Infrastructure Commission (INFCOM)

Standing Committee on Measurements, Instrumentation and Traceability (SC-MINT)

Expert Team on Quality, Traceability and Calibration (ET-QTC)

Measurement Terminology

Part-3: Measuring Instruments Related Terms

Andrea Merlone (INRIM)
Drago Groselj (ARSO)

WORLD METEOROLOGICAL ORGANIZATION

The result of a measurement…

…is expressed using three components

value	uncertainty	unit
20.3	±0.1	°C

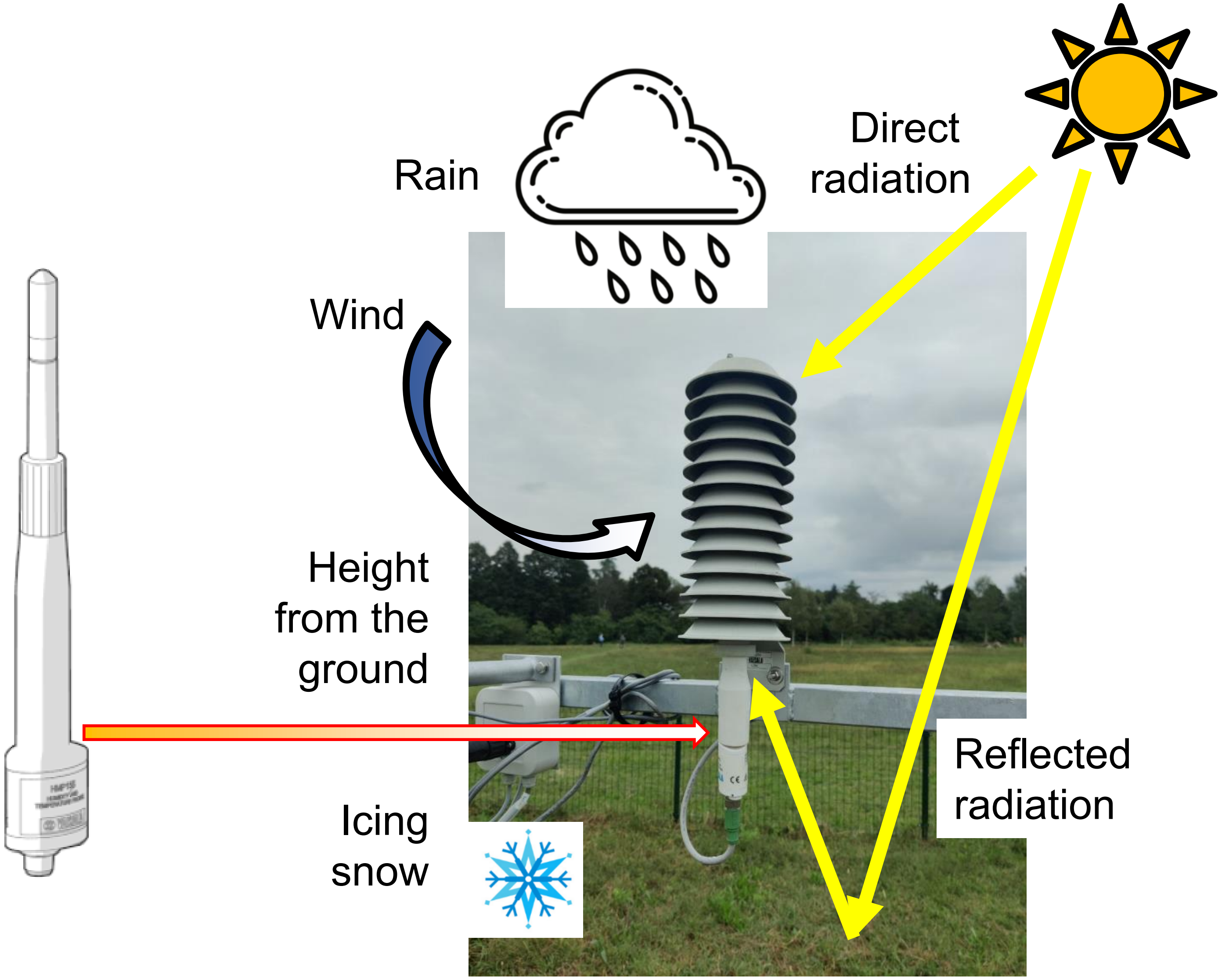
$$t_{air} = (20.3 \pm 0.1)\ °C$$

WORLD METEOROLOGICAL ORGANIZATION

Measured value

Associated Quantities of Influence

- **Calibration**
- Resolution
- Drift
- Logger
- Sensitivity
- Hysteresis
- Repeatability



MEASURING INSTRUMENT

Device used for making **measurements**, alone or in conjunction with one or more supplementary devices

For example a resistance bridge to measure resistance of thermometers

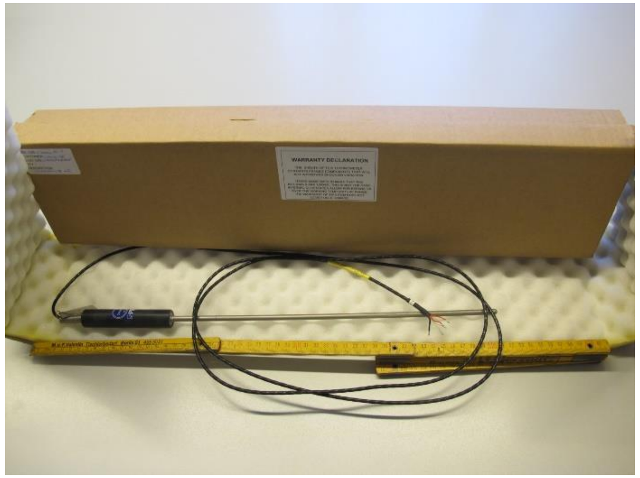
MEASURING SYSTEM

Set of one or more measuring instruments and often other devices, including any reagent and supply, assembled and adapted to give information used to generate measured quantity values within specified intervals for quantities of specified kinds

WORLD
METEOROLOGICAL
ORGANIZATION

SENSOR

element of a **measuring system** that is directly affected by a phenomenon, body, or substance carrying a **quantity** to be measured



EXAMPLES:

- Sensing coil of a platinum resistance thermometer,
- Rotor of a turbine flow meter,
- Bourdon tube of a pressure gauge,
- Float of a level-measuring instrument,
- Photocell of a spectrometer,
- Thermotropic liquid crystal which changes colour as a function of temperature.

MEASURING TRANSDUCER

device, used in measurement, that provides an output quantity having a specified relation to the input quantity

WORLD
METEOROLOGICAL
ORGANIZATION

INDICATION

quantity value provided by a **measuring instrument** or a **measuring system**

NOTE 1: An indication may be:

- presented in visual or acoustic form
- transferred to another device.
- given by the position of a pointer on the display for analog outputs,
- a displayed or printed number for digital outputs,
- a code pattern for code outputs,
- an assigned quantity value for material measures.

PROPERTIES OF MEASURING DEVICES

SENSITIVITY

Also expressed as the smallest change in the measured quantity that causes a change in the indication

Not the same!

RESOLUTION

For digital instruments, it is normally expressed as last digit visualized. For analog devices is the amplitude of each mark or graduation in a scale.

For example, a datalogger records pressure values with 1 Pa as last digit, but the read instrument has a sensitivity around 5 Pa

WORLD METEOROLOGICAL ORGANIZATION

PROPERTIES OF MEASURING DEVICES

STABILITY (of a measuring instrument)

property of a **measuring instrument**, whereby its metrological properties remain constant in time

INSTRUMENTAL DRIFT

continuous or incremental change over time in **indication**, due to changes in metrological properties of a measuring instrument

NOTE: Instrumental drift is related neither to a change in a **quantity** being measured nor to a change of any recognized **influence quantity**.

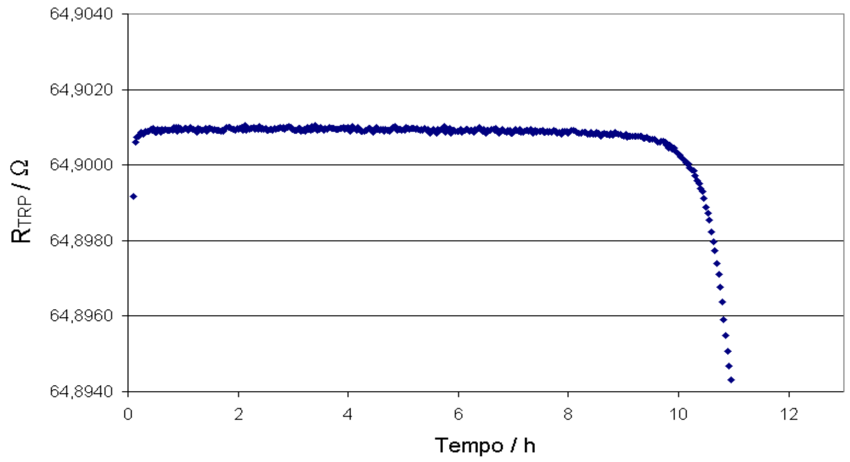
WORLD METEOROLOGICAL ORGANIZATION

PROPERTIES OF MEASURING DEVICES

STABILITY

Normally included as a component of uncertainty (suggested: rectangular distribution).

In calibration certificates, it indicates the stability of the sensor under calibration during a defined interval, where the reference value is considered stable (within a certain uncertainty).

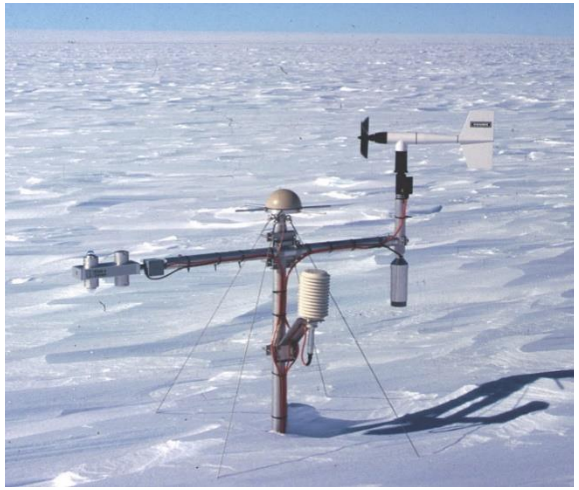


INSTRUMENTAL DRIFT

For **instruments used in field**, drift can increase due to environmental conditions and influencing quantities (i.e. harsh environment).

If the drift is within correct operational features, it can be evaluated and corrected after recalibration.

It’s a component of instrument ageing.



PROPERTIES OF MEASURING DEVICES

STEP RESPONSE TIME

duration between the instant when an input **quantity value** of a **measuring instrument** or **measuring system** is subjected to an abrupt change between two specified constant quantity values and the instant when a corresponding **indication** settles within specified limits around its final steady value.

EXAMPLE: for meteorological thermometers see the ISO 17714:2007
system response time: time needed for the temperature recorded by the thermometer within the screen to reach 63 % of a step change in the external temperature, with a given external wind speed of 1 $m \cdot s^{-1}$

NOTE 1 to entry: The system response time is a combination of the response times of the screen and the thermometer, and depends on the thermometer time constant.

NOTE 2 to entry: The response time of the system is also dependent on wind speed and design of shields. For this reason, a given air speed of 1 $m \cdot s^{-1}$ is used.

WORLD METEOROLOGICAL ORGANIZATION

PROPERTIES OF MEASURING DEVICES

REPEATABILITY

Repeatability (of results of measurements)
closeness of the agreement between the results of successive measurements of the same measurand carried out under the same conditions of measurement.

Repeatability conditions include the **same** measurement procedure, the **same** observer, the **same** measuring instrument, used under the **same** conditions, the **same** location, repetition over a **short period** of time.

(GUM B.2.15 [VIM:1993, definition 3.6])

PROPERTIES OF MEASURING DEVICES

REPRODUCIBILITY

Reproducibility (of results of measurements)
closeness of the agreement between the results of measurements of the same measurand carried out under changed conditions of measurement

The changed conditions may include principle of measurement, method of measurement, observer, measuring instrument, reference standard, location, conditions of use, time.

Instrument drift/change between repeated calibrations.

(GUM B.2.15 [VIM:1993, definition 3.7])

CALIBRATION

operation that, **under specified conditions**, in a first step, establishes a relation between the **quantity values** with **measurement uncertainties** provided by **measurement standards** and corresponding **indications** with associated **measurement uncertainties** and, in a second step, uses this information to establish a relation for obtaining a **measurement result** from an **indication**.

NOTE 1: A calibration may be expressed by a statement, calibration function, **calibration diagram**, **calibration curve**, or calibration table. In some cases, it may consist of an additive or multiplicative **correction** of the indication with associated measurement uncertainty.

NOTE 2: Calibration should not be confused with **adjustment of a measuring system**, often mistakenly called "self-calibration", nor with **verification** of calibration.

CALIBRATION

- Is required to establish a documented traceability
- Allows to detect instrument drifts or damages
- Generates a correction function to be applied to the instrument readings
- Generates the correction calibration uncertainty as a fundamental component of the combined measurement uncertainty
- Is required to complete the measurement uncertainty budget

CALIBRATION CERTIFICATE

Calibration Certificate

Customer: *ABC COMPANY*

Certificate: 640369-00-1

UNIT IDENTIFICATION

Manufacturer: **FLUKE** — Serial: **7563011**

Model: **744** — ID: **H277**

Description: **PROCESS CALIBRATOR**

CALIBRATION DATE

Cal Date: **16-Dec-2008**

Due Date: **16-Dec-2009**

CALIBRATION CONDITIONS

Temperature: **21.88 °C**

Humidity: **20 %**

Barometric Pressure: **N/A**

GENERAL INFORMATION

Procedure: **FLUKE 744: (SPEC:1Y) RS-232 /5500,3458** Rev: **1**

As Received: **Selon les Normes\Within Specification**

As Returned: **Tel que Reçu\As Received**

Remark: **N/A**

ÉTALONS UTILISÉS \ STANDARDS USED

ID	Manufacturer	Model	Cal Date	Due Date
INV022	HEWLETT PACKARD	3458A	11-Jul-2008	11-Jul-2009
INV009	FLUKE	5500A	30-Oct-2008	30-Oct-2009

The calibration was performed using measurement standards traceable to the National Measurement Institute Standards (NMIS) part of the National Research Council of Canada (NRC) or the National Institute of Standards and Technology (NIST), or to accepted intrinsic standards or measurement, or is derived by ratio type self-calibration techniques. Measurement uncertainties given in this report are based on a coverage factor of k=2 corresponding to a confidence level of approximately 95%.

Calibrated by: *C. Reed* — Approved by:

Certificate: 640369-00-1
Asset: 7563011.744 — Calibration Certificate — Page 1 of 7

This calibration certificate may not be reproduced, except in full, unless with the permission of ITM Instruments Inc.

The calibration uncertainty

is NOT

the measurement uncertainty

…it is only one component of the overall measurement uncertainty

…in meteorological observations it is frequently not the dominant component

…the calibration procedure should be such that the instrument is calibrated in conditions similar to those met in field use

…the effect of the uncontrolled (out of laboratory) environmental factors in field should be evaluated as further measurement uncertainty contributions

TRACEABILITY (metrological traceability)

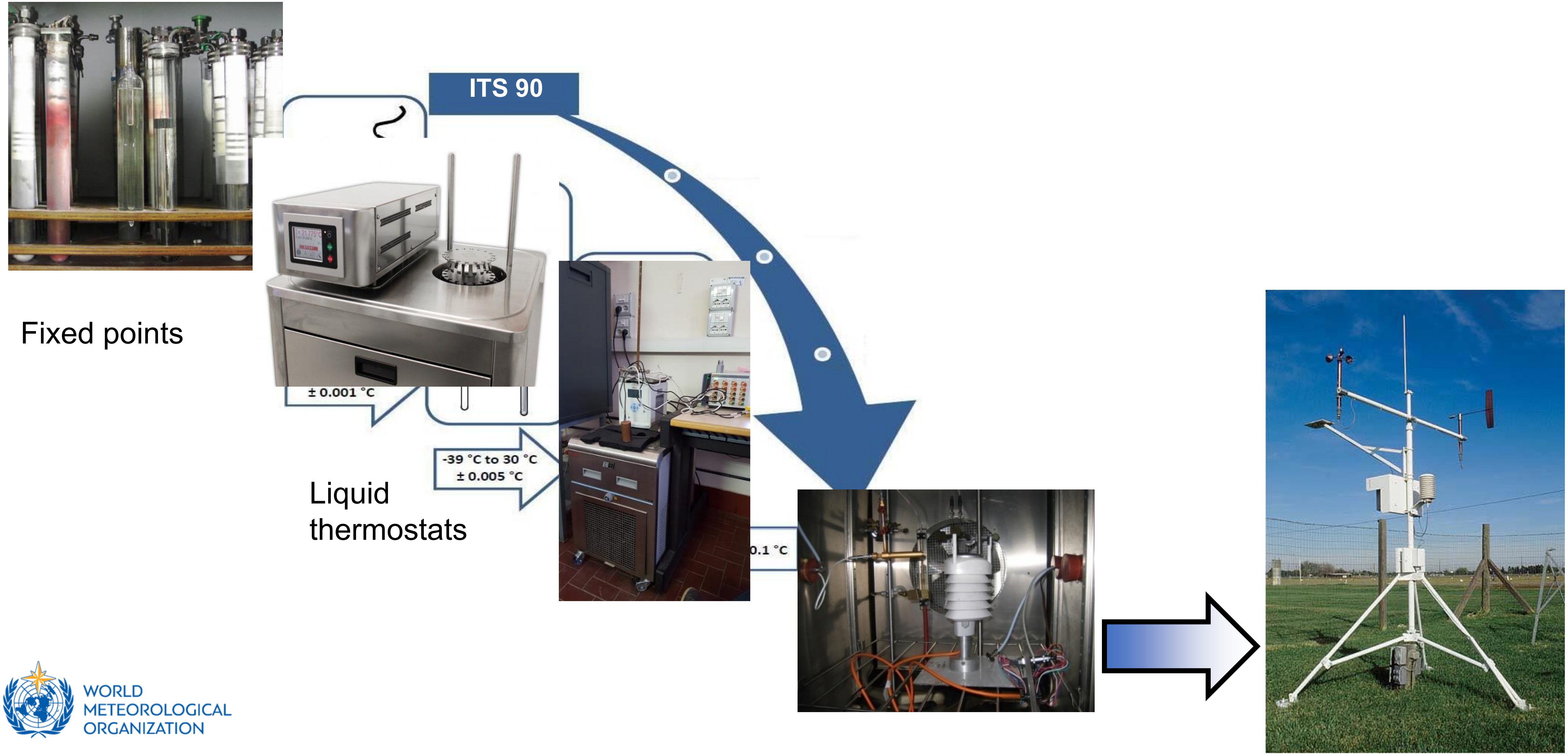
property of a **measurement result** whereby the result can be related to a reference through a documented unbroken chain of **calibrations,** each contributing to the **measurement uncertainty**

METROLOGICAL TRACEABILITY CHAIN

sequence of **measurement standards** and **calibrations** that is used to relate a **measurement result** to a reference

NOTE 1 A metrological traceability chain is

- defined through a **calibration hierarchy**.
- used to establish **metrological traceability** of a measurement result.



WORLD METEOROLOGICAL ORGANIZATION

Field Validation is not a calibration

The following factors may contribute to motivate a field validation.

i. A desire to maximise the interval between exchanges of instruments or sensors at the site.

ii. A desire to reduce the workload of maintenance teams, by removing the need to change out instruments or sensors, which subsequently proves unnecessary.

iii. A desire to minimise the levels of uncertainty in the data provided by the observing network.

- **The validation does not produce a calibration correction.**
- **It gives important information about the optimal operational conditions of the instrument.**
- **It is based on a tolerance between the reading of the instrument under test and a travelling reference.**

Thank you.

WORLD
METEOROLOGICAL
ORGANIZATION

wmo.int