VAISALA

Application Note

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# Understanding metrological traceability in calibration

Metrological traceability is an important part of measurement. One of the best ways to understand an instrument's measurement performance is to assess its accuracy. The instrument should be calibrated against an SI-traceable reference to ensure the quality of measurement data. Quality data, in turn, provides reliable information for decision making.

National Metrology Institutes (NMI) create SI units with detailed and analyzed uncertainties. The units are then transferred to secondary standards (e.g. to accredited laboratories) for use in calibrations. The traceability chain for industrial instruments is established through calibration against the secondary standards. Finally, the manufactured measurement instrument is calibrated against the industrial standard with a calculated uncertainty. Thus, an unbroken and documented chain of calibrations to the SI unit is achieved. Measurement values from the manufactured instrument is considered to be SI-traceable with a known uncertainty.

The more calibration steps there are between the SI unit and the manufactured instrument, the greater the measurement uncertainty. Ideally, the chain of traceability in calibrations should be as short as possible for demanding applications.

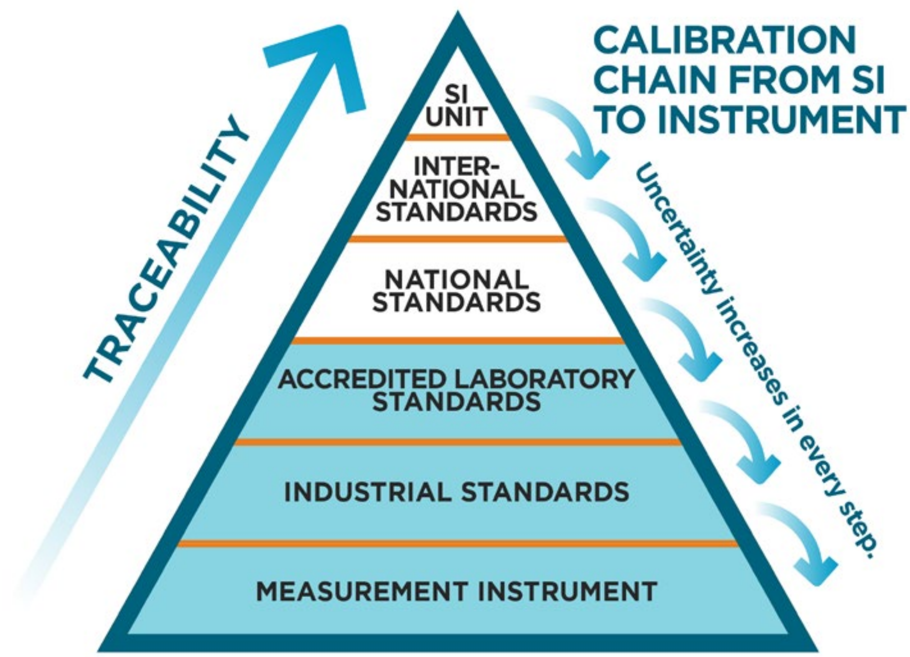


***Figure 1:*** *Metrological traceability (Calibration Chain) from an SI unit to a measurement instrument. Blue shading indicates the level of traceability of Vaisala instruments.*

## Assessing traceability

How do you know if your instrument is indeed SI-traceable? One way is to study its calibration certificate. For example, the following information should be available:

1. Calibration results include measurement uncertainties
2. All calibration references are identified
3. Notes on how uncertainties are determined and what uncertainty sources are included
4. Description of how the SI traceability was established
5. Reference and ambient conditions

## Sample calibration certificate

3 The H2O2 measurement of HPP272 was calibrated by comparing the instrument's H2O2 readings to a generated reference H2O2 reading. The reference H2O2 reading was calculated based on reference equipment measurement results: H2O2 liquid flow, H2O2 liquid density, nitrogen flow, gas pressure and temperature.

4 The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to a coverage probability of approximately 95 %. The measurement results are traceable to the international system of units (SI) through national metrology institutes (NIST USA, MIKES Finland, or equivalent) or via ISO/IEC 17025 accredited calibration laboratories.

1 **Hydrogen peroxide results**

| Reference H2O2 [ ppm ] | Observed H2O2 [ ppm ] | H2O2 Error [ ppm ] | Acceptance Limit [ ppm ] | Pass/Fail |
|---|---|---|---|---|
| 499 | 489 | -10 | ±25 | Pass |
| 997 | 997 | 0 | ±50 | Pass |

**Relative saturation results**

| Reference Relative Saturation [ %RS ] | Observed Relative Saturation [ %RS ] | Relative Saturation Error [ %RS ] | Acceptance Limit [ %RS ] | Pass/Fail |
|---|---|---|---|---|
| 11.1 | 11.3 | 0.2 | ±3.0 | Pass |
| 35.3 | 36.3 | 1.0 | ±4.0 | Pass |

**Reference equipment used in calibration**

| Type | Identity Number | Certificate Number | Calibration Date | Calibration Due Date |
|---|---|---|---|---|
| Liquid pump | 18156 | C03898 | 2019-11-21 | 2020-05-31 |
| Pressure and temperature | 19273 | K008-C01855 | 2019-06-04 | 2020-06-30 |
| Pressure and temperature | 19274 | K008-C01854 | 2019-06-04 | 2020-06-30 |
| Density meter | 17897 | H92-194620001 | 2019-11-12 | 2020-11-30 |
| Mass flow controller | MF 13700 | C04239 | 2019-12-19 | 2020-12-31 |
| Mass flow controller | 17894 | D01569 | 2020-05-05 | 2021-05-31 |
| Mass flow meter | 17896 | C03716 | 2019-11-01 | 2020-11-30 |

**Calibration uncertainty (k=2, ~95% confidence level):**

1 **H2O2**

Concentration ± 10 ppm @ 500 ppm, ± 20 ppm @ 1000 ppm

**RS**

5 Relative saturation ± 2 %RS @ 10 %RS, ± 4 %RS @ 40 %RS

**Ambient conditions:**

| Humidity [ %RH ] | Temperature [ °C ] | Pressure [ hPa ] |
|---|---|---|
| 26 ± 4 | 22 ± 2 | 1007 ± 20 |

***Figure 2:*** *Factory calibration certificate for Vaisala's HPP272 hydrogen peroxide probe.*

## Calibration should match the application

A manufactured instrument can have SI-traceable calibration even though it was not calibrated in an accredited laboratory. Typically, calibration certificates provided by instrument manufacturers include these kinds of calibrations.

In the worst-case scenario, calibrations may not actually be SI-traceable. Documentation indicating the SI traceability chain should always be available to the instrument end user. At Vaisala this is a standard for every product.

It is helpful, especially for demanding applications, to understand what you are looking for in terms of calibration references and measurement uncertainties.

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