TEMPERATURE EXTREMES AND THE SNOW SCALE

Hubert Howe[1]

PURPOSE

The purpose of this investigation is to determine the effect of temperature extremes on the standard snow scale reading and to quantify these effects. An additional benefit will be to determine the optimum temperature for snow scale calibration checking.

PROCESS

Equipment

Ten snow scales were selected at random from the scales available for use in the Calgary office. Five of the scales had never been in field service having been purchased in 2005. The other five scales had been in service for between 15 and 20 years. The new scales were all graduated in centimeters and the older scales were graduated in inches. All the scales had passed a routine snow scale calibration check completed at about 20 degrees Celsius.
The calibration weight set was made up of eight certified one pound metal weights suitable for incrementally adding to a metal weight stand. The weight stand consisted of a metal rod with a base plate at the bottom and a hook at the top to attach it to the snow scale.

The test setup was made up of a 5/8 threaded rod and two level tripods. The set up was portable so the unit could be moved to different locations so the full temperature range could be experienced. The temperature sensor used was a Barnant RTD Logger model 600-1085 digital thermometer. The sensing probe was housed in a seven plate R.M.Young gill shield and suspended from the test set up suspension rod.
Test facilities ranged from a cold chamber to the great outdoors. Exposure of the equipment to direct sunlight was minimized to prevent heating of the equipment above the ambient air temperature.

Procedure

The procedure used was designed to minimize potential errors due to equipment inconsistency or set up deviations. The scales were suspended from the threaded rod in the same sequence for each test and were left for one half hour to acclimatize. The calibration weights were also acclimatized and were added in the same order for each test. In an effort to simulate operational conditions, the scales were loaded, read, and then unloaded in order, which allowed the scale to rest for a time before being loaded with the next higher weight. Each scale was initially loaded with the weight stand and a non-calibrated weight to obtain an initial reading and simulating the empty tube. Then the first weight was added and each scale was loaded with this weight and a reading obtained. This was repeated until each scale was loaded to the maximum. Each scale was loaded for about three seconds before being read. In some cases the scale could be made to read two values for the same weight, and the scale was indicated as being sticky when this occurred. Temperature readings were taken at the beginning of each weight increase and recorded to the tenth of a degree. The warmer temperature tests were done in a warehouse, the five-degree test was done in a refrigerated cool room and the cold temperature tests were done outdoors. The outdoor tests were done in the shade to avoid heating due to solar radiation. Two tests were done near the minus ten degree mark as a check on the process to ensure consistency. The readings were entered directly into an Excel spread sheet on a laptop computer.

Data

Assumptions were made at the beginning based on the engineering of the snow sample equipment. These assumptions are based on information from the equipment manufacturer. It is assumed that 1 ounce loading on the English snow scale is equivalent to 1 inch of water equivalent which would translate into 25.4 millimeters of water equivalent on the metric snow scale. This would extend to 16 inches per one-pound weight or 40.64 centimeters. These values were used to determine the expected values and the errors were calculated as a percentage of deviation from these expected values. Graphs for each scale plotted the actual readings as well as the expected

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[1]Alberta Environment, Calgary, Canada

values to visually show the deviation of the scale from the expected. Some of the typical graphs are shown including the worse and best case scenarios.

The expected values were calculated by adding 16 inches or 40.64 centimeters to the initial scale reading. This resulted in each scale having a different set of expected values and the expected value scale would shift with temperature if the initial load on the scale resulted in a different reading at different temperatures. It was assumed that the initial reading had a 0% error and was correct, even if it deviated from the initial reading at a different temperature. This simulated field conditions as the scale would be read with the empty tube set and water equivalent calculated based on the difference.

Analysis

Percentage errors were calculated based on deviation from expected values after the initial scale reading was obtained. This was done because the initial readings varied depending on the scale. The new metric scales were much more consistent in the starting values while the older English scales varied from near 0 to almost 16 inches. The result was that the scales that started near 0 had a larger usable range and could accommodate an additional calibration weight before reaching their maximum reading. The metric scales all started near the 40-millimeter mark and would not allow addition of the eighth calibration weight before reaching their maximum reading.

English Scales

The English scales are graduated in 1-inch increments, so reading confidence was taken to be the nearest half-inch. A one-half inch increment could result in a discrepancy of 3.1% with one weight (16 inches SWE) added, but this would reduce to 0.6% with 5 weights (80 inches SWE) in place. The English scales, with the exception of CALSS04 operated smoothly, consistently settling on the same reading. They showed virtually no temperature effect at the low end of the scale, but with a 112-inch WE equivalent load the readings were between 1 and 2 inches lower at minus 20 degrees Celsius then at plus 20 degrees. The resulting measurement error due to temperature would be between 0,89 in the best case and 1.79 percent in the worse case depending on the scale. The temperature error appears to be fairly linear, gradually increasing as the load increases and as the temperature decreases.

Metric Scales

The metric scales are graduated in 2-centimeter increments, so the reading confidence was taken to be 1 centimeter. A one-centimeter increment could result in a discrepancy of 2.5% with one weight (40.6 cm WE) in place, but this would reduce to 0.5% with 5 weights (203 cm SWE) in place. The metric scales were more prone to being sticky. Sticky is defined as being able to have the scale settle on more than one value with the same load in place. This characteristic was not consistent and did not get worse with decreasing temperatures. The value that was predominant out of 5 readings was taken to be the true value for this test. The metric scales did show a small shift at the low end on the scale due to temperature. The change ranged from 1 to 2 cm WE at the 40 cm SWE level The change due to temperature expanded to 4 to 5 cm SWE with a 284 cm SWE load in place. This would translate into an error of 0.70% in the best case to 1.41% for the worse case. The temperature error appears to be fairly linear, gradually increasing as the load increases and as the temperature decreases.

CONCLUSIONS

Temperature does have an effect on the snow scale performance. This effect causes the scale to under read at moderately low temperatures and this error is relatively small. The scales appear to perform better at plus 20 degrees Celsius than at minus 20 degrees Celsius. The newer metric scales appear to have slightly lower error numbers, but they do tend to be more erratic and slightly less linear. This may be due to the smaller graduations on the scale and rounding errors or inconsistency in reading the smaller scale. The errors found at moderately low temperatures are probably insignificant, but more work should be done to determine what these errors are at extremely low temperatures.