Deutsche Akkreditierungsstelle GmbH

Annex to the Accreditation Certificate D-K-15007-01-00 according to DIN EN ISO/IEC 17025:2018

Valid from: 26.08.2020

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Holder of certificate:

Carl Zeiss Industrielle Messtechnik GmbH

with its calibration laboratories

Carl-Zeiss-Straße 22, 73447 Oberkochen

Willy-Messerschmitt-Straße 1, 73457 Essingen

Calibration in the fields:

Dimensional quantities

Length

- **Gauge blocks**
- **Diameter**
- **Form error**
- **Linear thermal expansion coefficient**

Coordinate measuring technology

- **Step gauges**
- **Virtual coordinate measuring machines**
- **Application coordinate measuring machines**
- **Coordinate measuring machines** [a)]

Thermodynamic quantities

Temperature quantities

- **Resistance thermometers**
- **Thermocouples**
- **Direct reading thermometers**

[a)] on permanent laboratory and on-site calibration

Abbreviations used: see last page

The certificate together with its annex reflects the status at the time of the date of issue. The current status of the scope of accreditation can be found in the database of accredited bodies of Deutsche Akkreditierungsstelle GmbH.
https://www.dakks.de/en/content/accredited-bodies-dakks

Permanent Laboratory - Oberkochen

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 according to DIN EN ISO 3650:1999	10 mm to 2000 mm nominal size	I_DI_S_ALM_01_01_A_12: 2019/10 Measurement of the mean size with flat mirror laser interferometer with mechanical probing of the measurement surface. The wringing of both measurement surfaces must be checked using a suitable flat mirror plate.	for the mean size: $0.05\ \mu m + 0.3 \cdot 10^{-6} \cdot l$	l = gauge block length Measuring surface quality as stated in QMH rsp. in the work specifications.
			for the mean size: $0.05\ \mu m + 0.25 \cdot 10^{-6} \cdot l$	The uncertainty of measurement of the linear coefficient of thermal expansion of object to be calibrated $U(\alpha) \leq 0.1 \cdot 10^{-6}\ K^{-1}$
Gauge blocks made of ceramics according to DIN EN ISO 3650:1999	10 mm to 500 mm nominal size		for the mean size: $0.05\ \mu m + 0.4 \cdot 10^{-6} \cdot l$	
Gauge blocks made of steel according to DIN EN ISO 3650:1999	50 mm to 500 mm nominal size	I_DI_S_ALM_01_01_A_13: 2019/10 Measurement of the mean size with a coordinate measuring machine in comparison with a gauge block made of steel of the same nominal size and determining the parallelism of the measurement	$0.08\ \mu m + 0.4 \cdot 10^{-6} \cdot l$	l = gauge block length
Length of workpieces with plane parallel surfaces with optical measurement surface quality	10 mm to 2000 mm nominal size	I_DI_S_ALM_01_01_A_12: 2019/10 Measurement of the length with flat mirror laser interferometer with mechanical probing of the measurement surface. Measurement surface quality (planarity and parallelism), the linear coefficient of thermal expansion α and its uncertainty are considered in the measurement uncertainty.		l = measured length
			$0.05\ \mu m + 0.15 \cdot 10^{-6} \cdot l$	material: glass ceramics or ceramics with a coefficient of linear thermal expansion $\lvert\alpha\rvert \leq 0.05 \cdot 10^{-6}\ K^{-1}$ and its uncertainty $U(\alpha) \leq 0.05 \cdot 10^{-6}\ K^{-1}$
			$0.05\ \mu m + 0.25 \cdot 10^{-6} \cdot l$	material: steel with an uncertainty of the coefficient of linear thermal expansion $U(\alpha) \leq 0.1 \cdot 10^{-6}\ K^{-1}$
			$0.05\ \mu m + 0.3 \cdot 10^{-6} \cdot l$	material: steel
			$0.05\ \mu m + 0.4 \cdot 10^{-6} \cdot l$	material: ceramics

[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.

Permanent Laboratory - Oberkochen

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 dimension for the calibration object Length: 2500 mm Width: 180 mm Height: 80 mm Maximum measurable length at the calibration object: 1450 mm	I_DI_S_ALM_01_01_A_25: 2018/04 Measurement of length and temperature changes and mathematical derivation of the thermal expansion coefficient CTE	$U_{CTE}(t) = 0.02 \cdot 10^{-6}\ K^{-1} + 1.5 \cdot 10^{-3} \cdot CTE + (0.027 \cdot 10^{-6}\ K^{-1}\ m) / L$ for 10 °C ≤ t ≤ 30 °C	L = measured length CTE = thermal expansion coefficient The CTE is given as a model in the form of a linear component α and a quadratic component β. Example: $U_{CTE}(t) = 0.07 \cdot 10^{-6}\ K^{-1}$ for steel: L = 1 m $U_{CTE}(t) = 0.09 \cdot 10^{-6}\ K^{-1}$ for steel: L = 0.5 m
Step gauge blocks	to 2080 mm	I_DI_S_ALM_01_01_A_06: 2019/05 Measurement of the mean size with flat mirror laser interferometer with mechanical probing of the measurement surface. The perpendicularity deviation of the measuring surfaces must not exceed 1.5'.	unidirectional probing: $0.03\ \mu m + 0.09 \cdot 10^{-6} \cdot l$ bidirectional probing: $0.04\ \mu m + 0.09 \cdot 10^{-6} \cdot l$	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 $U(\alpha) \le 0.05 \cdot 10^{-6}\ K^{-1}$
	to 2080 mm	I_DI_S_ALM_01_01_A_06: 2019/05 Measurement of the mean size with flat mirror laser interferometer with mechanical probing of the measurement surface. The perpendicularity deviation of the measuring surfaces must not exceed 1.5'.	unidirectional probing: $0.03\ \mu m + 0.14 \cdot 10^{-6} \cdot l$ bidirectional probing: $0.04\ \mu m + 0.14 \cdot 10^{-6} \cdot l$	l = step length; material: steel with an uncertainty of the coefficient of linear thermal expansion $U(\alpha) \le 0.1 \cdot 10^{-6}\ K^{-1}$
			unidirectional probing: $0.03\ \mu m + 0.18 \cdot 10^{-6} \cdot l$ bidirectional probing: $0.04\ \mu m + 0.18 \cdot 10^{-6} \cdot l$	material: steel
	to 2500 mm	I_DI_S_ALM_01_01_A_06: 2019/05 Measurement of the mean size with flat mirror laser interferometer with mechanical probing of the measurement surface. The perpendicularity deviation of the measuring surfaces must not exceed 1.5'.	unidirectional probing: $0.06\ \mu m + 0.09 \cdot 10^{-6} \cdot l$ bidirectional probing: $0.08\ \mu m + 0.09 \cdot 10^{-6} \cdot l$	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 $U(\alpha) \le 0.05 \cdot 10^{-6}\ K^{-1}$

[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.

Permanent Laboratory - Oberkochen

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Step gauge blocks	to 2500 mm	I_DI_S_ALM_01_01_A_06: 2019/05 Measurement of the mean size with flat mirror laser interferometer with mechanical probing of the measurement surface. The perpendicularity deviation of the measuring surfaces must not exceed 1.5'.	unidirectional probing: $0.06\ \mu m + 0.14 \cdot 10^{-6} \cdot l$ bidirectional probing: $0.08\ \mu m + 0.14 \cdot 10^{-6} \cdot l$	l = step length; material: steel with an uncertainty of the coefficient of linear thermal expansion $U(\alpha) \leq 0.1 \cdot 10^{-6}\ K^{-1}$
			unidirectional probing: $0.06\ \mu m + 0.18 \cdot 10^{-6} \cdot l$ bidirectional probing: $0.08\ \mu m + 0.18 \cdot 10^{-6} \cdot l$	material: steel
Setting ring and plug gauges; inside and outside cylinder Diameter	3 mm to 400 mm	DKD-R 4-3 part 4.1:2018 I_DI_S_ALM_01_01_A_07: 2017/06 Measurement of the 2-point diameter with flat mirror laser interferometer with mechanical probing of the measurement surface.	$0.08\ \mu m + 0.15 \cdot 10^{-6} \cdot d$	d = diameter material: glass ceramics or ceramics with a coefficient of linear thermal expansion $\lvert\alpha\rvert \leq 0.05 \cdot 10^{-6}\ K^{-1}$ and its uncertainty $U(\alpha) \leq 0.05 \cdot 10^{-6}\ K^{-1}$
Setting ring and plug gauges; inside and outside cylinder Diameter	3 mm to 400 mm	DKD-R 4-3 part 4.1:2018 I_DI_S_ALM_01_01_A_07: 2017/06 Measurement of the 2-point diameter with flat mirror laser interferometer with mechanical probing of the measurement surface.	$0.08\ \mu m + 0.25 \cdot 10^{-6} \cdot d$	d = diameter material: steel with an uncertainty of the coefficient of linear thermal expansion $U(\alpha) \leq 0.1 \cdot 10^{-6}\ K^{-1}$
			$0.08\ \mu m + 0.3 \cdot 10^{-6} \cdot d$	material: steel
			$0.08\ \mu m + 0.4 \cdot 10^{-6} \cdot d$	material: ceramics
		I_DI_S_ALM_01_01_A_08: 2017/06 Measurement with coordinate measuring machines	$0.7\ \mu m + 2 \cdot 10^{-6} \cdot d$	
Roundness deviation	3 mm to 400 mm	Talyrond 61 with Multiple layer procedure	$0.015\ \mu m + 7 \cdot 10^{-2} \cdot RONt$	$RONt$ = roundness deviation
		Single-layer procedure	0.1 µm	
Straightness deviation of surface lines	0 mm to 100 mm	I_DI_S_ALM_01_01_A_08: 2017/06	$0.4\ \mu m + 0.1 \cdot STRt$	$STRt$ = straightness deviation
Parallelism deviation of surface lines	axial lenght		$0.4\ \mu m + 0.1 \cdot STRt$	
Straightness deviation of surface lines	> 100 mm to 500 mm		$0.8\ \mu m + 0.1 \cdot STRt$	
Parallelism deviation of surface lines	axial lenght		$1.0\ \mu m + 0.1 \cdot STRt$	

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Permanent Laboratory - Oberkochen

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Setting ring and plug gauges; inside and outside cylinder Diameter	16 mm, 30 mm, 50 mm nominal size	DKD-R 4-3 part 4.1:2018 I_DI_S_ALM_01_01_A_11: 2018/11 Measurement of the 2-point diameter with a coordinate measuring machine in comparison with a ring or plug of the same nominal size	0.11 µm + 0.25 · 10^{-6} · d	d = diameter
Magnification standards (cylinder with flat area; flick-standard)	flat area to 300 µm Diameter to 50 mm	I_DI_S_ALM_01_01_A_09: 2017/06 Measurement with roundness measuring machines	0.12 µm + 0.02 · RONt	RONt = roundness deviation
Balls Diameter	2 mm to 200 mm	I_DI_S_ALM_01_01_A_07: 2017/06 Measurement of the 2-point diameter with flat mirror laser interferometer with mechanical probing of the measurement surface	0.08 µm + 0.15 · 10^{-6} · d	d = diameter 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 $U(\alpha) \le 0.05 \cdot 10^{-6}$ K^{-1}
Balls Diameter	2 mm to 200 mm	I_DI_S_ALM_01_01_A_07: 2017/06 Measurement of the 2-point diameter with flat mirror laser interferometer with mechanical probing of the measurement surface	0.08 µm + 0.25 · 10^{-6} · d	d = diameter material: steel with an uncertainty of the coefficient of linear thermal expansion $U(\alpha) \le 0.1 \cdot 10^{-6}$ K^{-1}
			0.08 µm + 0.3 · 10^{-6} · d	material: steel
			0.08 µm + 0.4 · 10^{-6} · d	material: ceramics
		I_DI_S_ALM_01_01_A_08: 2017/06 Measurement with coordinate measuring machines	0.7 µm + 2 · 10^{-6} · d	d = diameter
Roundness deviation		Talyrond 61 with Multiple layer procedure	0.015 µm + 7 · 10^{-2} · RONt	RONt = roundness deviation
		Single-layer procedure	0.1 µm	
Balls Diameter	25 mm and 30 mm nominal size	I_DI_S_ALM_01_01_A_10: 2017/06 Measurement of the 2-point diameter with a coordinate measuring machine in comparison to a ball of the same nominal size	0.09 µm + 0.35 · 10^{-6} · d	d = diameter

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Permanent Laboratory - Oberkochen

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Coordinate measuring technology				
Ball and hole bar	to 2000 mm Axially distance between ball and hole center points	I_DI_S_ALM_01_01_A_14_I1: 2017/06		l = distance between ball and hole center points
		Measurement with flat mirror laser interferometer with mechanical probing of the measurement surface	0.08 µm + 0.3 · 10^{-6} · l	material: steel
			0.08 µm + 0.15 · 10^{-6} · l	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 $U(\alpha) \le 0.05 \cdot 10^{-6}\ K^{-1}$
Temperature quantities				
Resistance thermometers (SPRT only), as a measuring chain with display	0.01 °C	DKD-R 5-1:2018 I_DI_S_ALM_01_01_A_19: 2017/06 Triple point of water TPW	2 mK	Calibration at temperature fixed points of ITS-90
	29.7646 °C	DKD-R 5-1:2018 I_DI_S_ALM_01_01_A_18: 2017/06 Melting point of gallium	2 mK	
Resistance thermometers (Pt-100), as a measuring chain with display	0.01 °C	DKD-R 5-1:2018 I_DI_S_ALM_01_01_A_19: 2017/06 Triple point of water TPW	5 mK	Calibration at temperature fixed points of ITS-90
	29.7646 °C	DKD-R 5-1:2018 I_DI_S_ALM_01_01_A_18: 2017/06 Melting point of gallium	5 mK	
Resistance thermometers (Pt-100 and SPRT), as a measuring chain with display (Precision thermometers)	0 °C to 45 °C	DKD-R 5-1:2018 I_DI_S_ALM_01_01_A_17: 2017/06	10 mK	Comparison with standard resistance thermometers in thermostatic bathes
Direct indication resistance thermometers connected with evaluation electronics (portable measuring instrument)	3 °C to 45 °C	DKD-R 5-1:2018 I_DI_S_ALM_01_01_A_16: 2017/06	0.1 K	Comparison with resistance thermometers in thermostatic bathes
Direct indication thermocouples connected with evaluation electronics (portable measuring instrument)	3 °C to 45 °C	DKD-R 5-3:2018 I_DI_S_ALM_01_01_A_16: 2017/06	0.3 K	

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Permanent Laboratory - Oberkochen and on-site Calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Coordinate measuring technology Coordinate measuring machines using a contacting probing system and control software CALYPSO, CMM-OS and CALIGO (Software of Carl Zeiss Industrielle Messtechnik GmbH)	Coordinate measureing machines featuring a measuring volume with a space diagonal ≤ 3818 mm	I_DI_S_ALM_01_01_A_15: 2019/11 Calibration of metrological characteristics according to guideline: DKD-R 4-3: part 18.1:2018 and the below mentioned standards: DIN EN ISO 10360		l = measured length
		Determination of the length measurement deviation E_0 and E_{150} using step gauges made of steel or glass ceramics according to DIN EN ISO 10360-2:2010	For l to 1100 mm 0.04 µm + 0.14 · 10^{-6} · l For l to 1980 mm 0.08 µm + 0.25 · 10^{-6} · l For l to 2520 mm 0.2 µm + 0.4 · 10^{-6} · l Temperature compensation with external temperature detecion: For l to 1100 mm 0.04 µm + 0.47 · 10^{-6} · l For l to 1980 mm 0.08 µm + 0.53 · 10^{-6} · l For l to 2520 mm 0.2 µm + 0.61 · 10^{-6} · l with ΔT = 0.4 K	
		Determination of repeatability range R_0 using step gauges made of steel or glass ceramics according to DIN EN ISO 10360-2:2010	0.022 µm	
		Determination of probing deviation form P_{FTU} on a ball standard according to DIN EN ISO 10360-5:2011	0.05 µm	Measurement of a ball standard made of ceramics with a diameter of 25 mm
		Determination of the radial 4-axis deviation FR on two ball standards according DIN EN ISO 10360-3:2000	0.16 µm	The distance between ball and axis of rotary table is 206 mm
		Determination of the tangential 4-axis deviation FT on two ball standards according DIN EN ISO 10360-3:2000	0.15 µm	The distance between ball and the tangent plane is 0 mm

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Permanent Laboratory - Oberkochen and on-site Calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Coordinate measuring machines using a contacting probing system and control software CALYPSO, CMM-OS and CALIGO (Software of Carl Zeiss Industrielle Messtechnik GmbH)	Coordinate measuring machines featuring a measuring volume with a space diagonal ≤ 3818 mm	Determination of the of the axial 4-axis deviation FA on two ball standards according to DIN EN ISO 10360-3:2000	0.16 µm	The distance between ball and the rotary table plate is 280 mm
		Determination of scanning probing deviation THP and scanning-test time τ on a ball standard according to DIN EN ISO 10360-4:2003	0.05 µm 0.9 s	Measurement of a ball standard made of ceramics with a diameter of 25 mm
		Determination of multiple stylus deviation form P_{FTM} on a ball standard according to DIN EN ISO 10360-5:2011	0.05 µm	
		Determination of multiple stylus deviation size P_{STM} on a ball standard according to DIN EN ISO 10360-5:2011	0.098 µm	
		Determination of multiple stylus deviation location P_{LTM} on a ball standard according to DIN EN ISO 10360-5:2011	0.05 µm	
Coordinate measuring machines using a contacting probing system and control software CALYPSO, CMM-OS and CALIGO (Software of Carl Zeiss Industrielle Messtechnik GmbH)	Coordinate measuring machines featuring a measuring volume with a space diagonal ≤ 20 m	I_DI_S_ALM_01_01_ A_15_I10: 2020/03 Calibration of metrological characteristics according to guideline: DKD-R 4-3 Sheet 18.1:2018 DIN EN ISO 10360		
		Determination of the length measurement deviation E_0 by laser tracer according to DIN EN ISO 10360-2:2010	0.22 µm + 0.33 · 10^{-6} · l	The transition from the unidirectional laser measurement to bidirectional, tactile measurement, is performed by a ball connection measurement. Also for CMM in duplex-measuring mode.
		Determination of the repeatability range R_0 by laser tracer according to DIN EN ISO 10360-2:2010	0.22 µm	

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Permanent Laboratory - Oberkochen and on-site Calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1]	Remarks
Coordinate measuring machines using a CT sensor technology and control software CALYPSO (Software of Fa. Carl Zeiss Industrielle Messtechnik GmbH)	Coordinate measuring machines featuring a measuring volume with a space diagonal ≤ 171 mm	I_DI_S_ALM_01_01_A_15_I20: 2019/11 Calibration of metrological characteristics according to guideline: DKD-R 4-3 part 18.1:2018 VDI/VDE 2630 part 1.3:2011		
		Determination of deviation in ball distance $S_{D(TS)}$ using CT-test-specimen according to VDI/VDE 2630 part 1.3:2011	0.5 µm	
		Determination of the length measurement deviation $E_{(TS)}$ using CT test equipment according to VDI/VDE 2630 part 1.3:2011	0.86 µm	
		Determination of probing deviation size $P_{S(TS)}$ using CT test equipment according to VDI/VDE 2630 part 1.3:2011	0.47 µm	
		Determination of probing deviation form $P_{F(TS)}$ using CT test equipment according to VDI/VDE 2630 part 1.3:2011	0.42 µm	
Coordinate measuring machines using an optical probing system and control software CALYPSO, NEO-Select (Software of Fa. Carl Zeiss Industrielle Messtechnik GmbH)	Coordinate measuring machines featuring a measuring volume with a surface diagonal ≤ 440 mm	I_DI_S_ALM_01_01_A_15_I30: 2020/03 Calibration of the metrological characteristics according to guideline: DKD-R 4-3 part 18.1:2018 DIN EN ISO 10360		
		Determination of the length measurement deviation E_U and E_{UXY} using line scale made of glass according to DIN EN ISO 10360-7:2011	$0.08\ \mu m + 0.22 \cdot 10^{-6} \cdot l$ Temperature compensation with external temperature detection: $0.08\ \mu m + 0.31 \cdot 10^{-6} \cdot l$ with $\Delta T = 0.4$ K	l = measured length
		Determination of the repeatability range R_U and R_{UXY} by line scale made of glass according to DIN EN ISO 10360-7:2011	0.082 µm	
		Determination of the probing deviation P_{F2D} on a circle standard according to DIN EN ISO 10360-7:2011	0.041 µm	not with NEO-Select Software

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Permanent Laboratory - Oberkochen and on-site Calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Coordinate measuring machines using an optical probing system and control software CALYPSO, NEO-Select (Software of Fa. Carl Zeiss Industrielle Messtechnik GmbH)	Coordinate measuring machines featuring a measuring volume with a surface diagonal ≤ 440 mm	Determination of the probing deviation P_{FV2D} on a circle standard according to DIN EN ISO 10360-7:2011	0.041 µm	
		Determination of the probing deviation P_{S2D} on a circle standard according to DIN EN ISO 10360-7:2011	0.13 µm	not with NEO-Select Software
		Determination of the probing deviation P_{SV2D} on a circle standard according to DIN EN ISO 10360-7:2011	0.13 µm	

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Permanent Laboratory - Essingen

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement [1)]	Remarks
Coodinate measuring technology				
Prismatic workpieces	Coordinate measuring machine with one for the implementation of the calibration procedure specified measuring volume with the dimensions X = 1160 mm Y = 2060 mm Z = 620 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 30 mm.	Tactile measurements 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 stylus (zero distance between center of the probing ball and the pinole axis) maximum: $U_{E0} = 0.3\ \mu m + 2 \cdot 10^{-6} \cdot L$ and for measurements with lateral stylus (150 mm distance between center of the probing ball and the pinole axis) maximum: $U_{E150} = 0.4\ \mu m + 2 \cdot 10^{-6} \cdot L$ 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 = 0.3 µm L = 1000 mm U = 1.9 µm L = 1980 mm U = 7.4 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 respecttively 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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Permanent Laboratory - Essingen

Calibration and Measurement Capabilities (CMC)

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 = 1160 mm Y = 2060 mm Z = 620 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 10360-5: 2018 E, is in the specified measuring volume: for the determination of the form deviation (evaluation to Tschebyschew) U = 0.23 µm for the determination of the diameter (evaluation to Gauß) U = 0.34 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.
Step gauge blocks	to 1100 mm	I_DI_S_ALM_01_01_A_24: 2019/11 Measurement of the mean size with a coordinate measuring machine in comparison with a step gauge block of the same nominal size	0.06 µm + 0.22 · 10^{-6} · l	l = step length
Length standards for optical metrology Distances of edges aligned in the same direction (unidirectional) and center-to-center distances of structures on flat substrates (photomasks with CR layer)	to 350 mm	I_DI_S_ALM_01_01_A_26: 2018/04 Substitution measurement with a line scale and the same nominal lengths using a coordinate measuring machine and optical scanning in transmitted light.	0.09 µm + 0.14 · 10^{-6} · l	l = measured length of $\lvert\alpha\rvert \leq 0.5 \cdot 10^{-6}$ K^{-1} and $U\alpha \leq 0.1 \cdot 10^{-6}$ K^{-1} The linear thermal expansion coefficient α and its uncertainty are taken into account in the measurement uncertainty.
		I_DI_S_ALM_01_01_A_26: 2018/04 Substitution measurement with a line scale using a coordinate measuring machine and optical scanning in transmitted light.	0.15 µm + 0.1 · 10^{-6} · l	

[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
Length standards for optical metrology Diameter of structures on flat substrates (photo-masks with CR layer)	0.06 mm to 10 mm	I_DI_S_ALM_01_01_A_26: 2018/04 Substitution measurement with a circular normal and the same nominal diameters using a coordinate measuring machine and optical scanning in transmitted light. Twenty-five single-points are probed according to the dot pattern of the DIN EN ISO 10360-7: 2011. For layer thickness between 30 nm and 190 nm. The calibration object is identical to the traceability standard.	0.25 µm	Diameter and form error refer to the probing points
Roundness deviation ($RONt$)			0.3 µm	
Length standards for optical measurement technology Roundness deviation ($RONt$) of structures on flat substrates (photo-masks with CR layer)	0.06 mm to 10 mm	I_DI_S_ALM_01_01_A_26: 2018-04 Measurement with a coordinate measuring machine and optical probing in transmitted light. Twenty-five single-points are probed according to the dot pattern of the DIN EN ISO 10360-7: 2011. For layer thickness between 30 nm and 190 nm.	0.6 µm	Form error refers to the probing points
Length standards for optical metrology	2D-Range: 900 mm x 1100 mm	I_DI_S_ALM_01_01_A_22: 2018/12 Measurement of center distances and X-, Y-coordinates with a calibrated coordinate measuring machine and optical probing. The measurement is performed on symmetrical 2D structures (center of a circle, middle of the line, center of a reticle).	$0.7\ \mu m + 2 \cdot 10^{-6} \cdot l$	l = measured length
	2D- Range: 1200 mm x 1980 mm		$1.4\ \mu m + 2.2 \cdot 10^{-6} \cdot l$	

[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
Two-point diameter and distances	up to 1100 mm	I_DI_S_ALM_01_01_A_28: 2018/11 Substitution measurement with a calibrated standard (ball, ring or step gauge) with a coordinate measuring machine and tactile single-point probing.	Calculation of the measurement uncertainty using the method „Virtual coordinate measuring machine“ based on ISO/TS 15530-4: 2008 taking into account the substitution effect $0.1\ \mu m + 0.4 \cdot 10^{-6} \cdot l$	l = measured length
	up to 2060 mm		$0.25\ \mu m + 0.3 \cdot 10^{-6} \cdot l$	
Balls Diameter	to 30 mm	I_DI_S_ALM_01_01_A_27: 2018/11 Substitution measurement with a ball by means of a coordinate measuring machine and tactile single-point probing. Twenty-five single-points are probed according to the dot pattern of the DIN EN ISO 10360-5: 2011.	Calculation of the measurement uncertainty using the method „Virtial coordinate measuring machine“ based on ISO/TS 15530-4: 2008 taking into account the substitution effect 0.1 µm	d = Diameter (measurement of the hemisphere) The best measurement uncertainty is only achieved with the same nominal dimension. Diameter and form error refer to the probing points.
Form error			0.07 µm	

Abbreviations used:

CMC	Calibration and measurement capabilities
DKD-R	Guideline of Deutschen Kalibrierdienstes (DKD), published by the Physikalisch-Technischen Bundesanstalt
VDE	Association for Electrical, Electronic & Information Technologies
VDI	The Association of German Engineers
I_DI_S	Calibration instruction of the Carl Zeiss Industrielle Messtechnik GmbH

[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.