SUMMARY OF PULPING AND PAPERMAKING EXPERIMENTS ON EUCALYPTUS

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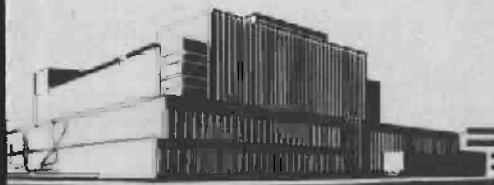

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

SUMMARY OF PULPING AND PAPERMAKING EXPERIMENTS ON EUCALYPTUS[1]

(1926 to June 1957)

Forest Products Laboratory,[2] Forest Service
U. S. Department of Agriculture

Introduction

Eucalyptus is native to Australia, but it is now being planted extensively throughout the world. About 600 species of eucalyptus are known. Only 10 or 12 are used commercially, however. Large plantations of eucalyptus are grown for lumber and other wood products in South Africa, Brazil, Argentina, Chile, and other countries.

The eucalypts are the principal woods used for papermaking in Australia. Smaller amounts are used in South Africa, Chile, Brazil, Spain, and Portugal. The South American and South African plantations are now well stocked and capable of yielding important quantities of pulpwood in addition to other products. The Forest Products Laboratory has tested several species of eucalyptus for pulp and papermaking. This report is a summary of the results of these studies for the past 31 years.

Chemical Analysis, Fiber Measurements, and Physical Tests on Wood

The chemical analysis, fiber measurements, and physical tests made on several of the samples of eucalyptus are given in table 1.

Sulfite Pulping

Sulfite pulping tests were made on E. tereticornis and E. saligna from Brazil. The pulps were of a quality satisfactory for use as the chemical pulp component in newsprint and similar printing paper. The cooking conditions and the yields, strengths, and bleachabilities of the pulps are given in table 2.

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[1] This report previously issued as a Pulp and Paper Division report of limited distribution.

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

Sulfate Pulping

Data on the sulfate pulping of E. tereticornis, E. saligna, and E. kertoniana from Brazil are given in table 3. These pulps compared favorably in strength with good-quality sulfate pulps made from other hardwoods, and undoubtedly they could be used in a wide variety of paper products. The properties of a sample of commercial E. regnans bleached sulfate pulp received from Australia are also given in table 3.

The semibleached E. saligna pulp was made into a newsprint-type paper without the addition of groundwood or other kinds of pulp, but with clay added to improve the opacity of the paper. The paper was slightly stronger than commercial newsprint but more absorbent and porous, and somewhat less opaque. The data for this experiment are given in table 4, machine run No. 3692.

Other sulfate and sulfate semichemical pulping experiments on E. saligna are discussed on pages 4 and 5.

The E. regnans sulfate pulp from Australia was used in making creped tissue paper. The properties of the paper are shown in table 5 in comparison with a similar kind of paper made from commercial hardwood sulfate pulps in the United States. The eucalyptus paper had high absorbency (low test value) and good strength.

Cold Soda Pulping

Cold soda pulping experiments were made on a mixture of equal parts, by weight, of E. saligna, E. kertoniana, E. tereticornis, and E. alba from Brazil. By this process the chips were steeped in a caustic soda solution for about 2 hours at atmospheric temperature, washed, and fiberized. The yield of pulp was about 90 percent. The conditions used in these tests are given in table 6. Increasing the caustic soda concentration from 50 to 100 grams per liter decreased the pulp yield slightly. The pulps were bulky and slightly darker and weaker than the average of cold soda pulp made from hardwoods grown in the United States.

A newsprint-type paper was made from a furnish consisting entirely of the semibleached pulp. The properties of the paper are given in table 4, machine run No. 3672. The overall quality of the paper was comparable to standard newsprint paper, though it was low in opacity and in oil penetration (a measure of receptivity to ink in printing).

Neutral Sulfite Semichemical Pulping

E. gigantea from Tasmania was readily pulped by the neutral sulfite semichemical process to produce pulps in yields of 70 to 75 percent. The pulping data are given in table 7.

The unbleached pulps were fairly strong although, except for tearing strength, they were weaker than aspen semichemical pulp, which is considered to be among the strongest of hardwood semichemical pulps.

The eucalyptus pulp made at 70 percent yield was bleached to a brightness of 85 percent with an increase in strength. In relation to bleached aspen pulp that was comparably prepared, the bleached eucalyptus pulp was weaker in bursting and tensile strength, about equal in folding, and stronger in tearing strength. The strength data are given in table 8.

The unbleached E. gigantea pulps were converted into linerboard. The board made from the lower yield pulp (digestion No. 5296) was slightly over general requirements in bursting strength for this product, and that made from the higher yield pulp (digestion No. 5291) was slightly under. The data are given in table 9. The experimental aspen linerboard included for comparison barely meets the bursting strength requirement.[4] These hardwood linerboards were considerably lower in tearing strength and folding endurance, but higher in compression resistance, than a commercial southern pine kraft linerboard.

A sample of E. robusta from Puerto Rico (see table 1 for chemical analysis and physical test data) was digested by the neutral sulfite semichemical process to about 74 percent yield. The tearing strength of the pulp was higher than is usually associated with the other strength properties, and its stiffness was good. The pulping conditions and pulp property data are given in tables 7 and 8.

E. robusta chips were mixed with an equal volume of Inga vera chips (commonly called guaba in Puerto Rico) and cooked to a 74 percent yield under conditions similar to those used for the eucalyptus alone (digestion No. 5620, table 7). The strength of this pulp (table 8) was slightly lower than the average of the two species when cooked separately to the same yield. The eucalyptus-guaba pulp mixture was made into nine-point corrugating board. Though the strength of the board (table 10) did not equal, in all respects, similar board made from aspen, its strength was adequate and its stiffness (as measured by the flat-crush resistance test) was good.

The conditions used for pulping a sample of E. saligna from Brazil by the neutral sulfite semichemical process are given in table 7, and the properties of the pulp are given in table 8. The strength of this pulp was equal to that obtained

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[4] The yield of aspen pulp from which this board was made was relatively high (80 percent). A pulp made at a little lower yield would have undoubtedly proved to be more satisfactory.

from such dense hardwoods as oak, birch, and maple. This pulp was also comparable to a sulfate semichemical pulp (table 11) made from the same sample of wood. The ring-compression and flat-crush resistance of boards made from these two pulps are given in table 10. There was no important difference between the two, and both boards were higher in ring compression than commercial corrugating-grade pulp used for comparison.

Sulfate, Soda, and Groundwood Pulping of E. Saligna from Brazil

The wood used in this investigation (sample (J) 1397, table 1) corresponded closely in chemical composition and physical properties to other samples of eucalyptus received from Brazil.

Pulps covering a wide range in yield were prepared by the sulfate and soda processes. The cooking data and pulp properties are given in table 11. The following were of particular interest:

(1) A hot-refined sulfate pulp was cooked to a yield of 60 percent, using 10 percent of chemicals calculated as sodium oxide. The pulp had strength characteristics suitable for wrapping papers.

(2) A high-strength sulfate pulp was obtained at a yield of 54 percent, using 12 percent of chemicals calculated as sodium oxide. The strength of this pulp developed rapidly in the beater and was adequate for either use of the pulp alone, or as a high proportion of blends with long fiber in most kraft papers.

(3) A bleachable-grade sulfate pulp (with a chlorine requirement of less than 5 percent) produced a yield of 50 percent, using 19 percent of chemical calculated as sodium oxide. The pulp was strong and soft but required longer beating than the higher yield pulps to develop its maximum strength.

(4) A high-strength soda pulp was cooked to a yield of 52 percent, using 14.7 percent of chemical calculated as sodium oxide.

(5) A bleachable-grade soda pulp (with a chlorine requirement of less than 5 percent) was cooked to a yield of 46 percent, using 26 percent of chemical calculated as sodium oxide.

The sulfate and soda pulps were equal to, or higher in strength, than similar types of pulps made from North American hardwoods. The sulfate pulps were stronger than soda pulps of the same grade and had the added advantages of higher yield and lower chemical requirement for pulping.

A conventional three-stage process was used for bleaching certain pulps that had been cooked for easy bleaching. Pulp loss due to bleaching was less than

5 percent in all instances. The bleached sulfate pulps were stronger, and the soda pulps were equal in strength, to a commercial bleached sulfate pulp made from hardwoods from the northeastern United States (table 11). The bleached pulps were also equal to the commercial pulp in such qualities as opacity, bulk, porosity, and softness.

Two weights of wrapping paper were made from blends of the eucalyptus sulfate pulp and a commercial northern pine sulfate pulp. The papers had good formation and bursting strengths were comparable to paper made from southern pine sulfate pulp, but their tearing resistances were lower. A book paper that had good quality characteristics was made from a furnish consisting of 89 percent bleached sulfate pulp from eucalyptus, and 11 percent bleached sulfate pulp from commercial western softwood (percentages based on fiber furnish). A writing paper containing 89.5 percent eucalyptus bleached sulfate pulp and 10.5 percent of the softwood bleached sulfate pulp had characteristics of a No. 1 bond paper (table 12).

At a 75 percent yield from E. saligna, sulfate semichemical pulp required 6.3 percent of chemicals calculated as sodium oxide (table 11). A comparison of this pulp with one made by the neutral sulfite semichemical process is given on page 4.

The groundwood pulps made from the E. saligna were too weak for use in papermaking, except in very limited amounts. For bleaching, the groundwood pulp required about 10 percent available chlorine (as calcium hypochlorite) to reach 60 percent brightness, and 15 percent for 70 percent brightness. This pulp was also bleached to 60 percent brightness with 1.5 percent of sodium hydrosulfite. The chemigroundwood pulps were also weak and were extremely difficult to bleach. Brightnesses obtained were 55 percent with 20 percent of calcium hypochlorite and 37 percent with 5 percent of sodium hydrosulfite. No further increase in brightness was obtained with higher amounts of chemical.

Table 1.--Chemical analysis, fiber measurements, and physical tests on eucalyptus

Species	Source	Job (J) or Project (P) No.	Chemical analysis[1]									Fiber length				Physical tests			
			Cellulose			Lignin	Total pentosans	Solubility in				Ash	Average	Minimum	Maximum	Standard deviation	Density[2]	Specific gravity[2]	Average age	Average diameter	Volume of heartwood
			Cross and Bevan	Holo	Alpha			1 percent NaOH	Hot water	Alcohol-benzene	Ether										
			Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Mm.	Mm.	Mm.		Lb. per cu. ft.		Yr.	In.	Percent
E. saligna	Brazil	(P) 168-J25	54.8			33.1	16.5	17.4	3.5								29.6	0.475	15		80
Do.	do.	(J) 1246		74.7	48.9	27.7	15.5	14.8	3.2	1.1	0.3	0.2	0.87	0.57	1.32	0.166	36.5	.585		3.9	
Do.	do.	(J) 1397		72.3	49.7	25.3	14.7	13.3	3.3	1.7	.2	.1					34.1	.546		5.0	
E. tereticornis	do.	(P) 168-J25	49.8			36.4	14.5	19.2	5.6								30.3	.485	13		80
Do.	do.	(J) 1246															35.9	.575		4.6	
Do.	Argentina												.61	.23	.96	.143	29.6	.475	(3)	2.7	
E. kertoniana	Brazil	(J) 1246		74.3	50.3	28.1	15.0	13.6	3.1	1.5	.3	.1	.93	.57	1.26	.182	32.0	.513		4.5	
E. alba	do.	(J) 1246															34.9	.560		5.0	
E. globulus	Argentina												.79	.44	1.20	.123		.453	(3)	3.3	
E. robusta	Puerto Rico	(J) 1387		66.6	47.7	27.5	16.2	12.2	2.5	2.1	.3	.5						.490		3.5	[4] 41
E. gigantea	Tasmania	(J) 1083		71.8	49.0	22.0	13.6	16.3	6.5	3.6	.3	.2									

[1] Moisture-free basis.

[2] Moisture-free weight and green volume.

[3] Sample from a 5-year-old plantation, middle of height of trunk of the tree.

[4] Judged to be heartwood from the color; air permeability unusually high for heartwood.

Table 2.--Sulfite pulping and papermaking experiments on E. saligna and E. tereticornis (Project 168-J25)

Species	Cooking liquor				Cooking schedule					Pulp yield[1]		Bleach requirement[2]	Properties of the paper[3]				
	Free SO_2	Combined SO_2	Total SO_2	Volume[4]	To 110° C.	To maximum temperature	Total time	Maximum temperature	Pressure at maximum temperature	Screened pulp	Screenings		Ream weight[5]	Thickness	Bursting strength	Tensile strength	Breaking length
	Percent	Percent	Percent	Gal.	Min.	Min.	Min.	°C.	P.s.i.	Percent	Percent	Percent	Lb.	Mils	Pts. per lb. per rm.	Lb. per in. width	M.
E. saligna	3.8	1.5	5.3	54	180	660	660	145	75	47.4	1.0	4.9	38	3	0.56	14.85	4,985
E. tereticornis	3.8	1.5	5.3	64	180	675	675	141	75	45.0	1.5	10.5	36	3	.36	9.26	3,285

[1] Moisture-free basis.

[2] Chlorine consumed in a single-stage hypochlorite bleaching test.

[3] Ninety percent eucalyptus pulp and 10 percent commercial spruce sulfite pulp.

[4] Per 100 pounds moisture-free wood.

[5] Ream of 500 sheets, each 24 by 36 inches.

Table 3.--Sulfate pulping of *E. tereticornis*, *E. saligna*, and *E. kertoniana*

Species	Job (J) or Project (P) No.	Cooking liquor: Active alkali as Na_2O		Cooking liquor: Sulfidity[3]	Cooking liquor: Liquor-to-wood ratio	Cooking schedule: Maximum temperature	Cooking schedule: To maximum temperature	Cooking schedule: At maximum temperature	Pulp yield[1]: Screened pulp	Pulp yield[1]: Screenings	Bleach requirement[2]	Properties of the pulp: Beating time[4]	Properties of the pulp: Freeness (Canadian Standard)	Properties of the pulp: Bursting strength	Properties of the pulp: Tearing resistance	Properties of the pulp: Breaking length	Properties of the pulp: Double folds	Properties of the pulp: Brightness[5]
		Amount[6]	Concentration															
		Percent	Gm. per l.	Percent		°C.	Min.	Min.	Percent	Percent	Percent	Min.	Ml.	Pts. per lb. per rm.[7]	Gm. per lb. per rm.[7]	M.	Number	Percent
E. tereticornis	(P)168-J25	27.3	36.0	17.2	7.6	156	420	75	38.5		7	0		[8]0.73		[8]6,040		
E. saligna[9]	(J) 1246	15.6	39.1	30.0	4.0	170	90	90	48.0	0.2	5.5	0	565	.31	0.84	3,490	3	75
												50	250	1.31	1.26	10,000	700	
E. kertoniana	(J) 1246	15.6	39.1	30.0	4.0	170	90	90	49.4	.1	4.9	0	605	.21	.66	2,660	1	74
												60	250	1.31	1.17	10,400	670	
E. regnans	Bleached pulp prepared commercially in Australia											0	625	.27	1.00	2,870	3	73

[1] Moisture-free basis.

[2] Chlorine consumed in a single-stage hypochlorite bleaching test.

[3] Based on active alkali.

[4] Standard beater test.

[5] Brightness of bleached pulp.

[6] Based on moisture-free wood.

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

[8] Ninety percent eucalyptus pulp and 10 percent commercial spruce sulfite pulp.

[9] See table 11 for other data on the sulfate pulping of *E. saligna*.

Table 4.--Properties of newsprint papers made from eucalyptus sulfate and cold soda pulps. Job 1246.

Properties	Machine run No. 3692	Machine run No. 3672	A commercial newsprint[1]
Furnish:			
E. saligna sulfate pulp (semibleached)....percent	100		
Eucalyptus cold soda pulp (semibleached)[2]..percent		100	
Clay (based on pulp).....percent	15		
Ream weight[3].....lb.	37	36	36
Thickness.....mils	3.1	4.6	3.0
Bursting strength:			
Mullen.....pts.	10.5	6.6	8.2
Per pound per ream.....pts.	.27	.18	.22
Tearing resistance.....gm. per lb. per rm.	1.07	.50	.66
Tensile strength.....lb. per in. width	9.7	7.7	7.5
Oil penetration.....sec.	6	10	43
Opacity.....percent	84.4	80.9	90.3
Brightness.....percent	76	70	62
Density.....gm. per cc.	.66	.43	.69

[1] Spruce sulfite 20 percent, spruce groundwood 80 percent.

[2] Mixture of equal parts by weight (moisture-free basis) of *E. saligna*, *E. kertoniana*, *E. tereticornis*, and *E. alba* woods.

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

Table 5.--Properties of creped tissue paper containing E. regnans sulfate pulp. Job 1078.

Paper machine run No.	2897	2896
Furnish:[1]		
Eucalyptus sulfate pulp (bleached)....percent:	50	.....
Aspen sulfite pulp (bleached).....percent:	.....	50
Spruce sulfite pulp (bleached).....percent:	50	50
Ream weight (25 x 40--500)[2].....lb.:	14	16
Thickness.....mils:	2.9	3.0
Density.....gm. per cc.:	.26	.29
Bursting strength.....Pts. per lb. per rm.:	.15	.15
Tearing resistance[3].....gm. per lb. per rm.:	59	57
Tensile strength[3].....lb. per in. width:	93	97
Absorbency.....sec.:	27	44

[1] The eucalyptus pulp was manufactured in Australia. The aspen and spruce pulps were commercially made in the United States.

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

[3] Average of in- and across-machine directions.

Table 6.--Cold soda pulping of eucalyptus species[1] from Brazil. Job 1246.

Treatment No.	2530	2553
Temperature[2] °C.	21	24
Sodium hydroxide		
Charged: amount[3] percent	23.8	45.8
concentration gm. per l.	50	100
Consumed: amount[3] percent	6.8	8.3
Pulp yield[3] percent	91	89
Chlorine consumption[4] percent		15
Brightness of bleached pulp percent		69

[1] Mixture of equal parts by weight (moisture-free basis) of E. saligna, E. kertoniana, E. tereticornis, and E. alba.

[2] The treating pressure was one atmosphere and the time 2 hours.

[3] Based on moisture-free wood.

[4] In a single-stage hypochlorite bleach. Amount based on moisture-free unbleached pulp.

Table 7.--Neutral sulfite semichemical pulping of E. gigantea (Job 1083), E. robusta (Job 1387), and E. saligna (Job 1097).

Procedure	E. gigantea		E. robusta		E. saligna
	Digestion 5291	Digestion 5296	Digestion 1407y	Digestion [1]5620	Digestion 1449y
Liquor charged:[2]					
Volume....gal.[3]	43.0	42.7	40.0	36.0	40.0
Concentration:					
Na_2SO_3....gm. per l.	90.0	120.5	38.8	51.4	44.3
$NaHCO_3$....gm. per l.	25.0	28.8	19.0	20.6	17.9
Amount:					
Na_2SO_3....lb.[3]	32.3	42.8	12.8	15.4	14.5
$NaHCO_3$....lb.[3]	9.0	11.22	6.3	6.2	6.0
Impregnation (indirect steam):[2]					
Temperature....°C.	120	120			
Time to temperature....hr.	.6	.6			
Time at temperature....hr.	1.5	1.5			
Blowback liquor:					
Volume....gal.[3]	37.2	56.3			
Concentration:					
Na_2SO_3....gm. per l.	76.3	98.1			
$NaHCO_3$....gm. per l.	17.4	7.7			
Amount:					
Na_2SO_3....lb.[3]	23.3	30.8			
$NaHCO_3$....lb.[3]	5.41	3.42			
Chemicals absorbed:					
Na_2SO_3....lb.[3]	9.0	12.0			
$NaHCO_3$....lb.[3]	3.6	7.8			
Cooking (direct steam to temperature, indirect at temperature):					
Temperature....°C.	170	170	170	175	175
Time to temperature....hr.	.25	.25	2.5	2.5	2.5
Time at temperature....hr.	1.67	2.5	1.0	2.3	1.3
Pressure....p.s.i.	145	140			
Concentration of spent liquor:					
Na_2SO_3....gm. per l.	5.1	4.1	10.7	10.6	8.6
Yield....percent[4]	75.2	70.7	78.7	74.3	74.9
Pulp lignin content....percent[4]		14.5			

[1] Equal parts by volume of E. robusta and Inga vera.

[2] Per 100 pounds of moisture-free wood.

[3] Before introduction of impregnating liquor, the wood was steamed for 1/2 hour at atmospheric pressure.

[4] Moisture-free basis.

Table 8.--Strength properties of E. gigantea, E. robusta, and E. saligna neutral sulfite semichemical pulps (Jobs 1083, 1387, and 1397 respectively).

Condition of pulp tested	Digestion No.	Yield	Brightness	Freeness (Schopper-Riegler)	Freeness (Canadian Standard)	Bursting strength	Tearing strength	Tensile breaking length	Folding endurance
		Percent	Percent	Ml.	Ml.	Pts. per lb. per rm.[1]	Gm. per lb. per rm.[1]	M.	Double folds
E. gigantea									
Unbleached	5291	75.2	20.5	700[2]		0.28	0.92	2,190	3
				550[3]		.46	1.17	3,442	7
Unbleached	5296	70.7	26.1	605[2]		.49	1.09	3,605	14
				550[3]		.54	1.18	4,250	20
Bleached[4]	5296	51.9	85.4	630[2]		.78	1.54	4,480	171
				550[3]		.86	1.55	6,140	300
E. robusta									
Unbleached	1407y	78.7			500[3]	.32	.70	3,500	2
					250[3]	.59	.78	5,800	27
Unbleached	5620[5]	74.3			500[3]	.25	.70	2,800	3
					250[3]	.56	.87	5,600	27
E. saligna									
Unbleached	1449y	74.9			675[2]	.15	.53	1,700	1
					250[3]	.95	1.09	7,700	215
Aspen									
Unbleached	5108-9-10	76.0	48.3	550[3]		.93	.86	8,230	161
Bleached	5108-9-10	62.0	85.0	550[3]		1.19	.95	8,620	284

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

[2] Freeness and other pulp tests on unprocessed pulp.

[3] Freeness and other pulp test data interpolated from standard beater test curves.

[4] Chlorine consumption 22 percent by a 3-stage bleaching process.

[5] Pulp made from equal parts by volume of E. robusta and Inga vera.

Table 9.--Properties of eucalyptus and other linerboards

Pulp composition of board	Digestion No.	Machine run No.	Weight	Thickness	Bursting strength		Tearing strength	Tensile strength	Folding endurance	Compression resistance
					Mullen	Unit				
			Lb. per 1,000 sq. ft.	In.	Lb. per sq. in.	Pts. per lb. per rm.[1]	Gm. per lb. per rm.[1]	Lb. per in. width	Double folds	Lb.
Eucalyptus semichemical	5291	2916	50.2	0.0158	94	0.54	1.23	75.9	65	34.8
Eucalyptus semichemical	5296	2917	46.4	.0148	111	.69	1.28	74.9	127	37.9
Aspen semichemical	5247	2913	61.0	.0148	127	.64	1.35	93.0	141	48.2
Southern pine kraft	Commercial board		46.3	.0135	116	.72	3.09	63.5	1,898	27.8

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

Table 10.--Properties of corrugating board made from E. robusta and E. saligna semichemical pulps

Property	Job 1387		Job 1397		
	E. robusta[1] neutral sulfite	Aspen[2] neutral sulfite	E. saligna[3] Neutral sulfite	E. saligna[3] Sulfate	Aspen[4] neutral sulfite
Freeness (Canadian Standard)....ml.	430.0	410.0	460.0	455.0	505.0
Weight....lb. per 1,000 sq. ft.	26.2	26.3	28.2	27.5	28.1
Thickness....mils.	9.2	7.5	11.9	10.5	11.0
Density....gm. per cc.	.55	.68	.45	.50	.49
Bursting strength (Mullen)....pts.	50.4	53.5			
(Unit)....pts. per lb. per rm.	.55	.59			
Tearing resistance....gm. per lb. per rm.	.79	.87			
Folding endurance....Double folds	53.0	50.0			
Tensile strength....p.i.w.	39.5	38.9			
Ring compression (average)....lb.	59.1	47.1	71.9	85.0	60.6
Flat crush resistance....p.s.i.	32.6	26.2	35.3	35.1	

[1] Pulp (digestion 5620) made from a mixture of equal parts by volume of E. robusta and Inga vera. Board made on experimental paper machine (machine run 4880).

[2] An average of several aspen corrugating boards made from commercial pulp on the experimental paper machine for comparison with machine run 4880.

[3] Tests made on handsheets pressed 5 minutes at 50 pounds per square inch and dried on a steam cylinder. Neutral sulfite pulp from digestion 1449y; sulfate pulp from digestion 3491x.

[4] A commercial aspen corrugating grade of pulp made into handsheets for comparison with handsheets made from E. saligna pulps.

Table 11.--Sulfate and soda pulping of Eucalyptus saligna from Brazil. Job 1397

Digestion No.	Type of pulp	Chemicals charged[1]		Chemicals consumed[2]	Pulp yield[3]		Permanganate No.	Properties of the pulp[4]						
		Active alkali as Na_2O			Screened pulp	Screenings		Beating time	Freeness (Canadian Standard)	Bursting strength	Tearing resistance	Double folds	Breaking length	Brightness
		Amount[2]	Concentration											
		Percent	Gm. per l.	Percent	Percent	Percent		Min.	Ml.	Pts. per lb. per rm.[5]	Gm. per lb. per rm.[5]	No.	M.	Percent
3494X	Sulfate semichemical	6.3	15.8	98.9	[6]74.9			0	630	0.18	0.73	1	1,920	
								41	250	1.00	1.15	280	8,550	
3492X	Hot-refined sulfate	10.0	25.0	94.5	[6]60.0			0	430	0.75	1.54	86	6,864	
								15	250	1.34	1.32	1,166	10,460	
4218-9	High-strength sulfate	12.0	30.0	90.2	54.1	0.3	14.3	0	600	.45	1.00	8	4,780	
								22	250	1.59	1.38	1,730	12,400	
4215-6	Bleachable-grade sulfate	19.0	47.5	73.5	50.6	0	10.4	0	610	.31	.82	2	3,590	
								[7]66	250	1.40	1.45	1,530	11,900	
								[7]62	250	1.32	1.35	1,100	9,800	81
3455X-6X-7X	High-strength soda	[8]14.7	36.8	84.0	51.6	.3	18.5	0	620	.14	.56	1	2,390	
								97	250	1.16	1.37	1,750	10,200	
3481X-4X-5X-8X	Bleachable-grade soda	26.0	65.0	57.1	45.9	0	12.3	0	645	.13	.59	1	1,994	
								71	250	1.01	1.17	870	8,900	
								[6]72	250	1.09	1.03	870	8,900	82
	Commercial bleached hardwood sulfate							48	250	1.09	1.10	530	9,200	

[1] Cooking conditions other than tabulated were: sulfidity of sulfate digestions, 20 percent (based on active alkali); liquor-to-wood ratio, 4:1; maximum temperature (except where otherwise noted) 165° C; time from 30° C. to maximum temperature, 90 minutes; time at maximum temperature, 90 minutes.

[2] Based on chemicals charged.

[3] Based on moisture-free wood.

[4] Beater test data values at 250 milliliters freeness are interpolated from curves. Tests made on unbleached pulp unless otherwise noted.

[5] Ream size 500 sheets, each 25 by 40 inches.

[6] Total yield cooked chips fiberized and not screened.

[7] Values in this line were obtained on bleached pulp.

[8] Maximum temperature, 170° C.

Table 12.--Data on paper made from Eucalyptus saligna sulfate pulp. Job 1397

Machine run No.	Eucalyptus pulp: Digestion No.	Eucalyptus pulp: Amount	Commercial pulp[1]: Amount	Basis weight: 25 by 40--500	Thickness	Density	Bursting strength	Tearing resistance	Double folds	Tensile strength	Air resistance	Castor oil penetration	Opacity	Brightness	Ash content
		Percent	Percent	Lb.	Mils	Gm. per cc.	Pts. per lb. ner rm.	Gm. per lb. per rm.	No.	P.i.w.	Sec. per 100 cc.	Sec.	Percent	Percent	Percent
						WRAPPING PAPER[2]									
4954	4218-19	70.0	30.0	34	2.7	0.69	0.55	1.25	61	15.1	8				
4955	4218-19	70.0	30.0	64	4.8	.73	.82	1.20	270	38.0	22				
						BOOK PAPER[3]									
4958	4215-16	89.0[4]	11.0[4]	52	3.9	.75	.36	.88	8	16.6	24	36	89	83	11.8
						WRITING PAPER (BOND)[5]									
4959	4215-16	89.5[4]	10.5[4]	41	2.9	.79	.43	.96	20	15.0	34	40	78	81	5.5

[1] Northern pine sulfate pulp used in wrapping paper runs; Western softwood sulfate used in book and writing paper runs.

[2] 15 percent rosin size added at beater.

[3] 1.1 percent rosin size, 16.7 percent clay, 1.1 percent titanium oxide (based on pulp) added at beater.

[4] Pulp bleached.

[5] 1.6 percent rosin size, 7.9 percent clay, based on pulp added at beater. Surface coated at size press with 5 percent starch (2 parts)-titanium oxide (1 part) solution.

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