ENGELMANN SPRUCE FOR PULP AND PAPER PRODUCTS

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Introduction

This report summarizes work that has been conducted at the Forest Products Laboratory since 1941 on the suitability of Engelmann spruce (Picea engelmanni) for pulp and paper manufacture.

Although the spruces are among the best and most used of woods employed by the pulp and paper industry, Engelmann spruce has not been used in large volume for this purpose. This is because it grows in the mountain ranges of the western parts of the United States and Canada in heretofore relatively inaccessible regions and at great distances from the present pulp and papermaking areas. Until recent years the use of Engelmann spruce for papermaking has been mostly in one mill at Spokane, Wash.

Remoteness of markets and the unfavorable transportation position in general to the Rocky Mountain area have acted as the major deterrents to development of a pulp and paper industry. However, increasing demand for paper in the United States and throughout the world and the diminishing supplies of the more desirable pulping species in papermaking centers have prompted interest in untapped wood resources in undeveloped regions. Since 1939 Engelmann spruce has been shipped into the Lake States in growing volume, and efforts are being made to establish pulp and paper mills for the use of this wood in the Rocky Mountain States.

Bark-beetle infestations in Colorado have killed several billion feet of Engelmann spruce timber in recent years. Occurrence of a similar infestation in the spruce forests of Western Montana and Northern Idaho is presently causing lumbermen and the Forest Service much concern.

Dead Engelmann spruce trees are satisfactory for papermaking if salvaged before they are extensively decayed. That decay is not a serious problem from this standpoint, however, is shown by the fact that samples received at the Forest Products Laboratory for pulping tests have been practically

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

free of decay, although some of the spruce had been standing dead for 20 years or more. Likewise, bug-infested trees that are logged promptly will produce exactly the same quality of lumber or pulp as uninfested green trees.

Properties of Engelmann Spruce

The principal properties of Engelmann spruce that make it highly regarded for papermaking, are its relatively light color, indicating an absence of tinctorial and resinous substances that are troublesome to remove in pulping, its long slender fibers (about 3 mm.), and moderately low density. Because of these properties it can be pulped easily by the sulfite, sulfate, and groundwood processes and made into a wide variety of papers.

Engelmann spruce has the lightest weight of the spruces, ranging from about 19 to about 22 pounds per cubic foot (moisture-free weight, green volume). White and black spruce weigh from 22 to 26 pounds per cubic foot. The lower density of Engelmann spruce is offset to a considerable extent by the relatively high solid volume of wood per cord, resulting from its thin bark and straightness. Consequently, the weight of wood and yield of pulp on the cord basis are comparable to those of other spruces. The yield and quality of pulp obtained from Engelmann spruce depend on density, rate of growth, straightness, size, soundness, and other characteristics. The source of the wood is not an important factor, except as environment may affect these properties and characteristics. For example, the density of Engelmann spruce in the northern part of its area of growth tends to be higher than in the southern part. Beetle-killed trees that have been standing for some years have a lower moisture content than live trees, and present certain technological problems, which, however, are not difficult to solve if given proper consideration.

Some of the properties and the chemical analysis of several samples of Engelmann spruce received for pulping tests are given in table 1.

Pulping of Engelmann Spruce

Sulfite pulps made from spruce, true firs, and hemlock are used for making newsprint, bond, book, writing, wrapping, and tissue papers, a wide variety of special papers and boards, and rayon and other cellulose derivatives. Experiments and mill production with Engelmann spruce, both live-cut and insect killed, show it to have practically the same sulfite pulping characteristics as eastern white and black spruce, and its pulps have papermaking properties falling in the normal range of those for these eastern spruces, the usual standards for comparison. However, the Forest Products Laboratory tests indicated that pulping conditions for the dry insect-killed wood may need to be slightly modified (that is, by rewetting of chips by steaming and by use of soluble-base cooking acid and a low-temperature, long-time cooking schedule) in order to obtain the most satisfactory pulping and the strongest pulps. Laboratory and mill experience have also indicated that

the lower-density samples of Engelmann spruce tend to give pulps having tearing strengths in the low portion of the normal range, a result that while not generally desirable, is probably not critical in most situations.

With the exception of resistance to tearing, the strongest pulps are made from spruce, balsam fir, and hemlock by the sulfate process. High tearing resistance is a characteristic of sulfate pulps made from the coarser-fibered southern pines and Douglas-fir. Spruce sulfate pulps are prized for the manufacture of the highest-quality specialty papers, wrapping and bag papers, and for blending with other pulps to impart strength in a wide variety of paper and board products. Experiments with live-cut and insect-killed Engelmann spruce show that this wood digests with the facility of the best quality softwoods used for sulfate pulping and that its pulps range in papermaking properties with the highest quality of softwood sulfate pulps, with the exception that bleachable pulps made from lower-density wood tend to have higher bursting and lower tearing strengths than usual. Specifically, the Engelmann spruce pulps, whether of the kraft or bleachable grades, are equal or superior (with the exception noted above) to those made from lodgepole pine or those made from jack pine, which among eastern softwoods is the most used for sulfate pulping.

High-quality groundwood pulp can be made from Engelmann spruce. Experiments on live-cut and beetle-killed wood showed it to be comparable to eastern spruces in energy consumption and other grinding characteristics, and that the pulp can be used for all the purposes for which groundwood is employed.

Table 2 gives the yield of pulp that can be expected from Engelmann spruce by the various processes.

Newsprint Paper from Engelmann Spruce

Newsprint papers were made in experiments with both live-cut and insect-killed Engelmann spruce. Acceptable-quality paper was made by conventional groundwood and sulfate pulping and papermaking prooedures. The strength and brightness of the papers were above average.

Table 3 shows a comparison of the properties of a typical experimental newsprint paper made from Engelmann spruce and average values for commercial newsprint.

Table 1.--Physical characteristics and chemical analysis of Engelmann spruce used in pulping experiments

	Live-cut wood from Montana	Live-cut wood from Oregon	Live-cut and beetle-killed wood from Colorado[1]	Beetle-killed wood from Colorado	Beetle-killed wood from Utah
Shipment No.	1509	2659	2466	3049	3030
Physical characteristics[2]					
Diameter....inches	11.4	9.3	10.8	13.6	12.7
Age....years	88	145	68	162	223
Rings per inch	15.5	31.5	12.5	24.8	33.7
Density....lb. per cu. ft.[3]	22.4	22.5	19.2	20.8	19.0
Chemical analysis[4]					
Lignin....percent	27.9	26.3	.....	28.2	27.4
Holocellulose....percent	.....	67.9	.....	67.3	70.7
Alpha cellulose....percent	42.4	44.3	.....	45.2	45.4
Total pentosans....percent	12.1	9.2	.....	7.4	8.4
Solubility in:					
Alcohol benzene....percent	1.3	2.8	.....	1.7	3.5
Ether....percent	0.5	1.4	.....	1.1	1.4
1 percent caustic soda.percent	8.0	12.2	.....	11.6	10.4
Hot water....percent	1.7	3.7	.....	1.8	1.3

[1] Average sample from 5 live-cut and 25 beetle-killed trees.

[2] Average of logs in the shipment.

[3] Moisture-free weight, green volume.

[4] Moisture-free material.

Table 2.--Typical yields obtained in pulping Engelmann spruce

Density of wood (moisture-free weight/green volume).....pounds per cubic foot..	20
Weight of moisture-free wood in 1 cord of rough wood.....pounds...	1,950
Sulfate pulping	
Kraft-type pulp:	
Yield unbleached pulp per 100 pounds of wood[1].....pounds...	46-50
Yield unbleached pulp cord[2].....pounds...	940-1,020
Bleachable type:	
Yield unbleached pulp per 100 pounds of wood[1].....pounds...	44
Yield unbleached pulp per cord[2].....pounds...	900
Yield bleached pulp per 100 pounds of wood[1].....pounds...	42
Yield bleached pulp per cord[2].....pounds...	855
Sulfite pulping	
Strong type:	
Yield unbleached pulp per 100 pounds of wood[1].....pounds...	48-50
Yield unbleached pulp per cord[2].....pounds...	980-1,020
Bleachable type:	
Yield unbleached pulp per 100 pounds of wood[1].....pounds...	48
Yield unbleached pulp per cord[2].....pounds...	980
Yield bleached pulp per 100 pounds of wood[1].....pounds...	45
Yield bleached pulp per cord[2].....pounds...	920
Groundwood pulping	
Yield pulp per 100 pounds of wood[1].....pounds...	95
Yield pulp per cord[3].....pounds...	1,970

[1] Moisture-free basis.

[2] Air-dry pulp. Losses of wood in barking, sawing, and chipping and of fiber in mill effluent, totaling about 6 percent, are included in this estimate.

[3] Air-dry pulp equivalent. Losses of wood in barking and sawing and of fiber in mill effluent, totaling about 4.5 percent, are included in this estimate.

Table 3.--Properties of experimental newsprint paper made from Engelmann spruce

	Experimental newsprint	Commercial newsprint[1]
Pulp furnish:[2]		
Semibleached sulfate.....percent..	15	.....
Groundwood.....percent..	85	.....
Tests on paper:		
Ream weight (25 x 40 - 500)[3].....pounds..	40	38
Thickness.....mils..	3.8	3.3
Density.....gm. per cc..	0.58	0.64
Bursting strength[4].....pts. per lb. per rm..	0.42	0.25
Tearing strength[4].....gm. per lb. per rm..	0.64	0.54
Tensile strength .....lb. per sq. in..	3,780	2,537
Castor-oil penetration.....sec..	126	50
Size No.....	0.58	.....
Gloss.....percent..	33	41
Porosity.....sec..	98	49
Opacity.....percent..	90	92
Brightness.....percent..	59	52

[1] Average of 56 commercial newsprint papers.

[2] Other ingredients: 1/2 percent rosin size and 1 percent alum.

[3] To convert to newsprint trade ream basis (24 x 36 - 500) multiply by 0.864.

[4] To convert to newsprint trade ream basis multiply by 1.157.