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NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

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The Moisture Content and Specific Gravity of the Bark and Wood of Northern Pulpwood Species

ABSTRACT.—Much information is available on the specific gravity of wood on a dry weight over green volume and dry weight over dry volume basis. This paper presents the conventional specific gravity of bark and wood chips along with specific gravity on a green weight over green volume basis. The relative specific gravities of bark and wood chips may be helpful in finding ways to remove bark particles from chips.

OXFORD: 825.71:812.211:812.31:861.0. KEY WORDS: chips, compression debarking, air flotation, liquid pressure segregation.

The moisture content and the specific gravity of wood chips and bark are important variables in the search for methods to remove the bark from the wood. The purpose of bark removal is to provide clean chips for the pulping process. A natural or induced difference in the properties of bark and wood can provide a basis for segregating the bark particles from the wood chips.

The Forest Engineering Laboratory is investigating three basic processes for removing bark from wood chips. The first is the compression debarking process where the bark and wood chips are passed between compression rolls. In this process the bark is either fragmented and screened out or adheres to the compression rolls and is "doctored" off. The second is an air flotation process where the bark and wood chips are segregated on an oscillating, air-lift deck. The third method is liquid medium segregation where the bark and wood chips are subjected to liquid pressure, changing the specific gravity sufficiently to segregate the bark from the wood. The specific gravity and moisture content have an effect on each of the bark segregation processes.

Although induced differences in moisture content and specific gravity are of great interest in bark removal after chipping, this paper will deal only with the natural moisture content and density values of bark and wood chips.

Samples for the data presented in this paper were taken from wood chips produced from unbarked stemwood and topwood of six northern species: aspen, jack pine, red pine, sugar maple, white spruce, and balsam fir. These species were cut in Baraga and Houghton Counties of Upper Michigan for studies on bark removal after chipping. Specific gravity and moisture content samples were taken from 7 to 16 cuttings (depending on species) throughout a 2-year period (table 1). For each cutting, over 1 cord of bolewood and over one-eighth cord of topwood was chipped.

Table 1. – *Number of cuttings and samples by species*

Species	Bolewood		Topwood	
	Cuttings	Bark & wood samples	Cuttings	Bark & wood samples
Aspen	16	69	11	49
Maple	13	55	11	36
Jack pine	15	59	12	41
Red pine	7	38	7	35
Balsam fir	7	40	7	35
White spruce	7	35	7	35

All bark and wood samples were analyzed for moisture content and specific gravity by TAPPI Standard T18m-53. In nearly all cases the wood was chipped within one or two days after felling. Samples for analysis were taken within 2 or three days after chipping.

As soon as the bark and wood samples were taken they were weighed in their "green"[1] condition (green weight). The chips were then soaked from one to four hours or to the point of maximum fiber saturation. After soaking, the chip and bark samples were placed in a screened basket and drained. The excess water was blown out with an air jet.

A container filled with water (enough to completely immerse the basket) was placed on a scale and balanced to zero. The sample basket was then immersed without contacting the sides of the container and weighed (immersed green weight). The sample was oven dried at 105°C. for 48 hours and weighed (dry weight). After drying, the chips are soaked in a solution of orange shellac plus alcohol and allowed to air dry. A container of kerosene was then balanced on the scale, and the procedure used for the immersed green weight was repeated (immersed dry weight).

In our studies of bark removal we are most interested in the "natural" specific gravity of the wood and bark. The reason is that in any process to segregate the bark and wood, the forces or physical action must act on the particles in their natural state. Therefore, in addition to the common method of reporting specific gravity (dry weight over green volume), we are reporting the specific gravity as dry weight over dry volume and green weight over green volume (tables 2 and 3).

[1] *The samples were stored in polyethylene bags but some moisture loss could have occurred between felling and sample collection.*

The following calculations were performed to arrive at moisture content and specific gravity:

$$\text{Moisture content (green weight basis)} = \frac{A - B}{A} \times 100$$

$$\text{Specific gravity} = \frac{\text{dry weight}}{\text{green volume}} = \frac{B \times F}{C - E}$$

$$\text{Specific gravity} = \frac{\text{dry weight}}{\text{dry volume}} = \frac{B \times F}{D - E}$$

$$\text{Specific gravity} = \frac{\text{green weight}}{\text{green volume}} = \frac{A}{C - E}$$

where A = green weight
B = dry weight
C = immersed green weight
D = immersed dry weight
E = weight of chip basket
F = specific gravity of liquid (water = 1 and kerosene = 0.80).

With the exception of aspen and jack pine, the mean specific gravities compared closely with the results obtained by Pronin[2] and Lamb and Marden.[3] A separate comparison was not made however for heartwood vs. sapwood or inner bark vs. outer bark.

One inconsistancy in the data requires comment. The dry weight over dry volume specific gravity for the bark from both the boles and tops of jack pine and white spruce was greater than the green weight over green volume specific gravity. This is just the opposite of what was observed with the other species. All of the data were rechecked and found to be correct. One explanation for this variation may be in the drying. It seemed that jack pine and white spruce bark decreased much more in volume than the bark of the other species.

[2] *Pronin, Dimitri. 1971. Estimating tree specific gravity major pulpwood species of Wisconsin. USDA For. Serv. Res. Pap. FPL-161, 16 p. For. Prod. Lab., Madison, Wis.*

[3] *Lamb, F. M., and R. M. Marden. 1968. Bark specific gravities of selected Minnesota tree species. For. Prod. J. 18(9):76-82.*

Table 2. — *The moisture content and the specific gravities for wood chips and bark produced from bolewood of six northern species*

Species	Wood				Bark			
	Moisture content [1]	Dry wt. / Gr. vol.	Dry wt. / Dry vol.	Gr. wt. / Gr. vol.	Moisture content [1]	Dry wt. / Gr. vol.	Dry wt. / Dry vol.	Gr. wt. / Gr. vol.
Aspen:								
Mean	50.3	0.367	0.455	0.742	47.0	0.505	0.821	0.955
S. Dev.	2.4	.014	.022	.035	3.1	.033	.035	.042
Range	45.4-55.6	.343-.407	.407-.511	.670-.819	40.3-54.1	.446-.602	.720-.890	.872-1.026
Maple:								
Mean	36.3	.562	.704	.883	37.5	.548	.798	.878
S. Dev.	2.4	.019	.024	.047	2.6	.026	.052	.050
Range	27.5-40.0	.504-.600	.632-.769	.773-.976	29.4-41.5	.480-.590	.667-.869	.765-.950
Jack pine:								
Mean	48.9	.371	.438	.721	54.9	.322	.769	.720
S. Dev.	4.5	.023	.036	.081	7.3	.042	.120	.055
Range	36.8-57.7	.317-.428	.343-.515	.406-.858	35.6-67.7	.246-.450	.472-1.19	.593-.980
Red pine:								
Mean	50.9	.376	.450	.772	55.1	.256	.482	.583
S. Dev.	6.2	.024	.032	.069	8.1	.016	.087	.084
Range	36.5-60.0	.323-.419	.398-.519	.626-.893	41.8-69.8	.226-.283	.354-.687	.454-.746
Balsam fir:								
Mean	57.7	.317	.382	.751	52.0	.366	.709	.760
S. Dev.	2.9	.014	.020	.058	3.3	.039	.027	.042
Range	51.9-63.5	.290-.347	.336-.422	.613-.848	44.4-60.6	.278-.445	.658-.782	.690-.848
White spruce:								
Mean	47.5	.336	.404	.660	61.4	.290	.783	.755
S. Dev.	9.9	.024	.028	.124	4.4	.029	.080	.053
Range	25.9-63.6	.303-.474	.359-.474	.433-.932	47.3-68.8	.236-.364	.619- 1.02	.631-.847

1/ Based on green weight.

Table 3. — *The moisture content and the specific gravities for wood chips and bark produced from the topwood of six northern species*

Species	Wood				Bark			
	Moisture content [1]	Dry wt. / Gr. vol.	Dry wt. / Dry vol.	Gr. wt. / Gr. vol.	Moisture content [1]	Dry wt. / Gr. vol.	Dry wt. / Dry vol.	Gr. wt. / Gr. vol.
Aspen:								
Mean	47.9	0.385	0.474	0.739	48.2	0.501	0.871	0.968
S. Dev.	2.2	.022	.029	.041	3.1	.035	.036	.044
Range	44.2-53.9	.343-.425	.395-.529	.658-.814	42.7-55.1	.419-.566	.775-.950	.866-1.060
Maple:								
Mean	36.7	.555	.697	.877	41.4	.531	.875	.906
S. Dev.	1.3	.025	.025	.043	3.7	.050	.052	.044
Range	34.1-40.0	.486-.602	.644-.757	.779-.962	34.7-53.9	.356-.605	.714-.974	.772-.976
Jack pine:								
Mean	54.9	.361	.433	.803	65.6	.259	.858	.756
S. Dev.	4.2	.029	.034	.057	5.1	.033	.101	.037
Range	43.2-63.0	.296-.421	.368-.500	.573-.939	58.0-75.1	.192-.313	.440-1.084	.680-.839
Red pine:								
Mean	59.6	.333	.391	.832	61.6	.268	.666	.705
S. Dev.	5.1	.017	.023	.067	6.0	.025	.091	.054
Range	39.5-65.0	.295-.366	.345-.437	.734-.936	43.5-71.9	.217-.324	.431-.808	.574-.803
Balsam fir:								
Mean	56.5	.331	.392	.762	54.8	.326	.704	.718
S. Dev.	2.3	.017	.024	.040	4.5	.041	.035	.038
Range	51.7-60.4	.303-.372	.341-.439	.680-.837	47.2-64.5	.240-.393	.630-.765	.610-.806
White spruce:								
Mean	55.2	.340	.408	.768	64.1	.267	.824	.749
S. Dev.	5.2	.019	.026	.090	5.0	.036	.059	.046
Range	40.9-61.5	.306-.385	.353-.459	.517-.889	54.7-72.9	.207-.335	.706-.960	.666-.877

1/ Based on green weight.

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