## DAkkS

## 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 <br> 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)
${ }^{\text {a) }}$ on permanent laboratory and on-site calibration

Thermodynamic quantities
Temperature quantities

- Resistance thermometers
- Thermocouples
- Direct reading thermometers


## Permanent Laboratory - Oberkochen

| Calibration and Measurement Capabilities (CMC) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Measurement quantity <br> / Calibration item | Range | Measurement conditions / procedure | Expanded uncertainty of measurement ${ }^{1)}$ | Remarks |
| Length <br> 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: <br> 2019/10 <br> Measurement of the mean size with flat mirror laser interferometer with mechanical probing of the measurement surface. <br> The wringing of both measurement surfaces must be checked using a suitable flat mirror plate. | for the mean size: $0.05 \mu \mathrm{~m}+0.3 \cdot 10^{-6} \cdot l$ | $l=$ gauge block length Measuring surface quality as stated in QMH rsp. in the work specifications. |
|  |  |  | for the mean size: $0.05 \mu \mathrm{~m}+0.25 \cdot 10^{-6} \cdot l$ | The uncertainty of measurement of the linear coefficient of thermal expansion of object to be calibrated $U(\alpha) \leq 0.1 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
| Gauge blocks made of ceramics according to DIN EN ISO 3650:1999 | 10 mm to 500 mm nominal size |  | for the mean size: $0.05 \mu \mathrm{~m}+0.4 \cdot 10^{-6} \cdot l$ |  |
| Gauge blocks made of steel according to DIN EN ISO 3650:1999 | 50 mm to 500 mm nominal size | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_13: } \\ & \text { 2019/10 } \end{aligned}$ <br> 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 | $0.08 \mu \mathrm{~m}+0.4 \cdot 10^{-6} \cdot l$ | $l=$ 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: <br> 2019/10 <br> Measurement of the length with flat mirror laser interferometer with mechanical probing of the measurement surface. <br> Measurement surface quality (planarity and parallelism), the linear coefficient of thermal expansion $\alpha$ and its uncertainty are considered in the measurement uncertainty. |  | $l=$ measured length |
|  |  |  | $0.05 \mu \mathrm{~m}+0.15 \cdot 10^{-6} \cdot l$ | material: glass ceramics or ceramics with a coefficient of linear thermal expansion $\|\alpha\| \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ and its uncertainty $U(\alpha) \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
|  |  |  | $0.05 \mu \mathrm{~m}+0.25 \cdot 10^{-6} \cdot l$ | material: steel with an uncertainty of the coefficient of linear thermal expansion $U(\alpha) \leq 0.1 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
|  |  |  | $0.05 \mu \mathrm{~m}+0.3 \cdot 10^{-6} \cdot l$ | material: steel |
|  |  |  | $0.05 \mu \mathrm{~m}+0.4 \cdot 10^{-6} \cdot l$ | material: ceramics |

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| Calibration and Measurement Capabilities (CMC) |  |  |  |  |
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| Measurement quantity <br> / 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 <br> Length: 2500 mm <br> Width: 180 mm <br> Height: 80 mm <br> Maximum measurable length at the calibration object: $1450 \mathrm{~mm}$ | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_25: } \\ & \text { 2018/04 } \end{aligned}$ <br> Measurement of length and temperature changes and mathematical derivation of the thermal expansion coefficient CTE | $\begin{aligned} & U_{\mathrm{CTE}}(\mathrm{t})=0.02 \cdot 10^{-6} \mathrm{~K}^{-1}+ \\ & 1.5 \cdot 10^{-3} \cdot C T E+ \\ & \left(0.027 \cdot 10^{-6} \mathrm{~K}^{-1} \mathrm{~m}\right) / L \\ & \text { for } 10^{\circ} \mathrm{C} \leq \mathrm{t} \leq 30^{\circ} \mathrm{C} \end{aligned}$ | $L=$ measured length <br> $C T E=$ thermal expansion coefficient <br> The CTE is given as a model in the form of a linear component $\alpha$ and a quadratic component $\beta$. <br> Example: <br> $U_{\mathrm{CTE}}(\mathrm{t})=0.07 \cdot 10^{-6} \mathrm{~K}^{-1}$ <br> for steel: $L=1 \mathrm{~m}$ <br> $U_{\mathrm{CTE}}(\mathrm{t})=0.09 \cdot 10^{-6} \mathrm{~K}^{-1}$ <br> for steel: $L=0.5 \mathrm{~m}$ |
| Step gauge blocks | to 2080 mm | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_06: } \\ & \text { 2019/05 } \end{aligned}$ <br> Measurement of the mean size with flat mirror laser interferometer with mechanical probing of the measurement surface. <br> The perpendicularity deviation of the measuring surfaces must not exceed 1.5'. | unidirectional probing: $0.03 \mu \mathrm{~m}+0.09 \cdot 10^{-6} \cdot l$ <br> bidirectional probing: $0.04 \mu \mathrm{~m}+0.09 \cdot 10^{-6} \cdot l$ | $l=\text { step length; }$ <br> material: glass ceramics or ceramics with a coefficient of linear thermal expansion $\|\alpha\| \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ and its uncertainty $U(\alpha) \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
|  | to 2080 mm | I_DI_S_ALM_01_01_A_06: <br> 2019/05 <br> Measurement of the mean size with flat mirror laser interferometer with mechanical probing of the measurement surface. <br> The perpendicularity deviation of the measuring surfaces must not exceed 1.5'. | unidirectional probing: $0.03 \mu \mathrm{~m}+0.14 \cdot 10^{-6} \cdot l$ <br> bidirectional probing: $0.04 \mu \mathrm{~m}+0.14 \cdot 10^{-6} \cdot l$ | $l=\text { step length; }$ <br> material: steel with an uncertainty of the coefficient of linear thermal expansion $U(\alpha) \leq 0.1 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
|  |  |  | unidirectional probing: $0.03 \mu \mathrm{~m}+0.18 \cdot 10^{-6} \cdot l$ <br> bidirectional probing: $0.04 \mu \mathrm{~m}+0.18 \cdot 10^{-6} \cdot l$ | material: steel |
|  | to 2500 mm | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_06: } \\ & \text { 2019/05 } \end{aligned}$ <br> Measurement of the mean size with flat mirror laser interferometer with mechanical probing of the measurement surface. <br> The perpendicularity deviation of the measuring surfaces must not exceed 1.5'. | unidirectional probing: $0.06 \mu \mathrm{~m}+0.09 \cdot 10^{-6} \cdot l$ <br> bidirectional probing: $0.08 \mu \mathrm{~m}+0.09 \cdot 10^{-6} \cdot l$ | material: glass ceramics or ceramics with a coefficient of linear thermal expansion $\|\alpha\| \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ and its uncertainty $U(\alpha) \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ |

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| 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 | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_06: } \\ & \text { 2019/05 } \end{aligned}$ <br> Measurement of the mean size with flat mirror laser interferometer with mechanical probing of the measurement surface. <br> The perpendicularity deviation of the measuring surfaces must not exceed 1.5'. | unidirectional probing: $0.06 \mu \mathrm{~m}+0.14 \cdot 10^{-6} \cdot l$ <br> bidirectional probing: $0.08 \mu \mathrm{~m}+0.14 \cdot 10^{-6} \cdot l$ | $l=$ step length; material: steel with an uncertainty of the coefficient of linear thermal expansion $U(\alpha) \leq 0.1 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
|  |  |  | unidirectional probing: $0.06 \mu \mathrm{~m}+0.18 \cdot 10^{-6} \cdot l$ <br> bidirectional probing: $0.08 \mu \mathrm{~m}+0.18 \cdot 10^{-6} \cdot l$ | 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 <br> I_DI_S_ALM_01_01_A_07: 2017/06 <br> Measurement of the 2-point diameter with flat mirror laser interferometer with mechanical probing of the measurement surface. | $0.08 \mu \mathrm{~m}+0.15 \cdot 10^{-6} \cdot d$ | $d=$ diameter <br> material: glass ceramics or ceramics with a coefficient of linear thermal expansion $\|\alpha\| \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ and its uncertainty $U(\alpha) \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
| Setting ring and plug gauges; inside and outside cylinder | 3 mm to 400 mm | $\begin{aligned} & \text { DKD-R 4-3 part 4.1:2018 } \\ & \text { I_DI_S_ALM_01_01_A_07: } \\ & \text { 2017/06 } \end{aligned}$ <br> Measurement of the 2-point diameter with flat mirror laser interferometer with mechanical probing of the measurement surface. | $0.08 \mu \mathrm{~m}+0.25 \cdot 10^{-6} \cdot d$ | $d=$ diameter <br> material: steel with an uncertainty of the coefficient of linear thermal expansion $U(\alpha) \leq 0.1 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
|  |  |  | $0.08 \mu \mathrm{~m}+0.3 \cdot 10^{-6} \cdot d$ | material: steel |
|  |  |  | $0.08 \mu \mathrm{~m}+0.4 \cdot 10^{-6} \cdot d$ | material: ceramics |
|  |  | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_08: } \\ & \text { 2017/06 } \end{aligned}$ <br> Measurement with coordinate measuring machines | $0.7 \mu \mathrm{~m}+2 \cdot 10^{-6} \cdot d$ |  |
| Roundness deviation | 3 mm to 400 mm | Talyrond 61 with <br> Multiple layer procedure | $0.015 \mu \mathrm{~m}+7 \cdot 10^{-2} \cdot \mathrm{RONt}$ | $R O N \mathrm{t}=$ roundness deviation |
|  |  | Single-layer procedure | $0.1 \mu \mathrm{~m}$ |  |
| Straightness deviation of surface lines | 0 mm to 100 mm | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_08: } \\ & \text { 2017/06 } \end{aligned}$ | $0.4 \mu \mathrm{~m}+0.1 \cdot S T R \mathrm{t}$ | STR $\mathrm{t}=$ straightness deviation |
| Parallelism deviation of surface lines | axial lenght |  | $0.4 \mu \mathrm{~m}+0.1 \cdot S T R \mathrm{t}$ |  |
| Straightness deviation of surface lines | > 100 mm to 500 mm |  | $0.8 \mu \mathrm{~m}+0.1 \cdot S T R \mathrm{t}$ |  |
| Parallelism deviation of surface lines |  |  | $1.0 \mu \mathrm{~m}+0.1 \cdot S T R \mathrm{t}$ |  |

${ }^{1)}$ 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 |
| Setting ring and plug gauges; inside and outside cylinder <br> Diameter | $16 \mathrm{~mm}, 30 \mathrm{~mm}, 50 \mathrm{~mm}$ nominal size | $\begin{aligned} & \text { DKD-R 4-3 part 4.1:2018 } \\ & \text { I_DI_S_ALM_01_01_A_11: } \\ & \text { 2018/11 } \end{aligned}$ <br> Measurement of the 2-point diameter with a coordinate measuring machine in comparison with a ring or plug of the same nominal size | $0.11 \mu \mathrm{~m}+0.25 \cdot 10^{-6} \cdot d$ | $d=$ diameter |
| Magnification standards (cylinder with flat area; flick-standard) | flat areato $300 \mu \mathrm{~m}$  <br> Diameter to 50 mm | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_09: } \\ & \text { 2017/06 } \end{aligned}$ <br> Measurement with roundness measuring machines | $0.12 \mu \mathrm{~m}+0.02 \cdot \mathrm{RONt}$ | $R O N \mathrm{t}=$ roundness deviation |
| Balls Diameter | 2 mm to 200 mm | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_07: } \\ & \text { 2017/06 } \end{aligned}$ <br> Measurement of the 2-point diameter with flat mirror laser interferometer with mechanical probing of the measurement surface | $0.08 \mu \mathrm{~m}+0.15 \cdot 10^{-6} \cdot d$ | $d=$ diameter material: glass ceramics or ceramics with a coefficient of linear thermal expansion $\|\alpha\| \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ and its uncertainty $U(\alpha) \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
| Diameter | 2 mm to 200 mm | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_07: } \\ & \text { 2017/06 } \end{aligned}$ <br> Measurement of the 2-point diameter with flat mirror laser interferometer with mechanical probing of the measurement surface | $0.08 \mu \mathrm{~m}+0.25 \cdot 10^{-6} \cdot d$ | $d$ = diameter <br> material: steel with an uncertainty of the coefficient of linear thermal expansion $U(\alpha) \leq 0.1 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
|  |  |  | $0.08 \mu \mathrm{~m}+0.3 \cdot 10^{-6} \cdot d$ | material: steel |
|  |  |  | $0.08 \mu \mathrm{~m}+0.4 \cdot 10^{-6} \cdot d$ | material: ceramics |
|  |  | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_08: } \\ & \text { 2017/06 } \end{aligned}$ <br> Measurement with coordinate measuring machines | $0.7 \mu \mathrm{~m}+2 \cdot 10^{-6} \cdot d$ | $d=$ diameter |
| Roundness deviation |  | Talyrond 61 with <br> Multiple layer procedure | $0.015 \mu \mathrm{~m}+7 \cdot 10^{-2} \cdot$ RONt | $R O N \mathrm{t}=$ roundness deviation |
|  |  | Single-layer procedure | $0.1 \mu \mathrm{~m}$ |  |
| Balls Diameter | 25 mm and 30 mm nominal size | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_10: } \\ & \text { 2017/06 } \end{aligned}$ <br> Measurement of the 2-point diameter with a coordinate measuring machine in comparison to a ball of the same nominal size | $0.09 \mu \mathrm{~m}+0.35 \cdot 10^{-6} \cdot d$ | $d=$ diameter |

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| Calibration and Measurement Capabilities (CMC) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Measurement quantity <br> / Calibration item | Range | Measurement conditions <br> / procedure | Expanded uncertainty of measurement ${ }^{1)}$ | Remarks |
| Coordinate measuring technology Ball and hole bar | to 2000 mm <br> Axially distance between ball and hole center points | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_14_I1: } \\ & 2017 / 06 \end{aligned}$ |  | $l=$ distance between ball and hole center points |
|  |  | Measurement with flat mirror laser interferometer with mechanical probing of the measurement surface | $0.08 \mu \mathrm{~m}+0.3 \cdot 10^{-6} \cdot l$ | material: steel |
|  |  |  | $0.08 \mu \mathrm{~m}+0.15 \cdot 10^{-6} \cdot l$ | material: glass ceramics or ceramics with a coefficient of linear thermal expansion $\|\alpha\| \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ and its uncertainty $U(\alpha) \leq 0.05 \cdot 10^{-6} \mathrm{~K}^{-1}$ |
| Temperature quantities Resistance thermometers (SPRT only), as a measuring chain with display | $0.01{ }^{\circ} \mathrm{C}$ | $\begin{aligned} & \text { DKD-R 5-1:2018 } \\ & \text { I_DI_S_ALM_01_01_A_19: } \\ & \text { 2017/06 } \\ & \text { Triple point of water TPW } \end{aligned}$ | 2 mK | Calibration at temperature fixed points of ITS-90 |
|  | $29.7646{ }^{\circ} \mathrm{C}$ | $\begin{aligned} & \text { DKD-R 5-1:2018 } \\ & \text { I_DI_S_ALM_01_01_A_18: } \\ & \text { 2017/06 } \end{aligned}$ <br> Melting point of gallium | 2 mK |  |
| Resistance thermometers (Pt-100), as a measuring chain with display | $0.01{ }^{\circ} \mathrm{C}$ | $\begin{aligned} & \text { DKD-R 5-1:2018 } \\ & \text { I_DI_S_ALM_01_01_A_19: } \\ & \text { 2017/06 } \\ & \text { Triple point of water TPW } \end{aligned}$ | 5 mK | Calibration at temperature fixed points of ITS-90 |
|  | $29.7646^{\circ} \mathrm{C}$ | $\begin{aligned} & \text { DKD-R 5-1:2018 } \\ & \text { I_DI_S_ALM_01_01_A_18: } \\ & \text { 2017/06 } \end{aligned}$ <br> Melting point of gallium | 5 mK |  |
| Resistance thermometers (Pt-100 and SPRT), as a measuring chain with display (Precision thermometers) | $0^{\circ} \mathrm{C}$ to $45^{\circ} \mathrm{C}$ | $\begin{aligned} & \text { DKD-R 5-1:2018 } \\ & \text { I_DI_S_ALM_01_01_A_17: } \\ & \text { 2017/06 } \end{aligned}$ | 10 mK | Comparison with standard resistance thermometers in thermostatic bathes |
| Direct indication resistance thermometers connected with evaluation electronics (portable measuring instrument) | $3{ }^{\circ} \mathrm{C}$ to $45^{\circ} \mathrm{C}$ | $\begin{aligned} & \text { DKD-R 5-1:2018 } \\ & \text { I_DI_S_ALM_01_01_A_16: } \\ & \text { 2017/06 } \end{aligned}$ | 0.1 K | Comparison with resistance thermometers in thermostatic bathes |
| Direct indication thermoscouples connected with evaluation electronics (portable measuring instrument) | $3{ }^{\circ} \mathrm{C}$ to $45^{\circ} \mathrm{C}$ | $\begin{aligned} & \text { DKD-R 5-3:2018 } \\ & \text { I_DI_S_ALM_01_01_A_16: } \\ & \text { 2017/06 } \end{aligned}$ | 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 <br> 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 $\leq 3818 \mathrm{~mm}$ |  |  |  |
|  |  | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_15: } \\ & \text { 2019/11 } \end{aligned}$ <br> Calibration of metrological characteristics according to guideline: <br> DKD-R 4-3: part 18.1:2018 and the below mentioned standards: DIN EN ISO 10360 |  |  |
|  |  | 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 $0.04 \mu \mathrm{~m}+0.14 \cdot 10^{-6} \cdot l$ <br> For $l$ to 1980 mm $0.08 \mu \mathrm{~m}+0.25 \cdot 10^{-6} \cdot l$ <br> For $l$ to 2520 mm $0.2 \mu \mathrm{~m}+0.4 \cdot 10^{-6} \cdot l$ <br> Temperature compensation with external temperature detecion: For $l$ to 1100 mm $0.04 \mu \mathrm{~m}+0.47 \cdot 10^{-6} \cdot l$ For $l$ to 1980 mm $0.08 \mu \mathrm{~m}+0.53 \cdot 10^{-6} \cdot l$ For $l$ to 2520 mm $0.2 \mu \mathrm{~m}+0.61 \cdot 10^{-6} \cdot l$ with $\Delta T=0.4 \mathrm{~K}$ | $l=$ measured length |
|  |  | Determination of repeatability range $R_{0}$ using step gauges made of steel or glass ceramics according to DIN EN ISO 10360-2:2010 | $0.022 \mu \mathrm{~m}$ |  |
|  |  | Determination of probing deviation form $P_{\text {FTU }}$ on a ball standard according to DIN EN ISO 10360-5:2011 | $0.05 \mu \mathrm{~m}$ | Measurement of a ball standard made of ceramics with a diameter of 25 mm |
|  |  | Determination of the radial 4-axis deviation $F R$ on two ball standards according DIN EN ISO 10360-3:2000 | $0.16 \mu \mathrm{~m}$ | The distance between ball and axis of rotary table is 206 mm |
|  |  | Determination of the tangential 4-axis deviation $F T$ on two ball standards according DIN EN ISO 10360-3:2000 | $0.15 \mu \mathrm{~m}$ | The distance between ball and the tangent plane is 0 mm |

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## Permanent Laboratory - Oberkochen and on-site Calibration

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| :---: | :---: | :---: | :---: | :---: |
| Measurement quantity <br> / 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 measureing machines featuring a measuring volume with a space diagonal $\leq 3818 \mathrm{~mm}$ | Determination of the of the axial 4-axis deviation $F A$ on two ball standards according to DIN EN ISO 10360-3:2000 | $0.16 \mu \mathrm{~m}$ | The distance between ball and the rotary table plate is 280 mm |
|  |  | Determination of scanning probing deviation THP and scanning-test time $\tau$ on a ball standard according to DIN EN ISO 10360-4:2003 | $\begin{gathered} 0.05 \mu \mathrm{~m} \\ 0.9 \mathrm{~s} \end{gathered}$ | Measurement of a ball standard made of ceramics with a diameter of 25 mm |
|  |  | Determination of multiple stylus deviation form $P_{\text {FTM }}$ on a ball standard according to DIN EN ISO 10360-5:2011 | $0.05 \mu \mathrm{~m}$ |  |
|  |  | Determination of multiple stylus deviation size $P_{\text {STM }}$ on a ball standard according to DIN EN ISO 10360-5:2011 | $0.098 \mu \mathrm{~m}$ |  |
|  |  | Determination of multiple stylus deviation location $P_{\text {LTM }}$ on a ball standard according to DIN EN ISO 10360-5:2011 | $0.05 \mu \mathrm{~m}$ |  |
| 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 $\leq 20 \mathrm{~m}$ | $\begin{aligned} & \text { I_DI_S_ALM_01_01_ } \\ & \text { A_15_I10: 2020/03 } \end{aligned}$ <br> Calibration of metrological characteristics according to guideline: <br> DKD-R 4-3 Sheet 18.1:2018 <br> DIN EN ISO 10360 |  |  |
|  |  | Determination of the length measurement deviation $E_{0}$ by laser tracer according to DIN EN ISO 10360-2:2010 | $0.22 \mu \mathrm{~m}+0.33 \cdot 10^{-6} \cdot l$ | 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 | $0.22 \mu \mathrm{~m}$ |  |

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## Permanent Laboratory - Oberkochen and on-site Calibration

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| Measurement quantity <br> / Calibration item | Range | Measurement conditions <br> / 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 $\leq 171 \mathrm{~mm}$ | $\begin{array}{\|l} \hline \text { I_DI_S_ALM_01_01_A_15_I2 } \\ \text { O: 2019/11 } \\ \text { Calibration of metrological } \\ \text { characteristics according to } \\ \text { guideline: } \\ \text { DKD-R 4-3 part 18.1:2018 } \\ \text { VDI/VDE } 2630 \text { part 1.3:2011 } \\ \hline \end{array}$ |  |  |
|  |  | Determination of deviation in ball distance $S_{\mathrm{D}(\mathrm{TS})}$ using CT-test-specimen according to VDI/VDE 2630 part 1.3:2011 | $0.5 \mu \mathrm{~m}$ |  |
|  |  | Determination of the length measurement deviation $E_{(\mathrm{TS})}$ using CT test equipment according to VDI/VDE 2630 part 1.3:2011 | $0.86 \mu \mathrm{~m}$ |  |
|  |  | Determination of probing deviation size $P_{\mathrm{S}(\mathrm{TS})}$ using CT test equipment according to VDI/VDE 2630 part 1.3:2011 | $0.47 \mu \mathrm{~m}$ |  |
|  |  | Determination of probing deviation form $P_{\text {F(TS) }}$ using CT test equipment according to VDI/VDE 2630 part 1.3:2011 | $0.42 \mu \mathrm{~m}$ |  |
| Coordinate measuring machines using an optical probing system and control software CALYPSO, NEO- <br> Select (Software of Fa. Carl Zeiss Industrielle Messtechnik GmbH) | Coordinate measuring machines featuring a measuring volume with a surface diagonal $\leq 440 \mathrm{~mm}$ | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_15_ } \\ & \text { I30: 2020/03 } \end{aligned}$ <br> 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 $E_{\mathrm{U}}$ and $E_{\mathrm{UXY}}$ using line scale made of glass according to DIN EN ISO 10360-7:2011 | $\begin{aligned} & 0.08 \mu \mathrm{~m}+0.22 \cdot 10^{-6} \cdot l \\ & \text { Temperature compen- } \\ & \text { sation with external } \\ & \text { temperature detection: } \\ & 0.08 \mu \mathrm{~m}+0.31 \cdot 10^{-6} \cdot l \\ & \text { with } \Delta T=0.4 \mathrm{~K} \end{aligned}$ | $l=$ measured length |
|  |  | Determination of the repeatability range $\mathrm{R}_{\mathrm{U}}$ and $R_{\mathrm{UXY}}$ by line scale made of glass according to DIN EN ISO 10360-7:2011 | $0.082 \mu \mathrm{~m}$ |  |
|  |  | Determination of the probing deviation $P_{\text {F2D }}$ on a circle standard according to DIN EN ISO 10360-7:2011 | $0.041 \mu \mathrm{~m}$ | not with NEO-Select Software |

[^6]
## Permanent Laboratory - Oberkochen and on-site Calibration

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

${ }^{1)}$ 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 - Essingen

Calibration and Measurement Capabilities (CMC)

| Measurement quantity <br> Calibration item |
| :--- |
| Coodinate measuring |
| technology |
| Prismatic workpieces |


| Range | Measurement conditions / procedure | Expanded uncertainty of measurement ${ }^{1)}$ | Remarks |
| :---: | :---: | :---: | :---: |
| Coordinate measuring machine with one for the implementation of the calibration procedure specified measuring volume with the dimensions <br> $X=1160 \mathrm{~mm}$ <br> $Y=2060 \mathrm{~mm}$ <br> $Z=620 \mathrm{~mm}$ <br> (the indications $X, Y, Z$ designate the coordinate axes in manufacturer notation) <br> Calibrations are performed with probing elements with a diameter in range $0,3 \mathrm{~mm}$ to 30 mm . | Tactile measurements using a calibrated coordinate measuring machine and determination of geometric parameters defined through control geometries (singlepoints, straight lines, planes, circles, balls, cylinders, tapers, toroids) using the evaluation software of the coordinate measuring machine. <br> The measuring points can be detected by single point or scanning method. <br> 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. <br> Excluded are evaluations of gearing parameters and free form surfaces and the use of a turntables in the measuring process. <br> 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 lengthmeasurements on steel artefacts in measuring positions according to DIN EN ISO 10360-2: <br> 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: $U_{\mathrm{E} 0}=0.3 \mu \mathrm{~m}+2 \cdot 10^{-6} \cdot L$ and for measurements with lateral stylus ( 150 mm distance between center of the probing ball and the pinole axis) maximum: $U_{\mathrm{E} 150}=0.4 \mu \mathrm{~m}+2 \cdot 10^{-6} \cdot L$ <br> 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: $\begin{aligned} & L=20 \mathrm{~mm} U=0.3 \mu \mathrm{~m} \\ & L=1000 \mathrm{~mm} U=1.9 \mu \mathrm{~m} \\ & L=1980 \mathrm{~mm} U=7.4 \mu \mathrm{~m} \end{aligned}$ | $L=$ measured length <br> The measurement uncertainty is task-specific. Therefore, no smallest applicable measurement uncertainty can be specified for any measuring tasks. <br> The here specified measurement uncertainties are exemplary for the respecttively described measuring tasks. <br> For general measuring tasks referred to the accredited scope the measuring uncertainty could be significant differently. <br> 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. <br> The measurement and evaluation strategy is explicitly documented in the calibration certificate. The dimension of a taskspecific measurement uncertainty can be estimated based on the information of a inspection plan. The laboratory can do this before the real measurement starts. |

[^7]| 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: $\begin{aligned} & X=1160 \mathrm{~mm} \\ & Y=2060 \mathrm{~mm} \\ & Z=620 \mathrm{~mm} \end{aligned}$ |  | 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) $U=0.23 \mu \mathrm{~m}$ for the determination of the diameter (evaluation to Gauß) $U=0.34 \mu \mathrm{~m}$ | 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 $150 \mathrm{~W} / \mathrm{U}$. |
| Step gauge blocks | to 1100 mm | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_24: } \\ & \text { 2019/11 } \end{aligned}$ <br> Measurement of the mean size with a coordinate measuring machine in comparison with a step gauge block of the same nominal size | $0.06 \mu \mathrm{~m}+0.22 \cdot 10^{-6} \cdot l$ | $l=$ step length |
| Length standards for optical metrology <br> 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 | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_26: } \\ & \text { 2018/04 } \end{aligned}$ <br> Substitution measurement with a line scale and the same nominal lengths using a coordinate measuring machine and optical scanning in transmitted light. | $0.09 \mu \mathrm{~m}+0.14 \cdot 10^{-6} \cdot l$ | $l=$ measured length of $\|\alpha\| \leq 0.5 \cdot 10^{-6} \mathrm{~K}^{-1}$ and $U \alpha \leq 0.1 \cdot 10^{-6} \mathrm{~K}^{-1}$ <br> The linear thermal expansion coefficient $\alpha$ and its uncertainty are taken into account in the measurement uncertainty. |
|  |  | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_26: } \\ & \text { 2018/04 } \end{aligned}$ <br> Substitution measurement with a line scale using a coordinate measuring machine and optical scanning in transmitted light. | $0.15 \mu \mathrm{~m}+0.1 \cdot 10^{-6} \cdot l$ |  |

[^8]
## Permanent Laboratory - Essingen

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 (photomasks with CR layer) | 0.06 mm to 10 mm | I_DI_S_ALM_01_01_A_26: <br> 2018/04 <br> 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. <br> For layer thickness between 30 nm and 190 nm . <br> The calibration object is identical to the traceability standard. | $0.25 \mu \mathrm{~m}$ | Diameter and form error refer to the probing points |
| Roundness deviation $(R O N \mathrm{t})$ |  |  | $0.3 \mu \mathrm{~m}$ |  |
| Length standards for optical measurement technology <br> Roundness deviation (RONt) of structures on flat substrates (photomasks with CR layer) | 0.06 mm to 10 mm | I_DI_S_ALM_01_01_A_26: <br> 2018-04 <br> Measurement with a coordinate measuring machine and optical probing in transmitted light. <br> Twenty-five single-points are probed according to the dot pattern of the DIN EN ISO 10360-7: 2011. <br> For layer thickness between 30 nm and 190 nm . | $0.6 \mu \mathrm{~m}$ | Form error refers to the probing points |
| Length standards for optical metrology | 2D-Range: <br> $900 \mathrm{~mm} \times 1100 \mathrm{~mm}$ | $\begin{aligned} & \text { I_DI_S_ALM_01_01_A_22: } \\ & \text { 2018/12 } \end{aligned}$ <br> 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). | $0.7 \mu \mathrm{~m}+2 \cdot 10^{-6} \cdot l$ | $l=$ measured length |
|  | 2D-Range: <br> $1200 \mathrm{~mm} \times 1980 \mathrm{~mm}$ |  | $1.4 \mu \mathrm{~m}+2.2 \cdot 10^{-6} \cdot l$ |  |

[^9]

## 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 |

[^10]
[^0]:    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.
[^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.

[^2]:    ${ }^{1)}$ 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.

[^3]:    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.
[^4]:    ${ }^{1)}$ 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.

[^5]:    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.
[^6]:    ${ }^{1)}$ 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.

[^7]:    ${ }^{1)}$ 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.

[^8]:    ${ }^{1)}$ 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.

[^9]:    ${ }^{1)}$ 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.

[^10]:    ${ }^{1)}$ 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.

