DETERMINING LOSS OF WOOD SUBSTANCE IN OUTSIDE CHIP STORAGE: A COMPARISON OF TWO METHODS

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SUMMARY

Two methods, determining loss in weight and determining loss in specific gravity, were used to evaluate loss in wood substance during outside chip storage. The same wood samples were evaluated by both methods, and results compared. The two methods gave almost equivalent results after 6 months storage in a tower that simulated a chip pile and in an experimental chip pile. After storage, change in green volume was negligible up to 6.5 percent weight loss, and verified the validity of the specific gravity method to evaluate losses in wood substance.

DETERMINING LOSS OF WOOD SUBSTANCE IN OUTSIDE CHIP STORAGE: A COMPARISON OF TWO METHODS

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INTRODUCTION

Pulpwood chips stored in outside piles are subject to microbiological and chemical attack that cause losses in wood substance (1, 6, 7).[2] Reliable, accurate methods for determining these losses in outside chip storage are economically significant; values for loss in wood substance can be combined with values for pulp yield (based on stored wood) to give the overall loss in pulp yield based on unstored wood.

Losses in wood substance during outside storage of chips are usually measured by determining loss in weight (direct weighing) or by determining loss in specific gravity (8). The two methods have often been reported as giving conflicting results (1, 6-9). A comparison of the two methods for determining loss of wood substance after fungal attack has been described (5). It was shown that loss in wood substance can be accurately assessed either by the direct weighing method or by the specific gravity method. The comparisons and the correlations in this earlier study were based on controlled laboratory experiments in which fungi cultures isolated from stored chips were used and temperature was held constant. The study here has been extended to include comparisons of the two methods for determining losses in a tower simulating a chip pile at the Forest Products Laboratory (11) and in a small experimental chip pile at Charleston, S.C.

The objective here was to compare two methods for determining loss of wood substance in outside chip storage, by weight loss and by specific gravity loss,

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.
[2] Underlined numbers in parentheses refer to Literature Cited at the end of this report.

EXPERIMENTAL

The experimental methods used here have been described (5,11,12). The techniques in determining lose in wood substance by determining weight loss or by determining loss in specific gravity have been described in detail (4,7,8).

Specific gravity (sp. gr.) was determined for each cross section sample. by TAPPI procedure T18m-53 (13). and is expressed on the basis of waterlogged (green) volume (V) and ovendry weight (o.d.). The percentage loss in specific gravity is determined from

$$\frac{\text{Sp. gr. (initial)} - \text{Sp. gr. (final)}}{\text{Sp. gr. (initial)}} \times 100$$

The percentage loss by direct weighing is determined from

$$\frac{\text{o.d. (initial)} - \text{o.d. (final)}}{\text{o.d. (initial)}} \times 100$$

Volume changes were determined from

$$\frac{\text{V (final)} - \text{V (initial)}}{\text{V (initial)}} \times 100$$

Tower Chip Pile Simulator Experiment

Cross sections (3.5 in. tangential by 1.5 in. radial by 0.25 in. longitudinal) of quaking aspen (Populus tremuloides Michx.) were cut from green logs. After waterlogging and determining green volumes, the samples were ovendried at 105° C. for 18 hours, and ovendried weights determined. The samples were then conditioned at 100 percent relative humidity for 24 hours, placed in contact with fresh green chips. and sterilized in autoclaves. The sections were kept in contact with the sterile green chips for 2 weeks; then they were placed in nylon mesh bags containing a weighed amount (approximately 300 g.) of fresh unsterilized chips of known moisture content. The bags were then placed at the center of the 9-foot level of the 16-foot tower (11,12). The bags were removed after 6 months. Losses in specific gravity, green volumes. and in weight were determined on the cross sections (5). Weight losses were determined on the chips In the mesh bags by direct weighing. Twelve aspen sections were used. Three samples were placed in each of four mesh bags. Temperature in the tower was monitored with copper-constantan thermocouples (11). The temperature profile of the tower at the 9-foot level is shown in figure 1.

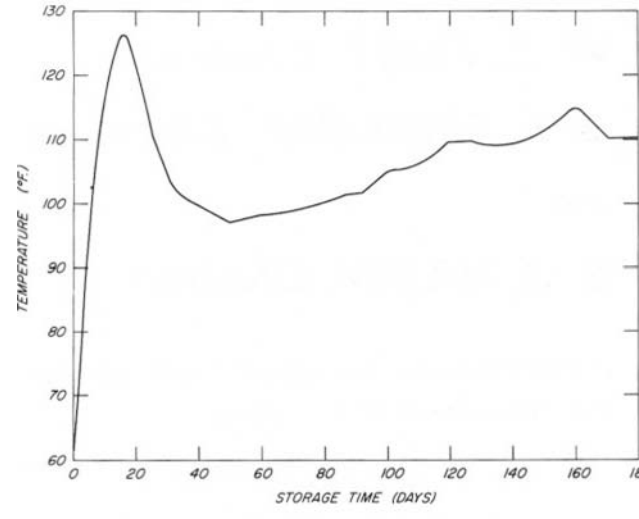

Figure 1.--Relationship of temperature in center of tower simulator to length of storage time.

(M 140 542)

Experimental Chip Pile

Cross sections of loblolly pine (Pinus taeda L.) (24) were prepared, and conditioned as described for those of the aspen. These samples were placed in nylon mesh bags with weighed amounts (approxmately 300 g.) of fresh loblolly pine chips of known moisture content (11,12). The eight sample bags containing the 24 cross sections were then placed at 8- and 12-foot levels of a 20-foot high chip pile of fresh loblolly pine with eight additional sample bags of chips only. Figure 2 is a schematic of the pile showing pile size and location of the samples. Copper-constantan thermocouples were placed at each sample location. A portion of the pile was removed after 2 months to recover experimental samples for pulping studies that will reported.

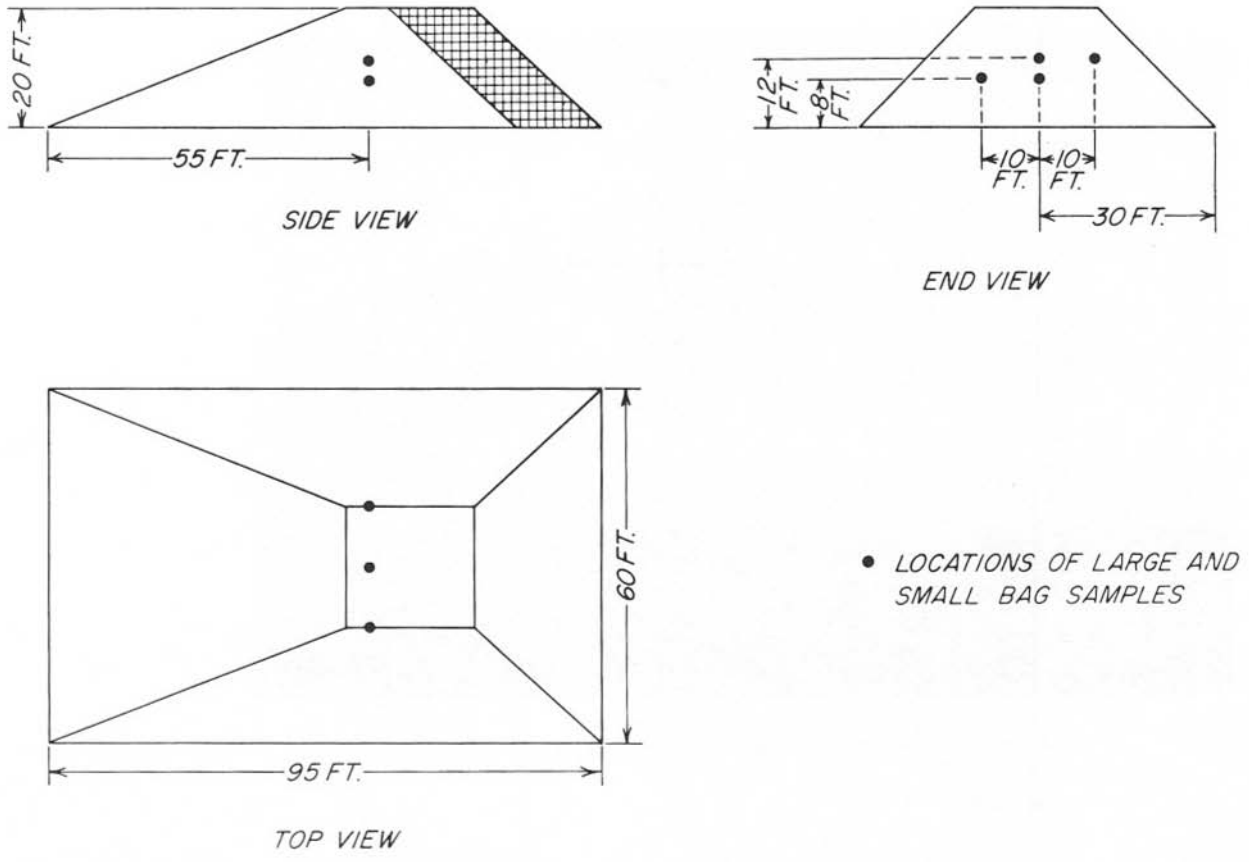

Figure 2.--Schematic of experimental chip pile. (Shaded area in side view represents portion of pile removed after 2 months.)

(M 140 544)

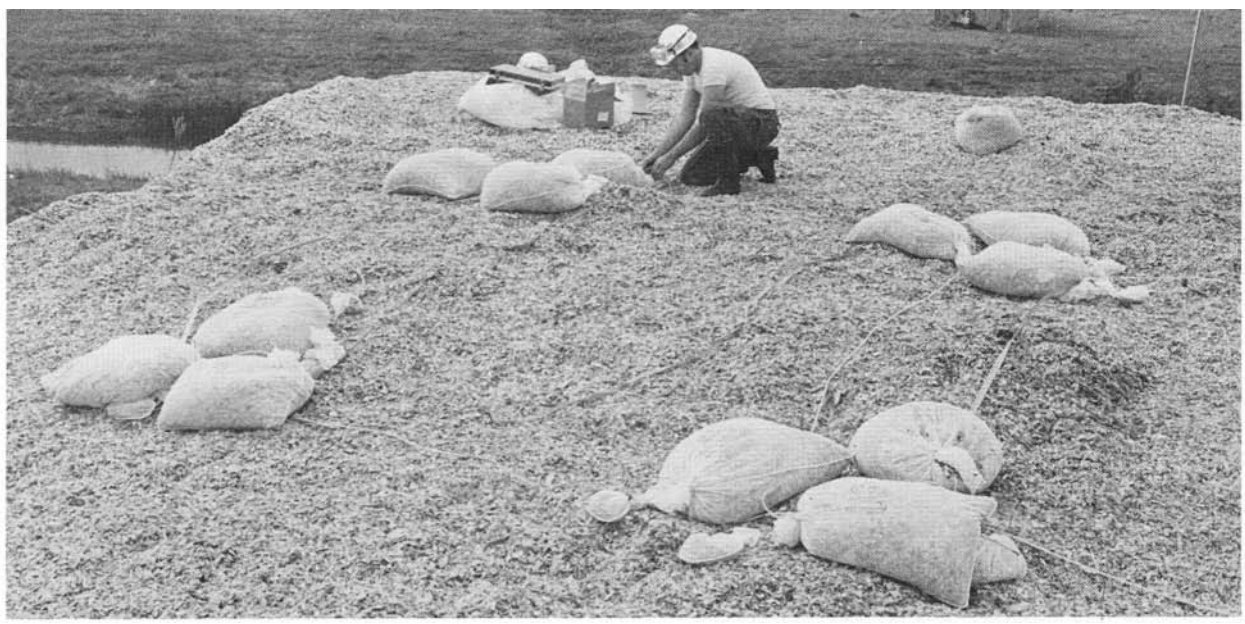

Figure 3.--Placing large- and small-bag samples in experimental chip pi Is.

(M 140 541-20)

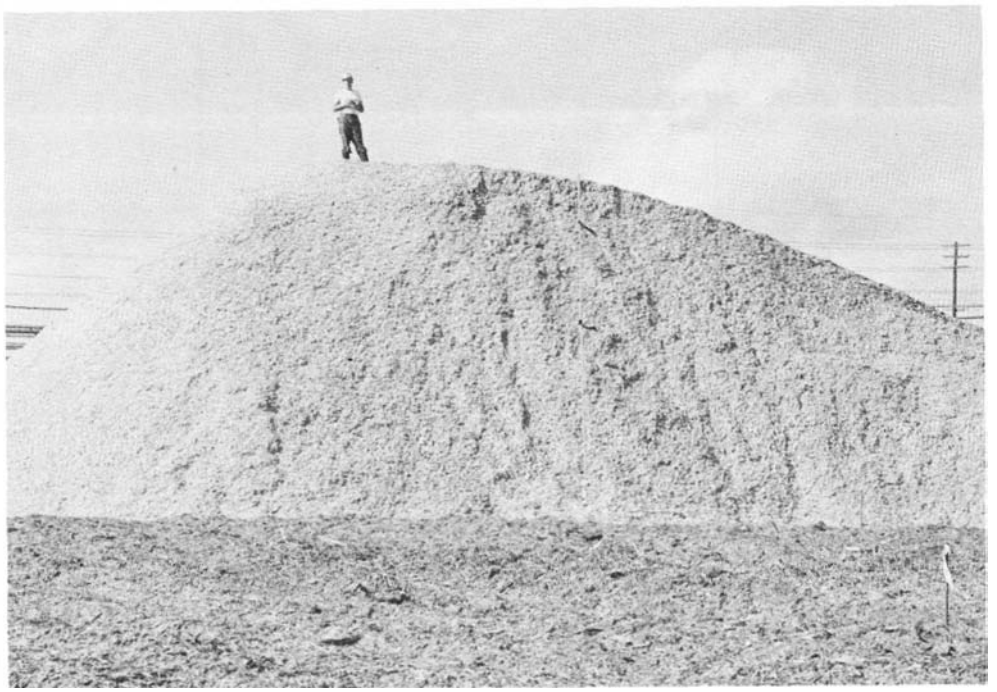

Figure 4.--Completed experimental chip pile.

(M 140 541-34)

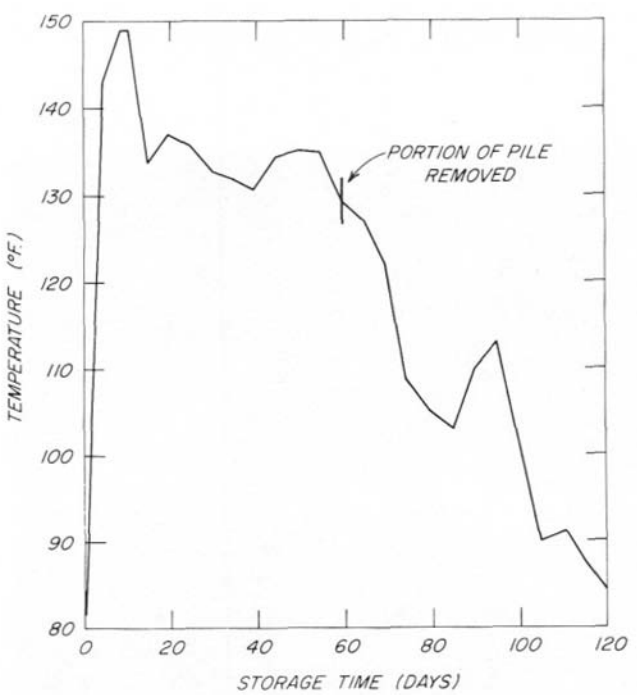

Figure 5.--Relationship of temperature in center of chip pile (8-foot level) to length of storage time.

(M 140 543)

Three large sample bags (approximately 20 kg.) were also placed at each location (fig. 3). Weight losses were measured on these samples by direct weighing as described (11, 12). The pile was constructed by using end loaders; figure 4 shows the pile after construction. The temperature profile of the pile at the center position at 8 feet is shown in figure 5.

RESULTS AND DISCUSSION

Tower Chip Pile Simulator Experiment

In table 1, losses in weight are compared with losses in specific gravity for quaking aspen after 6 months storage in a tower simulating a chip pile. The data from the cross sections show a direct relationship between losses in wood substance by the direct weighing method and those by the specific gravity method. These results confirm those reported for loss of wood substance on aspen and red pine caused by fungi isolated from a chip pile (5).

Table 1.--Losses in weight and in specific gravity of quaking aspen stored 6 months in a tower simulator of a chip pile

Sample No.	Wood chip weight loss[1]	Cross section: Weight loss (A)	Cross section: Specific gravity loss (B)	Weight loss minus specific gravity loss (A-B)	Volume change[2]
	Pct.	Pct.	Pct.	Pct.	Pct.
1	3.6	4.3	4.5	-0.2	0.2
2		4.5	4.9	- .4	.5
3		4.5	5.0	- .5	.6
4	4.3	4.3	4.2	.1	- .1
5		4.1	4.3	- .2	.2
6		4.3	4.3	0	.1
7	4.2	4.6	4.6	0	.1
8		4.3	4.5	- .2	.2
9		4.5	4.5	0	0
10	3.7	4.6	4.7	- .1	.2
11		4.5	4.5	0	- .1
12		4.4	4.3	.1	- .1
Av.	4.0	4.4	4.5	- .23	.16

[1] By determining by weight of chips in each sample bag.

[2] By determining volume by water displacement method on cross sections before and after storage.

Data for weight loss by direct weighing of the chips in the small sample bags correlate very well with those from the cross sections (table 1). It was reported earlier (5) that water-soluble materials produced by certain decay organisms should be removed to give accurate weight loss determinations. In quaking aspen it was found that only about 1 percent of the wood substance was soluble in water at room temperature before and after storage. Thus, water-soluble extractives are not produced to a large extent in this simulation of stored wood chips as wasfoundfor certain fungi (5) isolated from chip piles.

The green volume of each wood cross section is measured for determining specific gravity. For the specific gravity method to give reliable results, green volume must not change after attack by micro-organisms; this is the basic assumption in determining loss of wood substance by the specific gravity method (10). The results in table 1 show that after a loss of approximately 4.5 percent of wood substance green volume changes are very small. This confirms earlier work (5), and indicates; the specific gravity method should give valid results.

Experimental Chip Pile Experiment

Data for weight loss determinedby direct weighing of small and large bags of loblolly pine chip samples after 6 months of outside storage are shown in table 2. Losses varied randomly from a low of 1.9 percent to a high of 6.6 percent, Weight losses varied considerably at each location although sample bags were within 3 feet of each other. The variation is not unusual or unexpected (1, 6-8). Average weight losses at each sample location were fairly constant with the exception

Table 2.--Loss of ovendry wood substance for loblolly pine after 6 months outside storage (bag, samples)

Sample location		Weight loss	
Feet from bottom of pile (vertical)	Position from center line of pile	Small[1] samples	Large[2] samples
		Pct.	Pct.
8	Center	[3]2.8	4.7
		[3]5.1	5.3
		5.7	3.3
		3.0	--
		Av. 4.2	Av. 4.4
8	Exterior	[3]3.1	3.9
		[3]5.7	6.2
		4.6	4.4
		3.0	--
		Av. 4.1	Av. 4.8
12	Center	[3]3.5	3.8
		[3]4.6	3.8
		2.5	3.3
		1.9	--
		Av. 3.1	Av. 3.6
12	Exterior	[3]6.6	5.1
		[3]5.3	4.1
		4.5	3.8
		2.6	--
		Av. 4.8	Av. 4.3
Overall average		4.0	4.3

[1] Nylon mesh bags with approximately 300 grams of green wood chips.

[2] Nylon mesh bags with approximately 20 kilograms of green wood chips.

[3] Bag samples with small wood blocks for specific gravity loss determinations.

of the samples at the 12-foot center. The overall averages of weight losses from the two different sizes of sample bags were in close agreement.

Losses in weight and specific gravity for each cross section in eight of the small-bag samples are shown in table 3. Actual differences between the two methods ranged from 0.1 to 0.8 percent. These differences are about double those for aspen in the tower experiment (table 1), but the values still show good agreement. A consistent difference was the specific gravity method always gave a higher loss value. The reason can be seen in the data for volume change; green volumes increased for all the samples by an amount essentially equal to the difference between the values of weight. loss by direct weighing and those by determining specific gravity. This experiment, like the tower experiment, shows conclusively that changes in green volume are small after outside chip storage up to weight losses of 6.5 percent; thus the earlier work (5) is further confirmed.

Water-soluble extractives (room temperature) were determined and found to be approximately 1 percent before storage and 0.5 percent after. Thus, these extractives did not: have a significant effect on determining loss of wood substance by the direct weighing or by the specific gravity method after 6 months storage in the experimental chip pile (5).

Data for weight loss for the cross sections and for the chips in the small bags varied considerably with no consistence. At each sample location for the cross sections, fairly close agreement in weight loss was found, but differences in losses between those for the cross sections and those for the chip samples ranged from 0.2 to 3.9 percent. The values were inconsistent because weight losses in the chip samples were sometimes higher and sometimes lower than those for the cross sections, and were apparently not affected by the position of the sample in the pile. When all the data are averaged, however, close agreement is found.

The relatively large differences in the values for weight loss from the large- and small-bag chip samples and in the cross section samples merit further discussion, An inherent shortcoming in determining loss of wood substance by direct weighing is that initial ovendry weights of each sample must be calculated by measuring the moisture content of an additional representative sample. For small-bag samples, the technique involves taking a green sample of chips, dividing it in half, weighing both halves, and drying one-half for moisture content determination. The moisture content of the second half is assumed equal to that of the first half; then the ovendry weight is calculated. Extreme care must betaken in thoroughly blending the initial sample and in weighing both the green and the ovendried samples. Any error in determining moisture content will obviously be directly reflected in the ovendry weight calculation that will in turn be reflected in

the final determination of loss in wood substance.

In the large-bag samples, several small representative samples are taken out at random, weighed, ovendried, and weighed again. This gives the original moisture content and the calculated ovendry weight (12). After storage the process is repeated again for final moisture content and ovendry weight. Obviously, errors in any weighing will affect results, If the samples are not thoroughly blended and truly random samples selected for moisture content determinations, serious errors can result.

All of the samples in this study were carefully randomized and weighed. Every effort was made to eliminate operator error in weighing, The loss in weight and the loss in specific gravity in the cross sections should be the most reliable because each sample is weighed, stored, recovered, and reweighed for computation of loss. Even with these carefully controlled experiments on each cross section, variations in weight loss within each group of three in the small-bag samples was as high as 1 percent (table 3). Variations in weight loss as large as this are to be expected, since the

Table 3.--Losses in weight and in specific gravity of loblolly pine stored 6 months in chip pile (cross section)

Sample No.	Wood chip weight loss[1]	Cross section: Weight loss (A)	Cross section: Specific gravity loss (B)	Weight loss minus specific gravity loss (A-B)	Volume change[2]
	Pct.	Pct.	Pct.	Pct.	Pct.
1	2.8	6.0	6.5	-0.5	0.5
2		4.9	5.5	- .6	.6
3		6.0	6.7	- .7	.7
4	5.1	3.8	4.4	- .6	.6
5		4.4	5.1	- .7	.7
7	3.1	3.5	4.1	- .6	.6
8		3.1	3.6	- .5	.6
9		3.3	4.1	- .8	.8
10	5.7	3.2	3.3	- .1	.2
11		3.0	3.4	- .4	.4
12		3.2	3.6	- .4	.4
14	3.5	5.1	5.6	- .5	.5
15		4.6	5.1	- .5	.6
16	4.6	5.1	5.9	- .8	.8
17		4.7	5.3	- .6	.7
18		4.2	4.6	- .4	.5
19	6.6	3.9	4.5	- .6	.7
20		3.3	3.8	- .5	.5
21		3.8	4.6	- .8	.8
22	5.3	4.4	5.1	- .7	.7
23		3.8	4.6	- .8	.8
Av.	4.6	4.2	4.7	- .58	.60

[1] By direct weighing of chips in each small sample bag (table 2).

[2] By determining volume by water displacement method before and after storage.

extent of microbiological attack on individual samples of wood will vary greatly (2, 3).

The experiments here indicate that with carefully controlled conditions, variations of 1 to 3 percent can occur in determining loss in wood substance either by the direct weighing method or by the specific gravity method. To obtain a meaningful measure of loss in wood substance in a chip pile by either method. a sufficient number of samples must be employed.

CONCLUSIONS

The outside storage of pulpwood chips usually results in a lass of wood substance. This loss was assessed on the same sample by the following two methods: By determining loss in weight and by determining loss in specific gravity before and after storage. The results showthat thelosses of wood substance determined by these two methods were equivalent.

The results also showthat green volume changes are small when pulpwood chips have lost up to 6.5 percent wood substance after storage. Green volume changes of only 0.8 percent were found.

The conclusion from the results here is loss in wood substance in outside storage can be accurately determined either by determining loss in weight or by determining loss in specific gravity if a sufficient number of initial and final samples are included.

Acknowledgments

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