

E+E Elektronik Ges.m.b.H

*CALIBRATION AND TRACEABILITY IN MEASURING
TECHNOLOGY*

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Calibration and Traceability in Measuring Technology

This white paper provides you with an overview of the calibration certificates currently available on the market and explains the concept of traceability as well as the hierarchy of calibrations in the framework of international agreements.

1. Certificates

Different types of certificates are offered on the market to document the accuracy of measurement equipment. The spectrum of such certificates range from factory certificates provided free of charge to low-cost "ISO certificates" to real calibration certificates from an accredited calibration laboratory. The extremely wide price differences already make it clear that the different certificates document very different things, although the contrary is often suggested. In the following we therefore describe the different certificates and point out the crucial differences.

1.1 Calibration Certificate of an Accredited Calibration Laboratory

e.g.: DAkkS (D), Akkreditierung Austria (ÖKD, A), SCS (CH), UKAS (GB), NVLAP (US)

The quintessential characteristic of a calibration certificate is the traceability of measurement results and thus its international comparability.

A traceable calibration exhibits an unbroken chain of measurements all the way to a national standard or measurement standard. All of the measurement results obtained with traceable measuring equipment are, on the one hand, traceable to this national standard and, on the other hand, are also comparable to each other. The advantage of measuring equipment that is traceable to national standards (and thus, as a rule, also to international standards) is the worldwide comparability of the measurement results.

Particularly important is the statement of measurement uncertainties, the determination of which includes the measurement process.

Independent assessors must also examine the suitability of the process or measurement process in order to assure traceability. According to international agreements (ILAC), only inspection laboratories accredited according to EN ISO/IEC 17025 (calibration laboratories) are permitted to carry out traceable calibrations and thus guarantee complete international comparability of the calibration results.

A device that was merely compared with a traceable measuring device is not itself traceable since the measurement process was not performed in accordance with an accredited procedure.

1.2 "ISO Certificates"

ISO calibrations are comparative measurements of external test candidates with in-house reference equipment (factory-level standards) as a service. The reference equipment utilized is traceable to national standards. The comparative measurement is carried out in accordance with internal procedures which meet the requirements in accordance with ISO 9001 or ISO TS16949 as well.

ISO calibrations are not defined in any technical standard, but they are nevertheless offered on the market as "low-cost alternatives" to accredited calibration certificates. The comparative measurement merely provides information about the calibration condition of the equipment with the use of high-quality measuring equipment.

The measurement uncertainties of the reference equipment are usually documented. This information, however, says nothing about the uncertainty of the test because the process of calibration is not taken into account. Further uncertainty information is therefore meaningless and not comparable.

ISO calibrations purchased as additional external services are not traceable (there is no accredited process!). The measurement results are therefore not internationally comparable.

An ISO calibration only verifies the function of the equipment while stating a measurement deviation and is therefore not at all an alternative to a traceable calibration carried out by an accredited laboratory.

1.2.1 Company in-house calibration as part of the monitoring of test equipment

A system for monitoring test equipment within a company ensures that all quality-relevant measurement and test equipment used in a company are regularly calibrated against the company's own factory-level standards (reference equipment). The factory-level standards of a company must have undergone a traceable calibration procedure carried out by an accredited calibration laboratory.

The type and scope of metrological control in the course of test equipment monitoring are at the discretion of the company. These have to be adapted to the respective application so that the results obtained with the measuring equipment are sufficiently accurate and reliable. Company in-house departments that carry out calibrations in the framework of test equipment monitoring do not need to be accredited in order to meet the requirements of EN ISO 9001.

If, however, test equipment monitoring is outsourced to an external service provider, the commissioned service provider has to document his technical competence — i.e., the service is to be performed by an accredited calibration laboratory.

1.3 Works certificates in accordance with DIN EN 10204

DIN EN 10204 defines various inspection certifications which can be provided to buyers of products. Originally conceived only for metallic materials, this standard can also be applied explicitly to "non-metallic products", and is internationally accepted.

Since the manufacturer always confirms the proper condition upon delivery in accordance with his specifications, the standard can only be applied to new equipment. Only in this case can it be ensured that the equipment is in a condition that corresponds to the production processes. i.e.,

- Only new equipment out of production
- Only equipment out of one's own production

Two types of inspections are specified:

- **Non-specific inspection**
The manufacturer only confirms compliance with the specifications received; the products tested are not necessarily from the batch delivered (lot sampling).
- **Specific inspection**
The manufacturer confirms compliance with the received specifications, whereby the actual product delivered is explicitly inspected.

Four types of works certifications can be issued on the basis of specific and non-specific inspections:

Type	Description	Content	Confirmation by
2.1	Works certification	Confirmation of conformity with order	Manufacturer
2.2	Factory certification	Confirmation of conformity with order and specification of results of non-specific inspections (<i>e.g. lot sampling</i>)	Manufacturer
3.1	Acceptance test certificate 3.1	Confirmation of conformity with order and specification of results of specific inspections (<i>e.g. explicit measurements against plant standard</i>)	Acceptance inspector of the manufacturer independent of the production department (<i>e.g. Q-department</i>)
3.2	Acceptance test certificate 3.2	Confirmation of conformity with order and specification of results of specific inspections (<i>e.g. explicit measurements against plant standard</i>)	The acceptance inspector of the manufacturer independent of the production department and the acceptance inspector commissioned by the purchaser or the acceptance inspector designated in official regulations (<i>i.e., counter-inspection or official inspection</i>)

Table 1: Types of works certifications in accordance with DIN EN 10204, *comments in italics*

Certificates 2.2 und 3.1 are the most often requested; an explicit inspection, in particular for the 3.1 certificates, is carried out with an in-house standard and comparison with a specification. For ISO 9001-accredited manufacturers, this inspection roughly corresponds to an "ISO Certificate," and hence it remains the case that even the 3.1 Acceptance Test Certificates **are not traceable (there is no accredited process!)** and that the measurement results are not internationally comparable.

2. Traceability

The concept "traceability" describes a process in which the measured quantities displayed by a measuring device can be compared in one or several steps with a national standard for the indicated measurement quantities. These steps must form an unbroken chain of calibrations.

In each case, one measuring device is compared with one standard whose metrological characteristics are determined by a comparison with a higher-level standard. In this manner, a calibration hierarchy, or a hierarchy of testing instruments, emerges.

Departments which perform the comparisons within this chain have to document their appropriate competencies, e.g. through an accredited calibration department. Calibrations of other departments that are not accredited as calibration departments do not count as traceable in the sense of EN ISO 9001 or EN ISO/IEC 17025, since in this case there is no proof of technical competence.

The calibration of a product in accordance with in-house procedures (even if the company is certified in accordance with ISO 9001) does not count as traceable because the procedure and the measurement setup are not accredited. The requirements of EN ISO 9001 are met, however, if this calibration is carried out and documented in-house as part of the framework of inspection equipment monitoring.

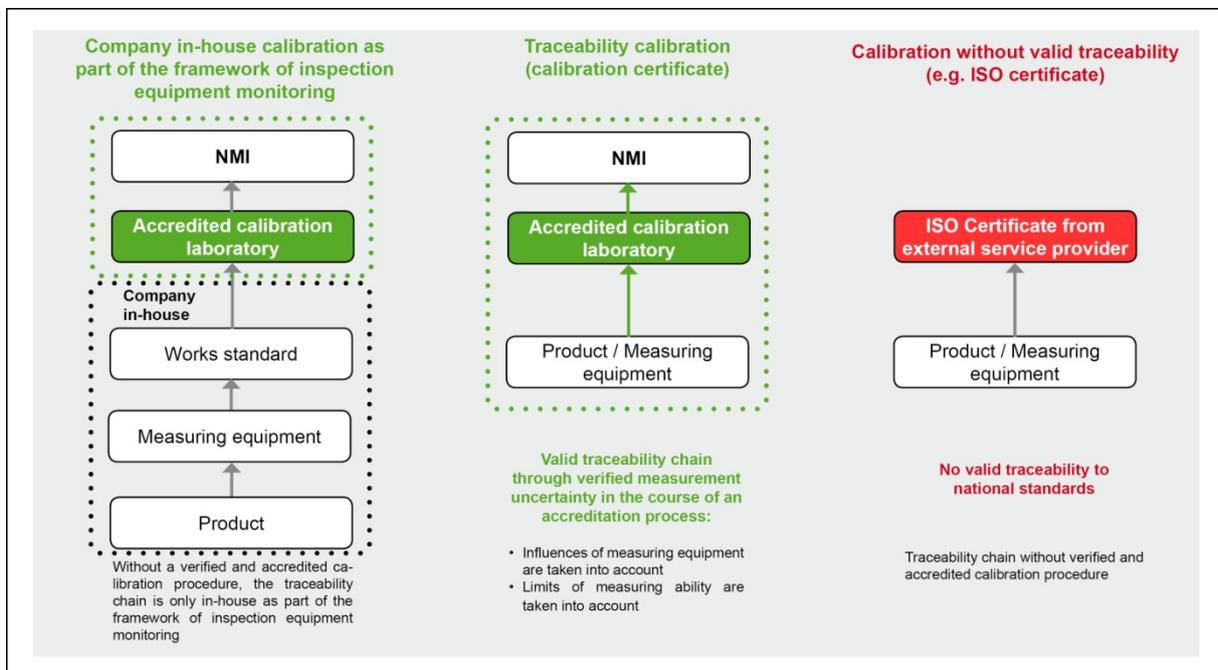


Illustration 1: Traceability chain of calibrations

3. Hierarchy of traceability and international agreements

See **Illustration 2** for an overview

3.1 BIPM (Bureau International des Poids et Mesures) with the CIPM (Comité International des Poids et Mesures), (<http://www.bipm.org/en/home/>)

The mission of the BIPM (International Office of Weights and Measures) headquartered in Paris is to secure the comparability of measurements worldwide. The BIPM works as an international laboratory and secretariat under the exclusive supervision of the CIPM and supports metrological cooperation between the member states. For its part, the CIPM is subordinate to the CGPM (**C**onférence **G**énéral des **P**oids et **M**esures).

3.2 National Metrological Institutes (NMI)

NMIs are at the top of the measuring equipment hierarchy in a state. They represent the basis for determining the values of all subordinate standards of a measured quantity. NMIs are, for example, the "Physikalisch-Technische Bundesanstalt (PTB)" in Germany (<http://www.ptb.de/>), the "Bundesamt für Eich- und Vermessungswesen (BEV) in Austria (<http://www.bev.gv.at/>), the METAS (Switzerland) (<http://www.metas.ch/metasweb>), NPL (GB), NIST (USA) etc.

NMIs are integrated into **Regional Metrological Organizations (RMO)**; in the European region this is the EURAMET (up to June 06 EUROMET).

Mutual recognition of NMIs is agreed upon in the **Mutual Recognition Arrangement (CIPM-MRA)**, (http://www.bipm.org/en/cipm-mra/mra_main_text.html). The aim is for all NMIs to be equivalent and mutually recognize each other in the framework of their calibration possibilities.

3.3 Calibration laboratories (**DAkKS**, **Akkreditierung Austria (ÖKD)**, etc.)

Calibration laboratories are subordinate to the NMIs and carry out the operational work of calibrations. They have to be accredited in accordance with ISO/IEC 17025.

Based on international agreements, all accredited laboratories that fulfill the **ILAC**-agreement are coequal (International Laboratory Accreditation Cooperation, ILAC <http://www.ilac.org/>). This applies in particular also to the DAkKS- or ÖKD -laboratories.

The aim of the ILAC-Agreement is, among other things, the international harmonization of accreditation and ensuring that accredited laboratories fulfill the ISO/IEC 17025.

Calibration laboratories for their part trace their measured quantities either via other calibration laboratories or directly to an NMI.

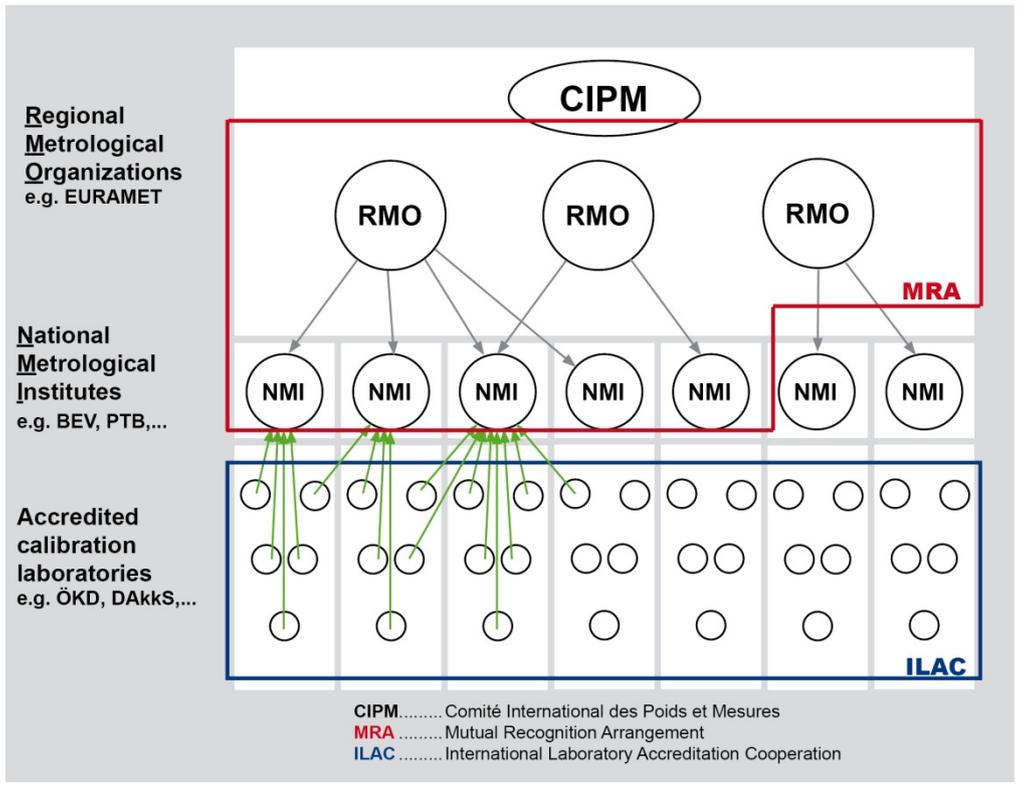


Illustration 2: Structure of traceability of calibrations

4. Calibration Laboratory & Designated Laboratory E+E Elektronik

As an independent operational unit, the E+E Elektronik GmbH operates an **accredited calibration laboratory** via "Akkreditierung Austria" (ÖKD) for air humidity and air temperature, dew point, air flow velocity and air circulation as well as pressure. In addition, E+E Elektronik watches over the Austrian national standard for air humidity and air flow velocity as a **Designated Laboratory** under the commission of the the "Bundesamt für Eich- und Vermessungswesen (BEV)".

In the calibration hierarchy, E+E Elektronik covers the level of an accredited calibration laboratory as well as the level of a National Metrological Institute (NMI) for air humidity and air flow velocity. (see **Illustration 3**).

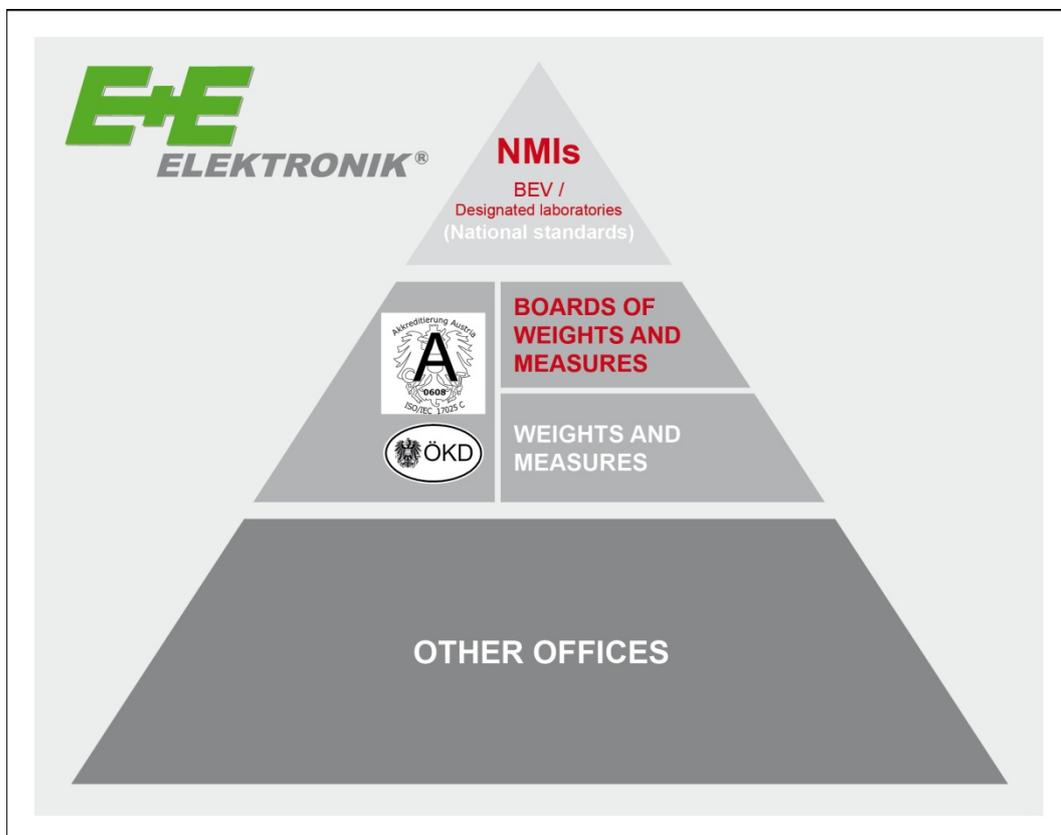


Illustration 3: Hierarchy of calibration departments

5. Author

Dr. Helmut Mitter is head of the E+E calibration department.

6. Company Profile

E+E Elektronik GmbH with headquarters in Engerwitzdorf/Austria is a company in the Dr. Johannes Heidenhain GmbH group. Employing about 250 people, the company develops and produces sensors and measuring transducers for relative humidity, CO₂, airflow velocity and flow rates as well as humidity calibration systems. The main areas of application for E+E products are building services engineering, industrial measurement systems and the automotive industry. The export ratio of about 97 % is achieved via E+E branch offices in China, Germany, France, Italy, Korea and the USA as well as an international distributor network. In addition, E+E Elektronik operates a state-accredited calibration laboratory and has been commissioned by the Bundesamt für Eich- und Vermessungswesen (BEV) (Austrian Federal Office of Metrology and Surveying) with the provision of national standards for humidity and airflow velocity.

7. Contact

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