Deutsche Akkreditierungsstelle GmbH

Annex to the Accreditation Certificate D-K-15151-01-00 according to DIN EN ISO/IEC 17025:2018

Valid from: 20.08.2020

Date of issue: 20.08.2020

Holder of certificate:

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Calibration in the fields:

Dimensional quantities

Length

- **Gauge blocks**
- **Diameter**
- **Form error**
- **Linear thermal expansion coefficient**
- **Line scales, distances**

Coordinate measuring technology

- **Virtual coordinate measuring machines**
- **Application coordinate measuring machines**
- **Step gauges**

Abbreviations used: see last page

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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Length				
Gauge blocks made of steel and ceramics according to DIN EN ISO 3650:1999	10 mm to 1000 mm nomonal size	DKD-R 4-3 part 3.1:2018 and VA-53_V01:2018-10 Measurement of the mean size compared with a steel step gauge	$0{,}10\ \mu m + 0{,}4 \cdot 10^{-6} \cdot L$	L = gauge block length
		Determination of the parallelism of the measured surfaces within a diameter of 6 mm around the mean size	$0{,}10\ \mu m + 0{,}2 \cdot 10^{-6} \cdot L$	
Setting rings and setting plugs Inside and outside cylinder	diameter 10 mm to 100 mm nomonal size	DKD-R 4-3 part 4.1:2018 and VA-56_V01:2018-10 VA-57_V01:2018-10 Measurement of the two-point diameter compared with a ring or plug and a step gauge		D = measured diameter
Diameter			$0{,}1\ \mu m + 0{,}4 \cdot 10^{-6} \cdot D$	
Roundness error			0,1 µm	
Straightness error			0,2 µm	
Parallelism error of the surface lines			0,25 µm	
Setting rings and setting plugs Inside and outside cylinder, balls and hemispheres	diameter 3 mm to 370 mm nomonal size	VA-59_V01:2018-10 VA-60_V01:2018-10 VA-61_V01:2018-10 Rondcom 54 with Multi position measurement		
Roundness error			$0{,}01\ \mu m + 0{,}05 \cdot 10^{-6} \cdot RONt$	$RONt$ = roundness error
Balls	diameter 10 mm to 100 mm nomonal size	VA-58_V01:2018-10 Measurement of the two-point diameter compared with a ball and a step gauge		
Diameter			$0{,}1\ \mu m + 0{,}4 \cdot 10^{-6} \cdot D$	
Roundness error			0,1 µm	
Taper sleeves and taper mandrels	10 mm to 150 mm nomonal size	VA-62_V01:2018-10 VA-63_V01:2018-10 Measurement of the two-point diameter in two measurement heights compared with a ring or plug and a step gauge		
Diameter			$0{,}2\ \mu m + 0{,}4 \cdot 10^{-6} \cdot D$	D = measured diameter
Taper angle			(150 mm / L)"	L = distance between the two measurement heights
Roundness error			0,1 µm	
Straightness error			0,5 µm	

[1)] The expanded uncertainties according to EA-4/02 M:2013 are part of CMC and are the best measurement uncertainties within accreditation. They have a coverage probability of approximately 95 % and have a coverage factor of k = 2 unless stated otherwise. Uncertainties without unit are relative uncertainties referring to the measurement value unless stated otherwise.

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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Thermal expansion coefficient CTE of workpieces and standards	Maximum length for 1D bodies: 1650 mm maximum area for 2D bodies: 1650 mm x 650 mm	VA-54_V01:2018-10 Measurement of the linear thermal expansion coefficient CTE within a temperature range of 20 °C to 30 °C	$U_{CTE}(t) = 0{,}03 \cdot 10^{-6}\ K^{-1} + 0{,}005 \cdot CTE(t) + (0{,}025 \cdot 10^{-6}\ K^{-1}\ m) / L$ for 20 °C ≤ t ≤ 30 °C	L = measured length CTE is the coefficient of thermal expansion in $10^{-6}\ K^{-1}$ Example: $U = 0{,}11 \cdot 10^{-6}\ K^{-1}$ for steel: L = 1 m $U = 0{,}14 \cdot 10^{-6}\ K^{-1}$ for steel: L = 0,5 m The calibration certificate includes the linear term of the CTE as a constant value, or the CTE depending on the temperature. Depending on the temperature indication of the CTE, a model of linear and quadratic components of the CTE was documented.

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Coordinate measuring technology				
Prismatic workpieces	Coordinate measuring machines with one for the implementation of the calibration procedure specified measuring volume with the dimensions: X = 1200 mm Y = 1800 mm Z = 650 mm (the indications X, Y, Z designate the coordinate axes in manufacturer notation) Calibrations are performed with probing elements with a diameter in range 0,3 mm to 40,0 mm.	Tactile measurement using a calibrated coordinate measuring machine and determination of geometric parameters defined through control geometries (single-points, straight lines, planes, circles, balls, cylinders, tapers, toroids) using the evaluation software of the coordinate measuring machine. The measuring points can be detected by single point or scanning method. Single-point measuring can be carried out either with fixed, predefined measuring force or with extrapolation on measuring force zero. Single point measurements in the form of „Self-centering measurements" are not used within the framework of the accreditation. Excluded are evaluations of gearing parameters and free form surfaces and the use of a turntables in the measuring process. The calibration values can be determined in a substitution and multilayer method by averaging in order to reduce the measurement uncertainty.	The uncertainty of measurement is determined according to ISO/TS 15530-4: 2008 "Evaluating task specific measurement uncertainty using simulation" using the "Virtual Coordinate Measuring Machine" method. The measurement uncertainty for bidirectional length-measurements on steel artefacts in measuring positions according to DIN EN ISO 10360-2:2010 and in the specified measurement volume is for a central styluses (zero distance between center of the probing ball and the pinole axis) maximum: U_{E0} = 1,5 µm + 1,5 · 10^{-6} · L and for measurements with lateral stylus (150 mm distance between center of the probing ball and the pinole axis) maximum: U_{E150} = 1,5 µm + 1,5 ·10^{-6} · L The smallest applicable measurement uncertainty for bidirectional length measurements on test pieces made of steel and of length L is in the specified measuring volume: L = 20 mm U = 0,5 µm L = 540 mm U = 1,0 µm L = 1060 mm U = 1,5 µm	L = measured length The measurement uncertainty is task-specific. Therefore, no smallest applicable measurement uncertainty can be specified for any measuring tasks. The here specified measurement uncertainties are exemplary for the respectively described measuring tasks. For general measuring tasks referred to the accredited scope the measuring uncertainty could be significant differently. The specified uncertainty in the calibration certificate only refers to the used measurement and evaluation strategy. This includes measuring point distribution, filtering of the measured values and outlier elimination. The measurement and evaluation strategy is explicitly documented in the calibration certificate. The dimension of a task-specific measurement uncertainty can be estimated based on the information of a inspection plan. The laboratory can do this before the real measurement starts.

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Prismatic workpieces	Coordinate measuring machines with a calibrated measuring volume of: X = 1200 mm Y = 1800 mm Z = 650 mm		The measurement uncertainty for diameter and form measurements on a ball made of ceramic with nominal diameter 25 mm, measured in scanning mode and with a measuring strategy according to DIN EN ISO 10360-4:2003, is in the specified measuring volume: for the determination of the form deviation (evaluation to Chebyshev) U = 1,3 µm for the determination of the diameter (evaluation to Gauss) U = 0,8 µm	The stated measurement uncertainties for the scanning mode have been determined in consideration of an wave filter according to DIN EN ISO 16610-21:2013 with a cut-off wavelength of 150 W/U.
Two-point distance measurements of prismatic bodies	to 1540 mm	Substitution measurement on a calibrated coordinate measuring machine with tactile single-point measurement. Calculation of the measurement uncertainty using the „Virtual coordinate measuring machine" method on the basis of ISO/TS 15530-4: 2008 taking account of the substitution effect.	0,2 µm + 0,5 · 10^{-6} · L	L = measured length The substitution is carried out with a DAkkS-calibrated steel step gauge of 1540 mm length. The substitution measurements refer to two-point distance measurements from direct measurements or from intersections of geometry elements.
Ball strips with internal or external balls and hole strips	to 1500 mm nomonal size distance of the ball or borehole centre points	VA-52_V01:2018-10 Measurement of the ball or borehole distance compared with a steel step gauge	0,12 µm + 0,4 · 10^{-6} · L	L = distance of the ball or borehole centre points
Ball plates with internal or external balls and hole plates	to 1150 mm nomonal size diagonal distance of the ball or borehole centre points and a maximum aspect ratio of 2:1	VA-55_V01:2018-10 Measurement of the ball or borehole distance compared with a steel step gauge	0,12 µm + 0,4 · 10^{-6} · L	L = distance of the ball or borehole centre points

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1]	Remarks
Length standards for optical metrology	> 0 mm to 300 mm	VA-70_V03:2019-02 Optical 1D distance measureents between symmetrical 2D structures (center of a circle, middle of the line, center of a reticle) nates with a calibrated coordinate measuring machine thanks to single-point proping with a video sensor compared to an optical scale. In the case of lines, the distance is measured via the center of the line or via a line as a unidirectional distance.	0,08 µm + 0,02 ·10^{-6} · L	L = measured length Materials with a coefficient of linear thermal expansion, i.e. quartz glass $\lvert\alpha\rvert \leq 1{,}0 \cdot 10^{-6}$ K^{-1} and its uncertainty $U(\alpha) < 0{,}5 \cdot 10^{-6}$ K^{-1}
			0,08 µm + 0,04 ·10^{-6} · L	Materials with calibrated uncertainty of the coefficient of linear thermal expansion $U(\alpha) \leq 0{,}04 \cdot 10^{-6}$ K^{-1} + 0,0007 · CTE + (0,03 · 10^{-6} K^{-1} m) / L
			0,08 µm + 0,08 ·10^{-6} · L	Materials without calibration of the coefficient of linear thermal expansion
Length standards for optical metrology		VA-71_V02:2019-02 Optical 1D distance measureents between symmetrical 2D structures (center of a circle, middle of the line, center of a reticle) nates with a calibrated coordinate measuring machine thanks to single-point proping with a video sensor compared to an optical scale. In the case of lines, the distance is measured via the center of the line or via a line as a unidirectional distance. For rods with a length of over 2150 mm, the measuring range is extended by a connection measurement with two overlapping target marks on the calibration object.		
	> 300 mm to 1180 mm	axially parallel	0,35 µm + 0,8 ·10^{-6} · L	L = measured length
	> 1180 mm to 1780 mm	axially parallel	0,35 µm + 1,0 · 10^{-6} · L	
	> 1780 mm to 2150 mm	diagonally	0,35 µm + 1,0 · 10^{-6} · L	
	> 2150 mm to 3000 mm	connection measurement	0,40 µm + 1,0 · 10^{-6} · L	

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Length standards for optical metrology	up to a diagonal distance of 200 mm and a maximum aspect ratio of 2: 1	VA-72_V03:2019-02 Optische 2D Distanzmes- Optical 1D distance measureents between symmetrical 2D structures (center of a circle, middle of the line, center of a reticle) nates with a calibrated coordinate measuring machine thanks to single-point proping with a video sensor compared to an optical scale with the multilateration process. In the case of line crosses, the distance is measured via the crossing point of the center of the line.	0,09 µm + 0,02 · 10^{-6} · L	L = distance between the center of the circle or the intersection of line crosses Materials with a coefficient of linear thermal expansion, i.g. quartz glass $\lvert\alpha\rvert \leq 1{,}0 \cdot 10^{-6}\ K^{-1}$ and its uncertainty $U(\alpha) < 0{,}5 \cdot 10^{-6}\ K^{-1}$
			0,09 µm + 0,04 · 10^{-6} · L	Materials with calibrated uncertainty of the coefficient of linear thermal expansion $U(\alpha) \leq 0{,}04 \cdot 10^{-6}\ K^{-1}$ + 0,0007 · CTE + (0,03 · $10^{-6}\ K^{-1}$ m) / L
			0,09 µm + 0,08 · 10^{-6} · L	Materials without calibration of the coefficient of linear thermal expansion
Length standards for optical metrology	up to a diagonal distance of 1200 mm and a maximum aspect ratio of 2: 1	VA-73_V02:2019-02 Optische 2D Distanzmes- Optical 1D distance measureents between symmetrical 2D structures (center of a circle, middle of the line, center of a reticle) nates with a calibrated coordinate measuring machine thanks to single-point proping with a video sensor compared to an optical scale with the multilateration process. In the case of line crosses, the distance is measured via the crossing point of the center of the line.	0,4 µm + 0,8 · 10^{-6} · L	L = distance between the center of the circle or the intersection of line crosses

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Step gauges	to 1540 mm nomonal size	VA-65_V01:2018-10 Measurement of the mean size with 2 laser interfero-meters in comparison with gauge blocks with mechanical probing of the measurement surface	0,05 µm + 0,15 · 10^{-6} · L	L = step length material: glass ceramics or ceramics with a coefficient of linear thermal expansion $\lvert\alpha\rvert \le 0{,}05 \cdot 10^{-6}\ K^{-1}$ and its uncertainty $U(\alpha) < 0{,}05 \cdot 10^{-6}\ K^{-1}$
Step gauges	to 1540 mm nomonal size	VA-65_V01:2018-10 Measurement of the mean size with 2 laser interfero-meters in comparison with gauge blocks with mechanical probing of the measurement surface	0,05 µm + 0,25 · 10^{-6} · L	L = step length material: steel with a coefficient of linear thermal expansion $U(\alpha) \le 0{,}04 \cdot 10^{-6}\ K^{-1} + 0{,}007 \cdot CTE + (0{,}03 \cdot 10^{-6}\ K^{-1}m) / L$
Step gauges	to 1540 mm nomonal size	VA-65_V01:2018-10 Measurement of the mean size with 2 laser interfero-meters in comparison with gauge blocks with mechanical probing of the measurement surface	0,05 µm + 0,3 · 10^{-6} · L	L = step length material: steel
Step gauges	to 1540 mm nomonal size	VA-51_V01:2018-10 Measurement of the mean size compared with a steel step gauge	0,10 µm + 0,4 · 10^{-6} · L	L = step length
Step gauges	to 1100 mm nomonal size	VA-66_V02:2018-12 Measurement of the mean size compared with a step gauge with $\lvert\alpha\rvert \le 0{,}05 \cdot 10^{-6}\ K^{-1}$	0,06 µm + 0,16 · 10^{-6} · L	L = step length material: glass ceramics or ceramics with a coefficient of linear thermal expansion $\lvert\alpha\rvert \le 0{,}05 \cdot 10^{-6}\ K^{-1}$ and its uncertainty $U(\alpha) < 0{,}05 \cdot 10^{-6}\ K^{-1}$
Step gauges	to 1100 mm	VA-66_V02:2018-12 Measurement of the mean size compared with a step gauge with $\lvert\alpha\rvert \le 0{,}05 \cdot 10^{-6}\ K^{-1}$	0,06 µm + 0,23 · 10^{-6} · L	L = step length material: steel with a coefficient of linear thermal expansion $U(\alpha) \le 0{,}04 \cdot 10^{-6}\ K^{-1} + 0{,}0007 \cdot CTE + (0{,}03 \cdot 10^{-6}\ K^{-1}\ m) / L$

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Step gauges	to 1100 mm	VA-66_V02:2018-12 Measurement of the mean size compared with a step gauge with $\lvert\alpha\rvert \leq 0{,}05 \cdot 10^{-6}\ \mathrm{K}^{-1}$	$0{,}06\ \mu\mathrm{m} + 0{,}27 \cdot 10^{-6} \cdot L$	L = step length material: steel

Abbreviations used:

CMC	Calibration and measurement capabilities
DIN	Deutsches Institut für Normung e.V.
DKD-R	Guideline of Deutschen Kalibrierdienstes (DKD), published by the Physikalisch-Technischen Bundesanstalt
VA-XX	Calibration instruction of the eumetron GmbH

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