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Hydrometry — catching-type liquid precipitation measuring gauges

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Introduction

This Standard covers instrumentation that measures rainfall intensity (RI) and liquid precipitation by collecting the volume of water that falls on a fixed area. The collected volume of water is divided by the fixed area of the collecting device to give a value for volume per unit area, termed rainfall depth, and measured in $mm \cdot h^{-1}$ or $kg \cdot m^{-2}$. Unlike many other meteorological instruments, there is no absolute physical standard against which a raingauge (hereafter called catching-type liquid precipitation measuring gauges) can be compared. Many different types, shapes, and sizes of catching-type liquid precipitation measuring gauges are acceptable for the measurement of rainfall and rainfall depth, each reflecting a specific requirement. Most consist of a circular collecting device, delineating the fixed area of the sample, and a funnel leading into a storage reservoir and/or measuring system. Some types of automatic gauges do not require a funnel. Since various sizes and shapes of orifice and gauge heights are used in different countries, the measurements are not strictly comparable.

NOTE 1 This standard specifies only the functional requirements of catching-type liquid precipitation

measuring gauges, and does not include specification, design and installation conditions.

(REFERENCE: BS 7843-3:2012, Introduction)

(REFERENCE: WMO-No.:2012, CH 6.1.2 & CH 6.1.4.1)

(REFERENCE: BS EN 17277:2019)

Hydrometry — catching-type liquid precipitation measuring gauges

1 Scope

This International Standard specifies the typical requirements of instrumentation for measuring liquid precipitation, primarily for the purpose of hydrological and meteorological observation. Its scope is limited to both non-recording and recording catching-type precipitation gauges for the measurement of liquid precipitation. The standard covers design criteria for the gauges and elements of uncertainty that need to be considered in their construction.

This International Standard is supplemented by an annex providing guidance on the types of catching-type liquid precipitation measuring gauges currently available and the measurement uncertainty associated with them (see Annex A).

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.

ISO 772:2011, *Hydrometry — Vocabulary and symbols*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

JCGM 200:2012*(E/F) International guide of metrology – Basic and general concepts and associated terms (VIM) 3rd Edition: 2008*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 772, BS 7843-3 and ISO/IEC Guide 98-3 apply.

3.1
accuracy (of measurement)
qualitative expression for the closeness of a measured value to the true value

Note 1 to entry: The quantitative expression of accuracy should be in terms of uncertainty. Good accuracy implies small random and systematic errors.

[SOURCE: ISO 772:2011, CH 7.38]

3.2
calibration
process which establishes, under specified conditions, the relationship between the values indicated by a catching-type liquid precipitation measuring gauge and the corresponding known values indicated by a measurement standard with associated measurement uncertainties.

[SOURCE: BS 7843-3:2012, CH 3.1]

3.3
error of measurement
result of a measurement minus a true value of the measurand

Note 1 to entry: The term relates equally to

— the uncorrected result, and

— the corrected result.

Note 2 to entry: The known parts of the error of measurement may be compensated by applying the appropriate correction. The error of the corrected result

[SOURCE: ISO 772:2011, CH 7.24]

3.4
precipitation (liquid and solid)
precipitation is defined as the liquid or solid products of the condensation of water vapour falling from clouds or deposited from the air onto the ground. It includes rain, hail, snow, dew, rime, hoar frost, and fog precipitation

[SOURCE: WMO No.8 :2012, CH 6.1.1]

3.5
rain measure
graduated measuring cylinder made of clear glass or plastic, used by the observer for measuring the volume of collected liquid and melted solid precipitation

[SOURCE: BS 7843-3:2012, CH 3.10]

3.6
rainfall
total liquid component of precipitation, including condensation from the atmosphere, collected and measured by a catching-type liquid precipitation measuring gauge

[SOURCE: BS 7843-3:2012, CH 3.7]

3.7
rainfall intensity
accumulated precipitation in unit time

[SOURCE: BS 7843-3:2012, CH 3.9]

3.8
raingauge
an instrument that measures rainfall

3.8.1
automatic raingauge
collecting raingauge that measures rainfall by automatic means

[SOURCE: BS 7843-3:2012, CH 3.11.1]

3.8.2
collecting raingauge
instrument that collects precipitation falling through an orifice of the known cross-sectional area for the measurement of its water equivalent volume, mass or weight accumulated over a measured period

[SOURCE: BS 7843-3:2012, CH 3.11.2]

3.8.3
storage raingauge
collecting raingauge that accumulates rainfall and melted solid precipitation in a collecting vessel for manual measurement of its volume

[SOURCE: BS 7843-3:2012, CH 3.11.3]

3.9
resolution
quantitative expression of the ability of an indication device to distinguish meaningfully between closely adjacent values of the quantity indicated

[SOURCE: ISO 772:2011 CH 7.1]

3.10
uncertainty
estimate characterizing the range of values within which the true value of a measurand lies

[SOURCE: ISO 772:2011 CH 7.35]

3.10.1
combined uncertainty
standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighted according to how the measurement result varies with changes in these quantities

[SOURCE: ISO 772:2011 CH 7.43]

3.10.2
expanded uncertainty
expanded uncertainty quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the values that could be attributed to the measurand

[SOURCE: ISO 772:2011 CH 7.42]

3.10.3
type A evaluation of uncertainty
evaluation of a component of measurement uncertainty by a statistical analysis of measured quantity values obtained under defined measurement conditions

[SOURCE: ISO 772:2011 CH 7.40]

3.10.4
type B evaluation of uncertainty
evaluation of a component of measurement uncertainty determined by means other than a type A evaluation of measurement uncertainty

[SOURCE: ISO 772:2011 CH 7.41]

3.10.5
standard uncertainty
uncertainty of the result of a measurement expressed as a standard deviation

[SOURCE: ISO 772:2011 CH 7.39]

4 Instrument specifications

4.1 General

Catching-type liquid precipitation measuring gauges are classified as non-recording and recording types. The non-recording type has ordinary and storage gauges. The recording type has weighting, tipping-bucket, and floating types. It usually has a resolution of 0.1 mm to 1 mm, and the measuring rainfall intensities in the range 0.1 to 1,000 mm·h^{-1} or higher. Measurement errors may occur according to installation conditions, measurement environment, and solid precipitation.

The catching-type liquid precipitation measuring gauge shall be made of circular orifice and shall be formed perpendicular to the outer slope and the inner surface with sharp edges. Edge diameters shall be less than 0.2 percent of diameter in any direction. The surface of the funnel shall consist of a stable, durable material such that the water drop is not maintained by surface tension, is freely moved towards the orifice and is passed to the measuring mechanism.

NOTE Although this standard specifies the functional requirements of catching-type liquid precipitation measuring gauges, consideration of the siting and exposure of gauges is important. More specifically, the installation conditions, measurement environment, and solid precipitation are well documented in the references below.

(REFERENCE: BS 7843-3:2012, CH 7.2.3)

(REFERENCE: BS 7843-3:2012, CH 6.1.5)

(REFERENCE : WMO CIMO_Guide-7th_Edition-2008-WMO No 8, CH 6)

4.2 General gauge specifications

The gauge manufacturer should provide general specifications that may impact the measurement of precipitation, these include but are not limited to:

a) Measurement range for precipitation intensity or total rainfall volume

b) Resolution

c) Accuracy

d) Size of orifice area

e) Standardized communication interfaces and protocols for data transmission

f) Power supply and consumption

g) Height of gauge (including rim height placement to avoid interference from deposited snow or other materials near gauge)

4.3 Environment

4.3.1 General

Liquid precipitation measuring gauges shall operate within the ranges of temperature in 4.3.2 and the ranges of relative humidity in 4.3.3.

NOTE 1 Wind should be taken into consideration in areas that are prone to inclement weather conditions

(REFERENCE : WMO Guide to Meteorological Instruments and Methods of Observation, PART 1)

4.3.2 Temperature

Catching-type liquid precipitation measuring gauges shall operate within the following temperature range:

a) Operating temperature

— Maximum temperature : +60 °C

— Minimum temperature (catching-type liquid precipitation measuring gauges, excluding heating or weighing gauge without antifreeze) : 0 °C

— Minimum temperature (catching-type liquid precipitation measuring gauge, with heating or weighing gauge with antifreeze) : –40 °C

b) Storage temperature

— Maximum temperature : +40 °C

— Minimum temperature : –20 °C

(REFERENCE : BS 7843-3:2012, CH 11.1~11.2)

4.3.3 Relative humidity

Catching-type liquid precipitation measuring gauges shall operate within the following relative humidity range:

a) Operating relative humidity

— Maximum relative humidity : 100 % RH

— Minimum relative humidity : 0 % RH

b) Storage relative humidity

— Maximum relative humidity : 80% RH

— Minimum relative humidity : 0% RH

(REFERENCE : BS 7843-3:2012, CH 11.1~ 11.2)

5 Recording

5.1 Recording format

For recording and non-recording type liquid precipitation gauges, the length of each record to be stored in a data storage gauge or manual recording shall be at least eight digits for the year, month and day, eight digits for the hour, minute, second and millisecond (e.g. 2019/12/31 09:00:00:00). For rainfall intensity (RI), there shall be at least five digits (e.g. 00.000 $mm \cdot h^{-1}$), not including the decimal place, for the liquid precipitation amount which is measured in $mm \cdot h^{-1}$ or $kg \cdot m^{-2}$.

5.2 Recording interval

The recording interval must be specified by the network operator to ensure regulatory compliance and fit with regional and climatological constraints.

For recording type gauges, the measurement record of liquid precipitation should be transmitted to the recording device instantaneously or at a specified time according to the gauge user.

Non-recording type liquid precipitation gauges should be read manually at a specified interval to acquire the data.

Ordinary and Storage gauges should be emptied in line with network operating principles, commonly daily or monthly depending on gauge design and network purpose. Liquid precipitation is reported per unit of time, the manufacturer or network operator should specify the volume of liquid precipitation and time interval recorded in its most granular form.

6 Environmental protection and housing

The catching-type liquid precipitation measuring gauge should be constructed in a material that is durable and can endure natural weathering without changes to its surface characteristics. Sound watertight seams should be used throughout. The collecting funnel should fit firmly over the top of the measurement mechanism but should be removable without undue force. The gauge should be designed to minimize ingress by small animals and insects. The outer housing of the gauge should also prevent water from entering the measuring component of the gauge, apart from through the inlet funnel. Electrical connections for power supplies and outgoing signals should be provided using water-resistant plugs or terminals, suitable for the environmental conditions in which the gauge is deployed. Ingress Protection Code 67 (IP67) is suitable for this. Any marking identifying connectors should be weather-resistant and remain legible for the expected lifetime of the catching-type liquid precipitation measuring gauge.

(REFERENCE : IEC 60529:Edition 2.2 2013-08, CH 13~14)

7 Installation

The manufacturer shall provide clear instructions for the installation of catching-type liquid precipitation measuring gauges.

NOTE 1 Although outside the scope of this standard, it should be noted that measurements will be influenced by rim height either through individual gauge design or local deployment to allow for factors such as snow depth where close to ground level deployment is not practical. All gauge types should be sited to ensure operation within the manufacturer's design.

The rim of the gauge should be installed parallel to the ground surface. The design should maintain plane of rim level to within ±2° of the base plane. Failure to ensure that the rim is level will introduce a systematic error into measurement. The measurement mechanism of the gauge, e.g. a tipping bucket mechanism, also needs to be level to ensure there are no systematic errors.

The gauge should be installed securely to ensure that it remains stable. This must take into account impacts such as frost heave and changes in ground conditions.

The gauge should be sited to ensure that the surrounding surface minimises splashback that can result in an over-catch. A surface of gravel or short grass is typical and surfaces such as concrete should be avoided.

(REFERENCE : BS 7843-3:2012, CH 6.1.4)

8 Estimation of measurement uncertainty

8.1 General

The uncertainty of a value derived from primary measurements may be due to

a) Signal Noise which affects the value being measured (variation by the precipitation intensity), or

b) Resolution of the measurement process.

Two methods of estimation, Type A and Type B, are described in the Guide to the Expression of Uncertainty in Measurement (GUM 1995) for relating the dispersion of values to the probability of "closeness" to the mean value.

NOTE 1 Although installation and environmental factors are major sources of uncertainties, they are outside the scope

8.2 Factors of measurement uncertainty

In practice, there are many possible sources of uncertainty in a measurement, including

a) personal bias in reading

b) finite instrument resolution or discrimination threshold

c) variations in repeated observations of the measurand

(REFERENCE : GUM ISO/IEC Guide 98-3:2008, CH 3.3)

8.3 Type-A estimation

It is the method of evaluation of uncertainty by the statistical analysis of series of observations. It stems from manual reading and evaporation and wetting of the instrument.

(REFERENCE : GUM ISO/IEC Guide 98-3:2008, CH 2.3)

8.4 Type-B estimation

It is the method of evaluation of uncertainty by means other than the statistical analysis of series of observations. It stems from resolution, aging, and random error of the instrument.

(REFERENCE : GUM ISO/IEC Guide 98-3:2008, CH 2.3)

8.5 Data uncertainty

A precipitation measurement is not an absolute measurement. It is always relative to data, for example, atmospheric pressure, water temperature, and other factors. The uncertainty associated with the data should be combined with the uncertainty of the derived value.

(REFERENCE: ISO 4373:2008(E), CH 8.4)

8.6 Combined uncertainty

To determine the uncertainty of the derived value, *U*, it is necessary to combine the uncertainties of all primary measurements, *u*, thus,

$$U\left(precipitation\right)=\sqrt{u\left(precipitation\ data\right)^2+u\left(precipitation\ measurement\right)^2}$$

This illustrates the method when combining the uncertainty of a precipitation data value. Other components of measurement uncertainty are added by inclusion of their squared value within the brackets.

(REFERENCE : GUM ISO/IEC Guide 98-3:2008, CH 5)