Calibration Guidelines, Expert Reports, Technical Reports

Mass and Related Quantities

Reference	Title	Title (original)	Available in
Force and Torque			
DKD-R 3-3	Calibration of force measuring devices https://doi.org/10.7795/550.20240527	Kalibrierung von Kraftmessgeräten https://doi.org/10.7795/550.20240304	de, en
DKD-R 3-7	Static calibration of indicating torque wrenches	Statische Kalibrierung von anzeigenden Drehmomentschlüsseln https://doi.org/10.7795/550.20180823H	de
DKD-R 3-9	Continuous calibration of force transducers according to the comparison method	Kontinuierliche Kalibrierung von Kraftaufnehmern nach dem Vergleichsverfahren https://doi.org/10.7795/550.20180823J	de
DKD-R 3-10	Dynamic calibration of uniaxial force measuring devices and testing machines	Dynamische Kalibrierung von einachsig beanspruchten Kraftmessgeräten und Prüfmaschinen	
Sheet 1	Basic principles https://doi.org/10.7795/550.20171212A	Grundlagen http://dx.doi.org/10.7795/550.20240404	de, en
Sheet 2	Dynamic calibration of force transducers according to the sinusoidal method https://doi.org/10.7795/550.20190507AEN	Dynamische Kalibrierung von Kraftaufnehmern nach dem Sinusverfahren https://doi.org/10.7795/550.20190507A	de, en
Sheet 3	Dynamic verification of material testing machines using applied samples https://doi.org/10.7795/550.20190507BEN	Dynamische Verifizierung von Werkstoffprüfmaschinen mit applizierten Proben https://doi.org/10.7795/550.20190507B	de, en
DKD-R 9-1	Calibration and verification of the torque measuring device of torsion testing machines https://doi.org/10.7795/550.20210618B	Kalibrierung und Überprüfung der Drehmomentmesseinrichtung von Torsionsprüfmaschinen https://doi.org/10.7795/550.20210618A	de, en
DKD-R 9-2	Supplementary information regarding the calibration/verification of tensile/compression testing machines https://doi.org/10.7795/550.20220315	Ergänzung zur Kalibrierung/Prüfung von Zug-/Druckprüfmaschinen https://doi.org/10.7795/550.20220228	de, en
DKD-R 10-5	Static calibration of torque measuring devices with alternating torque https://doi.org/10.7795/550.20210407	Statische Kalibrierung von Drehmomentmessgeräten mit Wechseldrehmoment https://doi.org/10.7795/550.20200713	de, en, es
DKD-R 10-8	Static calibration of calibration devices for torque wrenches https://doi.org/10.7795/550.20200825A	Statische Kalibrierung von Kalibriereinrichtungen für Drehmomentschlüssel https://doi.org/10.7795/550.20200210	de, en, es

Pressure			
DKD-R 6-1	Calibration of Pressure Gauges https://doi.org/10.7795/550.20210422	Kalibrierung von Druckmessgeräten https://doi.org/10.7795/550.20201221	de, en, es, ru
DKD-R 6-2	Calibration of measurement equipment for vacuum	Kalibrierung von Messmitteln für Vakuum	
Part 1	Fundamentals	Grundlagen https://doi.org/10.7795/550.20180828AJ	de, ru
Part 2	Measurement uncertainties	Messunsicherheiten https://doi.org/10.7795/550.20180828AK	de, ru
Part 3	Electrical diaphragm vacuum gauges	Elektrische Membran-Vakuummeter https://doi.org/10.7795/550.20180828AL	de, ru
Part 4	Ionization vacuum gauges	Ionisations-Vakuummeter https://doi.org/10.7795/550.20180828AM	de
Part 5	Heat conduction vacuum gauges	Wärmeleitungs-Vakuummeter https://doi.org/10.7795/550.20180828AN	de
Mass			
DKD-R 7-2	EURAMET Calibration Guide No. 18: Guidelines on the Calibration of Non-Automatic Weighing Instruments	Richtlinie zur Kalibrierung nichtselbsttätiger Waagen Translation of EURAMET CG 18, Version 4 https://doi.org/10.7795/550.20180928	de
DKD-R 7-3	Application of the substitution procedure for the calibration of non-automatic weighing instruments https://doi.org/10.7795/550.20250306	Anwendung des Ersatzlastverfahrens zur Kalibrierung von nichtselbsttätigen Waagen https://doi.org/10.7795/550.20250129	de, en
DKD-E 7-1	Application of the substitution procedure for the calibration of non-automatic weighing instruments https://doi.org/10.7795/550.20220331	Anwendung des Ersatzlastverfahrens zur Kalibrierung von nichtselbsttätigen Waagen https://doi.org/10.7795/550.20220224	de, en
DKD-E 7-4	Determination and specification of the smallest achievable measurement uncertainties in the calibration of electronic non-automatic weighing instruments https://doi.org/107795/550.20260114	Bestimmung und Angabe von kleinstmöglichen Messunsicherheiten bei der Kalibrierung von elektronischen nicht selbsttätigen Waagen https://doi.org/107795/550.20251210	de, en
Hardness			
DKD-R 9-3	Supplementary information regarding the calibration/verification of hardness testing machines https://doi.org/10.7795/550.20230718	Ergänzung zur Kalibrierung / Prüfung von Härteprüfmaschinen https://doi.org/10.7795/550.20230127	de, en
DKD-R 9-4	Dynamic calibration of material testing machines	Dynamische Kalibrierung von Werkstoffprüfmaschinen https://doi.org/10.7795/550.20240606	de

Calibration Guidelines:
DKD calibration guidelines (DKD-R) are application documents that meet the requirements of DIN EN ISO/IEC 17025. The guidelines contain a description of technical, process-related and organizational procedures used by accredited calibration laboratories as a model for defining internal processes and regulations. DKD guidelines may become an essential component of the quality management manuals of calibration laboratories. The implementation of the guidelines promotes equal treatment of the equipment to be calibrated in the various calibration laboratories and improves the continuity and verifiability of the work of the calibration laboratories. In addition, the implementation of the guidelines allows the state of the art in the respective field to be incorporated into laboratory practice.

Expert Reports:
DKD expert reports (DKD-E) aim to provide background information and references in connection with other DKD documents as, for example, the DKD guidelines. In some cases, they may even go far beyond these documents. They do not replace the original DKD documents but do provide a lot of supplementary information worth knowing.

Download of DKD documents: https://www.ptb.de/cms/nc/en/metrological-services/dkd/publications.html

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Annex – Abstracts

Force and Torque	
DKD-R 3-3	**Calibration of force measuring devices** This guideline applies to all force measuring devices determining force through elastic deformation of a body. It can also be used for force transducers alone. It may only be used for force measuring devices that can be calibrated with increasing and decreasing loads, with at least 3 force steps. The guideline applies to static loading processes. In addition to the usual calibration sequences with three mounting positions, it also describes simplified sequences reducing the effort to a metrologically acceptable minimum and thus also the costs. For this purpose, certain prerequisites - such as the requirements of international rules for determining measurement uncertainty - must be met. The user may go beyond the effort described in this guideline but must not go below it. The guideline allows the realisation of practical calibration sequences and evaluations.
DKD-R 3-7	**Static calibration of indicating torque wrenches** This guideline applies to calibrations of transfer torque spanners used for the calibration of torque spanner calibration devices and of torque spanners of higher accuracy than those classified according to DIN ISO 6789. A procedure for determination of the relative expanded measurement uncertainty of these devices is described. An indicating torque spanner is defined as the entire device from the tool holder with insertion tool via the torque transducer up to and including the indicating device. The guideline generally applies to indicating torque spanners in which the torque is defined by measuring the elastic deformation of a deformable body or a measured quantity proportional to it. Within this guideline, transfer torque spanners are special torque measuring devices whose design allows the torque to be applied via a lever arm (comparable to the design of torque spanners) and which are insensitive to superimposed transverse forces and bending moments in accordance with the required measurement uncertainty. Due to their special design, transfer torque spanners enable the calibration of torque spanner calibration devices taking into account the actual force introduction conditions while at the same time allowing the variation of the force introduction parameters according to the variation range of the cross forces and bending moments occurring during the calibration of torque spanners. This guideline takes into account the deviating force introduction conditions on the calibration item compared to those of torque measuring devices according to DIN 51309 or EURAMET cg-14.
DKD-R 3-9	**Continuous calibration of force transducers according to the comparison method** The purpose of this guideline is to define minimum requirements for the calibration procedure and for the estimation of the measurement uncertainty in the continuous calibration of transducers for mechanical quantities. It applies to calibration items that must be supplemented by an adapter provided by the calibration laboratory to form a complete measurement chain. The adapter is part of the calibration equipment. Hence, the application of the guideline is basically restricted to the transducer as calibration item, without the adapter. For future calibration items with integrated signal matching this guideline can also be applied. In this case, it must be ensured that the criteria described in this guideline, for example with regard to synchronization and equal signal matching in the channel of the standard and the calibration item, are met. A prerequisite for the application of this guideline is that the force reference standard machine which operates according to the comparison method is capable of realising both a step-shaped and a continuous load curve. Here, continuous calibration sequences refer to a continuous change in the measured quantity whose time behaviour is ramp-shaped or $\sin^2$-shaped, for example. However, the process is to be regarded as quasi-static (in contrast to dynamic load with, for example, sinusoidal or intermittent time behaviour). The procedures and specifications in this edition of the guideline are provisionally designed to demonstrably achieve a minimum relative measurement uncertainty $\geq 1 \cdot 10^{-3}$ of the measured value.

DKD-R 3-10	**Dynamic calibration of uniaxial force measuring devices and testing machines**
Sheet 1	**Basic principles** The guideline is intended to support establishing metrological traceability of dynamic forces - which are frequently encountered in industry - to national standards. This document and the supplementary sheets only consider single-axis loads. Due to their frequency-dependent contributions, disturbing forces and moments play an important role in dynamic force measurement; however, the scientific and technical prerequisites for multi-axis dynamic force calibrations have not yet been established. The guideline is meant as a supplement to other standards and guidelines. The wide variety of dynamic force applications requires a wide variety of specific standards and guidelines for calibration, most of which are still to be developed in the future. This guideline aims to serve as an aid for these future standards and guidelines. Its scope has been set deliberately broad, covering force measuring devices and materials testing machines. It should therefore also apply, for example, to temporary test benches, which are common in many branches of industry for component testing or in crash measurement technology. The validity of existing calibration regulations and the necessity of their implementation are not restricted in any way. Force measuring devices and materials testing machines should also be statically calibrated (e.g. ISO 376 or ISO 7500) as proof of traceability in the case of dynamic calibration.
Sheet 2	**Dynamic calibration of force transducers according to the sinusoidal method** This sheet describes the dynamic calibration of force transducers which are used, for example, as transfer standards for the dynamic calibration of materials testing machines. The guideline does not restrict the validity of existing calibration requirements and the need to implement them. Even when dynamically calibrated, force measuring devices and materials testing machines should also have a static calibration (e.g. DIN EN ISO 376 or DIN EN ISO 7500) as proof of traceability.
Sheet 3	**Dynamic verification of material testing machines using applied samples** This sheet describes the dynamic verification of materials testing machines using applied samples. The dynamic verification helps to gain knowledge regarding the dynamic behaviour of the material testing machine and substantiates the results obtained by the testing of materials. Given that the applied samples in this guideline are used without further traceability, the procedure described does not constitute a calibration but an additional verification of the dynamic properties. In the verification procedure it is assumed - as a matter of principle - that the dynamic forces exerted and displayed by the testing machine correspond to the dynamic forces acting on the sample. Mass inertia of the specimen holders should only have a negligible influence. As a rule, the materials testing machine must be equipped with dynamic compensation in which the force signal is corrected by means of acceleration measurement. As a proof of traceability, the materials testing machine must always also be statically calibrated according to DIN EN ISO 7500.
DKD-R 9-1	**Calibration and verification of the torque measuring device of torsion testing machines** This guideline is applicable to the static calibration and verification of torsion testing machines using a procedure based on the calibration of materials testing machines according to DIN EN ISO 7500-1. The verification implies a general inspection of the torsion testing machine, including the parts used for the application of torque; a calibration of the torque measuring device of the torsion testing machine and a confirmation that the determined properties of the torsion testing machine meet the limits given for a specified class. The guideline refers to the static calibration and verification of torque measuring devices. The calibration results are not necessarily valid for high-speed tests or dynamic testing. It may also be used for the calibration and verification of indicating devices of testing machines or test rigs using the measurand torque, e.g. fastener test benches, brake test benches, etc. The guideline is not meant for the calibration of measuring instruments such as torque wrenches.

DKD-R 9-2	**Supplementary information regarding the calibration/verification of tensile/compression testing machines** The guideline shall serve to ensure a uniform procedure for the calibration/verification of materials testing machines according to DIN EN ISO 7500-1:2018-06 and DIN EN ISO 9513:2013-05. Special attention is paid to particularly important or unclearly defined points in the standard.
DKD-R 10-5	**Static calibration of torque measuring devices with alternating torque** This guideline supplements DIN 51309:2005-12 with the calibration of torque measuring devices with alternating torque. Torque transducers intended for quasi-static applications with alternating torque load are also calibrated quasi-statically with alternating torque. Suggestions for efficiently obtaining an alternating torque calibration curve from the curves for simple clockwise and anti-clockwise torque calibration are discussed. The hysteresis at the zero point, which is called mechanical remanence, provides information about the measurement uncertainty under alternating torque load and thus about the suitability of a transducer for this application. When using such a transducer, there are usually no investigations into the position of the zero point to which the measurement results refer. Consequently, twice the value of the hysteresis determined during the alternating torque calibration must be taken into account.
DKD-R 10-8	**Static calibration of calibration devices for torque wrenches** The guideline applies to the calibration of torque wrench calibration devices using torque transfer wrenches as transfer standards. It supports the corresponding requirements of DIN EN ISO 6789. A method for determining the relative measurement uncertainty of these devices is also described. The guideline excludes the use of fixed-length calibration beams and discs as transfer standards. The reason for this is that the determination of the parameter "span" for different lever arm lengths is not possible with this type of equipment; hence, it would not be possible to carry out an adequate calibration or to adequately determine the measurement uncertainty. Within the context of this guideline, torque wrench calibration devices are special torque measuring devices which – because of their design – allow torque to be applied via a torque measuring instrument with lever arm. The guideline takes into account the different conditions of force introduction and their effect on the calibration item as opposed to those of torque measuring instruments according to DIN 51309.

Pressure and vacuum	
DKD-R 6-1	**Calibration of Pressure Gauges** This guideline establishes minimum requirements for the calibration procedure and the evaluation of the measurement uncertainty in the calibration of pressure gauges. It applies to Bourdon tube pressure gauges, electric pressure gauges and pressure transmitters with electrical output for absolute pressure, differential pressure, and excess pressure with negative and positive values.
DKD-R 6-2	**Calibration of measurement equipment for vacuum** This guideline specifies the minimum requirements for the calibration of measuring equipment for vacuum. It does not replace the necessary work instructions for calibrations. The parts of this guideline contain the details for the calibration of the different types of vacuum gauges. The guideline applies to the calibration of reference standards, working standards and measuring devices for vacuum.
Part 1	**Fundamentals** Part 1 deals with the basics for calibrating vacuum gauges.
DKD-R 6-2	**Calibration of measurement equipment for vacuum**
Part 2	**Measurement uncertainties** Part 2 deals with the determination and quantification of measurement uncertainties and the preparation of measurement uncertainty budgets for the calibration of vacuum gauges.
Part 3	**Electrical diaphragm vacuum gauges** Part 3 refers to the calibration of direct measuring electrical diaphragm vacuum gauges, e.g. capacitive, piezoresistive and similar pressure transducers for absolute pressure measurement. The pressure range is typically 10^{-6} mbar to 1000 mbar. Long-term stable vacuum gauges are used as standards.
Part 4	**Ionization vacuum gauges** Part 4 applies to the calibration of ionization vacuum gauges. The pressure range is typically 10^{-12} mbar to 1 mbar. Suitable pressure gauges such as ionization vacuum gauges, gas friction vacuum gauges and diaphragm vacuum gauges are used as standards.
Part 5	**Heat conduction vacuum gauges** Part 5 applies to the calibration of heat conduction vacuum gauges according to Pirani, heat conduction vacuum gauges according to the convection principle, thermo-electrical vacuum gauges, and other heat conduction vacuum gauges. The pressure range is typically 10^{-4} mbar to 1000 mbar. Suitable pressure gauges as, for example, diaphragm vacuum gauges or gas friction vacuum gauges are used as standards.

Mass	
DKD-R 7-2	**Calibration of Non-Automatic Weighing Instruments** EURAMET Calibration Guide 18, Ver. 4.0 was published as German translation (DKD-R 7-2).
DKD-R 7-3	**Application of the substitution procedure for the calibration of non-automatic weighing instruments** In many cases there are not enough reference weights available for calibrations of non-automatic electronic weighing instruments. Moreover, placing the reference weights on the weighing instrument may prove to be difficult if the load receptor lacks sufficient space. Therefore, the substitution procedure is an appropriate option for calibrating high-capacity scales. The guideline contains additional requirements regarding the practical implementation of the substitution procedure, thus supporting the high competence required of an accredited calibration laboratory. The process of the substitution procedure is clearly illustrated by means of a specific example. The guideline helps to standardise the substitution procedure in the calibration of non-automatic weighing instruments. It should be noted that the measurement uncertainty during calibration and during use is significantly increased by the substitution procedure. The requirements regarding the use of the substitution procedure aim to ensure the practicality and comparability of the calculation of the uncertainty of measurement during calibration and when using the weighing instrument. The guideline is based on DKD-R 7-2 (01/2018), resp. EURAMET Calibration Guide No.18 (11/2015).
DKD-E 7-1	**Application of the substitution procedure for the calibration of non-automatic weighing instruments** The expert report is based on the calibration guideline DKD-R 7-2. It contains additional requirements regarding the practical implementation of the substitution procedure, thus supporting the high competence required of an accredited calibration laboratory. The substitution procedure is described in chapter 4.3.3 of DKD-R 7-2. By using the substitution procedure, the measurement uncertainty contribution of the load used increases with each substitution step and thus the measurement uncertainty of the weighing instrument to be stated in the calibration certificate. The substitution procedure is used to determine the indication error during calibration. The determination of repeatability and deviation due to eccentric loading is not subject of this expert report.
DKD-E 7-4	**Determination and specification of the smallest achievable measurement uncertainties in the calibration of electronic non-automatic weighing instruments** ILAC and BIPM agreed to replace the term ‘Best Measurement Capability’ (BMC) previously used within the scope of accreditation of calibration laboratories by the term ‘Calibration and Measurement Capability’ (CMC) from Appendix C of the Mutual Recognition Arrangement of the International Committee for Weights and Measures (CIPM MRA). The aim of this expert report is to provide accredited calibration laboratories with detailed information in order to help them determine and evaluate the best calibration and measurement capabilities and the smallest achievable measurement uncertainties when calibrating non-automatic weighing instruments. The CMC to be determined must describe the measurement uncertainty for the best available weighing instrument. It must be possible to calibrate this weighing instrument in such a way that the stated CMC is demonstrably achieved. Particular attention is paid to the term ‘best available weighing instrument’. In addition, this report outlines the specifications and assumptions that apply in order to determine the necessary measurement uncertainty contributions. Finally, a uniform, rule-compliant presentation of CMC data (calibration and measurement capabilities) in accordance with ILAC-P14 and ILAC-G18 (e.g. in the appendices to the accreditation certificates) should be derived. This revised presentation can serve as a basis for future accreditations in the field of calibration of non-automatic weighing instruments, as well as for the presentation of the measurement uncertainty associated with an actual measured value, as specified in calibration certificates.

Hardness	
DKD-R 9-3	**Supplementary information regarding the calibration/verification of hardness testing machines** This guideline supports the application of the standards DIN EN ISO 6506-2, DIN EN ISO 6507-2 and DIN EN ISO 6508-2 for the calibration and verification of hardness testing machines in a comparable and reliable manner. The guideline directly addresses particularly important or unclearly defined points of the above-mentioned standards.
DKD-R 9-4	**Dynamic calibration of material testing machines** The guideline deals with the dynamic calibration of materials testing machines which are used, for example, to determine S-N curves. A dynamically calibrated force transfer standard is used for this purpose which can be equipped with adapters that can be used to simulate both the stiffness and the mass ratios in the load path in everyday testing. The guideline can be used for the dynamic calibration of machines for frequencies between 0 Hz and 1 kHz and for forces between 1 N and 1 MN. The calibration procedure originated from the research project 18SIB08 ComTraForce (EMPIR programme). The working group "Dynamic Calibration" of DKD's Technical Committee "Materials Testing Machines" is continuously working on the document and further optimisations are being made.