

# Physikalisch- Technische Bundesanstalt



**DKD**

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**Guide  
DKD-L 4-1**


**Test value uncertainty in  
conformity assessment**

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		Edition:	04/2024
		Revision:	0
		Page:	2 / 20

## Deutscher Kalibrierdienst (DKD) – German Calibration Service

Since its foundation in 1977, the German Calibration Service has brought together calibration laboratories of industrial enterprises, research institutes, technical authorities, inspection and testing institutes. On 3rd May 2011, the German Calibration Service was reestablished as a *technical body* of PTB and accredited laboratories.

This body is known as Deutscher Kalibrierdienst (DKD for short) and is under the direction of PTB. The guidelines and guides developed by DKD represent the state of the art in the respective areas of technical expertise and can be used by the Deutsche Akkreditierungsstelle GmbH (the German accreditation body – DAkkS) for the accreditation of calibration laboratories.

The accredited calibration laboratories are now accredited and supervised by DAkkS as legal successor to the DKD. They carry out calibrations of measuring instruments and measuring standards for the measurands and measuring ranges defined during accreditation. The calibration certificates issued by these laboratories prove the traceability to national standards as required by the family of standards DIN EN ISO 9000 and DIN EN ISO/IEC 17025.

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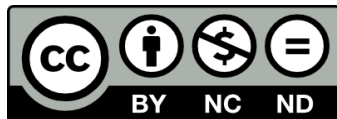
	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	3 / 20

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	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	4 / 20

## Foreword


DKD guides are recommendations on technical issues arising from the practical work in accredited calibration laboratories. The guides describe procedures which may serve as a model for the accredited calibration laboratories for defining internal processes and regulations. DKD guides may become an essential component of quality management manuals of calibration laboratories. The implementation of the guidelines will help to incorporate the state of the art in the respective field into laboratory practice. Thus, a standardization of procedures as well as an increased efficiency in the work of calibration laboratories shall be achieved.

DKD guides should not impede the further development of calibration procedures and processes. Deviations from guidelines as well as new procedures are permitted if there are technical reasons to support this action.

The present guide was prepared by the Technical Committee *Length* and approved by the Board of the DKD.


The content of this document is largely based on discussions held between April 2021 and April 2023 by the members of the following committees and working groups:

- DKD Technical Committee *Length*
- DKD Technical Committee *Measurement Uncertainty*
- DKD Executive Office
- DIN NA 152-03-02-07 UA
- PTB Department 5.3 *Coordinate Metrology*
- PTB Department 5.4 *Interferometry on Material Measures*
- PTB Working Group 8.42 *Data Analysis and Measurement Uncertainty*

	<p style="text-align: center;">Test value uncertainty in conformity assessment</p> <p style="text-align: center;"><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	5 / 20

## Table of contents

1	Purpose and scope of application.....	6
2	Introduction .....	6
3	Calibration and testing of metrological characteristics .....	6
3.1	Testing.....	6
3.2	Calibration .....	7
3.3	Verification.....	7
3.4	Distinction between calibration and testing according to DIN EN ISO 14978:2019-06 7	
3.5	Measurement uncertainty .....	9
3.6	Conformity statement.....	10
3.7	Test value uncertainty.....	10
3.7.1	Determination of the test value uncertainty .....	11
4	Evaluation of requirements using a decision rule based on the test value uncertainty ...	12
4.1	Verification of a calliper according to DIN EN ISO 13385-1:2020-03 taking into account the MPE values according to Annex B.....	12
4.2	Calibration of a calliper according to DIN EN ISO 13385-1:2020-03 .....	12
4.3	Conformity assessment of a calliper according to DIN EN ISO 13385-1:2020-03 taking into account the MPE values according to Annex B.....	13
4.4	Determining the risk of a false conformity statement in the evaluation of a calliper in accordance with DIN EN ISO 13385-1:2020-03 taking into account the MPE values according to Annex B.....	13
4.5	Ensuring metrological traceability of the calibration results according to DIN EN ISO 13385-1:2020-03 .....	14
4.6	Metrological traceability of the measured values determined by means of a calliper calibrated according to DIN EN ISO 13385-1:2020-03.....	15
5	Possible representation in the calibration certificate when applying DIN EN ISO 13385- 1:2020-03 Annex B.....	16
6	Summary.....	17
7	Bibliography .....	18

	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	6 / 20

## 1 Purpose and scope of application

The present guide seeks to emphasise the difference between test value uncertainty and measurement uncertainty according to GUM (*Guide to the expression of uncertainty in measurements*), documents [1-6]. It also seeks to clarify the consequences this difference implies when determining conformity by means of specifications. The basic statements are explicitly not limited to individual measurands or the application in the context of accreditations.

## 2 Introduction

The metrological traceability (see chapter 2.41 in [7]) of measurement results is essential for the consistency and comparability of measurement results. In particular, it is a requirement for laboratories in accordance with chapter 6.5 of DIN EN ISO/IEC 17025:2018-03 [8] to create confidence in the results of conformity assessment bodies as, for example, accredited calibration laboratories. However, in industry and research, the verification of the metrological traceability of measurement results of the measuring equipment used does also form part of many quality management systems and regulations such as DIN EN ISO 9001:2015 [9], IATF 16949:2016 [10] or DIN EN ISO 13485:2021 [11].

National and international recognition of measurement results is an essential prerequisite for delivering products and services in accordance with the agreed properties. The determination, evaluation, and confirmation as to whether a measuring equipment fulfils specified requirements (acceptance criteria) is usually carried out through the conformity assessment process (see chapter 4.1 in [12]). This can be done on the basis of calibrations or tests. The conformity statement in the corresponding reports must be based on a specified or agreed decision rule (see Chapter 7.8.6 in [8]). According to chapter 3.7 in [8], the decision rule describes how the measurement uncertainty is to be taken into account when making statements on conformity. This means that the statement of conformity is always linked to the measurement result within the scope of a calibration.


Some regulations dealing with the acceptance and verification of measuring equipment use the concept of “test value uncertainty” in the evaluation of conformity as part of the decision rule. This guide will discuss the extent to which test value uncertainty differs from measurement uncertainty and the consequences that arise from this for the statement of conformity.

## 3 Calibration and testing of metrological characteristics

Users of measuring equipment are responsible for its intended use and for determining the relevant metrological characteristics. Metrological characteristics of measuring equipment and material measures can be determined, for example, by calibration with reference values or by a verification test (here only a test) together with a statement of conformity (see chapter 6.1.4 in [13]). Both laboratory activities usually involve measurements, yet the objectives and the metrological statement are different.

### 3.1 Testing

According to DIN EN ISO/IEC 17000:2020-09 Chap. 6.2, testing is defined as “determination of one or more characteristics of an object of conformity according to a procedure” [12]. In this guide, the object of conformity describes an object (e.g. measuring device or material measure) to which specified requirements apply (see Chap. 4.2 in [12]). The procedure used describes the specified way to carry out an activity or a process (see Chap. 5.2 in [12]). Thus, the purpose of testing consists in examining the metrological characteristics of the measuring devices or material measures.

	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	7 / 20

### 3.2 Calibration

Calibration is defined as an “operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication” (see ISO/IEC Guide 99: 2007-12 Chap. 2.39 [14]). Calibration serves to establish the relationship between the input quantities provided by standards (reference devices) and the output quantities of the corresponding calibration item. The result of a calibration always consists of the measured value including the associated measurement uncertainty. Provided that an uninterrupted metrological traceability chain to a national or international standard is maintained, the calibration results obtained can be traced back to the International System of Units (SI), which in turn enables the unit of the measurand to be passed on with the aid of the calibrated measuring equipment (further requirements for metrological traceability are described in ILAC-P10:07/2020 [15]). Proof of metrological traceability ensures comparability and validity of the measurement results.

### 3.3 Verification

Verification in accordance with Chap. 6.6 of DIN EN ISO/IEC 17000:2020-09 [12] describes the “confirmation of truthfulness through the provision of objective evidence that specified requirements have been fulfilled” (see also Chap. 2.44 in [14]). As to laboratory activities, verification describes the “provision of objective evidence that a given item fulfils specified requirements” (see section 3.8 in [8]). In particular, this also includes the activity of confirming that the metrological characteristics of a measurement system are fulfilled.

In some regulations on Geometric Product Specification (GPS), the sequence of activities for preparation, measurement, mathematical evaluation and decision-making following a test instruction is referred to as verification test, or simply as test [see Chap. 3.1 in [16]].

#### Note on the term “verification”:


According to DIN EN ISO/IEC 17000:2020-09 [12], the term verification does not constitute an independent term of conformity assessment. The common English term “verification” should be translated as „Verifizierung“ (in German). In the context of [13], verification refers to testing as a means of determining the test values and verification as an activity to demonstrate compliance with specified requirements.

### 3.4 Distinction between calibration and testing according to DIN EN ISO 14978:2019-06

In its German version, the internationally valid standard DIN EN ISO 14978:2019-06 [13] distinguishes between two possible procedures to determine the metrological characteristics of measuring equipment (the English title of the standard is: *Geometrical product specifications (GPS) - General concepts and requirements for GPS measuring equipment*):

1. Calibration: determination of reference values
2. Verification: measurement of test values for the determining of conformity

Although the metrological realisation of the calibration and the testing can be very similar in the case of a length measuring machine, for example, the objectives and statements differ. Figure 1 shows both methods including the differences. In both cases, calibrated reference equipment must be used. The upper path describes the calibration. The calibration of a horizontal length measuring machine (single-coordinate measuring device) provides a good

	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	8 / 20

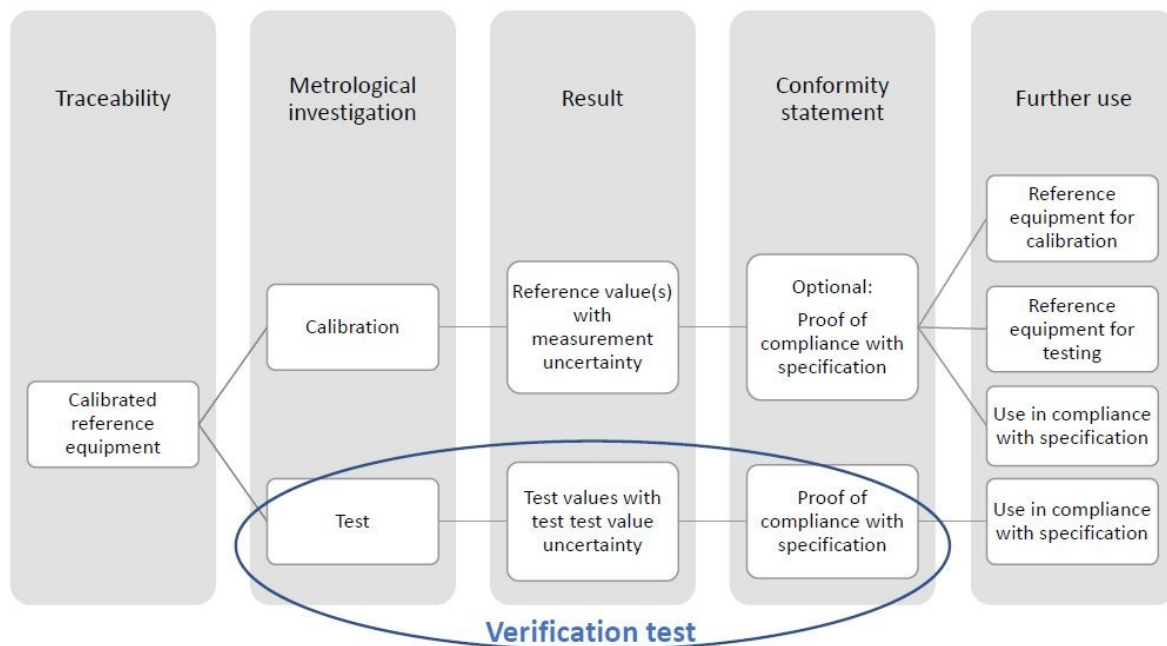
example. In this case, the measurement error is determined by comparing the results with calibrated measurement standards (material measures) such as gauge blocks. The measurement uncertainty associated with the calibration result takes into account all relevant influence quantities, such as the calibration uncertainty of the gauge blocks, the repeatability, the parallelism and flatness deviations of the measuring surfaces that can be determined during calibration as well as the influence of the environmental conditions. The information stated in the calibration certificate concerning the measurement error and the associated measurement uncertainty form the basis for metrological traceability (see chapter 2.41 in [14]). Thus, it is possible to pass on the SI unit of length. This means that the length measuring machine can be used as a reference device to calibrate gauge rings, for example, or as a device for testing and verifying that the specifications for cylindrical measuring pins are met. The aim of calibration is to establish metrological traceability.

Compliance with the specified requirements for the length measuring device (e.g. manufacturer's specifications) does not have to be demonstrated as part of the calibration. However, a subsequent statement of conformity is possible based on the calibration results.

In the second case (testing), the conformity of the length measuring device is verified against the manufacturer-specific or standardised limit deviations, for example. This is done according to a fixed test instruction based on the measured values. For this purpose, reference devices such as calibrated gauge blocks are used and various metrological characteristics of the length measuring device such as measurement deviation, repeatability, flatness and parallelism deviation are determined according to a defined test procedure. The result of a test in accordance with DIN EN ISO 14978:2019-06 is the documentation of the test result and the assessment of conformity based on the test results. This process is referred to as verification. The specified requirements on which the assessment is based are based, for example, on standardised limit deviations or the manufacturer's specifications. The aim of testing in accordance with DIN EN ISO 14978:2019-06 is to confirm compliance with the specification.

The fact that the length measuring device has passed the test does not in itself constitute proof of the metrological traceability of the measured values obtained with this measuring device. This means that it is not suitable per se as a reference device for calibrations or tests.






**Figure 1:** Calibration and testing procedure. Verification according to DIN EN ISO 14978:2019-06 includes not only the testing to determine the test result, but also the decision on compliance with the specification

### 3.5 Measurement uncertainty

Measurements do not provide exact values since each measurement depends on a large number of different influence quantities, the knowledge of which is or can never be perfect. The definition of measurement uncertainty indicates that the true value of a measured quantity is always unknown and lies within an interval around the measured value with a fixed probability of coverage. The limits of this interval are usually determined on the basis of the measurement uncertainty. The measurement uncertainty is therefore a quantitative measure for assessing the quality and reliability of the measurement result. The statement of measurement result is complete only if it contains both the value attributed to the measurand, and the uncertainty of measurement associated with that value (see Chap. 2.1 in [17]). The measurement uncertainty is a “non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used” (see Chap. 2.26 in [14]).

Measurement uncertainty is usually calculated in accordance with the internationally recognised ISO/BIPM “Guide to the Expression of Uncertainty in Measurement” (GUM, [1-6]) with the aim of making measurement results comparable worldwide. According to this, all relevant influences affecting the measurand must be taken into account and summarised into a combined measurement uncertainty using a mathematical model that describes the measurement process. The measurement uncertainty is therefore always made up of individual uncertainty contributions that can be attributed to the reference (the standard), the measurement method and the measurement object. When specifying the measurement uncertainty in result reports from accredited calibration laboratories, the GUM is the binding basis for determining the measurement uncertainty. Accordingly, the expanded measurement uncertainty  $U$  is calculated by multiplying the combined standard uncertainty  $u$  by a coverage factor  $k$  according to  $U = k \cdot u$ . The coverage factor  $k$  depends on the probability distribution of the output quantity of the measurement model and the selected coverage probability.

	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	10 / 20

In this document,  $U$  refers to the expanded measurement uncertainty with a coverage probability of approximately 95 %. The expanded measurement uncertainty thus describes an interval around the best estimate of the measurement in which the true value of the measured quantity can be found with a probability of approximately 95 %. With a normal distribution, this corresponds to a coverage factor of  $k = 2$ .

The calculation and visualisation of the measurement uncertainty according to GUM therefore makes it possible to state that the measured value has a certain relationship to the true value which cannot be determined.

### 3.6 Conformity statement

The statement of conformity confirms that defined acceptance criteria are met. In the case of measuring equipment, the determined measurement results are often used to decide whether, for example, limit values (specification limits or tolerances), which define an interval of permissible values, are complied with. If the true value of the measured quantity lies within the tolerance limits, it is considered compliant, otherwise it is considered non-compliant with the specification.


However, the true value of the measurement cannot be determined. The statement of conformity is based on the measured (inherently uncertain) results, which means that there is always a risk that the conformity is assessed incorrectly. However, the risk of incorrect assessment can be calculated by stating the expanded measurement uncertainty, which limits the range of values in which the true value is located with a probability of about 95 %.

According to DIN EN ISO/IEC 17025:2018-03, Chap. 7.8.6 [8], the application and documentation of a decision rule is therefore required when reporting statements of conformity. The decision rule describes “how measurement uncertainty is accounted for when stating conformity with a specified requirement” (see DIN EN ISO/IEC 17025:2018, Chapter 3.7 [8]).

Further information on the concept of decision rules in conformity assessment and examples of their application for calibration and testing laboratories can be found, for example, in ILAC-G8:09/2019 [18].

### 3.7 Test value uncertainty

In some regulations for acceptance and verification tests of measuring equipment, the concept of “test value uncertainty” is used to assess conformity with specified specifications (see, for example, DIN EN ISO 10360-2:2010-06 [19], DIN EN ISO 13385-1:2020-03 [20]). The decision rule to be applied is usually in accordance with the regulation according to ISO 14253-1 [21], if there is no specific requirement accompanying the specification. In addition, it is required that – instead of the measurement uncertainty – the test value uncertainty related to the test value is to be taken into account when determining conformity (see DIN EN ISO 14253-5:2016-12 [15]). However, DIN EN ISO 14253-1:2018-07 [21] does not mention a test value uncertainty. Since the test value uncertainty must not be confused with the measurement uncertainty according to GUM, which is part of the measurement result, the requirement of DIN EN ISO 13385-1:2020-03 [20] is not clear and therefore cannot be implemented consistently. However, it can be assumed that the intention of the authors of the standard DIN EN ISO 10360-2:2010-06 [19] is to use the test value uncertainty instead of the measurement uncertainty 10360-2:2010-06 [19] to use the test value uncertainty *instead of* the measurement uncertainty.

	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	11 / 20

When documenting the decision rules applied in the results reports, it is therefore important to check whether a test value uncertainty or a measurement uncertainty according to GUM, as provided for in DIN EN ISO/IEC 17025:2018-03 [8], has been taken into account.

### 3.7.1 Determination of the test value uncertainty

When calibrating a calliper, the measurement result consists of the determination of the indication error of the calliper from the known value of a measurement standard (material measure) and the associated measurement uncertainty according to GUM. The measurement uncertainty takes into account all relevant influence quantities associated with the reference and the measurement process, including the calliper.

The test value uncertainty quantifies the accuracy of the test value and “is not a measure of the performance of the indicating measuring instrument under test” [16]. However, the influence quantities to be considered in the test value uncertainty depend on the underlying test specification. DIN EN ISO 14253-5:2016-12 [16] provides guidance on the determination of the test value uncertainty.

Furthermore, Annex D in DIN EN ISO 14978:2019-06 [13] provides additional information on the consideration of influence quantities of the test value uncertainty which will be briefly presented here:

#### Influence quantities generally included in the test value uncertainty

- Reference equipment used
  - uncertainty in relation to the metrologically traceable value of the reference device (usually included in the calibration certificate)
  - fluctuation in relation to the representation of the reference standard (e.g. drift)

#### Influence quantities not generally included in the test value uncertainty

- Measuring equipment to be tested
  - fluctuations in the quality of the tested measuring equipment (e.g. repeatability, mechanical accuracy)
  - resolution of the measuring equipment to be tested


#### Permissible test situations

If a permissible test situation is defined as a range or interval, as for example, a permissible temperature range of 18 °C to 22 °C, then all fluctuations within the permissible test situation are not taken into account as contributions to the test value uncertainty.

If the permissible test situation is defined as an exact value (e.g. exactly 20 °C), then all contributions associated with necessary corrections must be taken into account in the test value uncertainty (e.g. uncertainty of the temperature measurement, uncertainty of the product from thermal expansion coefficient and thermally effective length).

#### Influences of the user

If the test specification requires an appropriately qualified user (tester) for a permissible test situation, then uncertainty contributions that are attributable to the user (e.g. measuring force, reading error) are **not** taken into account as contributions to the test value uncertainty (this is described in the regulations dealing with acceptance and verification tests of measuring equipment). In accordance with the requirements of DIN EN ISO/IEC 17025:2018, only competent testers may carry out conformity assessment activities.

	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	12 / 20

By not taking into account influence quantities such as the contributions of the measuring equipment to be tested or the tester, the test value uncertainty is always smaller than the measurement uncertainty according to GUM.

In contrast to the measurement result (consisting of measurement value and measurement uncertainty), the test result alone (consisting of test value and test value uncertainty) does not provide a range in which the true value of the measurand with a defined coverage probability is located. The risks of incorrect conformity decisions with regard to the true value of the measurand or the true indication error cannot therefore be calculated from the test value uncertainty. Here, the measurement uncertainty is absolutely essential.

## 4 Evaluation of requirements using a decision rule based on the test value uncertainty

In this chapter, specific requirements for the calibration and testing of measuring equipment are evaluated in terms of the extent to which they can be fulfilled on the basis of a test value uncertainty. These examples are intended to help ensure standardised communication and application of the test value uncertainty. The requirements of the standard DIN EN ISO 13385-1:2020-03 [10] are used for the examples. The evaluation can also be applied to other standards and regulations for the verification of measuring equipment using test value uncertainty.


### 4.1 Verification of a calliper according to DIN EN ISO 13385-1:2020-03 taking into account the MPE values according to Annex B

According to Chapter 2.44 of ISO/IEC Guide 99:2007-12 [14], verification is the provision of objective evidence that a given item (here: characteristics of the callipers) fulfils specified requirements. In the case under consideration, DIN EN ISO 13385-1:2020-03 [20] represents the specified requirement. In addition to the MPE values, Annex B specifies simple acceptance or rejection as a decision rule for demonstrating conformity or non-conformity, provided that the following applies to the measurement capability index  $C_m$ :  $C_m \geq 4$ . In this respect, verification can be carried out on the basis of a test value uncertainty.

**Supplementary note:** DIN EN ISO 13385-1:2020-03 requires that the measurement capability index  $C_m$  be calculated on the basis of the test value uncertainty instead of the measurement uncertainty. This approach certainly does not correspond to the original intention of JCGM 106 [4], but from the authors' point of view it does not constitute an impermissible requirement. However, since the measurement capability index  $C_m$  is calculated in the original sense (and in particular also according to its definition in ISO/TR 14253-6:2012) on the basis of the standard measurement uncertainty  $u$  (and not with a test value uncertainty) to  $C_m = \frac{T}{4u}$  (with the tolerance interval  $T$ ), there is a risk of misinterpretation here. A clarification of the terminology would be desirable, if not necessary.

### 4.2 Calibration of a calliper according to DIN EN ISO 13385-1:2020-03

The test procedure described in DIN EN ISO 13385-1:2020-03 [20] for checking the metrological characteristics of a calliper can also serve as the basis for calibration. DIN EN ISO 13385-1:2020-03 Chapter 6.2 [20] refers to the measurement uncertainty associated with a test value as the test value uncertainty and provides this as the basis for the decision rule. In accordance with the requirements of DIN EN ISO/IEC 17025:2018-03 Chapter 7.8.4

	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	13 / 20

“Specific requirements for calibration certificates”, the measurement uncertainty of the measurement result must be documented [8]. The determination of the measurement uncertainty according to GUM [1-6] is therefore mandatory as part of a calibration, and must be documented accordingly in the results report. Simply stating the test value uncertainty does not fulfil this requirement.

#### 4.3 Conformity assessment of a calliper according to DIN EN ISO 13385-1:2020-03 taking into account the MPE values according to Annex B

According to DIN EN ISO/IEC 17025:2018-03 [8], the following requirements essentially apply to the documentation of the conformity statement by a laboratory:

- 1) “7.1.3 When the customer requests a statement of conformity to a specification or standard for the test or calibration (e.g. pass/fail, in-tolerance/out-of-tolerance), the specification or standard and the decision rule shall be clearly defined. Unless inherent in the requested specification or standard, the decision rule selected shall be communicated to, and agreed with, the customer.”
- 2) “7.8.6.1 When a statement of conformity to a specification or standard is provided, the laboratory shall document the decision rule employed, taking into account the level of risk (such as false accept and false reject and statistical assumptions) associated with the decision rule employed, and apply the decision rule.”  
“NOTE Where the decision rule is prescribed by the customer, regulations or normative documents, a further consideration of the level of risk is not necessary.”

In the case under consideration, DIN EN ISO 13385-1:2020-03 [20] represents the basis for the decision rule regarding the statement of conformity. In Annex B the decision rule is clearly defined by simple acceptance or rejection under the condition that the measurement capability index  $C_m \geq 4$  (see supplementary note in chapter 4.1). The requirements of 7.1.3 are thus completely fulfilled.


Since the decision rule is specified in DIN EN ISO 13385-1:2020-03 [20] and thus in a normative document, the requirement to specify the risk in accordance with the note to 7.8.6.1 does not apply.

The statement of conformity can therefore be made on the basis of the decision rule of simple acceptance or rejection. This procedure is discussed in ILAC-G8:09/2019 in Chapter 5.1 [18]: “Cases where test standards have taken typical measurement uncertainty into account when setting the tolerance limits and the acceptance limit then equals the tolerance limit.”

The test value uncertainty is taken into account here as secondary condition when determining the measurement capability index  $C_m$  (see supplementary note in Chap. 4.1) but does not otherwise replace the measurement uncertainty. For conformity assessments, the measurement uncertainty must be known and documented (see Chap. 4.2), even if it is not directly included in the determination of the conformity statement.

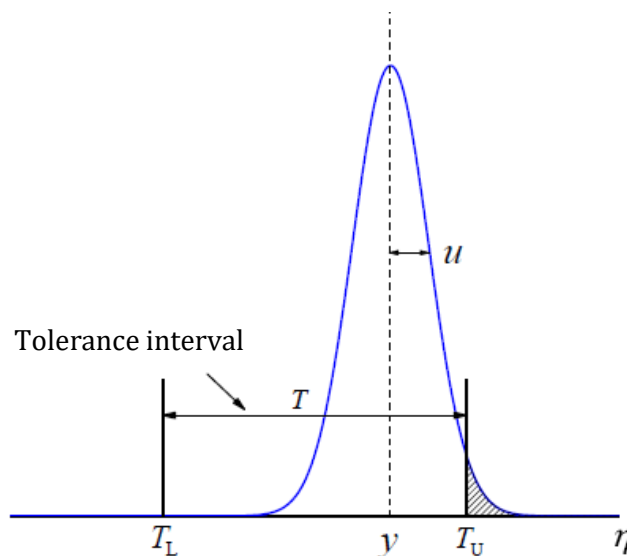
#### 4.4 Determining the risk of a false conformity statement in the evaluation of a calliper in accordance with DIN EN ISO 13385-1:2020-03 taking into account the MPE values according to Annex B

In the case under consideration, the specific risk according to ILAC-G8:09/2019 [18] is based on measurements of a single object. The specific risk of a false statement of conformity (related

	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	14 / 20

to the true indication error of the present calliper at a defined length) corresponds here – as with all statements of conformity based on measurements – to the probability that the assumed object is not compliant (shaded area in Fig. 2, from Chap. 3.3.13 in [4]).

There is the possibility of determining the risk of an incorrect statement on the basis of a test value uncertainty. However, this possibility does not describe the risk that the conformity statement is incorrect with regard to the deviation of the indication from the true value of the present calliper at a defined length. For this, all relevant influence quantities must be taken into account and not only those that are included in the test value uncertainty.



**Figure 2:** The knowledge about the measurand  $Y$  (the measurable property of interest, e.g. the deviation of the reading from the true value of the present calliper at a defined length) after a measurement is represented by a normal distribution with the best estimate  $y$  and the associated standard uncertainty  $u$ . Conforming values for the measurand  $Y$  lie within the bilateral tolerance interval. The shaded area outside the tolerance interval indicates the probability that the object does not meet the specification. Source of figure: [4] Figure 5.


#### 4.5 Ensuring metrological traceability of the calibration results according to DIN EN ISO 13385-1:2020-03

According to DIN EN ISO/IEC 17025:2018-03 Annex A.2 [8], metrological traceability is reached by ensuring:

- indication of the measurand (quantity that is measured),
- a documented and uninterrupted chain of calibrations leading back to indicated and suitable references (suitable references are national or international standards as well as intrinsic standards),
- that the measurement uncertainty for each step in the traceability chain is determined following agreed procedures,
- that each step of the chain is carried out using suitable procedures, including the measurement results and their associated and recorded measurement uncertainties,
- that the laboratories carrying out one or more steps in the chain prove their technical competence.

Requirement a) is fulfilled by the testing procedure described in DIN EN ISO 13385-1:2020-03 [20].

Requirement b) is fulfilled because DIN EN ISO 13385-1:2020-03 [20] prescribes the use of calibrated standards.

	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	15 / 20

Requirements c) and d) are fulfilled if the measurement uncertainty associated with the measurement result in the calibration of the calliper according to DIN EN ISO 13385-1:2020-03 [20] is indicated. According to Chap. 4.2, however, the sole indication of the test value uncertainty will not suffice.

Requirement e) is generally fulfilled if the calibration is carried out by an accredited calibration laboratory.

Given that the proof of metrological traceability of the measurement results is a basic prerequisite to fulfil the requirements of DIN EN ISO/ IEC 17025:2018 (for example during accreditation as calibration laboratory), the sole indication of the test value uncertainty according to DIN EN ISO 13385-1:2020-03 [20] will not suffice.


#### 4.6 Metrological traceability of the measured values determined by means of a calliper calibrated according to DIN EN ISO 13385-1:2020-03

This requirement is essential for those using callipers in conformity assessment (customers of calibration laboratories).

The requirement is often met by applying an internal test instruction in conjunction with an measurement process capability analysis (e.g. in accordance with VDA Volume 5). However, the factors “a)” to “e)” mentioned in Chapter 4.5 must also be met here. With regard to the test value uncertainty, point d) from Chapter 4.5 should be considered in particular at this point. It is assumed that the remaining points from Chapter 4.5 are met.

Since Annex B [20] of DIN EN ISO 13385-1:2020-03 specifies the simple acceptance or rejection as decision rule, the measurement uncertainty **from the calibration certificate** of the calliper (the test value uncertainty cannot be used at this point!) must be explicitly taken into account when determining the measurement uncertainty **during the application** of the calliper. In addition, the permissible error limits (MPE) of the calliper gauge used must be taken into account if the test instruction allows any calibrated calliper gauge to be used for the measurement. Alternatively, the known indication error (from the calibration certificate) must be corrected.

Therefore, a test value uncertainty cannot be directly used for the measurement process capability according to VDA Volume 5. To avoid ambiguity and confusion, the test value uncertainty should not be listed under the measurement results in a calibration certificate. If the test value uncertainty is to be stated, this can be done as a separate statement or table.

	<b>Test value uncertainty in conformity assessment</b> <a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	16 / 20

## 5 Possible representation in the calibration certificate when applying DIN EN ISO 13385-1:2020-03 Annex B

The following example shows measurement results for the calibration of a calliper up to 150 mm. The statement of conformity was made at the customer's request in accordance with DIN EN ISO 13385-1:2020-03 Annex B [20].

### Example: Calliper 0 to 150 mm DIN EN ISO 13385-1:2020 Form A Scale interval 0,05 mm

Characteristic / designation	Remark	Evaluation
Visual inspection		OK
Functional test		OK

Characteristic / designation	Desired value	MPE	Actual value	Expanded measurement uncertainty	Unit	Evaluation
Length	0.00	±0.05	0.00	0.030	mm	OK
Length (outside)	30.00	±0.05	29.95	0.031	mm	OK
Length (centre)	30.00	±0.05	30.00	0.031	mm	OK
Length (inside)	30.00	±0.05	30.00	0.031	mm	OK
Length (outside)	41.30	±0.05	41.30	0.032	mm	OK
Length (inside)	41.30	±0.05	41.35	0.032	mm	OK
Length (outside)	131.41	±0.10	131.45	0.034	mm	OK
Length (inside)	131.41	±0.10	131.50	0.034	mm	OK
Inside measurement	4.00	±0.05	4.10	0.031	mm	not OK
Inside measurement	25.01	±0.05	25.05	0.031	mm	OK
Depth measurement	41.30	±0.05	41.45	0.032	mm	not OK
Stepwise measurement	41.30	±0.05	41.30	0.032	mm	OK.

The measurement results obtained refer to the calibration item at hand.

The specification limits and decision rule were taken from DIN EN ISO 13385-1:2020 Annex B.

The decision rule is based on the simple criterion of acceptance or rejection, taking into account the uncertainty of the test value according to DIN EN ISO 14253-5:2016-12.


The measurement capability index  $C_m$  (calculated according to DIN EN ISO 13385-1:2020 on the basis of the test value uncertainty) was determined to be  $C_m \geq 4$ .

**Conformity decision:** **not OK**

#### Measurement uncertainty

The expanded measurement uncertainty  $U$  is stated; it is obtained by multiplying the standard measurement uncertainty by the coverage factor  $k = 2$ . It was determined in accordance with EA-4/02 M: 2022. The value of the measurand lies within the assigned value interval with a probability of approximately 95 %.



	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	17 / 20

## 6 Summary

The test value uncertainty describes an uncertainty associated with the test value when carrying out tests that can, for example, be used to verify measuring equipment. According to DIN EN ISO 14978:2019-06 [13], Annex D, the test value uncertainty does not usually include influences of the tested measuring equipment (including its resolution). Depending on the permissible test situation, other influences are also excluded. Therefore, and in contrast to the measurement uncertainty, the test value uncertainty does not provide a measure of the quality of the measured values. The metrologically significant conclusion that measurement results are comparable by stating the measurement uncertainty (in the sense of VIM Chapter 2.46 [7]) does not apply to test value uncertainties. Unlike the measurement uncertainty according to GUM [1-6], the test value uncertainty does not form part of the calibration result. The test value uncertainty alone does not provide any evidence of the metrological traceability of the measurement results. The test value uncertainty describes an uncertainty attributed to the test value when carrying out tests serving for example the verification of measuring equipment. According to DIN EN ISO 14978:2019-06 [13], Annex D, the test value uncertainty does usually not include influences originating from the measuring equipment (including its resolution).


The test value uncertainty can therefore not be regarded as a substitute for the measurement uncertainty. However, it can be a useful addition in the context of calibrations. For example, the secondary condition of the measurement capability index  $C_m \geq 4$  is used to limit the maximum permissible test value uncertainty even if simple acceptance or rejection is specified as a decision rule. This ensures that only suitable reference standards and environmental conditions (provided that exact environmental conditions are defined as a permissible test situation) are used or prevail.

### Supplementary note:

In practice, the test value uncertainty should always be explicitly referred to as such. Otherwise, there is the risk of it being confused with the measurement uncertainty. The following wording, which is taken from DIN EN ISO 13385-1 [20], serves as an example:


“As discussed in ISO 14253-5, when the user is sufficiently skilled, any variation in the test values associated with the skills of the user of the calliper is generally not included as a contributor to the measurement uncertainty.”

In fact, if the uncertainty of measurement were meant here, this statement would be simply wrong. However, it is clear from the context that it is not the uncertainty of measurement that is meant here, but rather the test value uncertainty. So, in this case, the statement is correct according to DIN EN ISO 14978:2019-06 [13], Annex D.

	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	18 / 20

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	<p>Test value uncertainty in conformity assessment</p> <p><a href="https://doi.org/10.7795/550.20240702">https://doi.org/10.7795/550.20240702</a></p>	DKD-L 4-1	
		Edition:	04/2024
		Revision:	0
		Page:	19 / 20

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