Infrastructure Commission (INFCOM)

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

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

Metrology in Meteorology

Part-3: Infrastructure of a standard laboratory (1)

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WORLD METEOROLOGICAL ORGANIZATION

Content

1. Laboratory premisses
2. Temperature
3. Humidity

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Laboratory premisses

- **Dedicated areas**: The laboratory should have clearly designated areas for different types of calibration (e.g. temperature, humidity, pressure, …) to reduce interference between different measurement activities.
- **Separate laboratory** areas from staff offices.
- **Temperature (and humidity) control**: The laboratory must maintain a stable temperature and humidity range to prevent environmental influence to calibration quality.
- **Stable power supply**: The laboratory must have a reliable, uninterrupted power supply. Power outages or fluctuations can negatively impact the calibration equipement and calibration process.

Laboratory premisses

- **Proper storage**: Sensitive and delicate instruments should be stored in designated areas that protect them from dust, dirt and damage.
- **Restricted access**: Access to the calibration laboratory should be restricted to authorized personnel only to maintain the integrity and confidentiality of calibration processes.
- Minimize building vibrations, best at ground level
- No large windows, wide doors
- Planned so equipment such as compressors and environmental chambers are not near sensitive instruments

Temperature – approach 1 (hard way)

1. Laboratory has primary temperature standards (fixed points) which cover the meteorological temperature range for your country.
   - Argon Triple Point: -189.3331 °C
   - Mercury Triple Point: -38.8344 ˚C
   - Water Triple Point: 0.010 ˚C
   - Gallium Melting Point: 29.7646 ˚C
   - Indium Freezing Point: 156.5985 ˚C

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Temperature – approach 1 (hard way)

2. A reference instrument (Standard Platinum Resistance Thermometer - SPRT)

3. Data acquisition unit

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Temperature – approach 1 (hard way)

Interpolating function

Temperatures are determined in terms of the **ratio of resistance** $R(T_{90})$ at temperature T_{90} and the resistance R(273.16 K) at the triple point of water:

Reference function $W_r(T_{90})$ is defined: $$W(T_{90}) = \frac{R(T_{90})}{R(273.16K)}$$

Range from 13.8033 K to 273.16 K	Range from 273.15 K to 1234.94 K
$\ln[W_r(T_{90})] = A_0 + \sum_{i=1}^{12} A_i \cdot \left[\frac{\ln\left(\frac{T_{90}}{273.16}\right)+1.5}{1.5}\right]^i$:	$W_r(T_{90}) = C_0 + \sum_{i=1}^{9} C_i \cdot \left[\frac{T_{90}-754.15}{481}\right]^i$

Numeric values of reference function coefficients (A_i, C_i) and inverse reference function (B_i, D_i) are available in literature.

Deviation function is a deviation of reference function $W_r(T_{90})$ and ratio $W(T_{90})$ is defined:

$$\Delta W(T_{90}) = W(T_{90}) - W_r(T_{90})$$

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Temperature – approach 1 (hard way)

Interpolating function

The forms of deviation function **differ** according to different temperature range and used fixed points. In the temperature range from 13.8033 K to 1234.94 K three forms of deviation function are defined:

- from 83.8058 K to 273.16 K:

$$\Delta W(T_{90}) = a \cdot [W(T_{90}) - 1] + b \cdot [W(T_{90}) - 1] \cdot \ln(W(T_{90}))$$

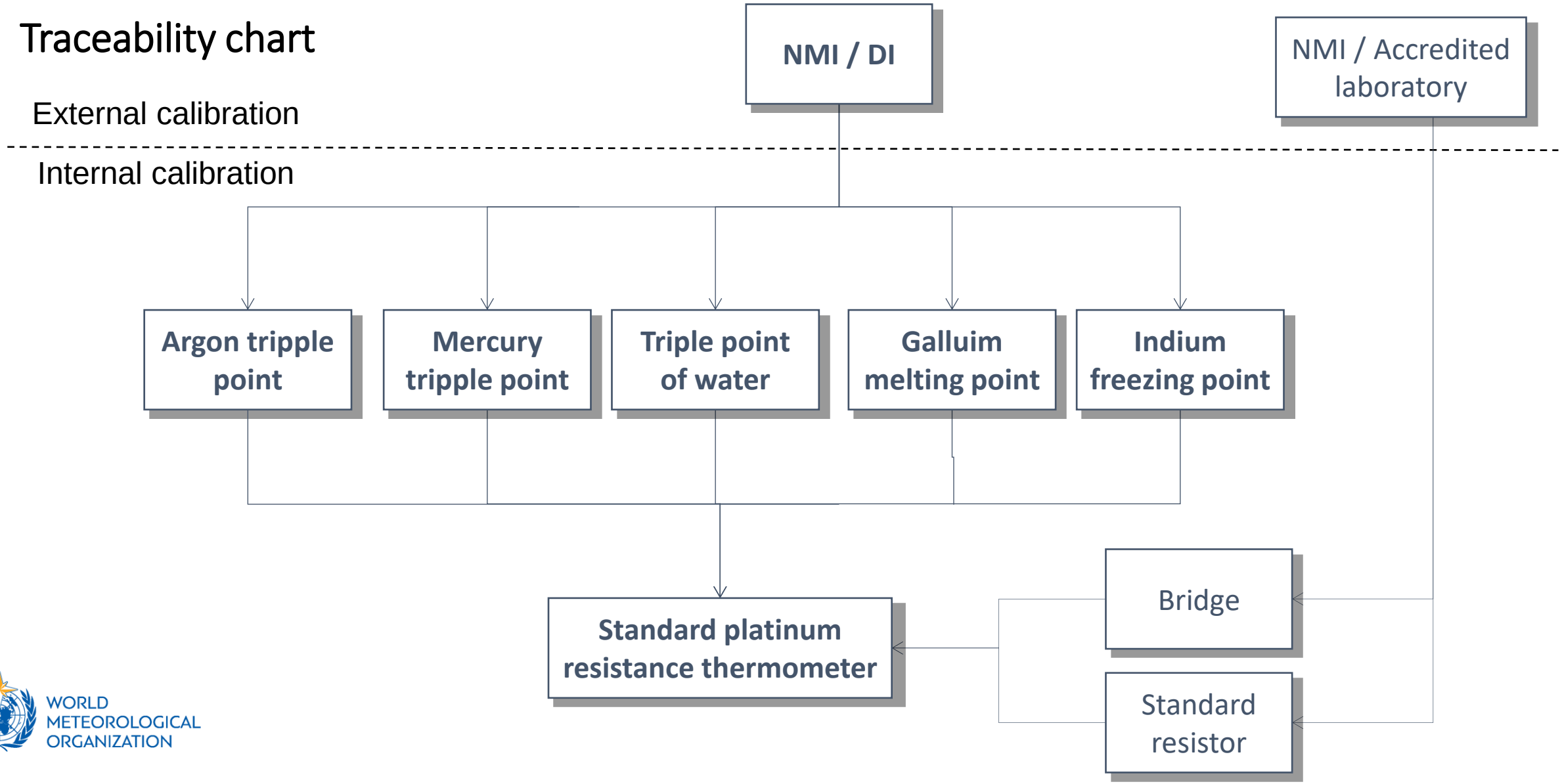
- from 273.15 K to 1234.94 K:

$$\Delta W(T_{90}) = a \cdot [W(T_{90}) - 1] + b \cdot [W(T_{90}) - 1]^2 + c \cdot [W(T_{90}) - 1]^3 + d \cdot [W(T_{90}) - W(660.323°C)]^2$$

Values of coefficients *a, b, c, d* depends on **temperature range** and **fixed point** used in **calibration** and they are results in calibration of standard platinum resistance thermometer.

Temperature – approach 1 (hard way)

Traceability chart



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Temperature – approach 2 (rational way)

Infrastructure of temperature laboratory:

- Reference thermometer (Semi Standard platinum resistance thermometer),
- Temperature-controlled medium
- Readout device for reference thermometer and instrument under calibration.

- SSPRTs may be calibrated at a National Metrology Institute and used to calibrate working references by comparison calibration.
- Thermometers under calibration are then compared with the working reference in a liquid bath or climatic chamber.

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Temperature – approach 2 (rational way)

Equipment for comparison calibrations

Liquid baths or climatic chambers

(temperature range –50°C to 50°C)

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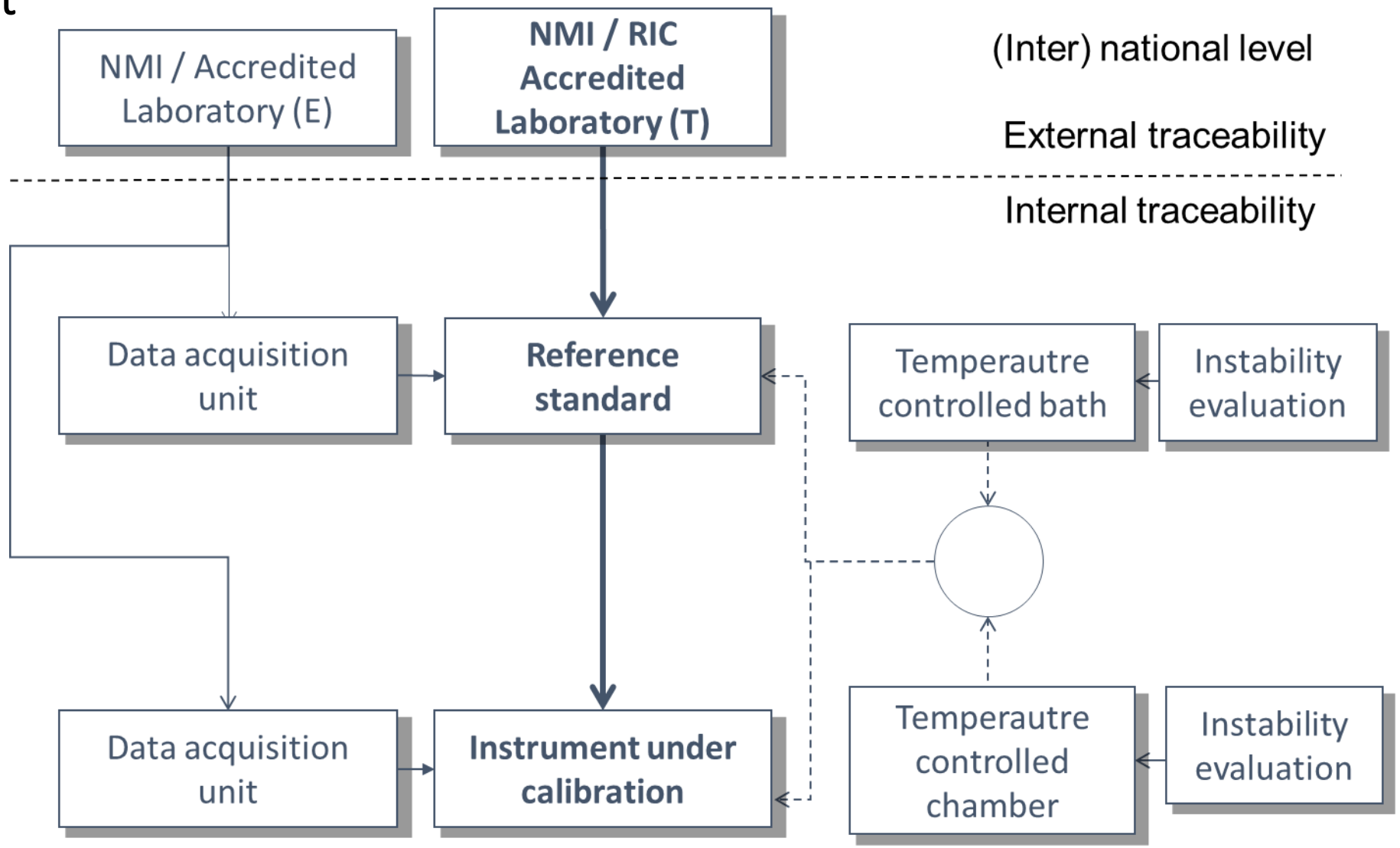
Temperature – approach 2 (rational way)

Traceability chart



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Content

Humidity

Humidity is more complex, various laboratories have different methods to create moist air and some are described as primary standards humidity generators.

Reference instruments are chilled mirror hygrometers or sometimes capacitive hygrometers.

Humidity generator

- Two - temperature humidity generator
- Two - pressure humidity generator
- Split stream humidity generator

Humidity

Climatic chamber

Controls humidity of air by controlling the temperature of a body of water within the chamber separately from that of the chamber air temperature.

Salt solutions

The water vapor concentration, and therefore the relative humidity over a salt solution is less than that over pure water.

Humidity

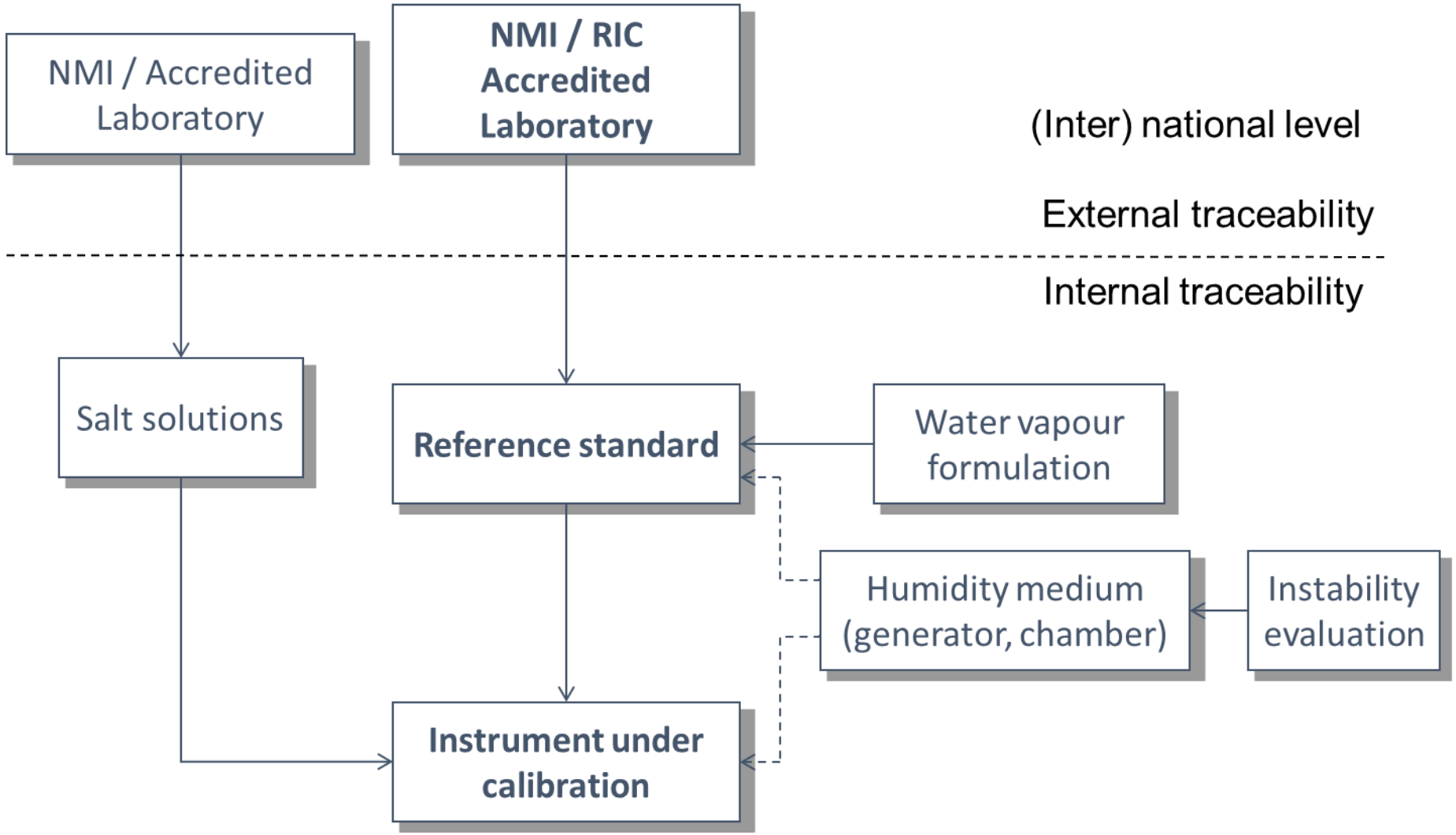
Chilled mirror hygrometer

A mirrored surface in contact with the gas stream to be monitored is cooled until condensation forms. The temperature at which condensation is formed is known as the dew point or frost point of the gas, and this temperature directly relates to the saturation water vapor pressure of the sample.

Advantage	Disadvantage
Uncertainty around 0.1 ° C	Expensive
Good long term performance	Contamination can cause incorrect readings
Wide measurement range	Dew points below 0° C require careful interpretation

Humidity

Traceability chart



Thank you.

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