

esz Calibration Certificate

Terms and Definitions

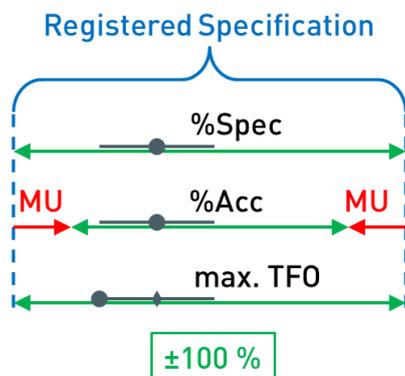
Foreword

esz AG calibration & metrology is accredited as a calibration laboratory and proficiency testing provider in accordance with DIN EN ISO/IEC 17025:2018 and DIN EN ISO/IEC 17043:2023. The requirements for the management system of both standards are generally in accordance with the principles of DIN EN ISO 9001. This means that esz AG also meets the principles of DIN EN ISO 9001 or comparable quality management guidelines for calibration. The need for additional certification of the esz AG according to DIN EN ISO 9001 is therefore not required.

This document contains explanations of terms and further information on the esz calibration certificate. This information is deliberately made available to everyone – customers, competitors and esz internally. This ensures that all parties involved speak the same language and have a common understanding. The content of this document is based on current normative requirements but also explains esz-specific terms and definitions.

Glossary

- **%TOL:** The following types of Occupied Tolerance Calculation are possible; the results are given in relative terms in %:
 - **Percentage of specification interval (%Spec):** Position of the deviation relative to the registered **specification** (standard calculation method).
 - **Percentage of acceptance interval (%Acc):** Position of the deviation relative to the registered **specification** minus the reported **measurement uncertainty**.
 - **Maximum tolerance field occupation (max. TFO):** Maximum position of the deviation plus or minus the reported **measurement uncertainty** relative to the registered **specification**.



- **%Spec:** Only for the Occupied Tolerance Calculation **maximum tolerance field occupation**, an additional column in the measurement blocks is indicating the position of the deviation relative to the registered **specification**.
- **Adjustment:** Intervention on the device under test intended to minimise the **deviation**.
- **Deviation:** Difference between measured value and nominal value. The deviation is not reported as soon as the calibration value and the measured value are known to be the same. **Rounding** may affect the representation.
- **Deviation type:** The following formats can be used to indicate the **deviation**:
 - **A:** Absolute (measurement unit)
 - **D:** In decibels (dB)
 - **R:** Relative (% , 10^{-6} , 10^{-9} , ...)
- **Issue date:** Shown in the footer of the calibration certificate, this date represents the creation date of this revision of the report.
- **Rem.:** Indication per measurement; six results are possible for the column "Remark"¹:
 - **Pass** - without remarks
>95% probability of being within specification (ILAC-G8:09/2019 Fig. 5, Pass)
 - **!**
Intervention threshold exceeded, >95% probability of being within specification
 - **Conditional Pass** - ?
with a probability of >50% to 95% of being within the specification, taking into account the measurement uncertainty (MU) (ILAC-G8:09/2019 Fig. 5, Conditional Pass)
 - **?!**
over the intervention threshold exceeded but with a probability of >50% to 95% of being within the specification, taking into account the MU
 - **Conditional Fail** - X?
with a probability of >50% to 95% of being outside the specification, taking into account the MU (ILAC-G8:09/2019 Fig. 5, Conditional Fail)
 - **Fail** - X
>95% probability of being outside the specification (ILAC-G8:09/2019 Fig. 5, Fail)
- **DAkKS:** Deutsche **Akkreditierungsstelle** (German Accreditation Body)

¹ The basis of the identification is a non-binary conformity statement with a guard band as described in ILAC-G8:09/2019, section 4.2.3. The guard band corresponds to the applied measurement uncertainty.

- **DGUV:** Tested according to DIN EN 50678 (VDE 0701) or DIN EN 50699 (VDE 0702) in accordance with DGUV Vorschrift 3
- **Intervention/warning threshold:** Set to 80% of specification per default and adaptable to customer requirements
- **Incoming Test/Outgoing Test:** Identification of a calibration before (incoming test) and after (outgoing test) an intervention on the device under test (e.g. an adjustment or repair) that has an influence on the measurement results or conformity assessment.

In accordance with the specific requirements for calibration certificates in section 7.8.4.1 d) of DIN EN ISO/IEC 17025:2018, results must be documented before and after an intervention. The incoming test is a key element of quality assurance, trackability and risk assessment. It enables the current state of the device under test to be assessed before an intervention. This is essential for analysing past measurement data of the device under test and deciding on necessary corrective actions.

The outgoing test documents the result of the adjustment or repair.

- **Approval date:** Date of confirmation of the calibration results and the conformity assessment by the authorized person
- **ILAC:** International Laboratory Accreditation Cooperation
- **ILAC evaluation:** Applied / defined (binary) decision rule for the conformity statement; the values appear in accordance (black) or not in accordance (marked **red**) with the specifications

		Decision Rule				
		ILAC evaluation None	ILAC evaluation PASS	ILAC evaluation FAIL		
Indication	Pass Without remark				Conformity Statement	Passed
	!					
	Conditional Pass ?					
	?!					
	Conditional Fail X?					
	Fail X					

- **PASS:** Standard decision rule according to the QM system of esz AG. Measurement results according to ILAC-G8:09/2019 Fig. 5, Pass and Conditional Pass are assessed as conforming to the specifications. Cases according to ILAC-G8:09/2019 Fig. 5, Conditional Fail and Fail are not considered to comply with the specifications.
- **None:** Decision rule according to ILAC evaluation "PASS" but without risk marking, i.e. question marks do not show during calibration and in the calibration certificate.
- **FAIL:** Decision rule according to DIN EN ISO 14253-1:2018-5.2 (on customer request). Measurement results according to ILAC-G8:09/2019 Fig. 5, Pass are assessed as conforming to the specifications. Cases according to ILAC-G8:09/2019 Fig. 5, Conditional Pass, Conditional Fail and Fail are not considered to comply with the specifications.
- **Date of Calibration:** Date or date range on which the calibration occurred.
- **Calibration Label:** Sticker attached to the device under test, providing an explicit reference to the calibration certificate
- **Calibration:** Documented metrological comparison between standard (esz AG) and device under test (customer) with determination of the **deviation**. **Adjustment** or repair can be carried out as a consequence after the calibration. After such an intervention, an additional calibration is required (see **Incoming Test/Outgoing Test**).
- **Nominal value:**
 - **Calibration of sources (including gauges):** The value set or indicated on the device under test.
 - **Calibration of measurement devices:** The value set or indicated on the standard.
- **Calibration Mark:** Unique identification of the calibration. This mark consists of the calibration certificate number, an identifier of the laboratory ("D-K-15019" for accredited calibration certificates or "esz AG" for factory calibration certificates) and the (month-specific) calibration date. It is written in the header of the calibration certificate
Examples: 405364-01-D-K-15019-2021-01 or 405364-02-esz AG-2021-01
- **Calibration Certificate:** Report according to the requirements of DIN EN ISO/IEC 17025:2018, Section 7.8. At esz AG calibration & metrology, this applies not only to accredited calibration certificates, but also in particular to the result reports of factory calibrations, including the requirements for metrological traceability. Nevertheless, they may not be accepted as proof of metrological traceability, as result reports without an accreditation symbol do not fall within the scope of the Multilateral Agreement (MLA) of the European co-operation for Accreditation (EA).

- **Calibration Certificate Number:** Located on the first page of the calibration certificate, this number is a unique identification for this calibration certificate.
- **Statement of Conformity:** Statement whether given results meet specified requirements or not (“Passed” or “Failed”)², meaning that measurements comply with specifications (successful conformity assessments per measurement step).

The definition of the specifications according to the manufacturer’s data or application requirements was agreed on at the time the order was placed.

A calibration is assessed as **Passed** if a successful statement of conformity is available for all specified measurement steps. A calibration is assessed as **Failed** if there is no successful statement of conformity or a defect for at least one specified measurement step.

- **LWL:** Optical waveguide
- **Multiple Values:** Repeatedly obtained measured values and nominal values are reported in the calibration certificate as an arithmetic mean value and marked distinctly. Additionally, the number n of values is reported. The stated deviation corresponds to the difference between the respective mean values of the measured value and the nominal value. The standard deviation of the stated deviation is considered in the measurement uncertainty (MU). A possible statement of conformity is carried out exclusively based on the mean values.

Nominal Value	Measured Value	Specification	Deviation	%TOL	MU
Ø 100,0 °C (n=3)	Ø 99,9 °C (n=3)	±1,5 %; ±1 D	-0,1 K	7 %	0,57 K
Ø 199,9 °C (n=3)	Ø 198,9 °C (n=3)	±1,5 %; ±1 D	-1 K	31 %	0,99 K

Optionally (at the customer’s explicit request), the underlying multiple values can be stated for information purposes in addition to the mean value (their additionally stated measurement uncertainty does not include the present variation).

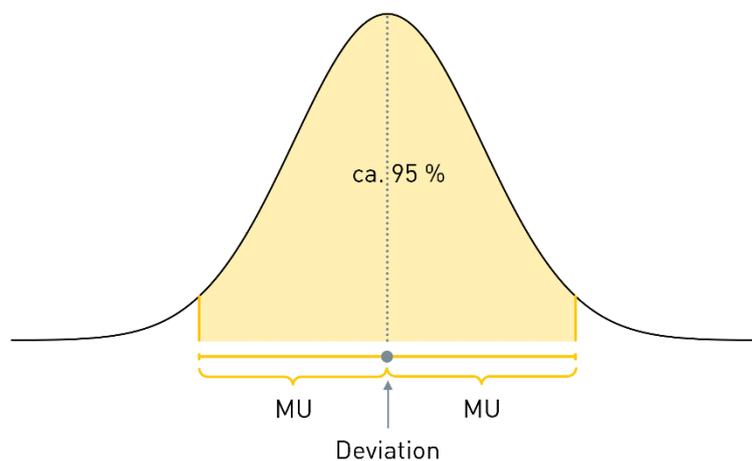
Nominal Value	Measured Value	Specification	Deviation	%TOL	MU
1,00000 V	0,97948 V		-0,02052 V		0,0059 • 10 ⁻³ V
1,00000 V	1,01946 V		0,01946 V		0,0059 • 10 ⁻³ V
1,00000 V	0,99989 V		-0,00011 V		0,0059 • 10 ⁻³ V
1,00000 V	1,00381 V		0,00381 V		0,0059 • 10 ⁻³ V
Ø 1,00000 V (n=4)	Ø 1,00066 V (n=4)	±0,045 V	0,00066 V	1 %	0,016 V

² DIN EN ISO/IEC 17000:2004

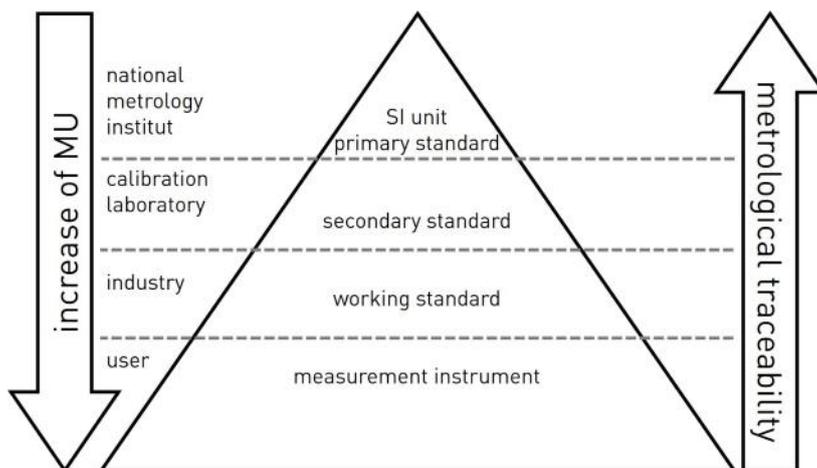
- **MU:** Measurement uncertainty

The measurement uncertainty is a non-negative parameter that takes into account all relevant influence quantities of a measurement and their effects. The measurement uncertainty depends on the measurand and the measurement method.

According to EA-4/02 M: 2022, the determination of the measurement uncertainty is based on a statistical approach, whereby each influence quantity is described by an appropriate probability density. A normal distribution (Gaussian) is assumed for the measurement result. A complete measurement result thus always requires the statement of a deviation (maximum of the normal distribution) and the associated measurement uncertainty (width of the normal distribution). The measurement uncertainty spans a symmetrical interval around the deviation in which the true value can be found with a probability of approx. 95 %.



Furthermore, the measurement uncertainty provides the basis for the metrological traceability. Metrological traceability to an SI unit or primary standard cannot be established without knowing the measurement uncertainty of each level within the metrological traceability pyramid. To establish metrological traceability to the next higher level, calibration with the higher-level (reference) standard is required.



- **MU (-) and MU (+):** In contrast to the symmetrical representation of the measurement uncertainty described above, an asymmetrical representation is chosen for certain measurands or parameters. The measurement uncertainty spans an asymmetrical interval around the deviation in which the true value can be found with a probability of approx. 95 %.



- **Measured value:**
 - **Calibration of sources (including gauges):** The value read on the standard.
 - **Calibration of measurement devices:** The value read on the device under test.
- **Next calibration:** Date for the next calibration agreed within the order placement. The definition and compliance to intervals for recalibrations lie within the user's responsibility
- **PTB:** Physikalisch-Technische Bundesanstalt (the National Metrology Institute of Germany)
- **Relative** (% , 10^{-6} , 10^{-9} , ...)
 - **Deviation** refers to
 - the nominal value when calibrating **sources (including gauges)**
 - the nominal value when calibrating **measurement devices**
 - **Measurement Uncertainty** refers to
 - the measured value when calibrating **sources (including gauges)**
 - the nominal value when calibrating **measurement devices**
- **Rounding:** All calculations, including the statement of conformity, are based on numerical values with the maximum available digit precision. The resulting numerical values in the calibration certificate are rounded. Resolution and readability can influence the rounding digit.

- **Rounding of the relative deviation:** The representation of the deviation for the deviation type relative (R) depends on how the number of significant digits of the deviation differs from the number of significant digits of the measurement uncertainty if the relative deviation were to be represented with the resolution and exponential notation of the MU. esz has defined a representation rule that distinguishes between three cases:

- Case 1: Deviation (Dev.) smaller than the measurement uncertainty ($|Dev.| < MU$)
- Case 2: Deviation greater than or equal to the measurement uncertainty ($|Dev.| \geq MU$)
- Case 3: Deviation is much greater than the measurement uncertainty ($|Dev.| \gg MU$)
If the difference between the significant digits reaches 3 (or more), the deviation is considered to be "much greater".

Implementation of the representation in the certificate to improve readability:

- Case 1 ($|Dev.| < MU$): Representation of the deviation with two significant digits, rounding to the last resulting digit, including a switch from e.g. % to 10^{-6} or 10^{-9}
 - Case 2 ($|Dev.| \geq MU$): Representation of the deviation with the resolution of the relative measurement uncertainty, rounding to the last resulting digit
 - Case 3 ($|Dev.| \gg MU$): Representation of the deviation with two significant digits, rounding to the last resulting digit, including a switch from e.g. 10^{-9} to 10^{-6} or %.
- **Specification:** Documented limits around the **nominal value** used for the **statement of conformity**.

In addition to the representation in the unit of the nominal value, the following notations are used in the calibration certificate:

- **%:** percent (10^{-2}) of the nominal value
 - **%FS:** percent (10^{-2}) of the range
 - **ppm:** parts per million (10^{-6}) of the nominal value
 - **ppmFS:** parts per million (10^{-6}) of the range
 - **ppb:** parts per billion (10^{-9}) of the nominal value
 - **ppbFS:** parts per billion (10^{-9}) of the range
 - **D:** Digit (smallest displayable or settable decimal place of the device under test)
- **TUR: Tolerance Uncertainty Ratio.** Relationship between tolerance field and measurement uncertainty (also specification measurement uncertainty ratio)

- **Ambient Conditions:** The ambient conditions are documented by indicating the measured values for temperature, relative humidity and barometric pressure. The values are also given in the form of ranges of measured values. The respective measured values of the ambient conditions are taken and documented at the beginning and end of the calibration. Parameters that are not relevant for the calibration can be marked with "n.a.". In addition, the expanded measurement uncertainty (coverage probability of approx. 95 %) of the measured values is specified (e.g. ± 1 K).

3. Ambient Conditions

Temperature (22,9 to 23,0) °C ± 1 K

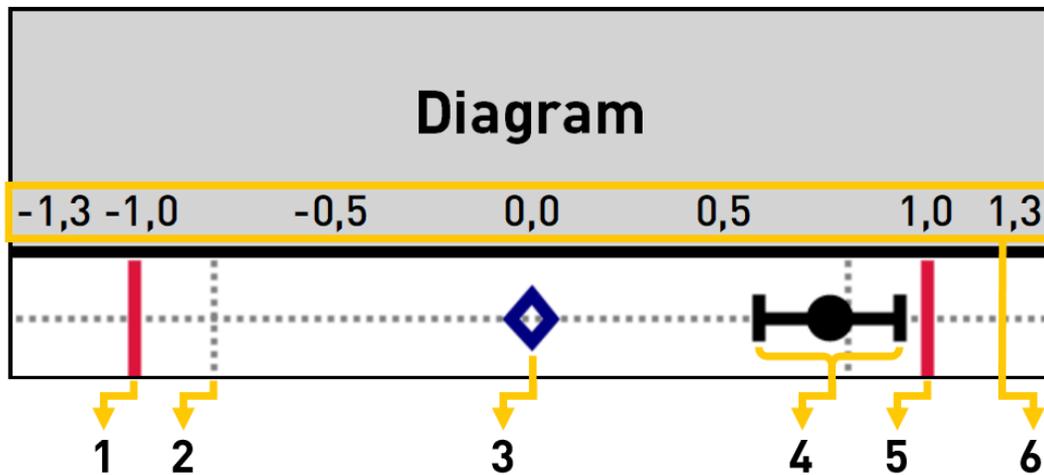
Relative Humidity 50 % ± 3 %

Barometric Pressure 1000 mbar ± 5 mbar

- **Calibration equipment and standards:** Documentation of the traceability of the present calibration by specifying the calibration standards used, including information on the calibration status of the standards and their traceability. If applicable, the traceability to national standards is included.

This documentation fulfils the requirement of DIN EN ISO/IEC 17025:2018, section 7.8.4.1c) for indication of traceability and is mandatory in the case of a factory calibration certificate. For an accredited calibration certificate, this may be omitted, since the accreditation of esz AG calibration & metrology by DAkkS already provides proof of traceable calibration.

- Diagram:** Visualisation of results with a **Statement of Conformity**. The representation is normalized to the registered **Specification** or a multiple of the **Measurement Uncertainty**.



- 1: Lower specification limit
- 2: Intervention/warning threshold
- 3: Deviation 0,0
- 4: Measured deviation with measurement uncertainty
- 5: Upper specification limit
- 6: Deviation scale