Infrastructure Commission (INFCOM)
Standing Committee on Measurements, Instrumentation and Traceability (SC-MINT)
Expert Team on Quality, Traceability and Calibration (ET-QTC)

Calibration of Precipitation Instruments

Part-1: Introduction

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Introduction to this topic

- water is the **basis of life** on earth
- people, plants and animals need **permanent access** to **drinking water**
- humans, and animals too, started damming up water very early on
- the search for water has always been an impulse for human migration

- in terms of quantity and intensity, they are of particular interest for
  - agriculture
  - transport and water consuming industry
  - water level forecasting on rivers
  - the dimensioning of wastewater treatment plants
  - and much industrial and social sectors

Historical information

4000 BC the first reference precipitation measurements in India

in a Jewish writing describing life between 200 BC and AD 200 it is reported that 540 mm of precipitation was measured in a year

around 1250 precipitation depths were regularly measured and recorded in China, the first measurement network was established also for snow

around **1440** the first rain gauge was standardised in Korea

Historical information

around **1662** the first tipping bucket rain gauge with funnel was invented by Christopher Wren with the support of Robert Hooke

the **first systematic rainfall measurements took place in Europe in the 17th century**

Historical information

the first Meteorological Congress in Vienna (1873) initiated the early meteorological requirements

the simple rain gauge according to Hellmann was invented in **1886** and it has a collecting area of 200 cm^2

1967 automated tipping bucket rain gauge was developed by Joss and Tognini

Content

Concepts and definitions

WMO-No. 8 (2024 edition Vol I, Ch 6)

Definition of precipitation #1:

- **Precipitation is defined as the liquid or solid products** of the condensation of water vapour **falling from clouds**, in the form of rain, drizzle, snow, snow grains, snow pellets, hail and ice pellets; or falling from clear air in the form of diamond dust, that are large enough to fall as a result of gravity.
- **Solid precipitation in the form of snow is less dense than liquid precipitation** and more variable in terms of structure (for example, different ice crystal shapes, or habits) and related aerodynamics.
- **Solid precipitation in the form of hail** and ice pellets **is denser than snow** and the related aerodynamics are more similar to liquid precipitation.

Concepts and definitions

WMO-No. 8 (2024 edition Vol I, Ch 6)

Definition of precipitation #2:

- The total **amount of precipitation** that reaches the ground in a stated period **is expressed in terms of the vertical depth of water** (or water equivalent in the case of solid forms) **to which it would cover a horizontal projection of the Earth's surface.**

- **Precipitation intensity** is defined as the **amount** of precipitation **collected per unit of time, usually in minutes or hours.**

Concepts and definitions

WMO-No. 8 Recommendations #1:

- The size of **the collector orifice** is less critical for liquid precipitation, but **an area of at least 200 cm^2** is required if significant amounts of solid precipitation are expected.

- Gauges with collecting areas of 200 cm^2 to 500 cm^2 are the most common, but users need to balance application requirements, budget and other operational considerations.

Concepts and definitions

WMO-No. 8 Recommendations #2:

- Shielded gauges **catch more** precipitation than their unshielded counterparts, especially for solid precipitation.
- Therefore, **gauges should be shielded either naturally** (for example, forest clearing) **or artificially** (for example, Alter, Canadian Nipher type, Tretyakov windshield) to minimize the adverse effect of wind speed on measurements of solid precipitation (Goodison et al., 1998; Nitu et al., 2018, see Part #4 References and links).

windshield according to Tretyakov

Concepts and definitions

WMO-No. 8 Recommendations #3:

- The most important requirements for a manual precipitation gauge are as follows:

  (a) **The rim** of the collector should have a **sharp edge** and should fall away vertically on the inside, and be **steeply bevelled** on the outside;

  (b) **The area of the orifice should be known to the nearest 0.5%**, and the construction should be such that this area remains constant while the gauge is in normal use;

Concepts and definitions

WMO-No. 8 Recommendations #4:

(c) **The collector** should be designed to prevent rain from splashing in and out. This can be achieved if the vertical **wall is sufficiently deep and the slope of the funnel is sufficiently steep** (at least 45%).

(d) The construction should be such as to **minimize wetting errors** achieved by choosing **the proper material** and minimizing the total inner surface of the collector;

Concepts and definitions

WMO-No. 8 Recommendations #5:

(e) **The container** should have a narrow entrance and be **sufficiently protected from radiation** to minimize the loss of water by evaporation; it should use a **funnel** when collecting rainfall.

Precipitation gauges used in locations where only weekly or monthly readings are practicable should be similar in design to the type used for daily measurements, but with a container of larger capacity and stronger construction.

The collector needs to have sufficient capacity to hold the highest expected amount of precipitation between observations.

Concepts and definitions

- **The unit** of precipitation is linear depth, usually in **millimetres**, which is equivalent to **volume/area** or **mass/area** for liquid precipitation.

- For **manual** measurements, daily amounts of precipitation should be read to the nearest **0.2 mm** and, **if feasible**, to the nearest **0.1 mm**; weekly or monthly amounts should be read to the nearest 1 mm (at least).

- **Daily measurements of precipitation should be taken at fixed times** common to the entire network or networks of interest.

- **Amounts less than 0.1 mm** are generally referred to as a **trace amounts**.

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Concepts and definitions

- **Precipitation intensity** is usually measured in **millimetres per hour** (mm h^{-1}); however, other time intervals may also be used (for example, 10- or 30-minute periods) depending on the purpose of the measurement (official certificates for insurance in case of damages, and so forth).

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Concepts and definitions

- **solid precipitation** such as snow, hail or ice grains **shall be melted**
  - automatic devices usually have a heated funnel
  - or antifreeze is added to the collection container
  - or solid precipitation is melted manually

Concepts and definitions

*In the following, the measurement of fallen water amount and intensity in **liquid** form (e.g. by melting) will be discussed.*

picture taken from Wikipedia: https://creativecommons,org/licenses/by-sa/4,0/deed,en
https://de,wikipedia,org/wiki/Schnee#/media/Datei:D%C3%BCsseldorf_Hofgarten_2009,jpg

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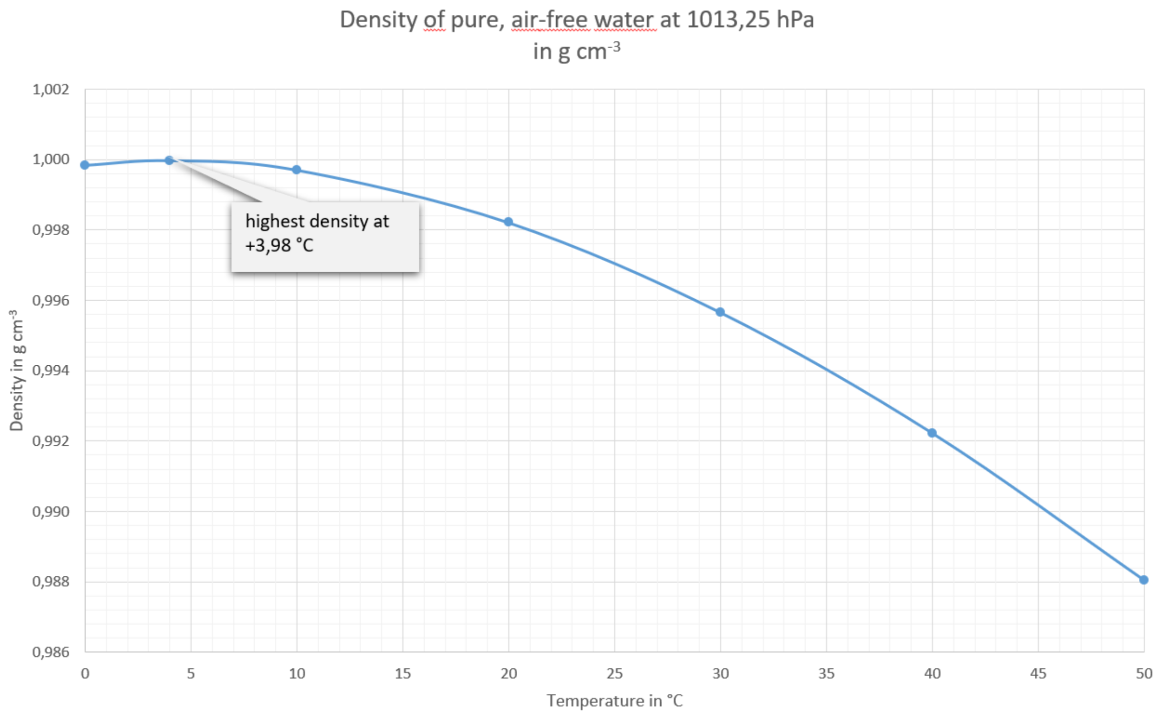
Concepts and definitions

- it can be assumed that the water is relatively pure, as it is the result of evaporation and condensation effects
- at $3.98\,°C$ and $1013.25\,hPa$ pure, air-free water has a density of $\frac{0.999975\,g}{cm^3}$
- but the density is influenced by
    - temperature of water
    - purity of the rain water
    - density of the condensation core
    - air-freeness of water
    - particles may have been collected and changed the density



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Concepts and definitions

- in reality, no one knows the true density of water and for the reason of simplicity it is assumed that the density is almost equal to

$$\approx 1\,\frac{g}{cm^3}$$

- in case of water it is usually assumed that

$$1\,cm^3 \approx 1\,ml \approx 1\,g$$

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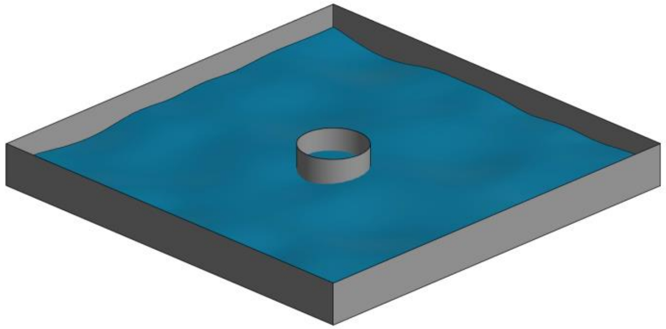
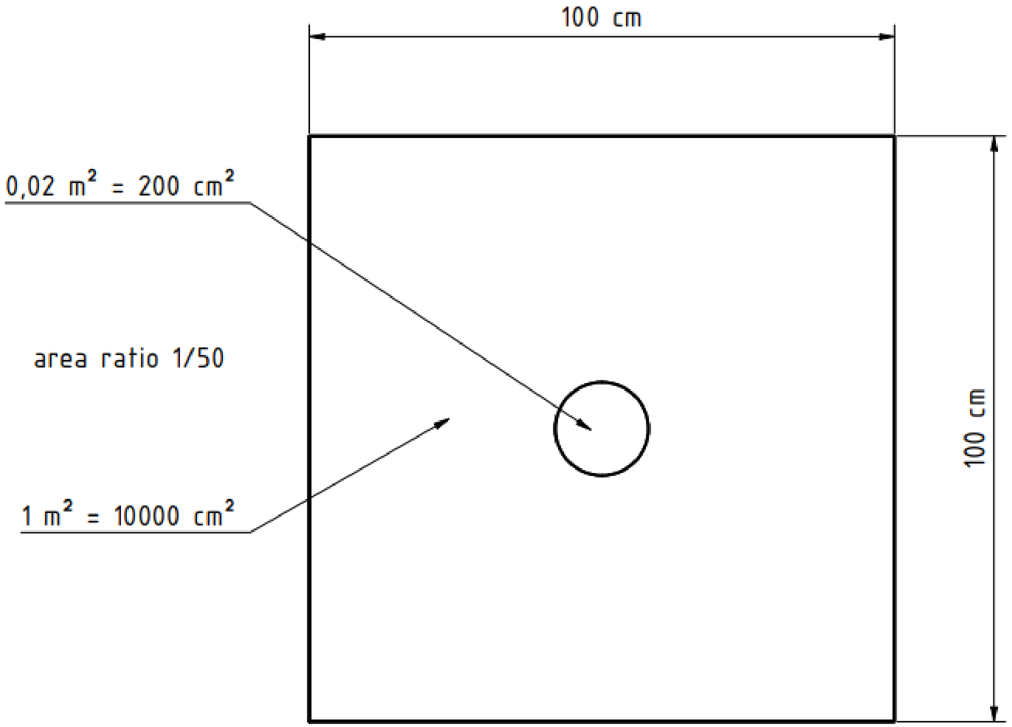
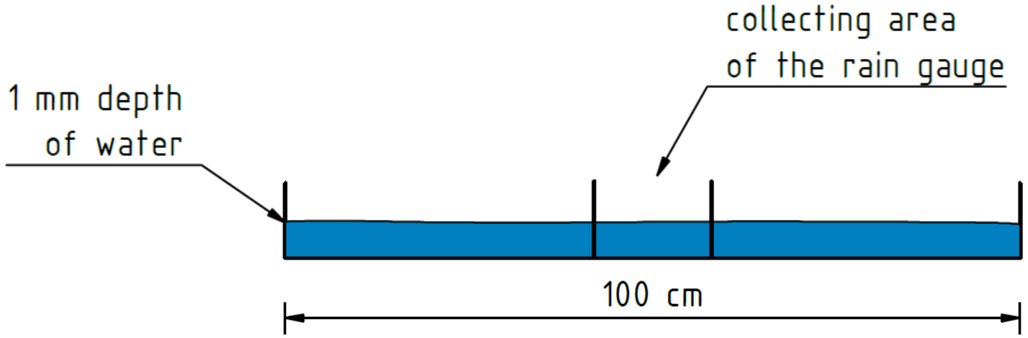
Concepts and definitions

- as already mentioned, precipitation depth of $1\ mm$ corresponds to a liquid quantity of $1\ litre$ over $1\ m^2$ of ground area

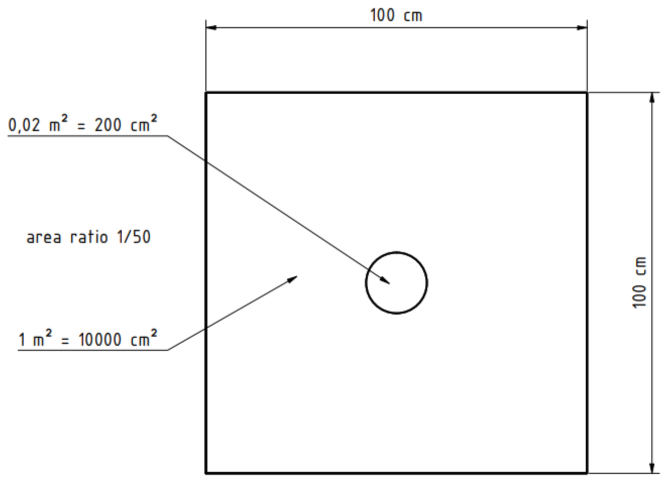






Concepts and definitions

- volume = depth of water x area



the area is one square metre	in this example the gauge has a collecting area of $200\ cm^2$
$V = h * A =$ $0.1\ cm * 100\ cm * 100\ cm =$ $1000\ cm^3 \approx 1000\ ml \approx 1000\ g$ $\rightarrow 1\ mm\ depth$ or $1\ \frac{litre}{m^2}$	$V = h * A =$ $0.1\ cm * 200\ cm^2 =$ $20\ cm^3 \approx 20\ ml \approx 20\ g$

Concepts and definitions

- in order to be able to determine the depth of precipitation from the contents of the collecting tank, the contents shall be weighed or measured with a measuring cylinder

  - at a depth of $1\,mm \Rightarrow 20\ g$ or $20\ ml$ is measured

Concepts and definitions

- the measured value therefore has to be divided by a divisor that matches the collecting area (the gauge has a collecting area of $200\ cm^2$)

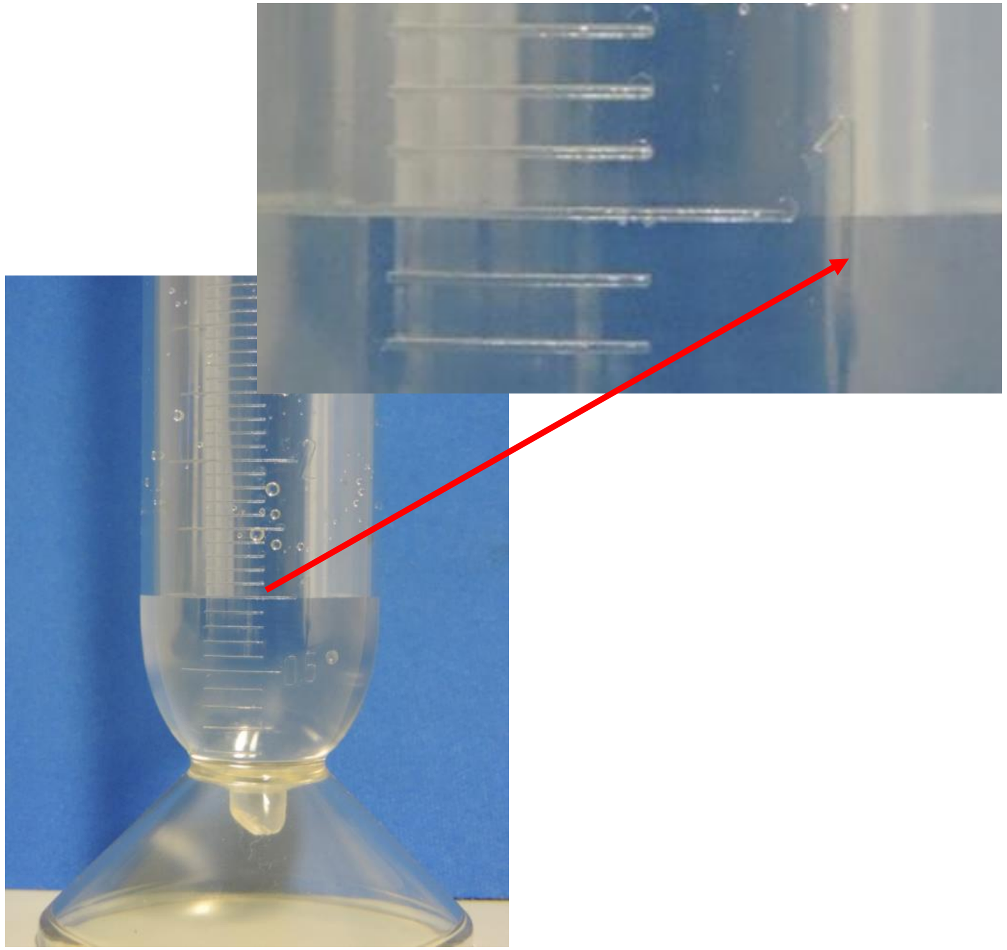
$$rain_{depth} = \frac{20\ g}{20 \frac{g}{mm}} = 1\ mm \qquad \text{or} \qquad rain_{depth} = \frac{20\ ml}{20 \frac{ml}{mm}} = 1\ mm$$

- automatic devices carry out the division internally

Concepts and definitions

- a measuring cylinder with adapted scale markings is normally used so that the conversion is not necessary and the precipitation depth can be read directly

  ⇒ reading 1 mm ≈ 20 ml



DUT reading 1 mm ≈ 20 ml

Calibration of Rain Gauges
End of Part 1

Thank you.

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