Purchased by the Forest Products Laboratory, U.S. Department of Agriculture, for Official Use.

Reliability of a Method for Measuring Specific Gravity to Determine Wood Losses in Outside Chip Storage

WALLACE E. ESLYN

Abstract: The accuracy of a method used at the U. S. Forest Products Laboratory (FPL) since 1959 for measuring specific gravity to determine losses of wood substance in pulpwood chips stored outdoors was recently questioned because of dissimilar results obtained by different methods of measuring. To assess the accuracy of the method, the specific gravities obtained with another method, termed "Direct Block," in which specific gravities are determined by direct measurement of volume of wood samples, were compared with those obtained on the same samples by the FPL method. The average specific gravity determined by the FPL method differed from that determined by the direct block measurement method by 0.0027 in sweetgum samples and by 0.0007 in southern yellow pine. A "*t*" test on paired values showed that differences were not significant at the 0.05 level in either the sweetgum or the southern yellow pine samples.

Keywords: Chips · Storage · Outdoor chip storage* · Deterioration · Density · Density measurement · Measurement · Accuracy · Reliability

SINCE 1959, investigations have been carried out at our laboratory on biodeterioration in pulpwood chips stored outdoors (1-4) in which wood losses were determined by comparing specific gravities of non-stored chips with those of chips stored for varying time periods. The method used for determining specific gravity was developed by Lindgren and coworkers for use in early chip-storage studies (1, 2). The FPL method differs mainly from that of the standard TAPPI method (5) in two areas: (1) a surfactant is used to limit water adherence to the soaked chips, and (2) a centrifuge is not required to remove excess water from the soaked chips. The method is still being used by our laboratory in a study in which wood losses are determined in pulpwood chips during outdoor storage in the northwestern United States. In the study, comparisons of losses obtained by the FPL method with those obtained by industrial cooperators, who use a somewhat different method to measure specific gravity, show the results to differ appreciably. Primarily, the two methods differ in the manner in which excess water is expelled from water-soaked wood chips. In addition, losses determined by both of the specific gravity methods vary from those determined by yet another method in which the weight of the sample after storage is subtracted from the weight of the sample prior to storage. The weight-measurement method necessitates determining accurately the average moisture content of the sample both prior to and following storage.

Because of the dissimilarity of these results, it was considered highly desirable that the reliability of the FPL method for determining wood chip weight losses be reassessed. To achieve this, two studies were undertaken. In the first study, reported here, the specific gravity values given by the FPL method were compared with the values given by a method involving direct measurement of chip volume. In this study, only sound chips were used.

The FPL method is based on the principle of water displacement. In methods using this principle, the manner in which excess water is removed from water-soaked chips apparently accounts for the different values in specific gravity that are sometimes obtained. Failure to remove all free water, e.g., the water trapped between closely adhering chips, or the removal of too much water, e.g., the water that bounds within chip interiors, will result in errors in determining chip volume.

In the second study (6), the accuracy of specific gravity determinations was investigated by comparing the results with known amounts of decay in small wood blocks and by comparing weight losses based on specific gravities with those obtained by ovendrying and weighing wood prior to and following fungal attack. Results show that volume remains sufficiently unchanged in decaying wood chips to warrant the use of specific gravity methods for measuring rates of decay.

DETERMINING SPECIFIC GRAVITY OF PULPWOOD CHIPS WITH FPL METHOD

Specific gravities are based on the green volume and the ovendry weight of the pulpwood chips. Figure 1 shows the equipment used to measure chip volumes. Preparatory procedure for measurement is as follows. The chips are first shaken on a 5/16-in. screen and the fines removed; pieces of bark, large knots, and exceedingly pitchy wood are manually removed and discarded. The chips are then soaked for 48 hr in distilled water contained in polyethylene bags, after which about 2.5 liters are transferred to a basket of 1/8-in. mesh screening. The basket has a handle and a hinged lid that can be hooked for quick closing.

To determine chip volume, the basket and contents are dipped into water containing a small amount of Aerosol OT to reduce adherence of surface water, permitted to drain for 10 sec, and swung 10 times (at arms length) to discharge free water. Then the basket, held by a string, is immersed in a container of water (Fig. 1), counterbalanced on a scale, and the scale reading is recorded. The procedure is repeated two to three times to confirm the accuracy of the measurement. The volume of the basket

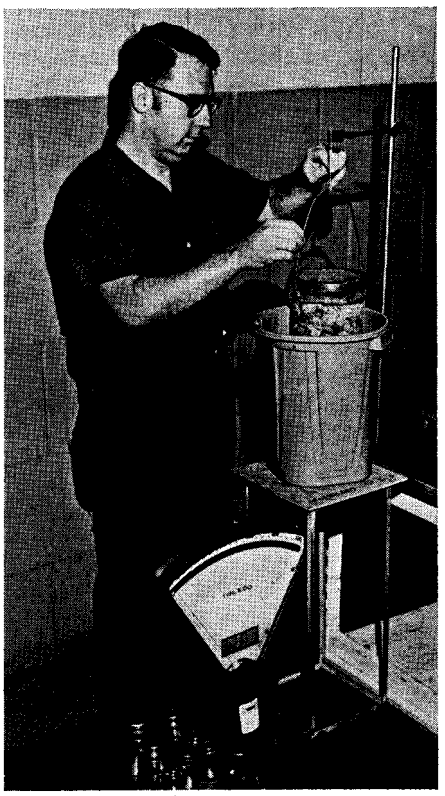

Fig. 1. Basket containing pulpwood chip sample being immersed in a container of water counterbalanced on a scale.

WALLACE E. ESLYN, Plant Pathologist, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, Madison, Wis. 53705. The Laboratory is maintained in cooperation with the University of Wisconsin.

Reprinted from Tappi, The Journal of the Technical Association of the Pulp and Paper Industry, Vol. 54, No. 8, August 1971. Copyright, 1971 by TAPPI, and reprinted by permission of the copyright owner

is then subtracted to give the volume of the green chips. The chips are then dried in a circulating oven at 105°C for 24 hr, after which their specific gravities are determined by dividing the ovendry weight of the chips by the volume of the green chips.

DETERMINING ACCURACY OF FPL METHOD

First Test

To test its accuracy, the FPL method was compared with a method in which wood volume is determined by direct block measurement (DB). The test proceeded in the following manner.

Thirteen blocks were cut from green logs of both sweetgum and southern yellow pine; each block was cut to 5 × 5 × 2 (longitudinal) in. and carefully measured to determine its volume. To maintain them in the green condition, the blocks were wrapped tightly in polyethylene bags immediately following cutting and stored at 2°C for a few days. When removed from storage, each block was placed on a large sheet of paper and chipped with a hand ax. The chips from each block were placed in containers of distilled water and held for 48 hr. Then, their volumes were determined by the FPL water displacement method described above. The direct block estimate of specific gravity was obtained by dividing the ovendry weight of the chips by the calculated volume of the green block.

In all blocks, specific gravities based on DB measurements were either equal (one block) or higher than those obtained by the FPL method. For sweetgum, the differences in specific gravities ranged from zero to +0.017, with an average of +0.0086. Based on the average block specific gravity, this would mean a difference of 1.7%. In the southern pine, the differences ranged from +0.007 to +0.014, with an average difference of +0.0109, or 2.0%.

The discrepancy between the specific gravity values obtained by the two different methods was larger than had been expected, and it was thought to have been primarily caused by the swelling of the wood after chipping rather than by entrapment of water between the chips. The swelling could occur if compressive stresses existed in the original block from a cause such as growth stresses. Swelling would increase the volume of each chip sample more than that of the block from which it had been cut. This would result, as has been shown, in lower specific gravities for the chips than for the original blocks.

Second Test

To avoid the possible confounding effects associated with expansion of the chips, the test was rerun using small chip-sized blocks. This precluded the need of chipping the blocks, thereby eliminating the potential error induced by swelling of the wood after chipping.

Blocks were cut as carefully as possible to 1 × 0.5 × 2 (longitudinal) in. from green logs of both sweetgum and southern yellow pine. Fifty of these blocks, whose total volume equaled that of one of the large blocks used in the first test, constituted one sample. The volume of each 50-block sample was then determined by direct measurement.

Twelve of the 50-block samples of both southern pine and sweetgum were placed into distilled water immediately after being cut and soaked for about 48 hr. The specific gravity of each sample was then determined as described for the chips in the first test. Specific gravities were also calculated on the basis of the ovendry weight of the blocks and the DB determination of volume. The specific gravities obtained by both methods were then compared.

The results for sweetgum wood are shown in Table I. The range of differences was −0.007 to +0.009. Average difference, which was appreciably lower than in the first test, was 0.0027 with a standard deviation of the difference of 0.0044. Based on the average specific gravity of the sweetgum blocks in test (0.4574), the average difference expressed in percent was 0.59%.

This observed average difference plus the fact that most differences were positive suggests a possibility of a small but consistent difference between the two procedures. However, a "*t*" test on the paired values showed the difference was not significant at the 0.05 level (t_{11df} = 2.159). Either a real difference did not exist or the difference was so small that it was masked by the normal variations in measuring accuracy.

Table I. Comparison of Sweetgum Specific Gravities Obtained by Direct Block Measurement (DB) and by the FPL Method

Sample No.	Specifc gravity, g/cm³ DB measurement	FPL method	Difference
1	0.451	0.452	+0.001
2	0.452	0.453	+0.001
3	0.449	0.453	+0.004
4	0.457	0.462	+0.005
5	0.469	0.462	−0.007
6	0.464	0.463	−0.001
7	0.461	0.464	+0.003
8	0.461	0.470	+0.009
9	0.460	0.466	+0.006
10	0.449	0.458	+0.009
11	0.457	0.458	+0.001
12	0.459	0.461	+0.002
Total	5.489	5.522	0.033

[a] Values reflect differences in the DB and the FPL methods of determining volume; same block weights were used to determine specific gravity by both methods.

Table II. Comparison of Southern Yellow Pine Specific Gravities Obtained by Direct Block Measurement (DB) and by the FPL Method

Sample No.	Specific gravity, g/cm³ DB measurement	FPL method	Differences
1	0.480	0.480	0.000
2	0.458	0.457	−0.001
3	0.483	0.485	+0.002
4	0.494	0.492	−0.002
5	0.494	0.493	−0.001
6	0.478	0.483	+0.005
7	0.495	0.496	+0.001
8	0.481	0.482	+0.001
9	0.488	0.488	0.000
10	0.495	0.496	+0.001
11	0.487	0.488	+0.001
12	0.495	0.497	+0.002
Total	5.828	5.837	0.009

[a] Values reflect differences in the DB and the FPL methods of determining volume; same block weights were used to determine specific gravity by both methods.

The results for southern yellow pine are shown in Table 11. The range of differences was from −0.002 to +0.005. The average difference was only 0.0007 or, based on the average pine sample specific gravity of 0.4857, it was 0.15%. Standard deviation of the difference was 0.0018. A "t" test on the paired values again showed that the difference (t_{11df} = 1.431) was not significant at the 0.05 level.

CONCLUSIONS

The similarity of the specific gravity values determined by both the FPL method and a reference method of measurement, termed "Direct Block," indicates that results obtained by the FPL method are well within tolerable limits of accuracy. The FPL method is, therefore, suitable for determining specific gravities of sound pulpwood chips. Furthermore, if decay has little effect on volume of wood chips as has been surmised in the past, then the method is suitable for use in determining wood substance losses in pulpwood chips during storage.

LITERATURE CITED

1. Rothrock, C. W., Jr., Smith, W. R., and Lindgren, R. M., *Tappi* **44** (1): 65 (1961).
2. Lindgren, R. M. and Eslyn, W. E., *Tappi* **44** (6): 419 (1961).
3. Hajny, G. J., Jorgensen, R. N., and Ferrigan, J. J., *Tappi* **50** (2): 92 (1967).
4. Eslyn, W. E., *Tappi* **50** (6): 297 (1967).
5. TAPPI Standard T 18 m-53, "Specific Gravity (Density) and Moisture Content of Pulpwood," New York, TAPPI, 1953.
6. Feist, W. C., Eslyn, W. E., Springer, E. L., and Hajny, G. J., *Tappi* **54** (8): 1271 (1971).

RECEIVED FOR REVIEW Dec. 21, 1970.
ACCEPTED May 16, 1971.

Mention of trade or proprietary names is solely for identification and does not imply any endorsement of the products by the U. S. Department of Agriculture.