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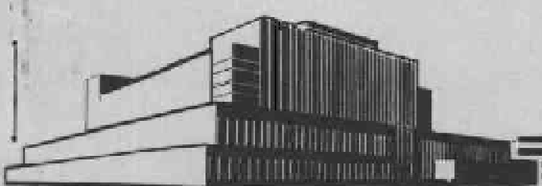
January 1959

No. 2141



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

BOARDS AND PAPERS FROM SHORTLEAF PINE, BLACK TUPELO, AND SOUTHERN WHITE OAK NEUTRAL SULFITE SEMICHEMICAL PULPS

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Summary

Shortleaf pine, black tupelo, and white oak were pulped over the semichemical range in yield by the neutral sulfite process. Requirement of sodium sulfite for a pulp yield of 75 percent was 19.5, 15.5, and 10.5 percent respectively on the weight of the wood. Standard test sheets made from pine and from tupelo were similar in density and strength. The tupelo sheets had unusually high tearing resistance for a hardwood semichemical pulp, but the other strength properties were average. The much lower density of the sheets made from white oak suggests that these fibers would be of value where high bulk, permeability, and opacity were required. More drastic wet pressing to increase the density of the oak pulp sheets would have improved their strength, which was below that of the tupelo pulps.

Satisfactory corrugating boards (except perhaps for stiffness, which was not determined) were made from pine which had been cooked to better than 80 percent yield, from tupelo cooked to 76 percent yield, and from oak cooked to 72 percent yield. The pine board was much bulkier than typical commercial hardwood boards, and the boards from all three woods were less dense than a board made from a commercial aspen neutral sulfite semichemical furnish. Linerboard made from shortleaf pine cooked to 71 percent yield was likewise bulkier than a commercial kraft linerboard. The experimental board had much less folding endurance but otherwise showed promise.

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

Both tupelo and oak pulps bleached normally by the chlorine-caustic soda extraction-hypochlorite process.

Bond and greaseproof papers made from the white oak pulp did not equal top grade commercial papers in strength, but the bond paper possessed exceptionally high opacity for a fully bleached hardwood semichemical pulp. Tupelo greaseproof paper made from pulp produced at a yield of 52 percent based on the wood had good strength and unusually low air permeability. Bond paper made from this bleached pulp had excellent strength but inadequate opacity. While the opacity of the tupelo paper could be improved it is unlikely that it could be brought to match commercial sulfite bond paper without blending the furnish with another type of fiber. A blend of bleached tupelo and oak pulps might be considered in order to take advantage of the good strength of the former and the higher opacity of the latter.

Introduction

This report summarizes three investigations of the pulping of the southern species -- shortleaf pine, black tupelo, and white oak -- by the neutral sulfite semichemical process. In each investigation, small-scale digestions were made on each wood over a range of conditions, so as to obtain pulps varying widely in yield. On the basis of tests made on these pulps, larger amounts of pulp were prepared for making appropriate papers and boards. Corrugating boards were made from all three species. Linerboards were made from shortleaf pine pulps; linerboards and greaseproof papers were made from black tupelo pulp; and greaseproof paper was made from white oak pulp. Bond papers were made from tupelo and from oak pulps.

Experimental

Arrangements for supplying suitable wood were made by the Southern and Southeastern Forest Experiment Stations. The shortleaf pine was shipped from Crossett, Ark., and the black tupelo from Carriere, Miss., while the white oak was furnished by a mill in Franklin, Va. Identification of the first two woods as *Pinus echinata* and *Nyssa sylvatica* respectively was confirmed at the Forest Products Laboratory. The oak could not be identified in cordwood form beyond it being a member of the white oak group, but it was assumed to be the *Quercus alba* requested.

The wood was reduced to nominal 5/8-inch chips with a 47-inch, 2-knife chipper and screened to remove sawdust, pinchips, and oversized material The chips were lightly steamed at a gage pressure of less than 10 p.s.i.

with the blow valve open to the atmosphere for 0.5 hour in the digester in order to remove air and accelerate penetration of the cooking liquor which was added subsequently. This liquor contained technical grades of sodium sulfite and sodium bicarbonate. The digester contents were heated to the maximum temperature over a period of 2.5 hours and the cooking continued until the concentration of sodium sulfite in the liquor had decreased to about 10 grams per liter. Further information on cooking times, maximum temperatures, and liquor concentrations is given in the tables. White oak was also cooked to a yield of 61.9 percent under different conditions (see the last digestion in table 3). In this the chips, after steaming, were impregnated at 120° C. for 1 hour with a highly concentrated liquor. After this impregnation the chemical in excess of the amount actually required for cooking was removed and the chips heated to maximum temperature in 10-15 minutes. It was believed that impregnation would give a more satisfactory material for bleaching. Subsequent developments have shown that such treatment is not needed.

The chips were cooked in stainless steel, tumbling digesters that were fitted with steam jackets for indirect heating. Material for the preliminary digestions was cooked in vessels of 0.8-cubic foot capacity, and softened chips were reduced to a pulp with an 8-inch single-rotating-disk mill. Material for papermaking experiments was cooked in 13-cubic foot vessels and fiberized in a 36-inch, commercial, double-rotating-disk mill.

For making bond and bleached greaseproof papers, the pulps were bleached by a conventional three-stage chlorination, caustic extraction, calcium hypochlorite treatment. Papers and boards were made on the 13-inch experimental paper machine. Pulp evaluation closely followed the 1950-1951 TAPPI standards.

Discussion

Wood

The wood in all three shipments averaged close to 6 inches in diameter, which is typical of much southern pulpwood. The densities of the woods were typical for the species and high enough to promise good yields of pulp per cord of wood, especially from the oak (table 1). The white oak contained 53 percent of heartwood. The pine contained only 4.6 percent, along with 3 percent of compression wood which has an unfavorable effect on pulp strength.

Although broadleaved species commonly contain a good deal less lignin than the coniferous species do, table 2 shows that all three woods had closely the same high lignin content. This shipment of tupelo contained only slightly more lignin than three other tupelos previously tested and was slightly lower in pentosans and caustic soluble material. Compared with several other lots of shortleaf pine, the present shipment was of average lignin content but it contained less pentosans and caustic soluble material. The lignin content of the oak was at the upper limit of the range described by other oaks which have been tested here, and this suggests that low yields of pulp per pound of wood would be obtained. The amount of hot-water solubles and caustic soda solubles was average for the oak, but the pine and the tupelo contained much less.

Pulping

The behavior in the digester of the three woods confirmed previous experience. Coniferous woods cook more slowly than deciduous woods. Among deciduous woods in general oaks cook to a given yield more readily than others. This is true of both cooking time and sodium sulfite requirements (table 3). For 75 percent yield, the respective requirements were 19.5, 15.5, and 10.5 pounds of sodium sulfite per 100 pounds of dry wood for pine, tupelo and oak, respectively. These figures were corrected to a common basis of 10 grams of sodium sulfite per liter in the spent liquor. The large proportion of lignin in coniferous woods is sometimes cited as contributing toward their resistance to sodium sulfite pulping, but it will be recalled that the three samples of wood all contained the same quantity of lignin. A characteristic of softwoods, which can be observed in the table, is the smaller amount of buffering chemical needed to keep the cooking liquor neutral.

For making bleached pulp, the lignin content of the unbleached pulp is of prime consideration as well as its yield. Other factors being equal species that give the greatest yield of pulp of a given lignin content are the most attractive. By this criterion, the order of preferance would be black tupelo, white oak, and shortleaf pine (table 4). However the yield differences at equal lignin content amounted to only a few percent.

Pulp Properties

As just mentioned, the shortleaf pine resisted lignin removal the most tenaciously of the three woods, and because of higher lignin content the pulp would presumably furnish the lowest yield of bleached pulp. Although there was little to choose from between the two deciduous woods in this respect, the oak pulps contained several percent less alpha cellulose and a great deal more pentosans than either the pine or the tupelo pulps (table 4). Shortleaf pine wood contains relatively small amounts of pentosans and this is reflected in the amount in the pulp. The pine pulp of highest yield contained 0.5 percent of ether soluble matter, while the lower yield pulps were in the 0.2-0.3 percent range.

The densities of the test sheets prepared from shortleaf pine and from black tupelo were similar in spite of the difference in reported fiber length -- 4.0 and 1.7 mm. respectively[2] -- and the larger proportion of short ray and parenchyma cells in hardwood. The sheets made from white oak pulp were much less dense because of the thicker cell walls as compared with tupelo. The thicker cell wall and the shorter fiber length, combine to give a stiffer fiber. Stiff fibers are desirable for making bulky papers and papers with low permeability.

Compared with semichemical pulps made from three southern red oaks[3] at yields of 70 percent, the white oak test sheets were less dense by from 0.06 to 0.11 gram per cubic centimeter. The strength of the white oak pulps was comparable to that of the southern red oak (Q. falcata), which had the lowest sheet density of the three southern red oaks previously investigated. The strength of the white oak pulps was much less than that of the scarlet oak pulps, the sheets of which incidently, were the highest in density of the three red oak pulps. This illustrates a frequently noticed correlation between the density of standard test sheets and the strength of the pulps.

At comparable yields, there was generally little difference between the strength of standard test sheets made from shortleaf pine and from black tupelo pulps. In tearing resistance, the tupelo pulps were frequently a little stronger. Although this tearing resistance was excellent compared with the average deciduous neutral sulfite semichemical pulp, the bursting strengths were mediocre and well below those obtainable with aspen or cottonwood. The folding endurance and breaking lengths of the tupelo pulps were also moderate.

Standard test sheets made from pine pulps that had been cooked in the larger digester were stronger than similar sheets made from the small-scale pulps. This is particularly noticeable in the pulp from the larger scale digestion that had been cooked to 71.2 percent yield (table 4). The differences between the

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[2]Density, Fiber Length, and Yields of Pulp for Various Species of Wood. Technical Note No. 191. Forest Products Laboratory, September 1953.

[3]Neutral Sulfite Corrugating Boards from Southern Red, Scarlet, and Black Oaks. Forest Products Laboratory Report No. 2067, December 1956.

two types of refiner which were used to break up the cooked chips are believed to be largely responsible.

The oak pulps were brown in color and were generally similar to kraft pulp in appearance, as could be anticipated from the color of the wood. The other two species of wood gave pulps of moderate brightness.

Corrugating Boards

Shortleaf pine, black tupelo, and white oak pulps were converted to nominal 9-point corrugating boards. For orientation, table 5 also includes average test results for 13 commercial hardwood boards as well as for a board made on the experimental paper machine from a commercial aspen pulp that had given an excellent product at the mill.

On the paper machine, the wet webs of pulps cooked to about 85 percent yield were weak, soft, anf fluffy. The pine board proved to be only slightly weaker than the average for the commercial boards in spite of its low density of 0.45 gram per cubic centimeter and lignin content of about 23 percent. A corrugating board made from black tupelo pulp which had been cooked to the lower yield of 76.4 percent was of greater density than the pine board. The strength of this board was much better than that of the average of the 13 commercial boards. To obtain a board of comparable quality from white oak, it was necessary to cook the pulp to 72 percent yield. Compared with the aspen board made at the Laboratory from commercial pulp, however, all of the experimental boards were bulky and -- with one exception -- lower in bursting strength.

Evidently, satisfactory quality corrugating board can be prepared from all of the three woods, although the important property of rigidity of the experimental boards was not evaluated. From the standpoint of tons of board per ton of wood, the order of preference appears to be pine, tupelo, and oak. On the basis of tons of board per cord of wood, the relative positions of oak and tupelo are reversed because of the greater specific gravity of oak.

The general strength of any of these boards could have been increased by cooking to a lower yield, by refining to a lower freeness, or by wet-pressing the board to greater density.

Linerboards

Linerboards in 42 and 32 pound weights were made from the shortleaf pine and black tupelo pulps. The density of the experimental boards was well below the average for 3 commercial kraft linerboards included in table 5 for reference. At 83 percent yield the pine board was too weak for consideration. However, reducing the yield to 71 percent about doubled the strength. The tearing resistance was greater than that of the reference boards and the tensile strength was comparable, but the folding endurance was much less. In bursting strength the pine board closely approached the 100 point specification for 42-pound test liner. With careful control of the papermaking variables it is likely that satisfactory linerboards can be produced from pine semichemical pulp.

The black tupelo linerboard was weaker and this pulp probably could not be converted into an acceptable substitute for standard test liner.

Bleaching

Well-cooked tupelo and oak semichemical pulps responded normally to bleaching by the standard 3-stage process. Although the black tupelo pulp contained more lignin than is usually recommended for a bleaching grade, it was readily fully bleached with the application of 1.35 pounds of chlorine per pound of lignin, which is within the normal range for neutral sulfite semichemical pulps (table 6). The yield of bleached pulp, amounting to 52.8 percent of the weight of the original dry wood, was lower than what can be obtained from aspen, i.e. 60-62 percent.

White oak pulp, which contained 10.5 percent of lignin, also bleached readily to a brightness of 86.5 percent with a total of 1.22 pounds of chlorine per pound of lignin. The yield of oak bleached pulp was comparable to that from the tupelo though the holocellulose content of the oak wood was 9 percent lower. The increase in pulp strength shown in table 7 as the result of bleaching is normal.

Papers

Greaseproof and bond papers were made from tupelo and white oak pulps that had been cooked to yields of 67.7 and 61.9 percent respectively.

Greaseproof.--The 4 tupelo greaseproof papers listed in table 8 were all made from the same batch of pulp; part of it was bleached for making the last two papers. The only difference between the first and second papers was that the furnish for the first paper was not jordanned. Similarly, the only difference between the third and fourth papers was that the furnish used in the third was not jordanned. Paper from the jordanned unbleached furnish was a little weaker than that from the unjordanned; but jordanning benefited the strength of the bleached pulp. All four papers had excellent resistance to castor oil and to air flow and therefore would be expected to exhibit good greaseproof characteristics. The paper from bleached jordanned stock matched a sample of commercial B-grade greaseproof paper in strength. The white oak greaseproof paper, which was made from bleached pulp, had considerably less bursting strength and less tensile strength than the reference paper, although the resistance to penetration by turpentine was very good.

Bond. -- The bleached tupelo pulp provided a bond paper of excellent strength. Bursting and tearing strengths were well above those of the commercial No. 1 sulfite bond which is included in table 8 for comparison. The brightness of the experimental paper was not recorded, but it can be presumed to be satisfactory since the brightness of the pulp was 83 percent. However, the opacity of 70 was low for an acceptable high grade bond paper. The formation was also not too good for an all-hardwood sheet, and the paper had a good deal of "rattle."

Since this paper had a low ash content in spite of the use of 7.5 percent of Whitetex clay on the paper machine and had greater strength than necessary, several points improvement in opacity could have been obtained by using a larger amount of filler. This would also have given a softer feel to the paper. Further processing in the beater or jordan would have improved the formation without reducing the freeness below the range generally preferred for papermaking. This additional processing, however, would have reduced the opacity.

The bond papers made from bleached white oak pulp had an opacity of 82-84, which is unusually good for a bond paper made from 100 percent hardwood semichemical pulp. Because of differences in density, ream weight, degree of processing, and filler retention among the various papers of this type made from different woods at the Laboratory, it is not possible to segregate the effect of species on opacity. It is conjectured that the oak pulps had a greater inherent opacity than that of some other hardwood pulps, a property greatly needed in bleached semichemical pulps.

The first oak paper, which was made with the addition of 3 percent of Titanox to the furnish, was weaker than the commercial reference paper. The amount of filler was accordingly reduced to 1 percent for the second paper. This provided a substantial increase in tearing resistance without otherwise benefiting the sheet, but also without greatly lowering the opacity. Increasing the density of the sheet by additional wet pressing would reduce the opacity but would improve the strength and lower the air permeability. The brightness of the papers was very good.

Conclusion

Of the three species of wood examined, the shortleaf pine required the most severe cooking for a given yield of pulp. Test sheets made from pulps cooked to medium yield were comparable in strength with those made from tupelo. Corrugating board having satisfactory properties was obtained at a yield of about 80 percent; and linerboards having interesting properties were made from pulps cooked to 70 percent yield.

Black tupelo pulps showed unusually good tearing resistance, The other strength values were close to average for hardwood semichemical pulp. Good corrugating board was made from pulp produced at 76 percent yield, but linerboard, comparable to kraft test liner, could not be made from pulp produced at about 74 percent yield. Fully bleached pulp was made into a satisfactory greaseproof sheet. A bond paper had low opacity, which, however, could be increased by adding additional filler to the paper machine furnish. The yield of bleached pulp amounted to 52 percent, compared with 60 to 62 percent yield available from aspen wood.

The white oak had the advantages of cooking rapidly with smaller amounts of chemical and of giving high yields of pulp per cord of wood. The short, thick walled fibers gave papers and boards of relatively high bulk and porosity. Except for the corrugating board, which at 72 percent yield was comparable with average hardwood boards in quality, the pulps and papers showed rather low strength. However, this could be improved by pressing the unusually bulky wet sheets to more nearly normal densities. A greaseproof paper made from the bleached pulp had excellent resistance to turpentine. Evidence indicates that papers of somewhat greater opacity can be made from bleached oak fibers than can be made by the other hardwoods commonly pulped by the semichemical process.

Table 1.--Physical measurements on southern shortleaf pine, black tupelo and white oak pulpwood used in semichemical pulping experiments

Species	Shortleaf pine	Black tupelo	White oak
Shipment No.	2984	2988	3043
Density.....Lb. per cu. ft.[1]	30.8	32.0	38.4
Diameter, inside bark.....Inch	6.0	6.3	5.4
Age.....Years	27.1	....	41.0
Rate of growth.....Rings per inch	9.15	....	15.2
Summerwood, by volume.....Percent	36.5	....	....
Heartwood, by volume.....Percent	4.6	....	53.0
Compression wood, by volume.....Percent	3.0	....	....
Bark, by volume, green basis.....Percent	7.0	....	....
moisture-free basis...Percent	7.7	....	....

[1]Based on moisture-free weight and dry volume.

Table 2.--Chemical analysis of southern shortleaf pine, black tupelo, and white oak pulpwood used in semichemical pulping experiments

Species	Shortleaf pine	Black tupelo	White oak
Shipment No.	2984	2988	3043
Lignin.....Percent	27.6	26.2	27.7
Holocellulose.....Percent	69.3	71.7	62.6
Alpha cellulose.....Percent	48.5	48.1	46.1
Pentosans (volumetric).....Percent	8.9	14.5	18.4
Solubility in:			
Alcohol benzene.....Percent	3.3	2.3	3.0
Ether.....Percent	2.2	.1	.4
1 percent NaOH.....Percent	12.2	12.8	19.8
Hot water.....Percent	2.8	1.6	6.1
Ash.....Percent	.5	.5	....

Table 3.--Cooking conditions[1] and yields, for neutral sulfite semichemical pulping experiments

Total yield of pulp	Sodium sulfite, concentration in liquor charged	Sodium bicarbonate, concentration in liquor charged	Sodium sulfite, per 100 pounds of wood[2]	Sodium bicarbonate, per 100 pounds of wood[2]	Maximum cooking temperature	Cooking time at maximum temperature	Sodium sulfite, concentration in spent liquor	pH of spent liquor
Percent	Gm. per l.	Gm. per l.	Lb.	Lb.	°C.	Hours	Gm. per l.	
				SHORTLEAF PINE				
87.2	35.3	16.3	11.8	5.4	175	0.6	9.8	7.8
75.4	59.3	17.4	19.6	5.7	175	4.1	10.3	7.9
64.6	81.5	18.3	27.1	6.1	175	6.5	14.2	....
53.3	105.7	18.0	35.2	5.9	175	9.0	14.2	8.4
[3]83.1	47.1	18.3	15.7	6.1	175	2.7	11.4	....
[3]71.2	74.2	18.8	24.7	6.2	175	6.5	14.2	....
				BLACK TUPELO				
[3]87.3	24.6	20.7	8.2	6.9	160	0.3	10.2	6.8
[3]76.4	43.7	21.0	14.6	7.0	170	2.8	10.0	....
[3]73.6	51.4	21.2	17.1	7.1	170	3.8	12.0	7.8
[3]67.7	66.2	21.2	22.1	7.1	170	6.4	12.7	....
60.8	81.2	18.5	26.9	6.1	175	6.8	9.6	....
				WHITE OAK				
85.4	16.0	26.0	4.3	6.9	150	0.0	6.1	7.2
78.5	31.0	18.6	8.4	5.0	171	0.2	9.4	6.8
70.3	53.1	23.0	14.2	6.1	170	1.8	10.5	....
63.1	85.3	22.6	22.8	6.0	170	4.5	15.6	....
[3]72.0	49.0	22.6	13.0	6.0	172	1.3	11.0	....
[3]61.9	150.7	39.8	24.0	8.5	172	6.0	12.2	....

[1]Cooking conditions common to all digestions except the last one: chips lightly steamed in digester for 0.5 hours before adding cooking liquor, 2.5 hours from 70° C. to maximum temperature, indirect heating throughout. Liquor charged per 100 lb. dry wood: pine and tupelo, 40 gal., oak, 32 gal. Last digestion: chips impregnated, after initial steaming, with concentrated cooking liquor, held 1 hour at 120° C., excess cooking liquor then removed, and direct steam used to heat from 120° to 172° C.

[2]Moisture-free basis.

[3]Pulps used for board and papermaking.

Table 4.--Properties of neutral sulfite semichemical pulps from shortleaf pine, black tupelo, and white oak

Total yield of pulp	Brightness[1]	Results of standard beater test: Bursting strength at freeness of[2] 500 ml.	Bursting strength at freeness of[2] 250 ml.	Tearing resistance at freeness of[2] 500 ml.	Tearing resistance at freeness of[2] 250 ml.	Breaking length at freeness of[2] 500 ml.	Breaking length at freeness of[2] 250 ml.	Folding endurance at freeness of[2] 500 ml.	Folding endurance at freeness of[2] 250 ml.	Sheet density at freeness of[2] 500 ml.	Sheet density at freeness of[2] 250 ml.	Beating time[3]	Chemical composition: Lignin	Holo-cellulose	Alpha-cellulose	Pentosans
Percent	Percent	Pts. per lb. per rm.[4]	Pts. per lb. per rm.[4]	Gm. per lb. per rm.[4]	Gm. per lb. per rm.[4]	Meters	Meters	Double folds	Double folds	Gm. per cc.	Gm. per cc.	Minutes	Per-cent	Percent	Percent	Percent
							SHORTLEAF PINE									
87.2	38.2	0.13	0.23	0.50	0.50	1,600	2,800	0	0	0.40	0.53	26	25.1	70.0	54.1	8.8
75.4	46.5	.39	.53	1.13	.89	4,100	5,200	16	33	.52	.62	13	20.5	74.1	60.2	8.3
64.6	46.7	.63	.72	1.50	1.10	5,900	6,700	50	72	.54	.62	14	15.5	78.8	67.2	8.1
53.3	48.6	1.09	1.22	1.90	1.49	8,900	10,000	190	260	.59	.68	13	8.2	85.0	71.3	8.7
[5]83.1	....	.29	.38	1.05	.83	3,500	4,500	5	13	.46	.58	21	23.2	72.8	....	....
[5]71.2	....	.66	.72	2.38	1.69	5,700	6,400	61	63	.47	.55	12	17.5	75.3	....	....
							BLACK TUPELO									
[5]87.3	49.8	.16	.23	.53	.56	1,800	2,700	0	0	.43	.52	19	23.6	70.3	52.9	14.3
[5]76.4	47.4	.32	.56	1.00	.93	3,300	4,700	5	16	.51	.63	19	19.0	74.4	61.5	12.9
[5]73.6	46.2	.41	.44	1.27	1.05	4,300	5,800	10	40	.51	.63	19	16.9	76.5	62.6	13.1
[5]67.7	50.1	.44	.64	1.46	1.17	4,400	6,300	14	50	.52	.67	17	13.7	79.4	64.7	13.9
60.8	47.9	.53	.71	1.71	1.30	5,000	6,800	30	115	.53	.68	15	9.5	85.1	70.5	14.1
							WHITE OAK									
[6]85.4	26.0	....	....	....	....	....	....	....	....	....	....	....	24.3	69.1	46.7	20.4
78.5	25.9	.11	.22	.43	.50	1,300	2,400	0	0	.33	.39	24	21.0	69.0	51.5	18.6
70.3	26.1	.24	.39	.70	.77	2,500	3,100	1	6	.44	.52	23	16.9	75.0	58.9	18.6
63.1	32.7	.29	.49	.81	.89	3,000	4,300	3	18	.48	.59	19	12.3	80.6	63.2	19.3

[1]Hunter reflectometer calibrated by TAPPI Standard T217sm42.

[2]Canadian Standard freeness.

[3]To reduce freeness from 500 to 250 ml.

[4]Ream of 500 sheets, 25 by 40 inches, 55 pounds air-dry.

[5]Pulps used in board and papermaking. Softened chips fiberized in 36-inch mill.

[6]Pulp too weak to be tested for strength.

Table 5.--Corrugating and linerboards from southern shortleaf pine, black tupelo, and white oak woods cooked by the neutral sulfite semichemical process

Machine run No.	Pulp yield	Headbox freeness (Canadian standard)	Weight per 1,000 square feet	Thickness	Density	Bursting strength: Mullen	Bursting strength: Unit	Tearing resistance	Folding endurance	Tensile strength
	Percent	Ml.	Lb.	Mils	Gm. per cc.	Pts.	Pts. per lb. per rm.[1]	Gm. per lb. per rm.[1]	Double folds	Lb. per inch of width
					CORRUGATING BOARDS					
					Shortleaf Pine					
3291	83.1	470	27.0	11.6	0.45	38.9	0.41	1.11	11	29.3
					Black Tupelo					
3295	87.3	500	26.1	11.7	.43	28.1	.31	.80	4	23.7
3296	76.4	520	25.9	8.9	.56	57.7	.64	1.31	63	38.9
					White Oak					
3518	72.0	....	26.1	8.7	.58	43.9	.48	.87	6	34.3
					Average of 13 Commercial Hardwood Boards					
	....	....	26.7	9.4	.55	....	.44	.99	....	32.6
					Aspen Neutral Sulfite Semichemical Furnish[2]					
	....	410	26.3	7.5	.68	53.5	.59	.87	50	38.9
					LINERBOARDS					
					Shortleaf Pine					
3292	83.1	470	30.3	11.9	.49	43.4	.41	1.23	15	31.5
3290	71.2	575	31.9	12.5	.49	88.4	.80	2.25	122	52.0
3289	71.2	575	42.6	16.3	.50	95.0	.65	2.65	155	63.8
					Black Tupelo					
3294	73.6	520	32.1	12.0	.52	61.6	.55	1.61	52	45.0
3293	73.6	520	41.2	14.7	.54	77.4	.55	1.45	57	57.3
					Kraft Linerboard[3]					
....	....	....	42.3	12.5	.65	116.1	.79	2.47	968	66.0

[1]Ream of 500 sheets 25 by 40 inches.

[2]Commercial furnish converted to board on the Forest Products Laboratory paper machine.

[3]Average of 3 commercial boards.

Table 6.--Bleaching[1] of black tupelo and white oak neutral sulfite semichemical pulps for papermaking experiments

Unbleached pulp			
Species		Black tupelo	White oak
Yield[2]	Percent	67.7	61.9
Lignin content	Percent	13.7	10.2
Bleaching Conditions			
Bleach No.		2123	2447
Stage 1, Chlorination			
Chlorine applied	Percent	12.50	11.0
Chlorine consumed	Percent	12.45	10.9
Temperature	°C.	25.	25.
Consistence	Percent	2.0	3.0
Duration	Hours	2.0	1.0
pH range		....	1.2-.7
Stage 2, Extraction			
NaOH applied	Percent	2.0	2.4
Temperature	°C.	51	51
Consistence	Percent	12.2	12.2
Duration	Hours	1.0	1.0
pH range		11.4-10.7	11.3-11.1
Stage 3, Calcium hypochlorite			
Available chlorine applied	Percent	6.0	1.50
Available chlorine consumed	Percent	5.92	1.17
Amount of NaOH for buffering	Percent	2.0	.6
Temperature	°C.	36	35
Consistence	Percent	10.0	11.8
Duration	Hours	4.0	4.5
pH range		8.8-9.3	11.0-9.5
Bleached pulp			
Brightness, G. E. equivalent	Percent	82.9	86.5
Yield,[2] based on unbleached pulp	Percent	78.0	84.5
based on wood	Percent	52.8	52.3

[1]Amounts of chemicals are calculated on the weight of unbleached pulp, moisture-free basis.

[2]Moisture-free weight basis.

Table 7.--Effect of bleaching on the strength of white oak neutral sulfite semichemical pulp

Processing time[1]	Freeness[2]	Bursting strength	Tearing resistance	Breaking length	Folding endurance	Sheet density
Minutes	Ml.	Pts. per per lb. rm.[3]	Gm. per lb. rm.[3]	Meters	Double folds	Gm. per cc.
			BEFORE BLEACHING			
0	510	0.31	1.07	3,520	5	0.50
4	450	.35	1.15	3,900	6	.52
10	350	.42	1.18	4,700	15	.57
17	250	.49	1.07	5,350	30	.63
20	200	.53	.99	5,670	47	.67
			AFTER BLEACHING			
0	460	.39	1.39	3,700	9	.56
1	450	.40	1.40	3,750	10	.56
6	350	.57	1.45	5,000	30	.62
12	250	.73	1.30	5,800	90	.71
15	200	.82	1.16	6,380	211	.77

[1]Standard test beater.

[2]Canadian Standard freeness.

[3]Ream of 500 sheets, 25 by 40 inches, weighing 55 lb. air-dry.

Table 8.--Properties of greaseproof and bond papers prepared from black tupelo and white oak neutral sulfite semichemical pulps

Machine run No.	Headbox freeness[1]	Basis weight[2]	Thickness	Density	Bursting strength	Tearing resistance	Folding endurance	Tensile strength	Penetration time: Castor oil	Penetration time: Turpentine	Air resistance	Opacity (contrast ratio)	Brightness G.E. equivalent	Ash content	Size number
	Ml.	Lb.	Mils	Gm. per cc.	Pts. per lb. per rm.	Gm. per lb. per rm.	Double folds	Lbs. per inch width	Seconds	Seconds	Seconds per 100 cc.	Percent	Percent	Percent	
								GREASEPROOF							
								Black Tupelo							
[3]3297	100	30.0	2.0	0.83	0.68	0.48	901	18.6	(4)		(4)				
[3]3298	(5)	29.1	2.0	.81	.59	.41	649	16.6	(4)		(4)				
3299	90	27.4	1.7	.89	.69	.46	901	15.0	(4)		(4)				
3300	[5]60	30.0	2.0	.83	.79	.55	885	19.0	(4)		(4)				
								White Oak							
3734	65	31.4	1.9	.91	.57	.47	856	16.9		1,800+					
								A Commercial, B-Grade Greaseproof Paper							
		36.0	2.0	1.01	.76	.48		19.1		1,250	2,700				
								BOND							
								Black Tupelo							
3301	540	48.0	3.8	.70	.71	1.37	145	22.2			12	70.1		2.3	0.96
								White Oak							
3735	690	51.2	4.1	.69	.27	.87	5	12.4	13		3	82.5	87.5	2.1	
3733	630	52.5	4.2	.69	.28	1.12	7	13.8	8		2	84.7	87.0		
								A Commercial No. 1 Sulfite Bond Paper							
		53.9	3.9	.76	.52	1.09	134	23.5			22	84.7	77.9	6.7	

[1]Schopper-Riegler freeness tester.
[2]Ream of 500 sheets, 25 by 40 inches.
[3]Unbleached pulp.
[4]Greatly in excess of commercial specifications.
[5]Jordanned.

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