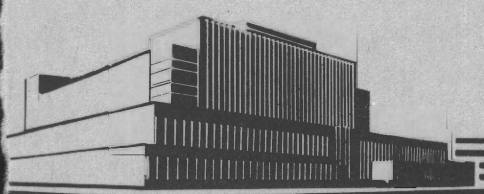
THE GROUNDWOOD AND SULFATE PULPING OF POLE-BLIGHTED AND HEALTHY WESTERN WHITE PINE

April 1960

No. 2185



FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

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

THE GROUNDWOOD AND SULFATE PULPING OF POLE-BLIGHTED AND HEALTHY WESTERN WHITE PINE

By

E. R. SCHAFER, Chemical Engineer
AXEL HYTTINEN, Chemical Engineer
and
J. S. MARTIN, Chemical Engineer

Forest Products Laboratory,[1] Forest Service
U. S. Department of Agriculture

Summary

Groundwood and sulfate pulping experiments were made on wood from healthy and pole-blighted western white pine. Pulps of good quality can be produced from both types, although those made from the healthy trees were, on the average, slightly higher in strength than those from the pole-blighted trees.

Introduction

This report discusses groundwood and sulfate pulping experiments made on wood from pole-blighted and healthy western white pine (Pinus monticola). Data on physical characteristics of the woods are also presented.

---

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

Physical Appraisal of the Wood

Locality, Site, and Forest Description

One-cord samples of both the healthy and the pole-blighted woods were received from the Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Mont. (now merged with the Intermountain Forest and Range Experiment Station, Ogden, Utah). The logs representing the healthy material were from eight trees cut in Kootenai County, Idaho. Those representing the pole-blighted material came from four trees, ranging from early to advanced stages of blight, cut in the same township. One of the pole-blighted trees had recently died. The others were live when cut. Topography for both sites was mountainous, the elevation being 3,000 feet. The soil was moist loam with a depth of 3 to 4 feet. The composition of the stands is given in table 1. There had been no burns in the stands. The site yielding the pole-blighted trees had been selectively cut in 1950, while the other site had not been logged.

Detailed tree data are given in table 2.

Physical Characteristics

Physical characteristics of the wood were determined on disks cut from logs representing all the trees. The average physical characteristics of the healthy and pole-blighted wood (shipments Nos. 3312 and 3315), as well as those of two previous shipments of western white pine (shipments Nos. 1526 and 2660), are given in table 3. These data indicated no important differences between the healthy and the pole-blighted wood that would be expected to affect their suitability for production of pulp. The density of both of these woods, like that of the western white pine from Oregon examined previously, was lower than that of many pulpwoods. The lower density would tend to give lower yields of pulp per cord of wood and, of course, lower production per digester charge.

Chemical Analysis

The chemical analysis of the present shipments and also those of the two previous shipments are given in table 4. The lignin contents of

the four samples are about the same. The present shipment of healthy and pole-blighted pine is higher in holo- and alpha-cellulose than the previous shipments of healthy wood. There is nothing particularly noticeable about the chemical analysis that would distinguish the healthy wood from the pole-blighted material.

Groundwood Pulping

Equipment and Procedure

The laboratory grinder used in these experiments has 3 pockets 16 inches wide comparable to commercial hand-fed grinders, but takes blocks of wood 6 inches in length instead of logs about 4 feet in length as in commercial grinders. The pulpstones are 54 inches in diameter (commercial size) by 8 inches in width. Two different pulpstones were used, one of 60-grit and the other of 90-grit aluminum oxide abrasive.

In the experiments the temperature of pulp in the grinder pit was maintained at 145° F., and its consistency between 3 and 4 percent. The peripheral speed of the pulpstone was 3,120 feet per minute. The pulps were screened through a flat plate screen having slots 0.008 inch in width. Pulp test sheets of about 115 pounds' basis weight (25 by 40-500) were made and tested by TAPPI standard methods. The screen analyses were made on an Appleton Selective screen.

Grinder Experiments

Data on the grinding conditions and the pulp properties are given in table 5.

Three grinding experiments were made on each of the healthy and pole-blighted wood, with the object of producing pulps covering a range of properties. This was done by adjusting grinding pressure and varying the stone surface sharpness.

The data show that pulps of good quality can be produced from western white pine and, also, that the blighted, as well as the healthy trees, should produce satisfactory groundwood pulps for use in printing paper furnishes. Consumption of energy should be no higher than for species used commercially.

Groundwood pulp quality is dependent, among other things, upon the moisture content of the wood. It has been observed with softwoods that the drier wood produces lower quality of groundwood pulp than wood of high moisture content.[2] The suitability of the pole-blighted material for groundwood pulping, if it had died before cutting, might therefore depend largely on the extent to which the trees had dried out. Though air-dried wood can be soaked in water so as to obtain somewhat better groundwood pulp than is obtained from dried wood, the results are not quite so good as those obtained from green wood. In these grinding experiments, the pole-blighted wood was only slightly drier on the average than the healthy wood. The slightly lower pulp strengths obtained from the pole-blighted wood could be attributed partly, at least, to the lower moisture content and also possibly to normal differences in physical characteristics of the two samples. Such variations were noted by the pole-blighted wood having nearly twice as much heartwood as the healthy wood, and by also containing some compression wood, which was not present in the healthy wood.

These experiments indicate that western white pine will produce groundwood pulps of good quality suitable for use in the manufacture of printing papers. It is expected that pole-blighted trees will produce groundwood pulps comparable in quality to those produced from healthy trees of comparable moisture content and physical characteristics.

Sulfate Pulping

The sulfate pulping of the wood from shipment No. 1526 (table 3) has been reported.[3] The experiments showed that good-quality pulps can

---

[2] "The Effect of Moisture Content of Wood on the Groundwood Pulping of White Spruce and Quaking Aspen," by E. R. Schafer and Axel Hyttinen, Paper Trade Jour. 131, 5 (Aug. 3, 1950). Also, "Groundwood Committee Brief on the Relationship of Wood Moisture and Wood Species to Pulp and Paper Quality and Paper Machine Efficiency," Technical Section, Canadian Pulp and Paper Association (June 1943).

[3] "Sulfate Pulping of Western White Pine (Pinus monticola)," by J. Stanley Martin and Mark W. Bray, Paper Trade Jour. III (2025) 35-38 (Dec. 19, 1940) T. S. 309-312.

be obtained from this species, though the strength values were a little lower than those of the average commercial sulfate pulp. The pulping of the wood from shipment No. 2660 (table 3) was under conditions similar to those for shipment No. 1526. The data for these cooks are given in tables 6 and 7, digestions Nos. 1989-90, 1991-92, and 1993-94. The yields of screened pulp were from 3 to 5 percent lower than those obtained from the wood of shipment No. 1526, but the pulps from the two samples of wood were comparable in strength. The yields of pulp obtained from the wood of shipment No. 2660 were also lower than those obtained from shipment No. 3312 (table 6) when cooked under the same conditions, but the strengths and permanganate number of the pulps were higher (table 7). The reasons for the differences are not apparent.

The wood of shipment No. 3312 and the pole-blighted material of shipment No. 3315 were pulped under identical sets of conditions. The cooks were on a small scale, using about 6 pounds of chips on a moisture-free basis per digester charge. The total chemicals ranged from 17.5 to 27.5 percent, and the active alkali ranged from 13.67 to 21.48 percent (table 6). Within these ranges, the yields of screened pulp obtained from the healthy wood varied from about 47 to 49 percent, whereas the variation in the yield of screened pulp from the blighted wood was from about 40 to 44 percent. Under the same conditions of pulping, the permanganate number of the blighted-wood pulp was from about 1 to 4 points higher than that of the healthy-wood pulp.

The strengths of the pulps may be compared at three freeness levels in table 7. The blighted-wood pulps were in most instances lower in bursting strength, tearing resistance, and folding endurance than the healthy-wood pulps when compared at the same cooking conditions and freeness. The difference was greater between pulps produced with the lower amounts of chemicals than with the higher amounts. Pulps made from the two types of wood were more nearly alike in breaking length than they were in the other strength properties, and there were a number of instances where the breaking length of the blighted-wood pulp was higher than that of the healthy-wood pulp.

Kraft semichemical pulps, in the range of 60 to 75 percent yield of pulp, were made from the two types of wood by reducing the amount of chemicals and/or reducing the time of digestion (digestions Nos. 2965X, 2972X, 2979X, and 2971X). There was practically no difference in results between the two kinds of wood when pulped for this grade.

In general, sulfate pulp of fairly good quality can be made from pole-blighted western white pine, though its strength and yield are likely to be a little less than those of pulps made from healthy wood.

Table 1.--The composition of the stands (Shipments Nos. 3312 and 3315)

Species present	Trees per acre[1]		Average
	Number	Percent	D.b.h.
AREA FROM WHICH HEALTHY TREES WERE CUT			
Western white pine	180	78	6.6
Western hemlock	20	9	8.6
Douglas-fir	5	2	6.7
Grand fir	10	4	7.1
Engelmann spruce	15	7	7.1
AREA FROM WHICH POLE-BLIGHTED TREES WERE CUT			
Western white pine	120	80	9.3
Western larch	10	7	7.0
Douglas-fir	20	13	10.2

[1] Minimum diameter of trees considered 5.6 inches diameter at breast height.

Table 2.--Tree data for western white pine (Shipments Nos. 3312 and 3315)

Tree No.	Number of 48-inch sections	Stump height	Crown length	Total height	Diameter at breast height	Crown width	Foliage density	Tree class[1]	Defects	
									Kind	Extent
		In.	Ft.	Ft.	In.	Ft.				Ft.
HEALTHY TREES (SHIPMENT NO. 3312)										
1	9	9	34	57	7.1	8	Medium	B		
2	14	12	41	78	10.0	11	..do...	A		
3	12	12	33	67	9.0	8	..do...	B	Butt rot	3-4
4	12	5	36	66	8.0	9	..do...	A		
5	11	9	34	66	7.8	6	..do...	B	Butt rot	1-2
6	10	12	34	56	8.4	7	..do...	A		
7	13	14	42	72	10.4	13	..do...	A	Rot	6-8
8	9	8	26	57	6.9	7	..do...	B		
POLE-BLIGHTED TREES[2] (SHIPMENT NO. 3315)										
A		12	53	80	11.6	14	..do...	B		
B	12	11	47	67	11.6	11	Thin	B		
C	12	14	45	69	10.1	8	..do...	B		
D	16	10	50	81	12.1	16	Thick	A		

[1] A - open, dominant; B - codominant, intermediate.

[2] Stage of pole-blighted tree: A - early; B - newly dead; C - advanced; D - medium.

Table 3.--Physical characteristics of healthy and pole-blighted western white pine

Shipment No.	3312	3315	2660	1526
Source	Idaho	Idaho	Oregon	Idaho
Condition when cut	Healthy	Pole-blighted	Healthy	Healthy
Diameter in.	6.4	7.9	11.5	6.1
Number of rings per log	30	32	175	47
Rate of growth rings per in.	9.3	8.1	30	15
Diameter of heartwood in.	3.0	4.9	9.5	.....
Heartwood content by volume percent	21.7	37.2	72	48
Compression wood by volume ...do...	0	2	.....	13
Summerwood by volume .....do...	16.8	14.2	.....	.....
Density, moisture-free weight and green volume....lb. per cu. ft. ..	21.2	20.8	21.5	23.2
Bark content:				
By moisture-free weight .. percent	.....	.....	12.6	9.3
By green volume .....do...	.....	.....	9.1	10.7

Table 4.--Chemical analysis of western white pine

Shipment No.	3312	3315	2660	1526
Source	Idaho	Idaho	Oregon	Idaho
Condition when cut	Healthy	Pole-blighted	Healthy	Healthy
Chemical analysis:[1]				
Lignin ..... Percent	25.4	25.1	25.4	24.8
Cellulose:				
Cross and Bevan ..... do	.....	.....	.....	61.1
Holo ..... do	73.8	68.5	64.3	.....
Alpha ..... do	50.4	47.0	42.3	41.5
Pentosans ..... do	7.8	7.4	7.9	10.7
Solubility in:				
Alcohol-benzene ..... do	2.9	3.7	8.3	3.4
Ether ..... do	1.3	2.1	5.6	1.6
1 percent sodium hydroxide ... do	11.3	15.7	15.6	11.6
Hot water ..... do	2.5	5.9	3.7	3.4

[1] Moisture-free wood basis.

Table 5.--The groundwood pulping of western white pine (*Pinus monticola*)

Grinder run No.	Wood dryness	Grinding data[1]				Properties of pulp suspension					Properties of pulp test sheets[2]				
		Stone surface condition[3]	Pressure of wood on stone	Grinding rate per 24 hour period[4,5]	Energy consumed per ton[4]	Freeness Schopper-Riegler	Freeness Canadian Standard	Screen analysis Retained on 24-mesh	Screen analysis Passing 150-mesh	Fiber length index[6]	Bursting	Tearing	Breaking length	Density	Brightness
	Percent		Lb. per sq. in.	Tons	Hp.-days	cc.	cc.	Percent	Percent		Pts. per lb. per ream	Gm. per lb. per ream	M.	Gm. per cc.	Percent
WOOD FROM HEALTHY TREES															
976	59	Medium	30	1.21	70	270	75	13.7	56.2	0.082	0.39	0.73	3960	0.45	57.1
977	59	Medium	40	2.17	59	350	110	12.6	39.2	.104	.28	.72	2980	.41	58.8
1007	59	Sharp	20	1.56	51	460	220	16.2	33.5	.114	.28	.86	2800	.42	.....
WOOD FROM POLE-BLIGHTED TREES															
978	64	Medium	30	1.43	66	255	60	12.8	42.2	.099	.31	.78	3200	.42	58.5
979	64	Medium	40	2.22	62	320	85	13.0	35.6	.110	.28	.65	3150	.42	58.8
1008	64	Sharp	20	1.42	56	335	150	16.4	39.6	.105	.23	.85	2660	.45	.....
SPRUCE--AVERAGE OF 8 EXPERIMENTAL GROUNDWOOD PULPS															
.....	.....	.....	.....	1.5	60	395	113	18	46.8	.092	.28	.77	2610	.42	59.0
AVERAGE OF 29 COMMERCIAL NEWSPRINT GRADE GROUNDWOOD PULPS															
.....	.....	.....	.....	.....	.....	350	.....	.....	.....	.....	.19	.59	1550	.....	52

[1] Conditions common to all grinder runs: grinder pit temperature, 145° F.; pit consistency, 3 to 4 percent; and peripheral speed, 3,120 feet per minute.

[2] Ream size, 25 x 40 - 500.

[3] Two different artificial (aluminum oxide abrasive) pulpstones were used. The stone with the surface of medium sharpness was composed of 90-mesh grit that with the sharp surface was composed of 60-mesh grit.

[4] Based on moisture-free wood.

[5] Per square foot of wood-stone contact area.

[6] Calculated from amounts retained on 24-, 42-, 80-, and 150-mesh screens, and on that passing the 150-mesh screen of the Tyler series.

Table 6.--Sulfate pulping of western white pine

Digestion No.	Chemicals charged[1]				Time at maximum temperature[2]	Chemicals consumed based on chemicals charged	Yield (moisture-free wood basis)		Permanganate number	Chemical analysis of pulp			
	Concentration		Amount (moisture-free wood basis)				Screened pulp	Screenings		Cellulose		Lignin	Pentosans
	Sodium hydroxide	Sodium sulfate	NaOH plus Na_2S	Active alkali						Holo	Alpha		
	Gm. per l.	Gm. per l.	Percent	Percent	Hr.	Percent	Percent	Percent		Percent	Percent	Percent	Percent
HEALTHY MATERIAL[3]													
2937X, 2938X	30.84	12.91	17.50	13.67	1.5	83.2	47.7	5.7	32.0			7.7	
2951X, 2952X	35.25	14.75	20.00	15.62	1.5	78.0	48.8	1.6	25.4	93.6	77.1	5.5	7.1
2953X, 2954X	39.66	16.59	22.50	17.57	1.5	72.6	48.3	.7	22.3			4.3	
2957X, 2958X	44.07	18.43	25.00	19.52	1.5	69.5	47.1	.4	17.8			3.8	
2963X, 2964X	48.47	20.28	27.50	21.48	1.5	66.7	46.1	.3	16.0			2.6	
[4]1991, 1992	35.25	14.75	17.50	13.67	1.5	87.4	44.5	1.7	34.1				
[4]1989, 1990	35.25	14.75	20.00	15.62	1.5	81.8	43.2	.6	29.2	92.5	79.4	6.0	6.7
[4]1993, 1994	35.25	14.75	22.50	17.57	1.5	77.1	43.3	.2	27.4				
2965X	35.25	14.75	20.00	15.62	0	64.5	[5]63.4		37.5			17.2	
2972X	17.63	7.37	10.00	7.81	0	94.4	[5]74.5					25.4	
POLE-BLIGHTED MATERIAL[6]													
2943X, 2944X	30.84	12.91	17.50	13.67	1.5	83.4	39.7	15.2	34.3			8.9	
2955X, 2956X	35.25	14.75	20.00	15.62	1.5	78.8	46.6	2.7	28.6			6.2	
2959X, 2960X	39.66	16.59	22.50	17.57	1.5	75.1	46.4	1.4	24.3			4.7	
2967X, 2974X	44.07	18.43	25.00	19.52	1.5	67.4	44.6	.6	18.2			3.7	
2961X, 2962X	48.47	20.28	27.50	21.48	1.5	66.9	44.2	.7	17.4			3.0	
2978X	48.47	20.28	27.50	21.48	2.5	69.8	43.1	.4	14.4			2.5	
2973X	52.88	22.12	30.0	23.43	1.5	62.9	43.1	.5	15.1			2.7	
2979X	17.63	7.37	10.00	7.81	0	96.3	[5]74.6					26.0	
2971X	35.25	14.75	20.00	15.62	0	63.6	[5]60.7		37.6			17.8	

[1]Liquor to wood ratio, 4 to 1; sulfidity, 30 percent.

[2]Time and temperature schedules: Room temperature to 150° C., 1 hour; 150° C. to maximum temperature of 170° C., 1/2 hour; and time at maximum temperature as tabulated.

[3]Digestions made on wood from shipment 3312, except as otherwise noted.

[4]Digestions made on wood from shipment 2660.

[5]Digested chips fiberized in a disk mill and not screened.

[6]Digestions made on wood from shipment 3315.

Table 7.--Strength data for unbleached sulfate pulps made from western white pine[1]

Digestion No.	Active alkali charged (moisture-free wood basis)	Yield screened pulp (moisture-free wood basis)	Permanganate number	Freeness (Canadian Standard)	Bursting strength	Tearing resistance	Folding endurance (MIT)	Breaking length	Sheet density
	Percent	Percent		Ml.	Pts. per lb. per ream^2	Gm. per lb. per ream^2	Double folds	M.	Gm. per cc.
HEALTHY MATERIAL[3]									
2937X, 2938X	13.67	47.7	32.0	600	1.42	1.63	1,680	9,700	0.76
				450	1.71	1.38	2,200	11,200	.82
				250	1.72	1.26	2,800	12,400	.87
2951X 2952X	15.62	48.8	25.4	600	1.55	1.49	1,760	10,800	.75
				450	1.71	1.38	2,100	11,100	.81
				250	1.87	1.38	2,480	12,200	.83
2953X, 2954X	17.57	48.3	22.3	600	1.38	1.82	1,420	10,500	.75
				450	1.61	1.60	2,130	11,300	.80
				250	1.66	1.33	2,390	11,800	.85
2957X, 2958X	19.52	47.1	17.8	600	1.39	1.69	1,420	10,900	.73
				450	1.52	1.57	1,840	11,300	.77
				250	1.54	1.43	2,030	11,600	.83
2963X, 2964X	21.48	46.1	16.0	600	1.30	1.97	1,100	9,800	.73
				450	1.49	1.60	1,170	10,300	.78
				250	1.50	1.48	1,800	11,100	.79
[5]1991, 1992	13.67	44.5	34.1	600	1.55	1.88	2,150	8,200	.75
				450	1.65	1.58	2,400	8,700	.82
				250	1.67	1.40	2,950	9,000	.89
[5]1989, 1990	15.62	43.2	29.2	600	1.40	2.06	2,100	7,500	.75
				450	1.48	1.73	2,300	8,800	.80
				250	1.58	1.48	2,800	9,700	.82
[5]1993, 1994	17.57	43.3	27.4	600	1.33	2.31	3,200	7,500	.72
				450	1.53	2.45	4,600	8,900	.77
				250	1.60	2.32	4,800	9,300	.78
2965X	15.62	[6]63.4	37.5	600	1.12	1.25	770	8,900	.73
				450	1.16	1.13	850	9,300	.77
				250	1.18	1.03	920	9,700	.78
2972X	7.81	[6]74.5	.....	600	.68	1.57	190	5,100	.52
				450	.82	1.22	360	6,700	.61
				250	.92	1.00	490	8,300	.69

Table 7.--Strength data for unbleached sulfate pulps made from western white pine[1] (cont.)

Digestion No.	Active alkali charged (moisture-free wood basis)	Yield screened pulp (moisture-free wood basis)	Permanganate number	Freeness (Canadian Standard)	Bursting strength	Tearing resistance	Folding endurance (MIT)	Breaking length	Sheet density
	Percent	Percent		Ml.	Pts. per lb. per ream[2]	Gm. per lb. per ream[2]	Double folds	M.	Gm. per cc.
POLE-BLIGHTED MATERIAL[4]									
2943X, 2944X	13.67	39.7	34.3	600	1.40	1.26	1,260	11,000	0.73
				450	1.51	1.20	1,800	12,000	.77
				250	1.55	1.18	2,280	12,700	.83
2955X, 2956X	15.62	46.6	28.6	600	1.42	1.49	1,330	10,200	.72
				450	1.51	1.32	1,530	11,500	.77
				250	1.59	1.30	1,950	11,900	.81
2959X, 2960X	17.57	46.4	24.3	600	1.54	1.50	1,650	11,200	.78
				450	1.50	1.31	1,720	11,800	.83
				250	1.45	1.25	1,820	12,400	.86
2967X, 2974X	19.52	44.6	18.2	600	1.30	1.51	1,100	10,100	.75
				450	1.47	1.37	1,620	11,500	.80
				250	1.55	1.35	2,100	11,800	.83
2961X, 2962X	21.48	44.2	17.4	600	1.26	1.63	980	9,900	.73
				450	1.36	1.37	1,380	10,500	.77
				250	1.40	1.23	1,740	10,900	.79
2978X	21.48	43.1	14.4	600	1.13	1.47	680	9,600	.71
				450	1.24	1.28	980	10,400	.78
				250	1.20	1.25	1,120	10,300	.80
2973X	23.43	43.1	15.1	600	1.25	1.46	900	10,100	.71
				450	1.36	1.32	1,140	10,700	.78
				250	1.33	1.23	1,380	11,200	.85
2979X	7.81	[6]74.6	.....	600	.51	1.50	60	4,700	.47
				450	.72	1.15	230	6,400	.57
				250	.82	1.00	400	7,000	.63
2971X	15.62	[6]60.7	37.6	600	1.22	1.25	700	9,600	.65
				450	1.28	1.13	810	10,200	.72
				250	1.26	1.03	950	10,500	.76

[1] Interpolated from beater test data curves.

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

[3] Pulps made from wood of shipment 3312 except as otherwise noted.

[4] Pulps made from wood of shipment 3315.

[5] Pulps made from wood of shipment 2660.

[6] Digested chips fiberized in a disk mill and not screened.