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Hidrometrija - Merjenje količine vode v snegu s pomočjo naprav za registracijo snežne mase

Hydrometry - Measurement of snow water equivalent using snow mass registration devices

Hydrometrie - Das Messen des Schnee-/Wasseräquivalentes

Hydrométrie - Mesurage de l'équivalent en eau de la neige au moyen de dispositifs d'enregistrement de la masse neigeuse

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English Version

Hydrometry - Measurement of snow water equivalent using snow mass registration devices

Hydrométrie - Mesurage de l'équivalent en eau de la neige au moyen de dispositifs d'enregistrement de la masse neigeuse

Hydrometrie - Messung des Schnee-Wasser-Äquivalents unter Verwendung eines Gerätes zur Erfassung der Schneemenge

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Foreword

This document (CEN/TR 15996:2010) has been prepared by Technical Committee CEN/TC 318 "Hydrometry", the secretariat of which is held by BSI.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

Introduction

Snow water equivalent (SWE) measurements

Snow water equivalent (SWE) is the height of water that would be obtained by melting the snowpack on a corresponding surface area, and is normally expressed in millimetres (mm).

Knowledge of the SWE is essential for estimation of total runoff and flood forecasting in river basins where snowfall occurs. Independent of the selected method, the SWE measurements should proportionally represent the total SWE in the studied area.

The parameter is predominant in avalanche theory and avalanche danger forecasting as well as for risk assessment of heavy snow loads. Additionally, the development of SWE measurements using satellite sensors has increased the need for validation and calibration using in-situ measurements.

Annex A is a list of methods for determination of SWE.

Snow mass registration devices

Snow mass registration devices are widely used in North America and Europe. Different problems experienced in the use of the equipment have resulted in a slow development of the technique, but improvements in equipment design and data management in recent years have increased interest in the method. Annex B shows a table of station networks running during publication of this report.

1 Scope

This Technical Report defines the requirements for the use of snow mass registration devices for measurement of SWE under natural environmental conditions. It includes weighing and pressure measuring methods.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 772:2000, *Hydrometric determinations — Vocabulary and symbols (ISO 772:1996)*

CEN ISO/TS 25377, *Hydrometric uncertainty guidance (HUG) (ISO/TS 25377:2007)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 772:2000 apply.

4 Symbols and abbreviated terms

Table 1 lists the symbols used in this document.

Table 1 — Symbols

Symbol	Term	Unit
SWE	Snow water equivalent	mm
M	Snow mass	kg
ρ	Density	kg/m^3
V	Volume	m^3
A	Area	m^2

Table 2 lists the abbreviated terms used in this document.

Table 2 — Abbreviated terms

Abbreviation	Term
SPA	Snow Pack Analyzer
GPR	Ground-penetrating radar
PVC	Polyvinyl chloride

5 Purpose of method

The use of snow mass registration devices provides stationary single point measurements of the total SWE and recording of the changes that take place due to further accumulation of snowfall or melting of the snowpack.

If the equipment is correctly mounted at a location where the snow accumulation is representative of the surrounding terrain, the data obtained by this method can be used for the prediction of melting water volumes. It can also be used for calculating the effect of heavy snow loads on structures in the area, avalanche prediction or just provide information on snow quantities in general.

6 Principle

The mass of the snow on top of a measuring device is equivalent to the mass of the water content in the overlying snow. This mass can be obtained by measuring the pressure in a pillow filled with anti-freeze solution, which is the most common method, or by using a flat plate mounted on weight sensors through which the mass of accumulated snow can be determined.

7 Operational requirements

7.1 General

Snow mass registration devices should be as large as possible to optimise the accuracy of the measurement. The most common areas are between 2 m^2 and 15 m^2.

The measuring device should be installed horizontally on a stable foundation. The top surface should be at the same level as the surrounding ground to minimize the effects of shear perimeter stress concentrations. To reduce environmental effects that cause SWE measurement errors the instrument should have low compressibility and a thermal conductivity similar to that of the surrounding soil (see 12.2).

It is recommended to imitate the properties of the surrounding ground using a permanent cover of, for example, camouflage netting or synthetic grass. This may also prevent snow blowing off the instrument following moderate snow falls.

The disturbance of snow accumulation at the measuring site due the measuring equipment should be minimized.

The site should be well drained. Water should not be allowed to collect on the device.

The equipment should be protected against interference by animals or unauthorized persons. If necessary, the installation could be protected by a fence, but it should not interfere with the accumulation and the ablation of the snow.

To be able to locate the exact position of the measuring device, it can be marked with reference poles of sufficient height to be seen above the snowpack at the expected maximum snow height.

7.2 Site selection

Detailed site investigations are required to select a representative location. To prevent the snow on the ground from being considerably influenced by the wind, a location surrounded by bush vegetation or a clearing in an open forest is preferable. Wind exposed areas should be avoided, as well as pronounced recessions in the terrain.

The site selected should be a considerable distance from larger trees, rock outcrops and buildings which could disturb natural accumulation and melting of the snow. An ideal distance between the instrument and the nearest obstacle is between 2/3 and three times the height of the obstacle.

The slope of the surrounding terrain should be such as to minimize the affect of snow creep on the measuring site.

Locations should be selected in order to avoid the risk of rising water levels affecting the installation. The soil should allow good natural drainage.

Snow mass registration devices are preferably located at, or close to, a climate station, since meteorological parameters are important for evaluation and validation of SWE measurements.

If the equipment on the site has to be supplemented with external power an accumulator can be used, recharged by a solar panel. In this case, sun conditions have to be considered.

7.3 Validation

Rapid and unexpected changes in the monitored SWE might be a result of snow metamorphoses, formation or break up of snow bridges, or shear stress concentrations along the perimeter of the measuring device (see Clauses 11 and 12). It can also be a result of leakage in the pressure system in the snow pillow, or a defective sensor. To be able to detect measurement errors it is necessary to establish a control programme.

Regular checks utilizing manual measurements of the SWE should be performed with samples being taken within a few metres from the instrument. It may be appropriate to undertake frequent manual measurements following the initial installation to ensure the correct performance of the instrument. Annex C summarizes the techniques for manual measurements.

Registration of meteorological parameters such as precipitation, air temperature, wind speed and the temperature of the snow at the surface and slightly above the ground at the site is valuable for checking the accuracy of the monitoring.

By use of simple numerical modelling of SWE based on observations of for example precipitation and air temperature, the registration can be evaluated continuously.

Additional measurements of snow depth in connection to the SWE recording system can also assess the performance of the SWE measurements. The combination of SWE and snow depth measurements can be used to derive an estimate of the snow density (Equation (1)):

$$\rho_{snow}\left[kg\,m^{-3}\right] = \frac{SWE\left[kg\,m^{-2}\right]}{d_{snow}\left[m\right]} \tag{1}$$

A calculated snow density outside typical values can be used as indication of problems with the measurement system. The maximum range for snow densities is between 50 kg·m^{-3} to 450 kg·m^{-3}, but typical values of a late winter snow pack is often around 250 kg·m^{-3} to 350 kg·m^{-3}.

7.4 Maintenance

In summertime the equipment including all complementary and protective devices on site, should be cleaned and checked and the zero point checked.

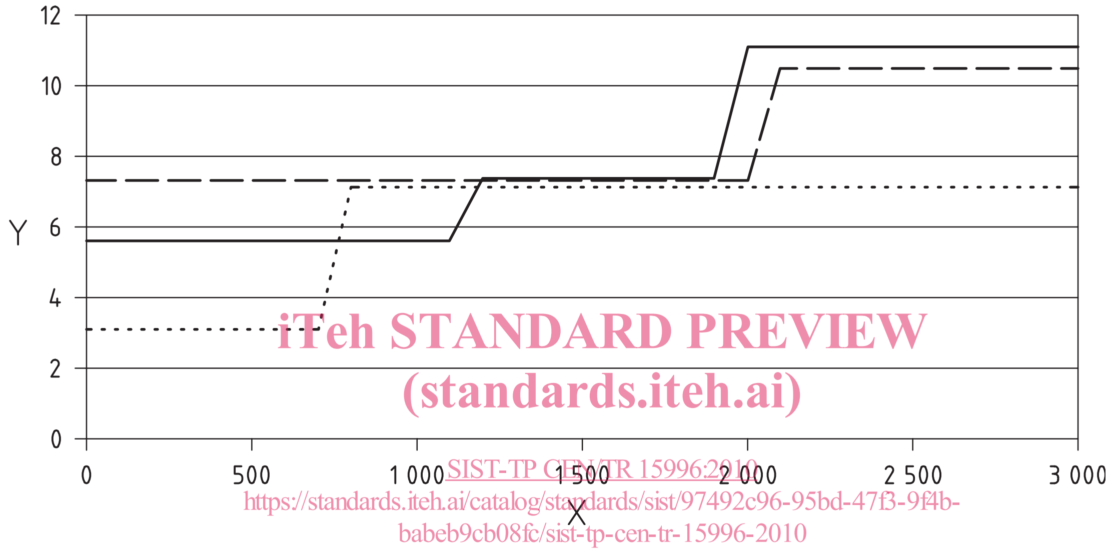
In addition, the site itself should be inspected for changes. New vegetation and obstacles that could have an affect of the measurements should be removed and drainage of the site may have to be improved.

8 Monitoring by hydrostatic pressure measurements

8.1 Description

Snow pillows for determination of SWE were developed in the early 1960s. The snow pillow consists of a flat bag completely filled with an anti-freeze fluid. The pillow should have a valve for filling the pillow and removing air bubbles. It can be in various shapes, sizes and materials. The most common snow pillows are circular, rectangular or hexagonal shaped and made of UV-resistant butyl, neoprene rubber or stainless steel.

The surface area of the snow pillow should be sufficiently large to minimize the affects of shear stress along the edges of the pillow or bridging in the snowpack (see Clause 12). Recommendations from United States Department of Agriculture (USDA) and Norwegian Water Resources and Energy Directorate (NVE) on the minimum area in relation to the maximum expected SWE is shown in Figure 1.



Key

Y Area (m^2) X SWE (mm)

— USDA steel pillow – – USDA butyl pillow --- NVE butyl pillow

Figure 1 — Recommendations on the minimum area of snow pillows in relation to the maximum expected SWE

A snow pillow with a depth of about 10 cm is recommended. This means that a pillow with an area of 3 m^2 requires approximately 300 l of fluid.

With a good installation, periodical control, and normal use and care, snow pillows should have a working life in excess of ten years.

8.2 Fluids

The snow pillow should be filled with an anti-freeze solution suitable for the minimum temperature expected. It is recommended to use environmental friendly solutions.

NOTE Where anti-freeze is used then the compliance to existing national environmental regulations should be adhered to.

Table 3 shows the most common anti-freeze mixtures, their freezing point, and their rate of toxicity.

Table 3 — Anti-freeze solutions used in snow pillows

Solution (50:50 by mass)	Freezing point	Toxicity
ethanol : water	- 32 °C	low
propylene glycol : water	- 34 °C	low
propylene glycol : ethanol		low
methanol : water	- 54 °C	high
ethylene glycol : methanol	- 40 °C	high
ethylene glycol : water	- 34 °C	high

The pressure in the fluid corresponds to the weight of snow lying on the pillow and is measured by a pressure sensor inside the pillow, or in a riser pipe connected to the pillow (see Annex D). The pressure sensor as well as any other equipment in contact with the anti-freeze fluid should be resistant to its corrosive effects.

A tracer in the fluid can be used to detect leaks and also to facilitate manual readings on a riser pipe scale.

8.3 Installation

In order to allow the surface of the pillow to level with to the surrounding area the ground should be excavated, or the site should be aggraded with filling material. Care must be taken to ensure that there is nothing that would damage the underside of the pillow. A padding of sand or crushed rock with a maximum particle size of 3 mm is ideal to protect the pillow. Local material may be used provided that the material has full contact with the bottom surface of the pillow and supports the load of the filled pillow system. If necessary a geotextile membrane can be used between the soil and the pillow.

It is recommended that two separate sensors are used to provide redundancy and also to be able to detect sensor errors.

If it is necessary to protect the unit from lateral pressure caused by the weight of the surrounding soil, protective measures should be considered.

When filling the snow pillow with the fluid it is important to ensure that no air bubbles remain inside the pillow. An examination a few days after installation should be undertaken to check for any signs of airlocks.

Any gaps in the ground that remain at the sides of and underneath the pillow after filling should be filled with sand.

The environmental concerns of using and disposing of anti-freeze should be addressed by the operating organization. The installation should be designed to minimize the risk of anti-freeze leaking into the surrounding natural environment.

8.4 Maintenance

The zero point of the pressure gauge should be confirmed on at least an annual basis during the snow-free season. The equipment should be cleaned and checked to see if there are any signs of leaks or damage to the pillow, connectors, ventilation valves and pipes. It is important to ensure that no air bubbles remain inside the pillow.

If possible, the snow pillow should be provided with a secure cover during the summer months in order to prevent damage and protect the material from strong sunlight. This is not necessary if the pillow has the type of permanent cover described in 7.1.