THE FLOTATION METHOD OF DETERMINING THE SPECIFIC GRAVITY OF WOOD

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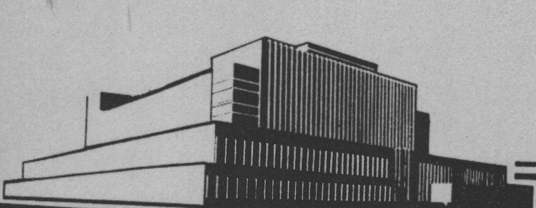

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

In Cooperation with the University of Wisconsin

THE FLOTATION METHOD OF DETERMINING THE SPECIFIC GRAVITY OF WOOD[1]

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A method of estimating the specific gravity of wood quickly and to a reasonably accurate degree with a minimum of time and equipment has been developed at the Forest Products Laboratory to assist suppliers of lumber used in war production in meeting specification requirements for weight. While the method may not be so accurate as the standard process described in Army-Navy Specification AN-W-4a, its time and labor saving features should make it useful for producers seeking a quick specific gravity test to guard against the use of underweight material and, at the same time, avoid the rejection of wood of acceptable specific gravity. The method is believed accurate enough to detect up to 90 percent of stock which should be rejectable for light weight. Use of the more accurate method outlined in Specification AN-W-4a is, of course, recognized as necessary in making final assessment of the quality of wood in such border-line cases as may arise from time to time.

Essentially, the method consists of determining the proportion of a piece of wood with parallel sides that is submerged when it is floated in water. To facilitate this determination, the method calls for a test specimen 1 inch square in cross section and 10 inches long, marked into 10 equal divisions of 1 inch. When a piece so marked is floated upright in a cylinder of water (fig. 1) its specific gravity at current moisture content can be ascertained by observing the proportion of the piece that is submerged.

For example, if six divisions of the piece are under water, the specific gravity is 0.60, while if it sinks to the seventh mark, the specific gravity is 0.70. When the water level reaches a point somewhere between two dividing marks on the piece, specific gravity may be visually estimated with reasonable accuracy; a water level half way between 6 and 7, for example, may be read as 0.65. Other intermediate levels may be rather closely estimated as 0.62, 0.67, and so on.

Any container, of suitable size to hold the specimen vertically or nearly so and yet allow the specimen to float freely may be used (fig. 1). If the container is filled with water so that it will overflow, the specimen can be quickly marked at the water level before absorption of water takes place.

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[1]This is one of a series of progress reports prepared by the Forest Products Laboratory relating to the use of wood in aircraft. Results here reported are preliminary and may be revised as additional data become available.

Tests of many samples of equal length can be speeded by use of a scale of the same length marked in 10 equal units. The proportion submerged is read by placing the specimen beside the scale. For rapid sorting, the required immersion depth may be marked on specimens before test.

For comparison with standard specific gravity values, specimens should be as nearly moisture free as possible unless the moisture content is known and the appropriate correction made. The method is not applicable to green wood.

Specimens for test may be cross cut from the ends of boards. If it is not convenient to cut specimens 1 by 1 by 10 inches in size, another size may be chosen -- a length of 5 inches, perhaps, with a uniform cross section. Where possible, specimens should be dried before test to an oven-dry condition.

When it is desirable to determine the specific gravity of specimens of various lengths (but, of course, with parallel sides) the specimen is floated and the water level marked. The immersed length is measured, and this value, when divided by the total length of the specimen, gives its specific gravity.

When testing samples that are not oven dry, but for which the current moisture content is known, a formula developed at the Forest Products Laboratory may be used to make a simple correction calculation from current volume and moisture content to oven-dry weight and volume. In this formula a correction factor, K, is employed as a constant for each change of 1 percent in moisture content for a given species. This factor compensates for shrinkage also. For a sample tested at X percent moisture content, the formula is:

Specific gravity equals current specific gravity at X moisture content minus KX.

Assuming a moisture content of 15 percent for a spruce specimen, and a current specific gravity reading by the flotation method of 0.42, the formula may be used as follows:

First from the accompanying table[2], obtain the correction factor, (0.00193) for spruce. Substituting the value in the formula, the following equation is obtained:

Specific gravity equals 0.42 minus (0.00193 times 15)

By simple arithmetic, the approximate specific gravity of the specimen at oven-dry weight and volume is found to be 0.39.

The values in the last two columns of the table have been computed to adjust the current specific gravity (grams per cubic centimeter, col. 11) and pounds per cubic foot (col. 12) for each 1 percent change in moisture content of aircraft woods.

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[2] Table 2-4 in 1943 edition of Wood Aircraft Inspection and Fabrication Manual.

Table 1 --Average and minimum values of specific gravity and weight for various aircraft woods under different conditions of moisture and accompanying adjusting constants

Species	Specific gravity based on weight when oven dry and volume when green	Specific gravity and weight per cubic foot based on weight and volume when oven dry				Grams per cubic centimeter and pounds per cubic foot based on weight and volume at 15 percent moisture content				Constants[1] for adjusting values for each 1 percent change in moisture content	
		Average		Minimum permitted		Average		Minimum permitted			
		Specific gravity	Weight per cubic foot	Specific gravity[2]	Weight per cubic foot	Grams per cubic centimeter[3]	Weight per cubic foot[4]	Grams per cubic centimeter[5]	Weight per cubic foot[6]	For grams per cubic centimeter[3]	For pounds per cubic foot[7]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
			Pounds		Pounds		Pounds		Pounds		
Hardwoods (broadleaved species)											
Ash, black	0.451	0.531	33.1	0.48	30.0	0.553	34.5	0.502	31.3	0.00147	0.092
Ash, commercial white[8]	.535	.618	38.6	.56	34.9	.651	40.6	.593	37.0	.00220	.137
Basswood, American	.325	.398	24.8	.36	22.5	.405	25.3	.367	22.9	.00047	.029
Beech, American	.563	.671	41.9	.60	37.4	.694	43.3	.623	38.9	.00153	.095
Birch, Alaska	.488	.594	37.1	.53	33.1	.607	37.9	.543	33.9	.00087	.054
Birch, paper	.484	.600	37.4	.54	33.7	.607	37.9	.547	34.1	.00047	.029
Birch, sweet and yellow	.574	.688	42.9	.58	36.2	.709	44.2	.601	37.5	.00140	.087
Cherry, black	.471	.534	33.3	.48	30.0	.569	35.5	.515	32.1	.00233	.145
Cottonwood, eastern	.372	.433	27.0	.39	24.3	.454	28.3	.411	25.6	.00140	.087
Elm, American	.458	.554	34.6	.50	31.2	.568	35.4	.514	32.1	.00093	.058
Elm, rock	.574	.658	41.1	.60	37.4	.696	43.4	.638	39.8	.00253	.158
Hickory (true hickories)[9]	.641	.801	50.0	.71	44.3	.806	50.3	.715	44.6	.00033	.021
Khaya ("African mahogany")	.429	.467	29.1	.42	26.2	.510	31.8	.463	28.9	.00287	.179
Locust, black	.659	.708	44.2	.64	39.9	.779	48.6	.711	44.4	.00473	.295
Magnolia, southern	.460	.530	33.1	.48	30.0	.559	34.9	.509	31.8	.00193	.120
Mahogany[10]	.459	.508	31.7	.46	28.7	.549	34.3	.501	31.3	.00273	.170
Maple, red	.486	.546	34.1	.46	28.7	.585	36.5	.499	31.1	.00260	.162
Maple, silver	.439	.506	31.6	.46	28.7	.534	33.3	.488	30.5	.00187	.117
Maple, sugar	.564	.676	42.2	.60	37.4	.697	43.5	.621	38.8	.00140	.087
Oak, commercial red[12]	.561	.676	42.2	.62	38.7	.695	43.4	.639	39.9	.00127	.079
Oak, commercial white[11]	.592	.719	44.9	.62	38.7	.736	45.9	.637	39.7	.00113	.071
Pecan	.601	.694	43.3	.62	38.7	.731	45.6	.657	41.0	.00247	.154
Sweetgum	.441	.530	33.1	.48	30.0	.546	34.1	.496	31.0	.00107	.067
Sycamore, American	.456	.539	33.6	.49	30.6	.560	34.9	.511	31.9	.00140	.087
Tupelo, water	.455	.524	32.7	.47	29.3	.553	34.5	.499	31.1	.00193	.120
Walnut, black	.513	.562	35.1	.52	32.4	.611	38.1	.569	35.5	.00327	.204
Yellowpoplar	.376	.427	26.6	.38	23.7	.454	28.3	.407	25.4	.00180	.112
Softwoods (coniferous species)											
Baldcypress	.425	.482	30.1	.43	26.8	.513	32.0	.461	28.8	.00207	.129
Cedar, Alaska	.415	.465	29.0	.41	25.6	.499	31.1	.444	27.7	.00227	.142
Douglas-fir (coast)											
Class N	.448	.512	31.9	.45	28.1	.543	33.9	.481	[13]30.0	.00207	.129
Class L	.381	.432	27.0	[14].38	23.7	.460	28.7	.408	[13]25.5	.00187	.117
Fir, California red	.372	.421	26.3	.38	23.7	.449	28.0	.408	25.5	.00187	.117
Fir, noble	.351	.403	25.1	.36	22.5	.426	26.6	.383	23.9	.00153	.095
Fir, Pacific silver	.351	.415	25.9	.38	23.7	.431	26.9	.396	24.7	.00107	.067
Fir, white	.348	.397	24.8	.36	22.5	.421	26.3	.384	24.0	.00160	.100
Hemlock, western	.382	.443	27.6	.40	25.0	.466	29.1	.423	[13]26.4	.00153	.095
Incense-cedar, California	.346	.365	22.8	.32	20.0	.406	25.3	.361	22.5	.00273	.170
Larch, western	.482	.587	36.6	.53	33.1	.600	37.4	.543	33.9	.00087	.054
Pine, eastern white	.344	.373	23.3	.34	21.2	.408	25.5	.375	23.4	.00233	.145
Pine, ponderosa	.379	.420	26.2	.38	23.7	.454	28.3	.414	25.8	.00227	.142
Pine, red	.440	.507	31.6	.46	28.7	.535	33.4	.488	30.5	.00187	.117
Pine, sugar	.348	.378	23.6	.34	21.2	.413	25.8	.375	23.4	.00233	.145
Pine, western white	.363	.418	26.1	.38	23.7	.441	27.5	.403	25.1	.00153	.095
Redcedar, western	.310	.342	21.3	.31	19.3	.370	23.1	.338	21.1	.00187	.117
Redwood	.380	.416	26.0	.38	23.7	.453	28.3	.417	26.0	.00247	.154
Spruce, red, white, and Sitka	.362	.407	25.4	.36	22.5	.436	27.2	.389	[13]24.3	.00193	.120
White-cedar, northern	.293	.315	19.7	.29	18.1	.346	21.6	.321	20.0	.00207	.129
White-cedar, Port Orford	.399	.440	27.5	[14].40	25.0	.477	29.8	.437	27.3	.00247	.154

[1](Columns 11 and 12.) To adjust value to an oven-dry weight and volume basis or to any desired moisture content, add constant to value to be adjusted for each 1 percent increase in moisture below the fiber-saturation point; subtract constant from value to be adjusted for each 1 percent decrease in moisture below the fiber-saturation point. These constants take shrinkage or swelling with moisture changes into consideration.

[2]Minimum permitted values are from ANC Handbook on Design of Wood Aircraft Structures Supplement No. 2, page 11, table 2-1, February 1943.

[3]Values in column 7 are obtained by taking 1.15 times the quantity, column 3 minus five-eighths of the difference between column 3 and column 2, namely, column 7 = 1.15 [col. 3 - 5/8 (col. 3 - col. 2)]; (col. 7 - col. 3) ÷ 15 = col. 11.

[4]Values in this column are equal to values in column 7 times 62.4.

[5]Values in this column are equal to values in column 5 plus column 7 minus column 3.

[6]Values in this column are equal to values in column 9 times 62.4.

[7]Values in this column are rounded from the product of the values in column 11 and 62.4. These may be used for direct adjustment of pounds per cubic foot with differences in moisture content below the fiber-saturation point but will be only approximate for changes greater than 8 percent moisture.

[8]Includes white ash, green ash, and blue ash.

[9]Includes shellbark hickory, mockernut hickory, pignut hickory, and shagbark hickory.

[10]Includes material from Central America and Cuba.

[11]Includes white oak, bur oak, swamp chestnut oak, and post oak.

[12]Includes northern red oak, southern red oak, laurel oak, water oak, swamp red oak, willow oak, and black oak.

[13]This value does not agree exactly with the value given in current ANC specifications. The values in the specifications were prepared under slightly different basic assumptions and are as follows: Douglas-fir, class N, 29.7, class L, 25.1; western hemlock, 26.7; Sitka spruce, 23.9.

[14]Maximum value permitted, Douglas-fir, class L, 0.47; Port Orford white-cedar, 0.55.

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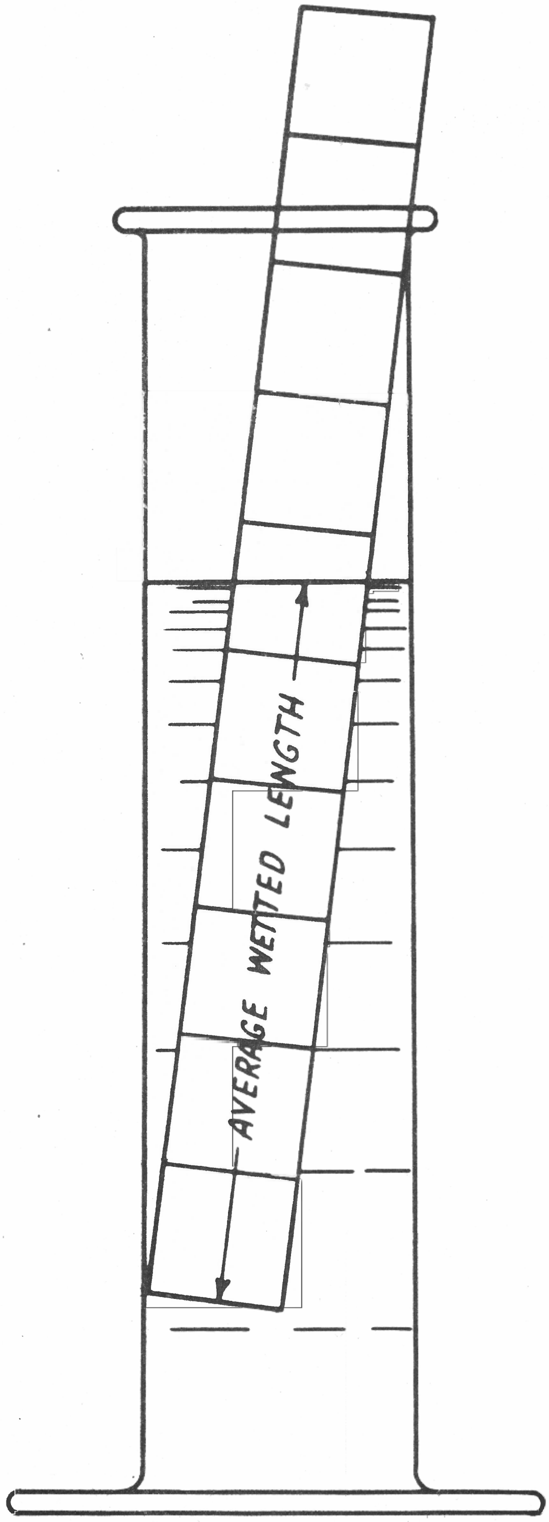

Figure 1.--Flotation method of determining specific gravity. The cylinder should be filled to overflowing with water, and the water line marked on the specimen immediately after immersion.

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