

# Traceable Calibration?

## Our CalShop and ISO/IEC 17025

*Before ISO/IEC 17025 replaced the corresponding European Standard (DIN EN 45001) about two years ago, “traceable” was often just a global term that manufacturers put in their catalog data and which was accepted without any real questions being asked. The new standard has hauled the subject of traceability into the limelight, since auditors now closely check that the calibrated measurement quantities can indeed be traced back to national standards. This has also resulted in an increased awareness of the subject among customers.*

*Does this mean everything has become more difficult? Depends on your point of view. Beforehand, measuring equipment could be calibrated with traceable accuracy, even if individual proof of such tended to take a long time. Calibration certificates have now become much more informative, since they indicate directly the traceable calibration of all relevant test equipment. But, to start with, even this is unusual. This article is therefore intended to make things a bit clearer.*

### **Calibration = Comparison with Standard Values**

Calibration means the comparison of the value indicated by a measuring instrument (end product) with a nominal value that is provided from a given standard. This usually requires a lot of measuring equipment in a complex test setup. And, all the relevant measuring equipment must itself be suitably calibrated to ensure an unbroken reference (trace) back to the standard kept at a national metrology institute. The calibration here always concerns a physical quantity such as electric tension (voltage), electric current, electric or magnetic field strength.

To ensure traceability, the ISO/IEC 17025 standard gives customers three possibilities of equal value:

1. The instrument can be calibrated directly by a metrology institute such as the PTB (German Bureau of Standards, Braunschweig) in respect of a physical quantity.
2. The instrument can equally be calibrated by an accredited laboratory. Accredited laboratories have been subjected to an approval procedure stipulated by e.g. the German Calibration Service DKD, SIT in Italy, UKAS in the United Kingdom or A2LA and NVLAP in the USA. Accredited laboratories are recognized by each other. This is regulated by agreements with the European Cooperation for Accreditation, EA, and the International Laboratory Accreditation Cooperation, ILAC among others.

3. The instrument can be calibrated by a calibration laboratory that fulfills certain exacting requirements. The laboratory must
  - operate programs of quality management and measuring equipment management,
  - demonstrate the qualification and equipment of its employees,
  - use validated methods and provide evidence of traceability.

Narda Safety Test Solutions offers the third of these options to its customers. Narda has ISO 9001 certification and already operates a solid program of measuring equipment management for its own purposes. The calibration laboratory is equipped with high-quality measuring equipment and the test lab staff have been thoroughly trained. They have access to all production documents and test regulations – and where can you find more know-how than at the manufacturers?

### Reference standards, working standards and measuring equipment

All the equipment used in the calibration of end products is itself calibrated regularly – as part of the measuring equipment management program – and tested before use. The equipment can be divided into three classes:

<i>Equipment</i>	<i>Equipment properties</i>	<i>Equipment calibration</i>
<b>Reference standard</b>	Highest quality equipment available on-site which is kept available for calibrating the measuring equipment and is not in constant use.	Calibrated by a metrology institute or an accredited laboratory. This ensures it can be traced without a break back to an SI unit.
<b>Working standard</b>	Equipment used continuously for calibration of end products.	As above.
<b>Measuring equipment</b>	Used continuously for calibration of end products. Often special, not commercially available equipment or equipment for which accredited calibration is not available.	Calibrated “in-house” using the reference standards.

Measuring equipment plays a special role at Narda Safety Test Solutions. This is because the E and H field probes manufactured by Narda fall into an “exotic” area for which standards are either unavailable or available only with restricted specifications. It is not enough to calibrate electric currents and voltages here. For example, the frequency range coverage alone required for electric field measurements runs from a few Hz up to 60 GHz, i.e. from extremely low frequency fields up into the millimeter wave range. A large number of measuring devices is therefore needed. Just for the EMR probes, some 100 items are needed, of which almost 50 are vital for confirmation of calibration data. External suppliers of such measuring equipment are few and far between, and “traceable calibration” is not always sufficiently documented.

## The trace back chain must be unbroken

This is the real heart of the problem. The chain tracing back to the standard can be as long as you like, as long as it is unbroken. In other words, manufacturer A provides the proof for manufacturer B, who in turn provides it for manufacturer C, and so on. But if just one in the chain cannot furnish proof, the problem is “passed down” to all the rest. For this reason, Narda Safety Test Solutions refers its in-house measuring equipment as directly as possible to accredited standards – and always if it is economically viable and technically possible to do so..

## Individual proof always required

Using the example mentioned above, i.e. the probes for the EMR range of instruments: Helmholtz coils, TEM cells and Horn antennas are needed to generate the calibration field. The device required depends on the physical quantity (electric or magnetic field) and the frequency range. Calibration must be traceable and provable as such for each item of measuring equipment. The statement: “our calibration is traceable” is too global. It can only apply to a particular product or product group.

## The equivalent model

The calibration accuracy has a decisive influence on the measurement uncertainty of the end product, the “test set”, which we naturally want to be very low. This not only influences the requirements placed on the measuring equipment used for the calibration, but also the type of measurement method to be used. A simple comparison measurement with an ideal probe with known properties is not always the best solution. That is because the measurement uncertainty of the probe can easily be of the same order of magnitude as that which is to be determined. As a rule, indirect methods must be used. The field is calculated from other physical quantities that can be measured with high precision, and their influence can be represented in terms of an equivalent model.

Staying with the EMR probes for electric fields: These are calibrated for frequencies between 100 kHz and 300 MHz using a TEM cell. The field strength  $E$  is represented mathematically by the equation

$$E = \frac{\sqrt{P_m * F_{th} * D * Z_L}}{d}$$

Where

$P_m$ : power

$F_{th}$ : power measuring probe correction factor

$D$ : attenuation for measurement range adjustment

$Z_L$ : characteristic impedance (nominally 50 ohms)

$d$ : Septum height, i.e. space between inner and outer conductors.

The equivalent model accounts for all the quantities relevant to calibration. Less important parameters such as the signal distortion of the amplifier are taken into

account in the tolerance analysis (“error calculation”). This then forms the basis for the published measurement uncertainty of the end product.

*Device under test in a TEM cell  
(photo at the right)*



**Calibration certificates: simpler, yet still confusing?**

Earlier calibration certificates included all the measuring equipment and thus corresponded to a description of the test setup in some ways. Current calibration certificates list precisely the standards for the relevant quantities and describe the methods used to demonstrate the connection between the proven quantity and the reference standard used. This is done by quoting the certificate numbers for all the standards along with the period of validity of the calibration.

This results in calibration certificates that look a bit strange at first glance:

Reference / Working Standard	Model	Serial Number	Certificate Number	Cal Due Date	Trace
Depth Caliper	0-300mm	220721020	431824 DKD-K-12001 04-04	22 Apr 2005	DKD
Vector Network Analyzer	ZVC	100032	0091 DKD-K-16101 04-02	24 Feb 2005	DKD
Power Sensor 4.2 GHz	8482A	US37295012	04D80 DKD-K-02201 04-04	15 Oct 2005	DKD
Power Meter, Two Channel	438A	2839U01422	2-61054379-1A	15 Oct 2005	UKAS
Attenuator, 30 dB	49-30-33	KCC 115	2508 DKD-K-00501 03-03	19 Sep 2004	DKD

The customer expects to see a TEM cell in the list, among other things, yet the certificate shows the calibration data for a depth caliper. However, it can be quickly seen from the equivalent model that the calibration field strength was determined from the dimensions of the TEM cell, among other things. Hence the appearance of the depth caliper in the table, as it is used to determine the septum height included as a relevant quantity in the equivalent model.

This gives the end user the guarantee that the calibration is traceable. The corresponding certificates can be viewed if required. The new calibration certificates are much clearer as a result: They show the auditor and the customer exactly what it is that furnishes proof of traceability.