	59	....
Southern pine[8]			79	85	....	....	....	....	....	....	.25	.59	2,060	....	58	....
Western hemlock[8]			50	95	....	....	....	....	....	....	.22	.62	2,500	....	54	....

[1] A sandstone with the grinding surface pattern produced by a 10 by 1-1/2 spiral burr was used. The stone surface was dull for runs 1144 to 1148 inclusive and medium sharp for runs 1159 and 1160. Common for all runs were: pit temperature 145° F.; peripheral speed of stone 3,120 feet per minute; and pit consistency, 3 to 4 percent.

[2] Basis weight of test sheets was 115 pounds per ream of 500 sheets, 25 by 40 inches.

[3] Moisture-free wood per 24 hours per square foot of wood-stone contact area.

[4] Per ton moisture-free wood.

[5] Calculated from screen analysis.

[6] Commercial book-grade pulp.

[7] Commercial newsprint-grade pulp.

[8] Experimental.

Table 3.--One-stage bleaching experiments on northern whitecedar and tamarack groundwood pulps

Bleach No.	Chemical: Kind	Chemical: Amount[1]: Applied	Chemical: Amount[1]: Consumed	Consistence	Temperature	Conditions: Duration	Conditions: pH: Initial	Conditions: pH: Final	Brightness of bleached pulp
		Percent	Percent	Percent	°C.	Min.			Percent
				NORTHERN WHITECEDAR[2]					
3981-2	Hydrogen peroxide[3]	2.0	1.9	10	60	240	10.6	9.0	49.5
3983-4	Sodium hydrosulfite[4]	1.0	....	3	80	30	5.5	....	46.9
						60	....	5.0	49.2
3985-6	..........do.........	2.0	....	3	80	30	5.5	....	44.2
						60	....	4.7	44.6
3987-8	Calcium hypochlorite[5]	10.0	10.0	10	37	15	11.4	10.0	51.6
				TAMARACK[6]					
4112	Hydrogen peroxide[3]	2.0	1.9	13	60	60	10.7	9.5	53.5
4113	..........do........	3.0	2.8	13	60	90	10.6	9.1	59.6
4115	Sodium hydrosulfite[4]	1.0	....	3	80	30	6.3	....	58.1
						60	....	5.5	60.1
4116	..........do.........	2.0	....	3	80	60	6.3	5.7	59.8
4111	Calcium hypochlorite[5]	10.0	10.0	10	37	25	11.4	9.5	47.5
4114	..........do.........	15.0	15.0	10	37	30	11.4	9.0	59.3

[1] Based on weight of moisture-free pulp.

[2] Grinder run No. 1145, pulp brightness 36.3 percent.

[3] Amounts in terms of 50 percent solution. Buffered and stabilized with 4 percent sodium silicate for the cedar pulp (5 to 6 percent for the tamarack pulp), 0.6 percent sodium hydroxide for the cedar pulp (1.6 percent for the tamarack pulp), and 0.05 percent magnesium sulfate.

[4] Air excluded with nitrogen, pH adjusted to 5 for the cedar pulp (6.3 for the tamarack pulp), and 0.5 percent of the trisodium salt of ethylenediamine tetra-acetic acid (EDTA) added before the hydrosulfite in order to inactivate metal ions that would catalyze its decomposition.

[5] Three percent sodium hydroxide for the cedar pulp (4 percent for the tamarack pulp) and 4 percent sodium silicate were added to obtain effective bleaching and maintain pulp strength.

[6] Grinder run No. 1160, pulp brightness 45.2 percent.

Table 4.--Cooking conditions and yield data for sulfate pulping of northern whitecedar and tamarack

Digestion No.	Cooking data[1]						Yield of moisture-free pulp per 100 pounds of moisture-free wood			Permanganate No.
	Chemicals charged			Chemicals consumed: based on chemicals added	Black liquor: density at 15° C.	Duration at maximum temperature	Screened	Screenings	Total	
	Initial concentration calculated as Na_2O	Per 100 pounds of moisture-free wood: NaOH plus Na_2S	Per 100 pounds of moisture-free wood: Calculated As Na_2O							
	Gm. per l.	Lb.	Lb.	Percent	°B	Hr.	Lb.	Lb.	Lb.	
NORTHERN WHITECEDAR										
3440	34.1	17.5	13.7	81.7	10.1	1.5	46.6	2.8	49.4	37.5
3444, 3450	39.0	20.0	15.6	77.4	11.2	1.5	45.7	.8	46.6	32.9
3445, 3451	43.9	22.5	17.6	70.4	12.0	1.5	43.6	.5	44.1	26.9
3452	48.8	25.0	19.5	68.9	12.7	1.5	42.7	.4	43.1	24.5
3441	53.6	27.5	21.5	65.4	14.6	1.5	41.3	.3	41.6	23.1
3447	58.5	30.0	23.4	61.9	14.2	1.5	39.1	.2	39.3	19.8
3453	58.5	30.0	23.4	65.2	14.1	2.5	39.5	.1	39.6	16.8
TAMARACK										
3501X	34.1	17.5	13.7	82.2	10.2	1.5	41.0	7.4	48.4	34.9
3505X	39.0	20.0	15.6	77.1	11.1	1.5	44.6	1.1	45.7	31.3
3507X	43.9	22.5	17.6	72.8	12.0	1.5	43.1	.5	43.6	26.7
3503X	48.8	25.0	19.5	68.9	12.7	1.5	41.7	.3	42.0	19.4
3499X	53.6	27.5	21.5	66.1	13.6	1.5	40.5	.2	40.7	17.4

[1] The cooking conditions other than those tabulated were as follows: weight of moisture-free wood, 5.0 pounds; maximum temperature, 170° C.; temperature-pressure increase period, 1.5 hours; sulfidity (based on active alkali), 25.5 percent; and liquor-wood ratio (including moisture in chips), 4 to 1.

Table 5.--Strength properties[1] of sulfate pulps made from northern whitecedar and tamarack

Digestion No.	Duration of beating to freeness of[2] 450 milliliters	Duration of beating to freeness of[2] 250 milliliters	Bursting strength at freeness of[2] 450 milliliters	Bursting strength at freeness of[2] 250 milliliters	Tearing strength at freeness of[2] 450 milliliters	Tearing strength at freeness of[2] 250 milliliters	Breaking length at freeness of[2] 450 milliliters	Breaking length at freeness of[2] 250 milliliters	Folding endurance at freeness of[2] 450 milliliters	Folding endurance at freeness of[2] 250 milliliters	Sheet density at freeness of[2] 450 milliliters	Sheet density at freeness of[2] 250 milliliters
	Minutes		Pts. per lb. per ream		Gm. per lb. per ream		Meters		Double folds		Gm. per cc.	
NORTHERN WHITECEDAR												
3444X, 3450X	34	60	1.56	1.57	1.45	1.15	11,500	12,000	3,800	5,200	0.87	0.96
3445X, 3451X	34	71	1.49	1.56	1.45	1.20	11,100	11,600	3,000	3,300	.83	.95
3452X	38	89	1.43	1.49	1.55	1.20	11,000	12,300	3,300	3,800	.83	.92
3441X	41	85	1.43	1.50	1.45	1.15	10,700	11,800	3,300	4,300	.86	.94
3447X	35	75	1.40	1.49	1.40	1.05	12,000	11,300	3,000	3,300	.84	.94
TAMARACK												
3501X	47	66	1.36	1.44	1.96	1.43	10,400	11,500	930	1,470	.69	.76
3505X	42	57	1.38	1.46	1.90	1.62	10,400	11,100	920	1,330	.69	.77
3507X	39	54	1.29	1.39	1.94	1.71	9,900	10,400	1,110	1,290	.70	.75
3503X	39	56	1.27	1.45	2.04	1.93	9,400	10,700	1,070	1,480	.69	.75
3499X	40	58	1.24	1.34	1.91	1.53	10,200	10,700	930	1,120	.69	.76
COMMERCIAL JACK PINE SULFATE PULP												
....	32	51	1.45	1.50	1.40	1.13	10,600	11,600	1,850	2,400	.8	.86

[1] Data on unbleached pulp interpolated from standard beater test curves. Test sheets were conditioned and tested at 23° C. and 50 percent relative humidity. Ream size was 500 sheets, 25 by 40 inches.

[2] Canadian Standard freeness.

Table 6.--The pulping of northern whitecedar and tamarack by the calcium-base sulfite process

Digestion No.	Time at 130° C.[1]	Combined SO_2 in spent liquor[2]	Permanganate No.	Yield of pulp: Soft screenings[3]	Yield of pulp: Hard screenings	Yield of pulp: Total
	Hours	Percent		Percent	Percent	Percent
NORTHERN WHITECEDAR						
1423y	3.25	0.34	32.4	(4)	0.2	51.4
1427y	[5]4.5	.23	25.7	1.2	.2	48.8
1422y	5.25	.18	17.7	(4)	.1	46.7
1426y	[5]6.75	.10	14.2	.4	.1	44.5
1430y	[5]8.00	.05	11.8	(6)	.2	44.0
TAMARACK						
1425y	3.25	.40	27.5	4.7	1.8	49.5
1429y	4.25	.29	22.4	1.9	.4	47.7
1424y	5.25	.12	13.4	.2	.4	44.5
1428y	5.90	-.08	10.5	.0	.4	43.4

[1] Conditions common to all digestions: Air-dry chips steamed 0.5 hour before adding the cooking liquor (60 gallons per 100 pounds of moisture-free cedar, 6.15 percent total, 1.175 percent combined sulfur dioxide; 50 gallons per 100 pounds of moisture-free tamarack, 6.55 percent total, 1.345 percent combined sulfur dioxide). Schedule: 2 hours to 110° C., 2 hours at 110° C., unless otherwise noted, and 2 hours to 130° C. Maximum pressure 80 pounds per square inch.

[2] Sander test.

[3] Screenings readily reduced to fibers by light mechanical action.

[4] Combined with the screened pulp.

[5] One hour at 110° C. instead of 2 hours.

[6] Combined with the hard screenings.

Table 7.--Physical properties of sulfite pulps from northern whitecedar and tamarack[1]

Digestion No.	Permanganate number	Bursting strength		Tearing resistance		Breaking length		Folding endurance		Sheet density		Beating time		Pulp brightness (G.E. equivalent)
		500-milliliter freeness[2]	250-milliliter freeness[2]	500-milliliter freeness[2]	250-milliliter freeness[2]	500-milliliter freeness[2]	250-milliliter freeness[2]	500-milliliter freeness[2]	250-milliliter freeness[2]	500-milliliter freeness[2]	250-milliliter freeness[2]	500-milliliter freeness[2]	250-milliliter freeness[2]	
		Pts. per lb. per rm.[3]	Pts. per lb. per rm.[3]	Gm. per lb. per rm.[3]	Gm. per lb. per rm.[3]	Meters	Meters	Double folds	Double folds	Gm. per cc	Gm. per cc	Min.	Min.	Percent
		NORTHERN WHITECEDAR												
1423y	32.4	1.08	1.19	1.02	0.88	8,050	10,200	540	1,030	0.84	0.93	9	19	34.3
1427y	25.7	1.05	1.21	.87	.72	9,000	10,700	550	2,000	.85	.97	8	22	38.0
1422y	17.7	1.02	1.11	.92	.70	8,300	10,200	690	1,320	.89	.99	7	18	37.3
1426y	14.2	.98	1.12	.98	.77	8,400	10,400	680	1,850	.86	.99	8	24	....
1430y	11.8	.93	1.03	.73	.65	7,300	8,900	410	700	.90	1.00	8	24	42.7
		TAMARACK												
1425y	27.5	.82	.87	.95	.76	7,500	8,600	280	580	.75	.82	10	16	34.3
1429y	20.0	.82	.89	1.02	.77	8,300	9,100	450	840	.77	.86	14	23	35.6
1424y	13.4	.68	.80	.87	.72	7,350	8,250	230	500	.77	.85	9	14	38.3
1428y	10.5	.64	.72	.87	.70	6,700	7,300	160	500	.79	.88	12	19	40.8

[1] Data interpolated from standard beater test curves.

[2] Canadian Standard freeness.

[3] Ream of 500 sheets, each 25 by 40 inches.

SUBJECT LISTS OF PUBLICATIONS ISSUED BY THE

FOREST PRODUCTS LABORATORY

The following are obtainable free on request from the Director, Forest Products Laboratory, Madison 5, Wisconsin:

List of publications on Box and Crate Construction and Packaging Data

List of publications on Chemistry of Wood and Derived Products

List of publications on Fungus Defects in Forest Products and Decay in Trees

List of publications on Glue, Glued Products, and Veneer

List of publications on Growth, Structure, and Identification of Wood

List of publications on Mechanical Properties and Structural Uses of Wood and Wood Products

Partial list of publications for Architects, Builders, Engineers, and Retail Lumbermen

List of publications on Fire Protection

List of publications on Logging, Milling, and Utilization of Timber Products

List of publications on Pulp and Paper

List of publications on Seasoning of Wood

List of publications on Structural Sandwich, Plastic Laminates, and Wood-Base Aircraft Components

List of publications on Wood Finishing

List of publications on Wood Preservation

Partial list of publications for Furniture Manufacturers, Woodworkers and Teachers of Woodshop Practice

Note: Since Forest Products Laboratory publications are so varied in subject no single list is issued. Instead a list is made up for each Laboratory division. Twice a year, December 31 and June 30, a list is made up showing new reports for the previous six months. This is the only item sent regularly to the Laboratory's mailing list. Anyone who has asked for and received the proper subject lists and who has had his name placed on the mailing list can keep up to date on Forest Products Laboratory publications. Each subject list carries descriptions of all other subject lists.