The Present Status of Snow Pillow Instrumentation

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I Introduction

With the demonstration that a "snow pillow" could accurately measure the water equivalent of the snow at Mt. Hood, Oregon in 1964-65, many innovations have been attempted and tested from the original design.

The pressure snow pillow gage is a large air mattress-like device 2 to 3 inches thick on which the snow falls with a minimum of natural physical change in the snow. It has a large surface area of about one hundred square feet and is filled with an anti-freeze fluid. As the snow falls on the pillow, it's internal pressure is increased. The pressure is directly related to the mass of snow resting on the pillow.

II Snow Pillow Development

The very first snow pillows were made of clear polyvinal plastic. This material proved to be too fragile for field use. The next family of pillows, were made from butyl rubber. These proved successful in testing at Mt. Hood in 1962-63 and 1963-64. After this first commercially produced butyl rubber pillows performed very poorly with about half of those sold reporting leaks and seamed failures. The manufacturer attempted to correct this by designing a double pillow. A butyl rubber pillow without any nylon or cloth reinforcing was enclosed within a protective butyl rubber cover with nylon reinforcing. The inside bladder was then filled with the anti-freeze solution. Several of these are in use and satisfactory results are reported.

Another approach by another manufacturer to this, has been to utilize a very strong synthetic nylon reinforced rubber used in storage tanks for gasoline and other liquids, these so designed pillows have been successful in field operations. A few of the rubber fabric pillows have had some damage due to animals. In the off season, or summertime, a protective wooden cover has been placed over some pillows to protect them from animals or other general damage. Some have been removed and stored.

Manometers and float recording equipment were used to measure and record the pressure changes of the snow pillows.

III Recent snow Pillow Instrumentation

Newly installed Snow Pillows have continued to use stand pipes with a variety of float recorders.

Some of these recorders operate weekly, others have negative wound springs and record up to 8 weeks or more.

One of the objections to the stand pipe float readout system, is the necessity for a shelter to house the stand pipe and recorders. In areas designed as Wilderness Areas, this rules out the use of such automatic recording instruments.

In order to reduce this construction to a minimum, various pressure transducers have been connected to snow pillows. These transducers, usually are of low range, i.e. 0-5 psi. A change in pressure results in a change in resistance, which is in turn usually directed into an AD recorder and then transmitted or recorded at the site on a strip chart. Sometimes in case of carbon or wire wound elements within the transducer, the transducers have been equipped with shakers to eliminate Hytheresis effects. Another type of transducer used, has been a linear variable differential transformer which produces a voltage output directly proportional to the displacement of a movable armature.

To date, the most reliable method in operation, has been the stand pipe and float system. One disadvantage with the float recorder, has been a diurnal variation due to temperature effects during clear and sunny days in which radiation is a maximum. This effect is very regular and has been observed in all parts of the West. In Colorado, the magnitude of this fluctuation, has been observed as high as one half to near one inch with a tall stand pipe 6 to 8 feet in height. No diurnal fluctuations are observed during periods of snow accumulation or cloudy weather.

Transducers not protected from large temperature changes in the field, have also produced variations in the apparent water equivalent of the snow.

Communication systems used with the various readout methods, for the most part, transmit digital information from the data collection site. There are a few instances where analog information of the readout transducer is transmitted directly and later converted at the logging site. The preference seems to be to convert at the data collection site and transmit in digital form.

Some of the communication systems report by pre-set timers, others, in addition to this, have interrogation capability. At some of the central base stations this information is received and printed out on a standard duty send-receive teletype printer. A few systems incoming data in BCD code is automatically punched on paper tape.

Power sources for the remote data collection sites are usually nickel cadmium batteries which are recharged by solar cells. Battery drain for the U.S. Corps of Engineers remote data collection sites in the Kings River Basin of California, are reported as follows:

Standby: 6 milliamps
Receive: 55 milliamps
Transmit: 1 Amp.

Using a 10 ampere-hour capacity battery provides a reserve of 30 days of operation of one call per day.

Installation

The majority of innovations with the installation has been related to attempts to "hide" or protect the rubber fabric material snow pillow from animals and the general public. Some pillows have been covered with plywood, hardware cloth and in a few instances, buried beneath the ground surface and covered with 2 to 3 inches of sand or soil. Satisfactory results have been observed and reported from these pillows that have been covered with a loose soil or sand. Corrections must be made for changes in water content of this soil layer. This however, is usually small in magnitude to water equivalent of the snow.

In another attempt to produce a pillow less vulnerable to tears, animals, etc, several pillows have been made of this galvanized material. The majority are 4 x 5 feet in size. In some instances, as many as four have been installed side by side and interconnected to the same recorder. The surface of these metal pillows acts in a similar manner as the flexable rubber fabric pillow, depressing with the external load of the snow and increasing the internal pressure. These devices are usually four to six inches thick. This winter (1967-68) is the first winter an attempt has been made to use these devices operationally. Thusfar, satisfactory results have been reported this winter with these instruments.

There is some question that these four by five metal pillows installed side by side and interconnected, will act as a single eight by ten unit in deep snow and will not overweigh the snow as the smaller diameter individual pillow tested at Mt. Hood did during the development work on the pressure pillow.

This winter's experience should provide information as to the operating characteristics of these metal units.

Future Developments

The pressure pillow device has proven a satisfactory and most accurate way to measure the water equivalent of the snow in the West. It's accuracy exceeds that of the snow tube used for many years.

Disadvantages reported of these instruments, has been the amount of fluid necessary, 250 to 300 gallons for a 12 foot diameter pillow, vulnerability to damage and leaks of the rubber fabric material.

Automatic remote stations have been hampered by equipment failure of transducers and telemetry.

The majority of the communication failures can be attributed to equipment installed and operated in environmental conditions less than favorable for its original intended use.

As the needs arise, and experience is gained by data collecting agencies, it is reasonable to expect specially designed equipment for snow pillows.

With experience to date, one might predict that a "solid state" type platform with a pressure sensitive surface connected to load cells may replace the fluid filled snow pillow and hydraulic system readout. Such a platform should have to be made rigid and made in sections for installation in very remote areas where helicopter would be the only mode of travel.