SNOW SAMPLING RESULTS WITH DIFFERING SNOW SAMPLERS

By

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I. INTRODUCTION

Little alteration has been made in the Standard "Federal Snow Sampler" since Geo. D. Clyde (1) (2) (references listed at end of paper) reported on the Utah snow sampler in 1932. Prior to that time Dr. James Church's Mt. Rose sampler was used widely in the West. The Mt. Rose cutting point had an inside diameter of 1.5 inches; thus the equivalent of one inch depth of water in a snow core was 1.02229 ounces. This required a specially calibrated scale. Clyde reduced inner diameter of the cutter to 1.4872 inches so that one inch of snow water equivalent weighed one ounce. Any commercial scale could be used to weigh Clyde's sampler.

Many efforts have ensued to improve the cutter or tube design so as to permit easiest sampling in deep snowpacks containing ice layers. (3) In the winter of 1951-52 the authors designed and tested several cutters in an effort to find a design favoring penetration of dense snow and ice layers with least effort. The most successful tests resulted from a cutter with thin wall having a minimum taper.

Several others engaged in snow surveying have experimented with cutter design with about the same results.

In recognition of this problem, the Western Snow Conference (4) established in 1951 a cash award to be given to the one who could improve the snow sampler cutter. So far the award is unclaimed. This indicates the difficulty of improved snow sampler design.

In the winter of 1961 at Montana State College some experimental plastic snow tubes were manufactured by Professor Charles Bowman. These tubes were made from "Ryertex", a fiberglas material of phenolic resin on a fine linen base. Wall thickness of these tubes was about 1/8 of an inch. The advantage of this fiberglas material in snow sampling is that the snow cores do not adhere to it as in the case of the aluminum tube, thus permitting easier self-cleaning of the tube after sampling. These tubes were identical in pattern with the Federal Snow Sampler but were somewhat heavier. Initial samplings by these tubes in deep snow proved them not sufficiently strong. One tube twisted off while sampling about 10 feet of snow at Mt. Hood, Oregon. The tubes were redesigned to eliminate the slots through which core length is viewed. The slots were replaced with 7/16-inch diameter holes spaced every two inches. This change increased the strength of the tubes. In subsequent severe tests, the tubes did not break.

Another set of tubes tested for easier sampling was made of aluminum of about twice the wall thickness of the Standard Federal Snow Tube. These were developed and suggested for test by Carl Rosen of Seattle. The added wall thickness allows the tube to be threaded together without any increased outside diameter at the joints as exists on the Federal Snow Sampler. The new design permitted easier tube penetration to the ground when sampling in deep snow. The added wall thickness about doubled the weight of each tube. This increased the sampling effort when four to seven tubes were used in deep snow. These tubes had 7/16-inch diameter holes spaced every inch for reading core lengths.

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II. COMPARISON OF SAMPLING RESULTS WITH STANDARD FEDERAL SNOW SAMPLING EQUIPMENT AND EXPERIMENTAL EQUIPMENT.

One hundred fifty paired snow samples were taken at various locations in the West during the 1960 and 1961 winters using the Federal and Bowman's experimental plastic snow sampler. These samples were taken within a few inches of each other by the same sampling crews in each case of paired samples.

Tables I and II show a summary of the number of sample sets classed by inches of water equivalent and density. The mean water equivalent of these 150 paired samples by the Federal Sampler was 23.87 inches. The mean difference between the 150 paired samples by the Bowman tubes and the Standard Federal Snow Sampler was 0.41 inches of water, with the Federal Sampler usually showing the greater amount.

TABLE I

Water Equivalent (inches of water)	Number of Paired Samples in Tests
0 - 10	40
10 - 20	56
20 - 30	8
30 - 40	15
40 - 50	16
50 - 60	4
60	11
	150 pairs

TABLE II

Density	Number of Paired Samples in Tests
20 - 30%	44
30 - 40%	60
40 - 50%	41
50%	5
	150 Pairs

In testing the sample pairs, fulfilling both conditions of densities greater than 40 percent and water equivalent greater than 30 inches (30 pairs), differences between mean water equivalent were found to be 4.97, with the Federal Sampler showing the greater water equivalent in 24 cases. Using the "t" test for paired samples and a pooled standard error, these differences were greater than expected from sampling variation. Inside cutter diameters were measured, and dimensions of both measured to be 1.485 inches. Thus, the statistically significant difference in mean water equivalent between the Bowman and Standard Federal Sampler aluminum tubes was not due to any variation in cutter diameters.

Similar tests were made between 42 samples with the Standard Federal Snow Sampler paired with 42 samples taken with the Rosen Sampler. Tables III and IV give the sampling range.

TABLE III

Water Equivalent (inches of water)	Number of Paired Samples in Tests
20 - 30	7
30 - 40	0
40 - 50	.0
50 - 60	10
60 - 70	12
70 - 80	13
	42 Pairs

TABLE IV

Density	Number of Paired Samples in Tests
30 - 40%	14
40 - 50%	15
50%	13
	42 Pairs

The mean water equivalent of these samples by the Federal Sampler was 63.6 inches. The mean difference between the Rosen tubes and Standard Federal Snow Sampler was 5.5 inches, with the greater water equivalents usually measured by the Federal Sampler. Again on testing the pairs, fulfilling both conditions of densities greater than 40 percent and water equivalent greater than 30 inches (15 pairs), differences between mean water equivalent were found to be 6.6 inches. These differences were greater than expected from sampling variation. Inside cutter diameters were measured and found to be 1.485 and 1.488 inches between the standard tube and Rosen tube. This 0.003-inch difference amounts to less than 1/1000 cubic inch in volume of a 30-inch snow tube; this could not account for more than a mere fraction of the difference.

The difference between snow samples as measured in the Federal Snow Sampler and the experimental fiberglas and straight wall sampler might be due to the open area of the slots in the Federal Sampler. There are seven slots per tube in the Federal Snow Sampler. These slots are three inches in length by 1/8 of an inch wide, making a total open area of 2.62 square inches per tube. In the fiberglas and straight wall tubes, there are 13 and 28 holes, respectively, for corresponding open areas of 0.32 square inches and 0.68 square inches per tube. Thus, the Standard Federal tube has eight to four times more open area in the inspection slots than either of the xperimental tubes.

Fourteen paired samples were taken with the Federal Snow Sampler with the slots closed and with slots open in the normal manner. The mean water equivalent of the 14 samples with slots open was 47.78 inches of water. The mean difference between water equivalent samples taken with the slots open and closed was 1.16 inches in favor of the open slots.

Tables V and VI give a resume of sampling range between the Federal Sampler with slots closed and open.

TABLE V

Water Equivalent (inches of water)	Number of Paired Samples in Tests
10 - 20	3
20 - 30	5
70	6
	14 Pairs

TABLE VI

Density	Number of Paired Samples in Tests
30 - 40%	3
40 - 50%	7
50 - 60%	4
	14 Pairs

There was no statistically significant difference between mean water equivalent of the 14 paired samples totalled. However, in the test with water equivalent greater than 70 inches, 4.3 inches more of water equivalent was measured by the Federal Snow Sampler with open slots. This is greater than expected because of sampling variation alone.

III. ANALYSIS OF RESULTS BETWEEN STANDARD FEDERAL SNOW SAMPLER AND EXPERIMENTAL EQUIPMENT.

In case of both the Bowman and the Rosen samplers, the mean difference between all samples when totalled as compared to all samples taken with the Federal Snow Sampler totalled was not statistically significant. Only when samples having densities greater than 40 percent and water equivalents greater than 30 inches are compared, was the mean difference in water equivalent greater than expected due to sampling variation.

This suggests that the greater open area of the inspection slots in the tubes of the Federal Snow Sampler permits the entrance of snow when sampling deep dense snowpacks. Usually sampling snowpacks greater than ten feet in depth requires a twisting action of the sampler in order to reach the ground. This action thus affords opportunity for a greater collection of snow by the 1/8 x 3 inch slots than by the 7/16-inch holes.

IV. DISCUSSION OF TEST RESULTS AND RECOMMENDATION CONCERNING USE OF NON-STANDARD EQUIPMENT IN SNOW SURVEYS.

Due to the extreme difficulty of taking samples in deep dense snow with the Bowman Sampler, due largely to the large couplings, it was concluded that this sampler offered no practical improvement over the Standard Federal Sampler.

The Rosen Sampler secures good cores, and although heavier than the Federal Sampler and thus somewhat more difficult physically to handle in joined lengths of 10 to 20 feet, offers excellent promise for improved work in deep dense snow. However, the Rosen tube in deep snow in these tests measured statistically less water equivalent than the Federal Sampler. In the relatively few samples taken, this difference averaged about 6 percent. The authors believe this is due to the restricted observation slots in the Rosen tube.

Unfortunately then, if the Rosen tubes were to be used as replacement for the Standard Federal Sampler, a bias would be introduced into comparisons of results of the future with the past. All past records would require an adjusted correction related to snow depth and density.

There were only about 150 (5) snow courses in the West before the introduction of the Utah snow sampler in 1932, thus most records collected prior to 1933 were likely made with the Mt. Rose equipment. The Soil Conservation Service began using the Federal Snow Sampler as developed from the Utah sampler in 1935 and it has been used almost exclusively since then for snow surveys in the western states. There are now approximately 1400 snow courses in the West; a conservative estimate of samplings made by the Federal Sampler since 1935 would amount to about 2/3 million samples.

Should the Rosen tube be adopted for further use, it is the authors' recommendation that it be used on courses to be established rather than on established courses.

REFERENCES

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