



Certificate of Calibration

AS LEFT

Certificate ID: L1T11606121421

Manufacturer Carl Zeiss
Model GageMax
Serial Number 124701
Customer ID -
Customer Miltera Machining Research Corp.
60 Struck Court
Cambridge, ON N1R 8L2 CA

The equipment identified in this certificate was calibrated with standards that are traceable to national metrology institutes (e.g. NIST) through calibration laboratories accredited to ISO 17025. All results are reported in units of measure as defined by the International System of Units (SI).

Job Number T11606

Calibration Certificate page 1 of 18

The user is responsible for definition of appropriate intervals of calibration.

Date of Calibration 2021-12-14

Please store in a secure location. Elliott-Matsuura Canada Inc. is not responsible for loss of data

Calibration Procedure ISO-10360

UAWT Version 9.6.0.752

Calibration certificates without signature are not valid.

Signature / Name
Matthew Joyce

Date
2021-12-14

The most noteworthy contributor to the uncertainty budget of a CMM is the deviation of temperature away from the standard of 20 degrees Celsius. This calibration certificate shall not be reproduced, except in full, without written approval of Elliott-Matsuura Canada Inc. Unless otherwise annotated in protocol results, machine condition is in good working order. The reported results relate only to the item(s) specified above. All measurements performed at 95% confidence level (K=2).

1. Calibration task

Indication error E_0 for length measurements and probing error P_{FTU} are measured on the coordinate measuring machine for sensor systems with scanning capability, scanning probing error THP and the time for the scanning test are calibrated.

For sensor systems with scanning capability, roundness form measuring error $RONt$ ($MZCI$) was measured. If a rotary table is installed, the four-axis errors FR , FT and FA were measured if this measurement was ordered.

The coordinate measuring machine had the following configuration at the time of calibration:

Controller:	C99N #124010 / FW: 27.13
Probe:	VAST XT gold #001R6EET
Measurement SW:	CALYPSO 2016
Reference sphere:	#L0464-A r=14.9953
Rotary table:	-
X measuring range:	500mm
Y measuring range:	750mm
Z measuring range:	500mm

2. Calibration procedure

Calibration of the metrological features of the coordinate measuring machine was performed according to Carl Zeiss IMT procedure CL-1001. This procedure is established and validated using international metrological methods.

Efforts were made to achieve ISO 10360-2, 6.3.2 which states *"The longest calibrated test length for each position shall be at least 66 % of the maximum travel of the CMM along a measurement line through the calibrated test length."*

When unable, $\geq 66\%$ of each linear axis is measured, via additional measurements if necessary.

The roundness form measurement errors $RONt$ ($MZCI$) were determined by measuring a master ring in the scanning mode with $D = 50\text{mm}$.

The four-axis measurement deviations FR (radial), FT (tangential) and FA (axial) were determined using two ceramic spheres with $D = 12\text{mm}$. The ceramic spheres were clamped with a horizontal distance from the rotary axis of $r = \text{mm}$ and a horizontal distance of $d = \text{mm}$ as well as a vertical distance of $h = \text{mm}$.

The single stylus form error P_{FTU} as well as the scanning probing error THP and their test duration were determined on a ceramic sphere with $D = 25\text{mm}$.

The customer is identified on page 1. The machine location is specified in section 3.

The calibration standards used are specified in the relevant sections of the measurement result documentation.

3. Ambient conditions

The maximum temperature deviation from 20°C during the measurement was 1.47°C. The calibration was performed on-site. The coordinate measuring machine is installed at the following location:

Miltera Machining Research Corp.
60 Struck Court
Cambridge, ON N1R 8L2 CA

Shop Floor

4. Measurement results

The measurement results apply only to the specified time of measurement. They also apply only to the relevant installation site and machine settings at the time of calibration. All settings and correction values were documented by the calibration laboratory.

4.1 Indication error for length measurements E_0

The following parallel and stepped gauge blocks are used to determine indication errors:

GCS number: E54 valid to 2022-04-13

The following temperature measuring device was utilized to perform temperature measurement to calculate deviation from a reference temperature of 20°C (if applicable).

GCS number: E42 valid to 2022-02-22

The determined indication errors E_0 and the maximum permissible indication error for length measurements $E_{0, MPE}$ are represented in the following diagrams.

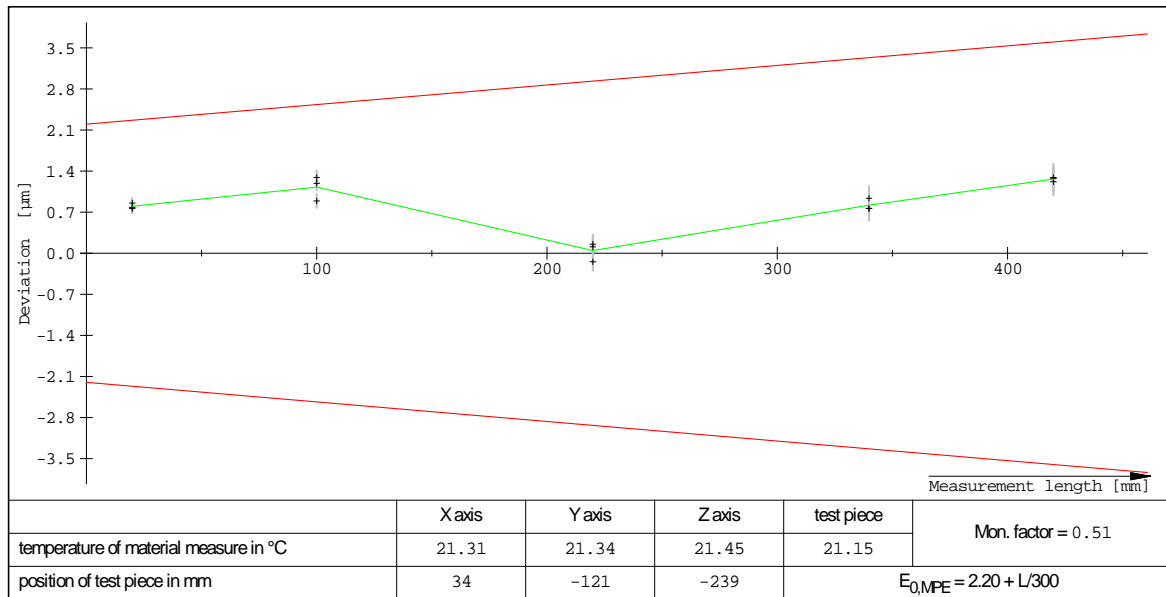
The maximum permissible indication error amounts to:

$$MPE_{E_0} = \pm (A + L/K) \leq B \quad (L \text{ in mm})$$

$$MPE_{E_0} = \pm (2.20 + L/300) \quad \mu\text{m}$$

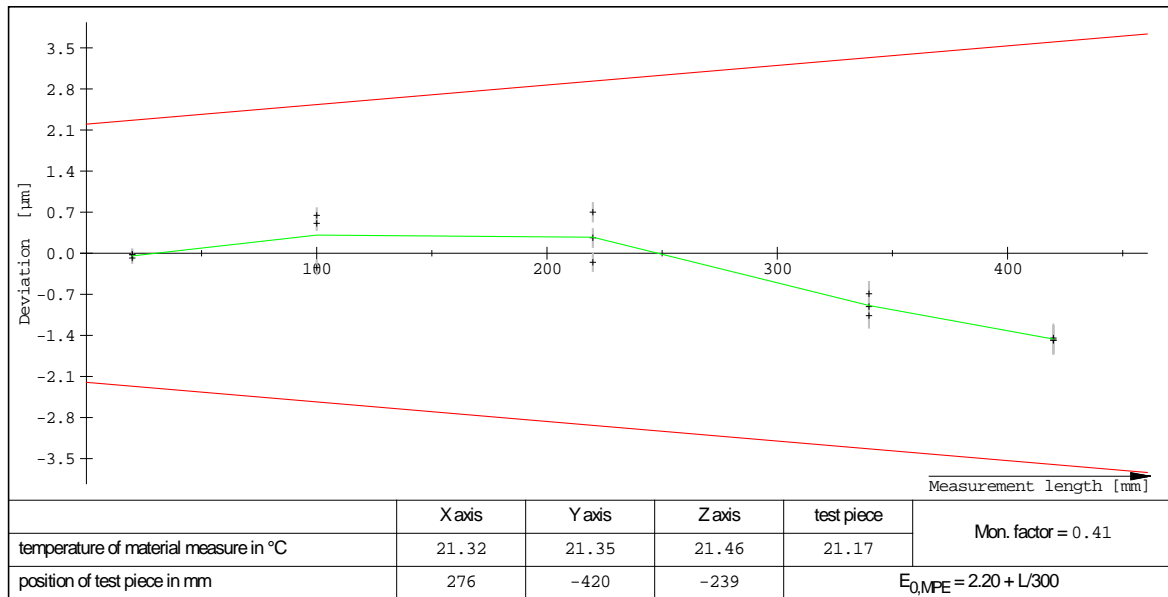
The measured results were determined with a stylus $L = 90 \text{ mm}$ and $D = 12.0 \text{ mm}$.

indication error in pos. 1 (X axis (rear-left))



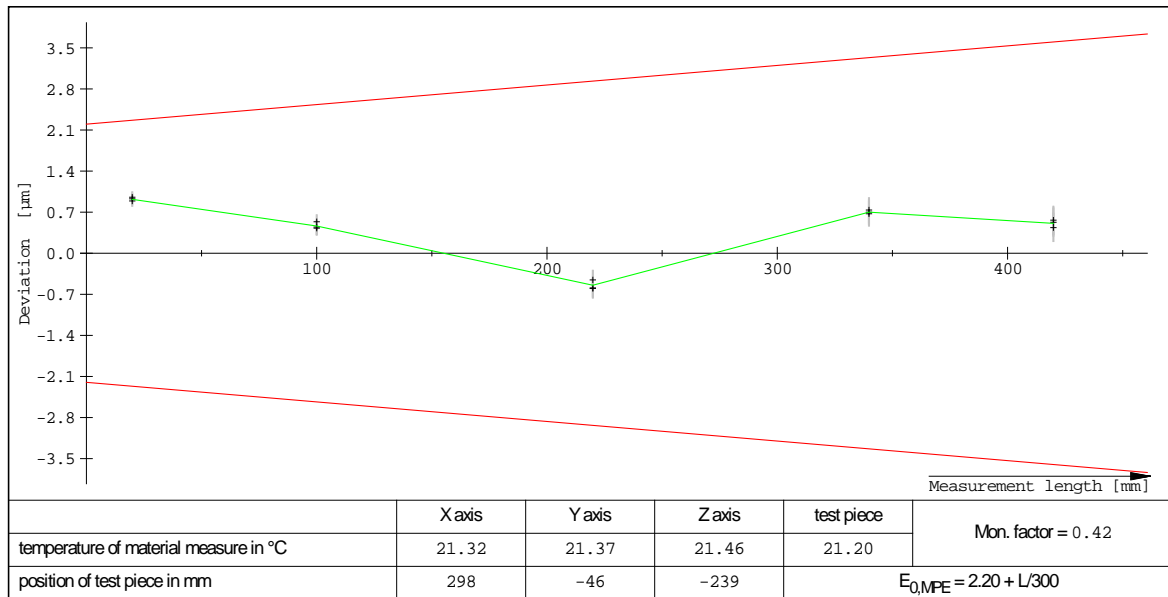
Measuring length L in mm		Deviations in mm		
nominal value	actual value	mean value	minimum	maximum
19.86837	19.86917	0.00080	0.00076	0.00085
99.95125	99.95237	0.00112	0.00089	0.00129
219.91936	219.91940	0.00004	-0.00014	0.00016
339.90338	339.90420	0.00082	0.00076	0.00093
419.91506	419.91632	0.00126	0.00122	0.00129

indication error in pos. 2 (X axis (front-right))



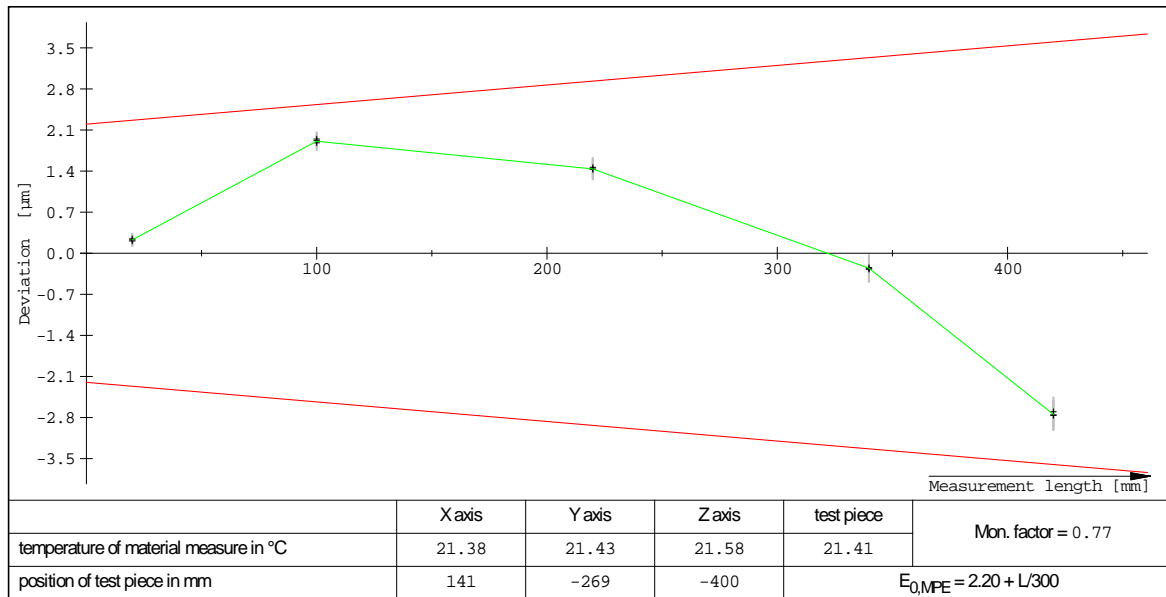
Measuring length L in mm		Deviations in mm		
nominal value	actual value	mean value	minimum	maximum
19.86837	19.86833	-0.00004	-0.00008	-0.00002
99.95125	99.95156	0.00031	-0.00024	0.00065
219.91936	219.91963	0.00027	-0.00015	0.00070
339.90338	339.90249	-0.00089	-0.00106	-0.00069
419.91506	419.91359	-0.00147	-0.00148	-0.00145

indication error in pos. 3 (Y axis)



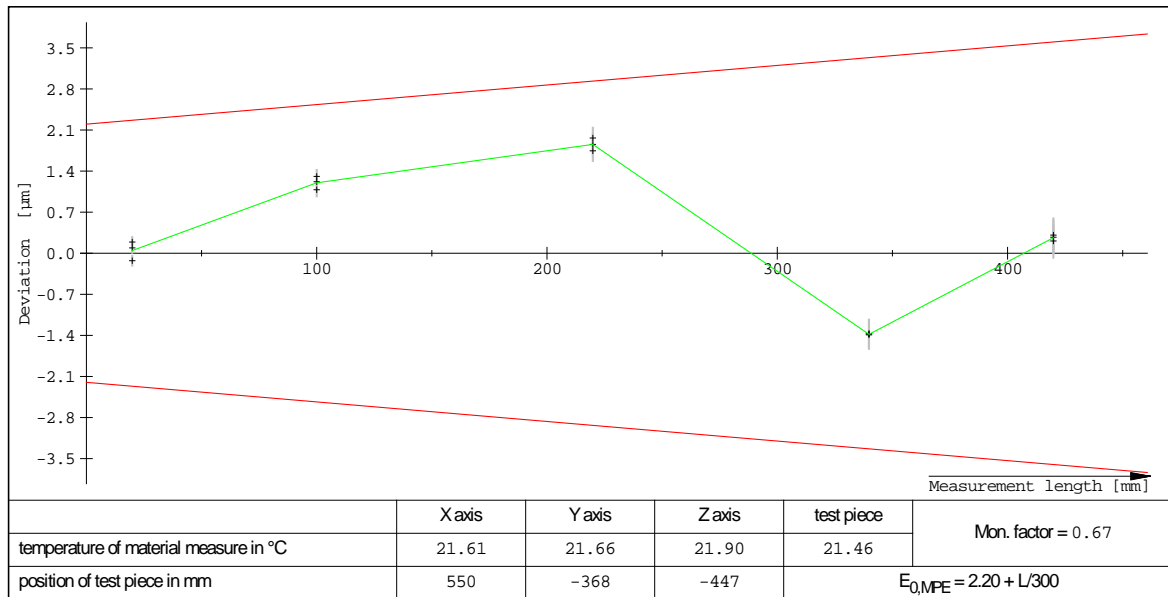
Measuring length L in mm		Deviations in mm		
nominal value	actual value	mean value	minimum	maximum
19.86837	19.86929	0.00092	0.00089	0.00095
99.95125	99.95172	0.00047	0.00043	0.00053
219.91936	219.91881	-0.00055	-0.00060	-0.00045
339.90338	339.90408	0.00070	0.00067	0.00073
419.91506	419.91557	0.00051	0.00044	0.00056

indication error in pos. 4 (Z axis)



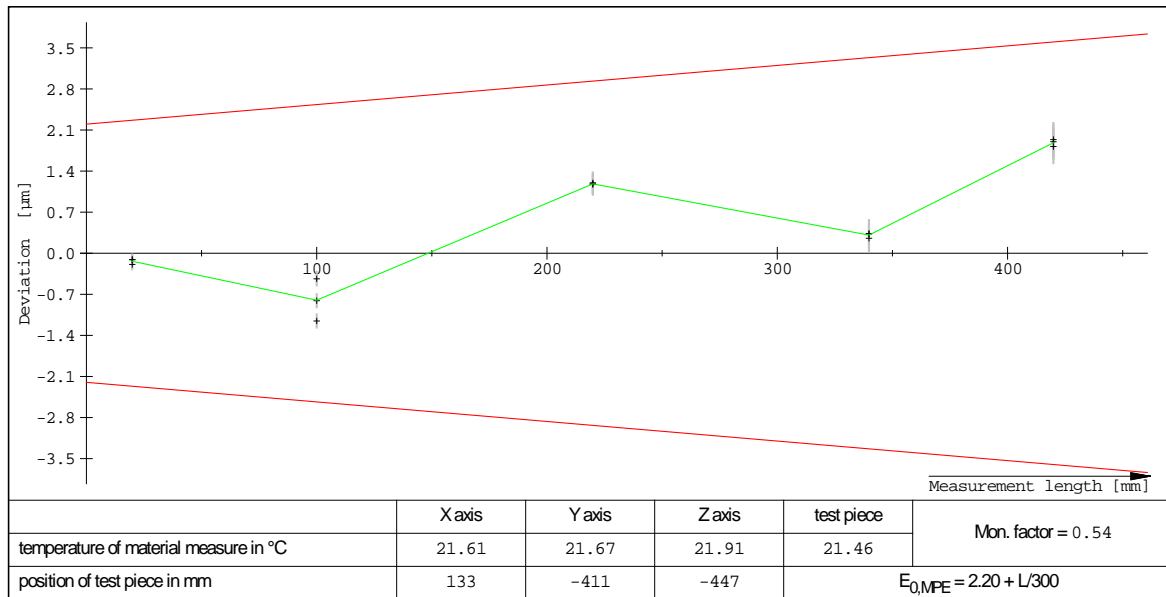
Measuring length L in mm		Deviations in mm		
nominal value	actual value	mean value	minimum	maximum
19.86837	19.86860	0.00023	0.00021	0.00025
99.95125	99.95316	0.00191	0.00188	0.00194
219.91936	219.92080	0.00144	0.00143	0.00146
339.90338	339.90312	-0.00026	-0.00027	-0.00024
419.91506	419.91232	-0.00274	-0.00276	-0.00270

indication error in pos. 5 (Spatial (front-right))



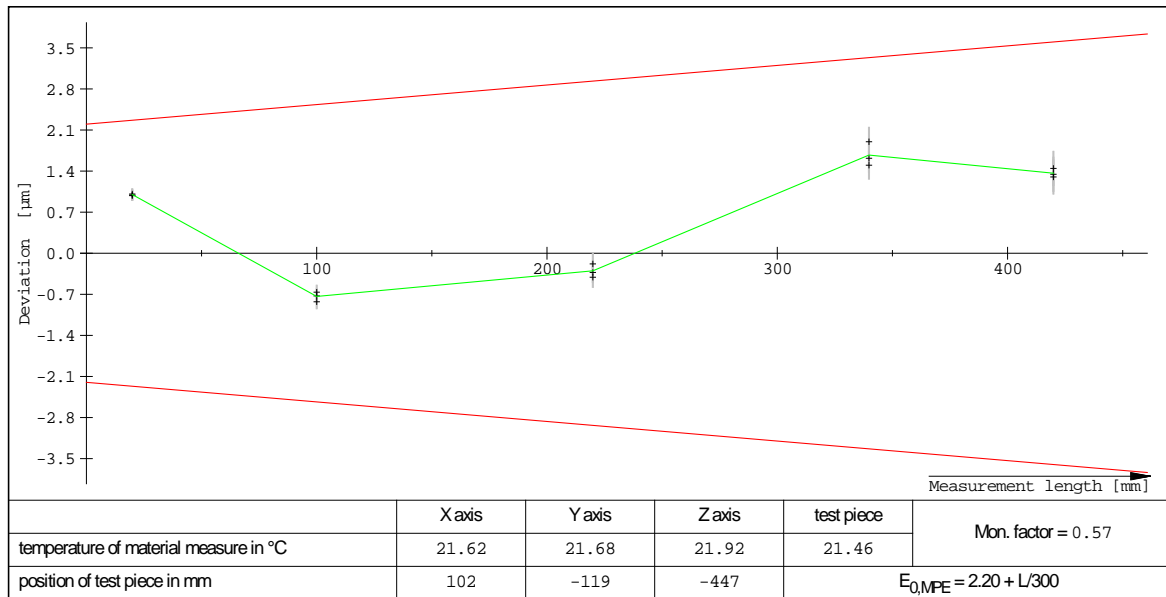
Measuring length L in mm		Deviations in mm		
nominal value	actual value	mean value	minimum	maximum
19.86837	19.86842	0.00005	-0.00013	0.00019
99.95125	99.95245	0.00120	0.00108	0.00131
219.91936	219.92121	0.00185	0.00174	0.00197
339.90338	339.90200	-0.00138	-0.00140	-0.00137
419.91506	419.91532	0.00026	0.00021	0.00031

indication error in pos. 6 (Spatial (front-left))



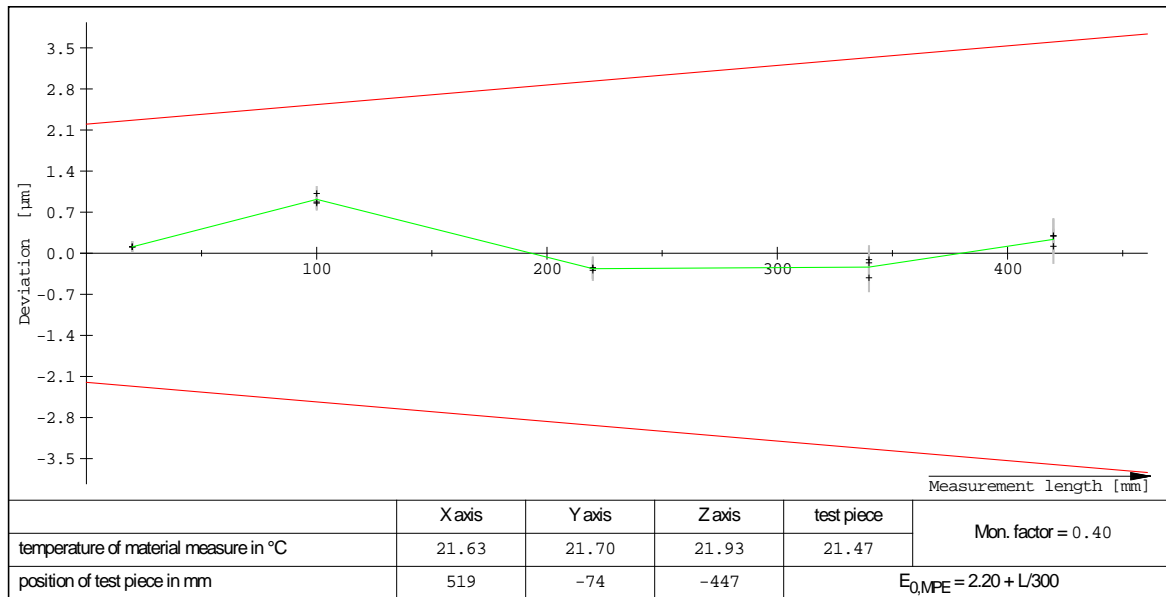
Measuring length L in mm		Deviations in mm		
nominal value	actual value	mean value	minimum	maximum
19.86837	19.86824	-0.00013	-0.00019	-0.00011
99.95125	99.95045	-0.00080	-0.00116	-0.00043
219.91936	219.92055	0.00119	0.00117	0.00120
339.90338	339.90369	0.00031	0.00025	0.00034
419.91506	419.91694	0.00188	0.00182	0.00194

indication error in pos. 7 (Spatial (rear-left))



Measuring length L in mm		Deviations in mm		
nominal value	actual value	mean value	minimum	maximum
19.86837	19.86937	0.00100	0.00099	0.00101
99.95125	99.95051	-0.00074	-0.00083	-0.00066
219.91936	219.91906	-0.00030	-0.00041	-0.00018
339.90338	339.90505	0.00167	0.00150	0.00190
419.91506	419.91643	0.00137	0.00130	0.00145

indication error in pos. 8 (Spatial (rear-right))



Measuring length L in mm		Deviations in mm		
nominal value	actual value	mean value	minimum	maximum
19.86837	19.86848	0.00011	0.00011	0.00011
99.95125	99.95216	0.00091	0.00085	0.00102
219.91936	219.91910	-0.00026	-0.00029	-0.00025
339.90338	339.90315	-0.00023	-0.00042	-0.00011
419.91506	419.91530	0.00024	0.00012	0.00030

4.2 Probing error P_{FTU}

The following ceramic sphere was used to determine the probing error:

GCS number: E57 valid to 2023-06-25

The max. permissible value : **2.2 μm**

Measured value: **$P_{FTU} = (1.68 \pm 0.06) \mu\text{m}$**

Position of test object: X = 160mm Y = -317mm Z = -375mm

Temperature of test object in °C: 21.30

The measured results were determined with a stylus L = 90 mm and a D of 12.0 mm.

4.3 Scanning probing error THP and scanning test duration

The following ceramic sphere was used to determine scanning probing error THP and the scanning test duration:

GCS number: E57 valid to 2023-06-25

The max. permissible value for scanning probing error THP: **3.3 μm**

The measured value of the : **THP = (1.93 \pm 0.06) μm**

The max. permissible value for the scanning test duration is: **50 s ^{*)}**

The measured value : **= (25.0 \pm 0.90) s ^{*)}**

Position of test object: X = 160mm Y = -317mm Z = -375mm

Temperature of test object in °C: 21.33

The measured results were determined with a stylus L = 50 mm and a D of 3.0 mm.

*) NOTE: This measurement is outside the scope of this laboratory's A2LA scope of accreditation

4.4 Roundness form measurement error RONT (MZCI)

The following master ring is used to determine roundness form measurement error **RONT (MZCI)**:

GCS number: E13 valid to 2023-05-13

Max. permissible roundness error: $t = 2.2 \mu\text{m}$

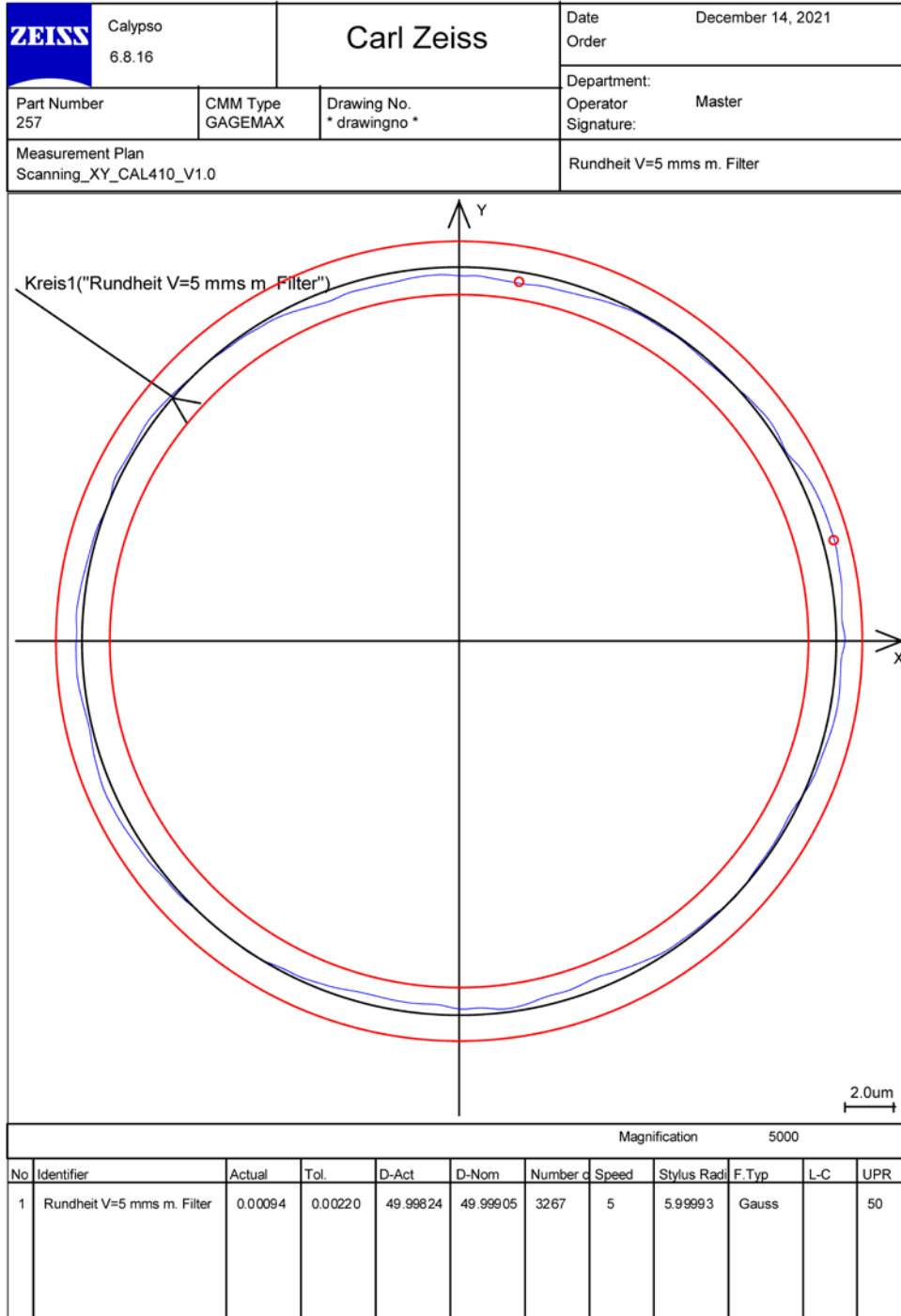
Measurement results:

In the X/Y plane: $t = (0.94 \pm 0.14) \mu\text{m}$ ($T = 21.3^\circ\text{C}$; stylus L = 94mm and D = 12.0mm)

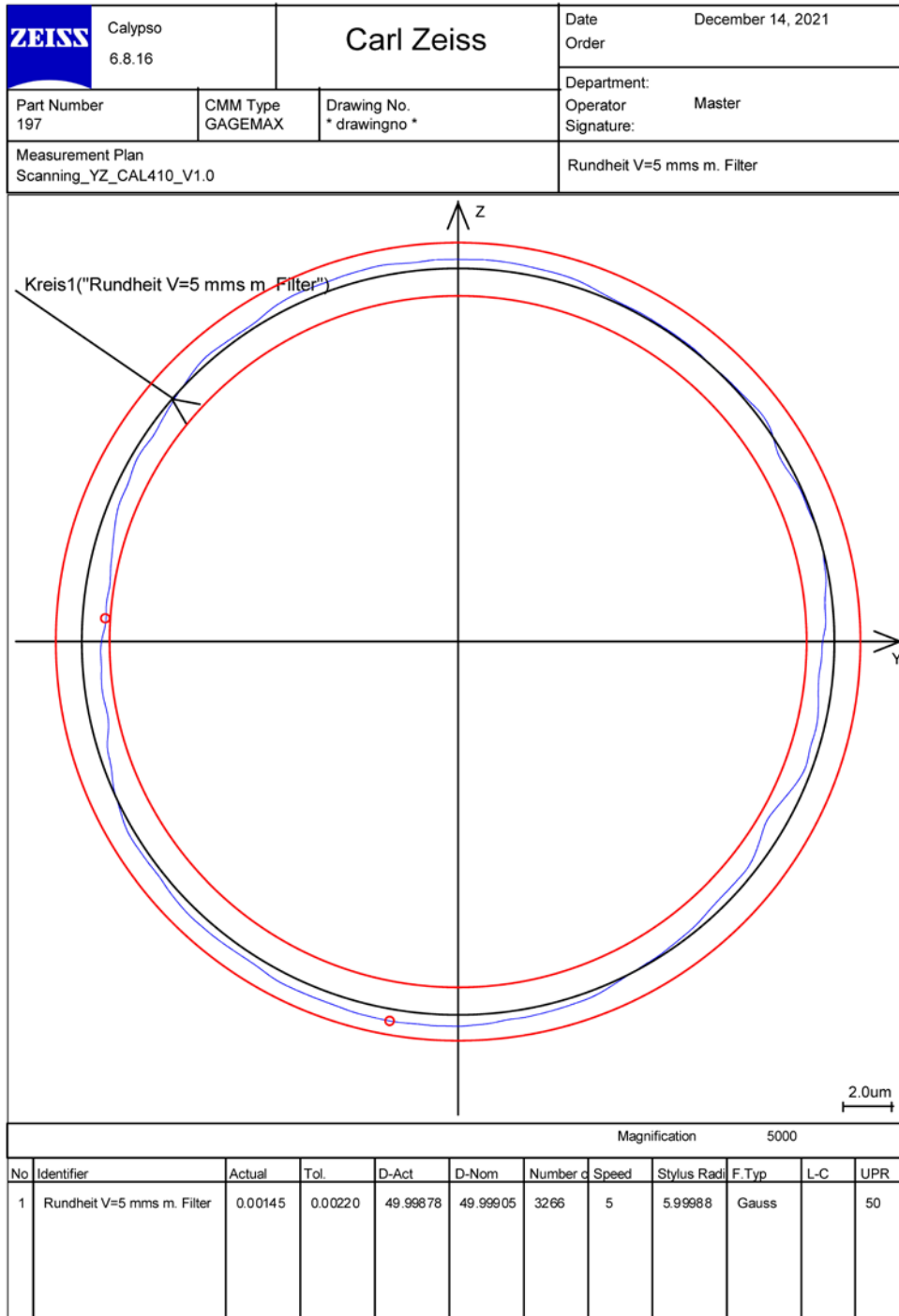
In the X/Z plane: $t = (1.66 \pm 0.14) \mu\text{m}$ ($T = 21.4^\circ\text{C}$; stylus L = 94mm and D = 12.0mm)

In the Y/Z plane: $t = (1.45 \pm 0.14) \mu\text{m}$ ($T = 21.4^\circ\text{C}$; stylus L = 94mm and D = 12.0mm)

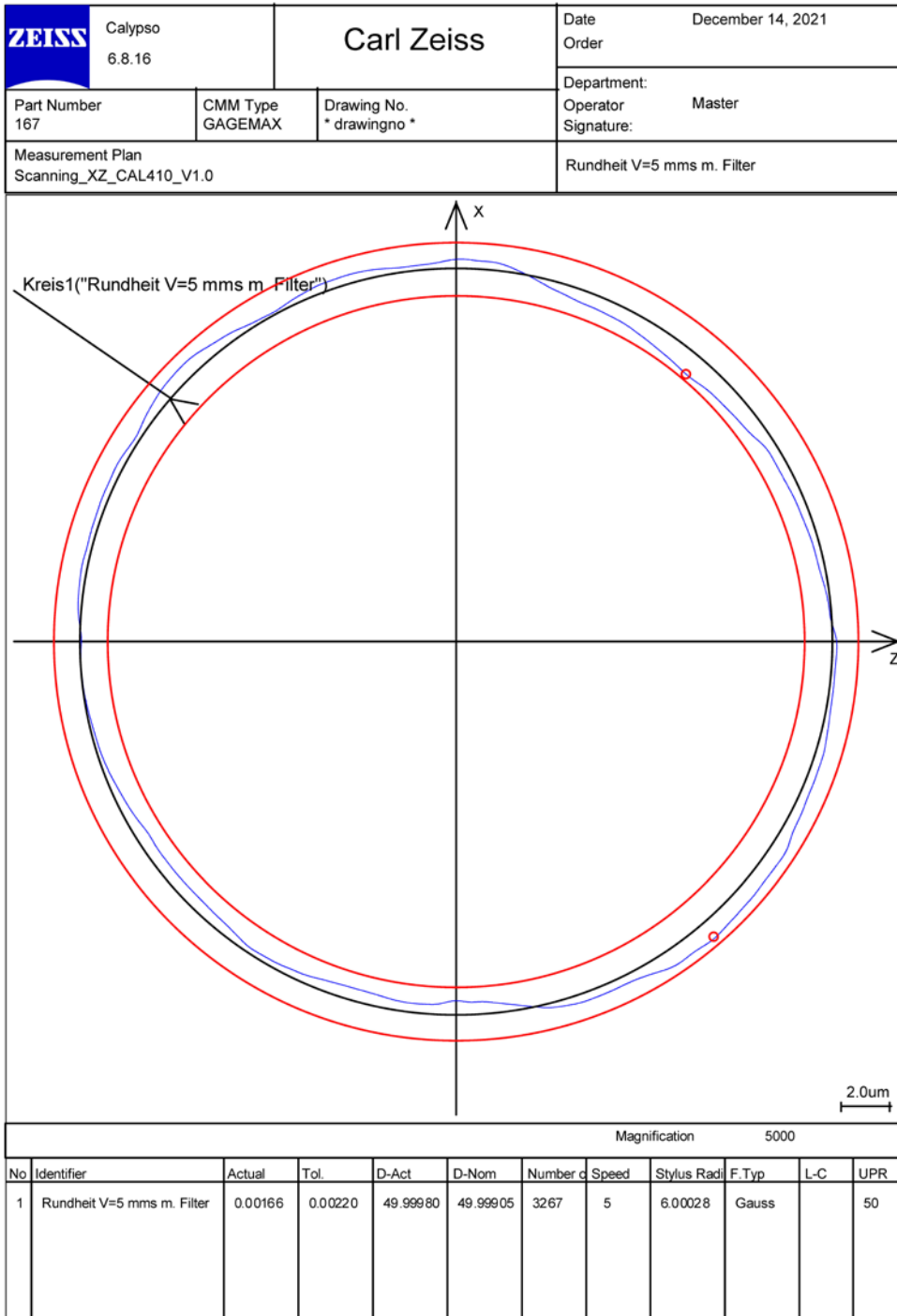
Roundness form measurement error RONT (MZCI) XY-Plane



Roundness form measurement error RONT (MZCI) YZ-Plane



Roundness form measurement error RONT (MZCI) XZ-Plane



5. Measuring uncertainty

The greatest measuring uncertainty experienced during calibration is reported on page 1 of the calibration certificate.

Zero Guard Banding: Uncertainty of measurement was not factored when determining compliance to relevant specifications.

The uncertainty of measurement represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of $K=2$. The probability that the value of the measured variable will lie within the allocated value interval is 95%.

6. Certificate of conformity

If confirmed below, the coordinate measuring machine fulfills the specified requirements. The performance of the coordinate measuring machine has been calibrated according to the relevant specifications.

[The coordinate measuring machine meets the original manufacturer's specification.](#)

7. Opinions / Interpretations resulting from calibration

Refer to the following Appendices:

1. Appendix A for MPE_{PFTU} results
2. Appendix B for MPE_{THP} results



ZEISS CALYPSO

6.8.16

Part name	MPE-P-C44-V070523-DuraMax		
Drawing number			
Order number	Appendix A	Last 1 measurements	► Approval ≠ Blocked
Variant			
Company		Part idnt	n.a176
Department		Time/Date	12/14/2021 1:27 PM
CMM Type	GAGEMAX	Run	All Characteristics
CMM No.	124701	No. measured values	37
Operator	Master	No. values: red	● 0
Text	<input type="text"/>	Measurement Duration	00:01:20.0

Name	Measured value	Nominal value	+Tol	-Tol	Deviation +/-
^Temperature Compensation	21.30				
Temperature AVG START	21.29615	0.00000			21.29615
MPE-P Value	0.00168	0.00000	0.00220	-0.00220	0.00168
X	160.67223	0.00000			160.67223
Y	-317.83870	0.00000			-317.83870
Z	-375.15051	0.00000			-375.15051
Time	53.00000	53.00000			0.00000
TimePerProbing	2.10000	2.10000			0.00000
Minimaler Radius	12.49811	12.49795	0.00250	-0.00250	0.00016
Maximaler Radius	12.49979	12.49795	0.00250	-0.00250	0.00184
Radii(1)	12.49979	12.49795	0.00220	-0.00220	0.00184
Radii(2)	12.49862	12.49795	0.00220	-0.00220	0.00067
Radii(3)	12.49882	12.49795	0.00220	-0.00220	0.00087
Radii(4)	12.49881	12.49795	0.00220	-0.00220	0.00086
Radii(5)	12.49960	12.49795	0.00220	-0.00220	0.00165
Radii(6)	12.49811	12.49795	0.00220	-0.00220	0.00016
Radii(7)	12.49870	12.49795	0.00220	-0.00220	0.00076
Radii(8)	12.49931	12.49795	0.00220	-0.00220	0.00136
Radii(9)	12.49898	12.49795	0.00220	-0.00220	0.00103
Radii(10)	12.49967	12.49795	0.00220	-0.00220	0.00172
Radii(11)	12.49864	12.49795	0.00220	-0.00220	0.00069
Radii(12)	12.49899	12.49795	0.00220	-0.00220	0.00105
Radii(13)	12.49871	12.49795	0.00220	-0.00220	0.00076
Radii(14)	12.49824	12.49795	0.00220	-0.00220	0.00029



ZEISS CALYPSO

6.8.16

Part name **MPE-P-C44-V070523-DuraMax**
 Order number Appendix A
 Part ident n.a176
 Operator Master
 Time/Date 12/14/2021 1:27 PM

Name	Measured value	Nominal value	+Tol	-Tol	Deviation +/-	
Radii(15)	12.49857	12.49795	0.00220	-0.00220	0.00062	
Radii(16)	12.49940	12.49795	0.00220	-0.00220	0.00146	
Radii(17)	12.49923	12.49795	0.00220	-0.00220	0.00129	
Radii(18)	12.49910	12.49795	0.00220	-0.00220	0.00115	
Radii(19)	12.49903	12.49795	0.00220	-0.00220	0.00108	
Radii(20)	12.49925	12.49795	0.00220	-0.00220	0.00131	
Radii(21)	12.49924	12.49795	0.00220	-0.00220	0.00130	
Radii(22)	12.49869	12.49795	0.00220	-0.00220	0.00074	
Radii(23)	12.49929	12.49795	0.00220	-0.00220	0.00135	
Radii(24)	12.49911	12.49795	0.00220	-0.00220	0.00116	
Radii(25)	12.49875	12.49795	0.00220	-0.00220	0.00080	
Temperature AVG END	21.28670	0.00000			21.28670	
Roundness1	0.00133	0.00000	0.00220	0.00000	0.00133	



ZEISS CALYPSO

6.8.16

Part name **MPE-THP-C46-V0804010-DuraMax**
 Drawing number VAST __VAST Speed: 25/25
 Order number Appendix B
 Variant
 Company
 Department
 CMM Type GAGEMAX
 CMM No. 124701
 Operator Master
 Text

Last 1 measurements
 ► Approval ≠ Blocked

Part id 382
 Time/Date 12/14/2021 1:40 PM
 Run All Characteristics
 No. measured values 14
 No. values: red ● 0
 Measurement Duration 00:00:51.0

Name	Measured value	Nominal value	+Tol	-Tol	Deviation +/-
^Temperature Compensation	21.31				
Temperature AVG START	21.32975	0.00000			21.32975
DIN EN ISO 10360-4					
Result 1: MPE-THP	0.00193	0.00330	0.00000	-0.00330	-0.00137 ●
Result 2: MPTtau	25.00000	29.00000	0.00000	-29.00000	-4.00000 ●
DIN EN ISO 10360-4 ► Service Information					
Form error 'Sphere THP' filtered	0.00193	0.00000	0.00330	0.00000	0.00193 ●
Form error 'Sphere THP' unfiltered	0.00448	0.00000	1000.00000	0.00000	0.00448 ●
Rnom-Ract	0.00129	0.00000	3.30000		0.00129 ●
R_min	12.49697	12.49795	0.00330	-0.00330	-0.00097 ●
R_max	12.49923	12.49795	0.00330	-0.00330	0.00129 ●
Diameter Sphere THP	24.99585	24.99589			-0.00004
X-Value 'Sphere THP'	161.29397	0.00000			161.29397
Y-Value 'Sphere THP'	-318.82004	0.00000			-318.82004
Z-Value 'Sphere THP'	-375.27668	0.00000			-375.27668
Temperature AVG - END	21.34010	0.00000			21.34010