Field Accuracy of Volumetric Snow Samplers at Mt. Hood, Oregon

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Abstract

Field tests of Volumetric Snow Samplers made at Mt. Hood, Oregon U.S.A. show considerable over measurement. This over-measurment varies from 5 to 17%. Cutter bluntness is responsible for this over measurement. Sharpening the cutter can reduce this error to 3 to 4%.

In a good many studies of glaciological, snow physics and radiation investigations, accurate measurments of the equivalent water content are required.

Near laboratory sites and areas where research facilities exist, accurate observations can be obtained by simple snow coring methods and melting the samples insuring against loss of snow and evaporation during the melting of the sample. However, in instances on remote glaciers or mountainous areas where a good majority of snow and ice research must by necessitated be done, logistic problem may prevent use of equipment for the melting of snow samples and the careful weighing of the resultant water. Under these field conditions hollow snow samplers are used. Technique usually is to push these volumetric samplers into the snow to the desired depth to obtain a core. The tube plus the extracted core are weighed. The empty tube weight is subtracted and if a calibrated scale and or tube is used the equivalent water content of the snow is obtained directly.

There are many volumetric snow samplers in use with varying diameters and cutter arrangements.

This paper describes field tests of a number of various types of volumetric snow sampling equipment available and being used in snow surveys in the United States. Most of the tests were performed by personnel of the U. S. Soil Conservation Service of which the author participated in at the Mt. Hood Snow Survey Test Site 1963–64 (Work *et al.*, 1965).

Five samplers were tested. Two of these were designed for relatively shallow low density of the eastern United States and high plains states.

Adirondack Sampler

This sampler is made of fiber glass. It has a sharp stainless steel circular cutter point. The inside diameter is 2.655 inches.

This sampler is 60.5 inches in length. Graduations at half-inch marks along the outside of the tube define snow depths up to 60 inches.

High Plains

The High Plains Snow Sampler was developed by the U.S. Corp of Engineers. It is of stainless tubing with steel driving handle attached to the tube. There is no special cutting point, the tube being ground to an edge at the driven end. The scale is an ordinary spring balance weighing in fractions of ounces. Because of the difficulty in holding cores in this tube and later dislodging the cores this sampler was tested only once.

Mt. Rose Sampler

The Mt. Rose Sampler developed by Dr. J. E. Church in 1909 has remained unchanged with the exception of aluminum in place of steel and the inside diameter reduced from 1.50 to 1.485 inches. The change from steel to aluminum reduces the weight by half and the reduction of the inside diameter to 1.485 inches enables one to use any scale graduated in ounces, thus establishing the weight of 1 inch of water equivalent in the tube at one ounce. Water equivalent then can be measured directly without any conversion.

Rosen

This sampler consists of heavy gage aluminum tubing, each tube 30 inches in length same as the Mt. Rose Sampler and graduated in the outside in inches and half-inches. It is coupled by threads cut directly in the aluminum tube. Thus there are no enlarged diameters at the couplings and the outside diameter of the tube is the same at all places above the cutter point. Inside diameter is the same as the Mt. Rose Sampler, *i.e.* 1.485 inches.

Snow cores and the sampler are weighed in any scale reading in ounces.

Bowman

The Bowman Sampler is the same essentially as the Mt. Rose Sampler except is made of "Ryertex". This is a plastic fiber material. An advantage of this tube is the fact that it does not transmit heat or cold as readily as metal, thus it is easier to use when snow and air temperatures differ markedly. The inner diameter of the cutting point is 1.485 inches.

Description of test method

A plot of ground at the Mt. Hood test site was levelled and covered with a thin layer of sawdust in the fall of 1963.

A heavy rectangular steel template of $2'' \times 3''$ angle iron, $5' \times 6'$ dimension was built. A sharp cutting edge was ground on one side of the angle iron, bevelled in. This cutting edge included the entire 22 foot perimeter of the template.

At time of each test the template was laid on the surface of the snow which was undisturbed from the time of first snowfall.

A wooden walk 12 inches wide was laid around the outer perimeter of the template. A wooden bridge above the snow surface, with footings in the planks spanned the template so that snow samples could easily be taken anywhere inside the template.

Except for the initial test of November 19, the template area, each test was divided into various parts of equal area by elastic bands stretched both ways over the sampling area.

In the first test, each of three men took one sample with each instrument in each segment of the template. The samples were considered paired in each sampling segment. From the 30 square foot area 122 samples were taken–10 or more by each snow surveyor for each snow sampler.

The cores of snow withdrawn by each sampler after each individual weighing were dumped into a can and accumulated for later bulk weighing, along with the snow from the pit.

When the snow depth exceedes sampler length, tests with the Adirondack and High Plains Samplers were discontinued, although one further test was made with the Adirondack Sampler, *i.e.*, Test #V.

After all the samples were taken and weighed, the template was pounded down to the sawdust, covering the surface of the ground. While the template was being driven it was kept level by a level bubble in each of the four sides. Thus a block of snow perfectly rectangular with perpendicular walls, and encompassing surface area of 30 square feet was cut.

The cut out snow was shoveled on a 4′×6′ box hung by block and tackle from a 500 lb capacity "Chatillon Scales". This scale was set to zero tare and the accumulated weight of the snow loads from the pit totalled and recorded. The weight of the total snow cores taken was also added. The error of the "Chatillon Scale" was not greater than one-half of one percent.

The total weight of the snow each test was converted into inches of water equivalent by use of the following expression:

$$\frac{E}{156.03} = X .$$

Where X=water equivalent inches and E=total weight of snow in pounds the factor 156.03 determined as follows:

$$A = \text{surface area } 5' \times 6' = 30\,\text{ft}^2$$
$$B = \text{water at } 32°\text{F} = 62.416\,\text{lb/ft}^3$$
$$C = 1/12\,\text{ft}^3 \text{ of water} = 5.201\,\text{lb}$$
$$\therefore\ D = \text{weight of 1 inch of water over } 30\,\text{ft}^2 = 156.03 .$$

The results of 7 tests at Mt. Hood are given in the following Tables:

Table 1. Test #I. Results at Mt. Hood Test Site

November 19, 1963—Very light intermittent snowfall
8.43″ = Template value for water equivalent in sampled area
( )* = Number of all samples taken by observers

Snow samplers Tested		Observer # 1	Observer # 2	Observer # 3	Average of total samples
ADIRONDACK	Inch. W. E. (water equivalent)	8.47	8.96	8.39	8.59 (29)*
	Dev. from true value (in.)	+0.04	+0.53	−0.14	+0.16
	% Diff. of true value	+0.005	+0.063	−0.017	+0.019

(Continued on following page)

Snow samplers tested		Observer # 1	Observer # 2	Observer # 3	Average of total samples
BOWMAN	Inch. W. E.	7.94	8.26	8.63	8.28 (27)*
	Dev. from true value (in.)	−0.49	−0.17	+0.20	−0.15
	% Diff. of true value	+0.058	−0.020	+0.024	−0.018
ROSEN	Inch. W. E.	8.63	9.06	8.48	8.70 (33)*
	Dev. from true value (in.)	+0.20	+0.63	+0.05	+0.27
	% Diff. of true value	+0.024	+0.075	+0.006	+0.032
FEDERAL SLOTTED	Inch. W. E.	8.73	9.47	9.26	9.12 (33)*
	Dev. from true value (in.)	+0.40	+1.04	+0.83	+0.69
	% Diff. of true value	+0.047	+0.123	+0.098	+0.081

Note: The average of all samples do not equal the average from the 3 sub set of each observer in as much as there were not the same number of samples taken by each observer.

Table 2. Test #II. Results at Mt. Hood Test Site

December 2, 1963

10.85″ = Template value for water equivalent in sampled area

( )* = Number of all samples taken by observers

Snow samplers tested		Observer # 1	Observer # 2	Observer # 3	Average of total of all samples
ADIRONDACK	Inch. W. E.	11.11	11.15	11.18	11.15 (30)*
	Dev. from true value (in.)	+0.26	+0.30	+0.33	+0.30
	% Diff. of true value	+0.024	+0.028	+0.031	+0.028
BOWMAN	Inch. W. E.	11.19	10.40	10.75	10.78 (30)*
	Dev. from true value (in.)	+0.34	−0.45	−0.10	−0.07
	% Diff. of true value	+0.031	−0.041	−0.009	−0.006
ROSEN	Inch. W. E.	11.15	10.77	10.82	10.91 (30)*
	Dev. from true value (in.)	+0.30	−0.08	−0.03	+0.06
	% Diff. of true value	+0.028	−0.007	−0.003	+0.006
FEDERAL SLOTTED	Inch. W. E.	11.61	11.48	11.68	11.59 (30)*
	Dev. from true value (in.)	+0.76	+0.63	+0.83	+0.74
	% Diff. of true value	+0.070	+0.058	+0.076	+0.068
HIGH PLAINS	Inch. W. E.	10.26	10.57	10.61	10.48 (30)*
	Dev. from true value (in.)	−0.59	−0.28	−0.24	−0.37
	% Diff. of true value	−0.054	−0.026	−0.022	−0.034

Table 3. Test #III. Results at Mt. Hood Test Site

February 3, 1964—Sunny day-good sampling
42.41″=Template value for snow water equivalent in sampled area
( )*=Number of all samples taken by observers

Snow samplers tested		Observer # 1	Observer # 2	Observer # 3	Average of total for all samples
ROSEN	Inch. W. E.	44.9	44.8	44.7	44.8 (18)*
	Dev. from true value (in.)	+ 2.5	+ 2.4	+ 2.3	+ 2.4
	% Diff. of true value	+ 5.9	+ 5.7	+ 5.4	+ 5.7
FEDERAL SLOTTED	Inch. W. E.	47.4	47.0	47.3	47.3 (18)*
	Dev. from true value (in.)	+ 5.0	+ 4.6	+ 4.9	+ 4.9
	% Diff. of true value	+11.8	+10.8	+11.6	+11.8
FEDERAL NO-SLOTS	Inch. W. E.	46.8	47.2	47.9	47.3 (18)*
	Dev. from true value (in.)	+ 4.4	+ 4.8	+ 5.5	+ 4.9
	% Diff. of true value	+10.4	+11.3	+14.0	+11.8

Table 4. Test #IV. Results at Mt. Hood Test Site

February 24, 1964
Water equivalent by template=51.6 inches
Number of samples taken with each snow sampler=20

Snow sampler	Depth	Core length	Water equiv.	Dev. from true value (in.)	% Diff. from true value
ROSEN	145.2	135.9	54.9	+3.3	+ 6.4
FEDERAL (STANDARD SLOTTED)	146.0	139.7	57.4	+5.8	+11.2
FEDERAL (NO-SLOTS)	146.0	138.8	57.2	+5.6	+10.8

Table 5. Test #V. Results at Mt. Hood Test Site

May 12, 1964-cloudy, very light rain fell intermittently
Water equivalent by template=85.4 inches
( )*=Number of samples taken

Snow sampler	Depth	Core length	Water equiv.
ROSEN (12)*	195.2	172.8	87.9
FEDERAL (12)*	196.5	180.8	94.1
LEUPOLD-STEVENS (12)*	194.2	184.4	92.2
ADIRONDACK #2 (5)*	195.0	194.3	85.0

Snow sampler	Inch. W. E.	Dev. from true value (in.)	% Diff. from true value
FEDERAL	94.1	+8.7	+10.2
L-S	92.2	+6.8	+ 8.0
ROSEN	87.9	+2.5	+ 2.9
ADIRONDACK # 2	85.0	−0.4	− 0.4
TEMPLATE	85.4	0	0

Table 6. Test ♯VI. Results at Mt. Hood Test Site

July 8, 1964–cool and overcast

Snow sampler	Snow depth (in.)	Core length (in.)	Water equiv. (in.)	Density (%)	Over-measurement by tubes (in.)	(%)
ROSEN	60.8	59.3	35.95	59.1	+2.78	8.4
FEDERAL SLOTTED WITH REGULAR CUTTER	60.8	60.8	38.95	64.1	+5.78	17.4
FEDERAL SLOTTED WITH FARNES' CUTTER	61.0	60.4	35.12	57.6	+1.95	5.9
TEMPLATE			33.17*	54.4		

* Corrected value obtained by adding 0.25 inches melt during test.

In general, the tests show that the Mt. Rose Sampler in common use within the United States measures a snow water content up to slightly over 10% more than actually exists in the snow pack. The percentage error increases with the increase in snow water content. Other samplers suitable for use in deep snow measure with an error of about 5 to 6%. The error found in the Mt. Rose Sampler is caused by the bluntness of the cutter point which must force a greater amount of snow into the tube than the mere measurment of the inside diameter of the cutter would indicate.

The effect of sharpness of the cutter was verified on January 16, 1965 at Mt. Hood when four Mt. Rose Samplers were tested with various cutter design in sharpness. Results of the January 16, 1965 test are given in Table 7.

Table 7

January 16, 1965
Water equivalent by template = 29.02 inches
Number of samples taken with each cutter = 20
All values in inches

Sample cutter	Depth	Core length	Water equiv.
Sharpened 16-tooth Federal (sharp-toothed)	59.8	58.6	30.1
Federal cutter-slight edge	59.8	59.1	30.7
Small toothed Montana	59.9	58.8	30.2
Standard federal cutter	60.0	59.9	32.6

Sample cutter	Inch. W. E.	Dev. from true value (in.)	% Diff. from true value
Sharp toothed	30.1	1.1	+ 3.72
Federal slight edge	30.7	1.7	+ 5.78
Small-toothed Montana	30.2	1.2	+ 4.06
Standard federal	32.6	3.6	+12.33
Template	29.02	0.0	0.0

Observers: Beaumont, Stockwell, Freeman.

Thus the overmeasurment of volumetric snow samplers can be reduced by half or more by simple sharpening of the cutter.

One ramification of these tests that can be singularly important is the comparison of snow tube records with other newly devices to measure snow water equivalent such as pressure pillow, platform or radio-active gages.

Reference

1) WORK, R. A. *et al.* 1965 Accuracy of field snow surveys. *CRREL Tech. Rept.*, **163**, 1–43.