Certificate of Calibration

AS LEFT

Certificate ID: L1T10655051821

For AS Found refer to; F1T10655051721

Manufacturer	Carl Zeiss
Model	Micura
Serial Number	201310510093
Customer ID	-
Customer	Miltera Machining Research Corp. 60 Struck Ct. Cambridge, ON N1R 8L2 CA
Job Number	T10655
Calibration Certificate page	1 of 19
Date of Calibration	2021-05-18

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).

A2LA is a signatory to several bilateral and multilateral recognition agreements. These agreements facilitate the acceptance of test and calibration data between A2LA-accredited laboratories and 46 economies around the globe. In addition, A2LA has recognition from over 30 federal, state and local government agencies, companies and associations.

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

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

UAWT Version 9.6.0.752

Calibration Procedure ISO-10360

Uncertainty of Length Measurement = 0.08 + L/2500 [µm] Temperature 20.38 °C

Calibration certificates without signature are not valid.

Signature / Name
Matthew Joyce

Date
2021-05-18

The most noteworthy contributor to the uncertainty budget of a CMM is the deviation of temperature away from the standard of 20 degrees Celsius.

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).

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1. Calibration task

Indication error E_0 for length measurements and probing error **PFTU** 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 #AC018926 / FW: 29.06
Probe:	VAST-XTG-D1 #00253TVS
Measurement SW:	CALYPSO 2020
Reference sphere:	#N1118 r=14.9872
Rotary table:	-
X measuring range:	500mm
Y measuring range:	500mm
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, ≥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 = 50mm.

The four-axis measurement deviations **FR** (radial), **FT** (tangential) and **FA** (axial) were determined using two ceramic spheres with D = 30mm. The ceramic spheres were clamped with a horizontal distance from the rotary axis of r = 206mm and a horizontal distance of d = 412mm as well as a vertical distance of h = 206mm.

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 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 0.65°C.
The calibration was performed on-site. The coordinate measuring machine is installed at the following location:

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

QA Lab

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: E32 valid to 2023-01-22

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

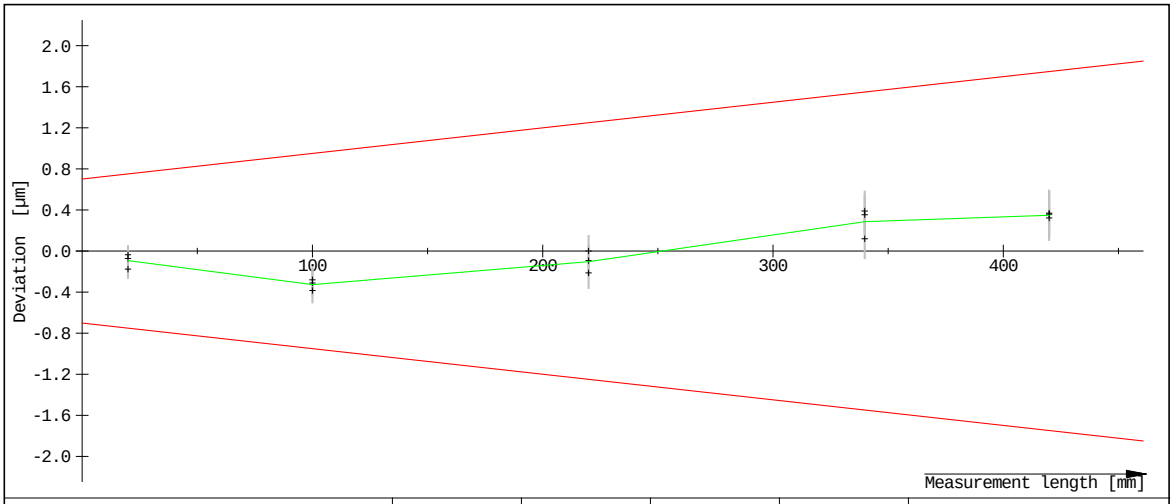
The maximum permissible indication error amounts to:

$MPE_{E0} = +/- (A + L/K) \leq B$ (L in mm)

$MPE_{E0} = +/- (0.70 + L/400)$ µm

The measured results were determined with a stylus L = 94 mm and D = 12.0 mm.

indication error in pos. 1 (X axis (bottom))



	X axis	Y axis	Z axis	test piece	Mon. factor = 0.41
temperature of material measure in °C	20.00	20.00	20.00	20.59	
position of test piece in mm	41	-448	-460	$E_{0,MPE} = 0.70 + L/400$	

Measuring length L in mm		Deviations in mm		
nominal value	**actual value**	**mean value**	**minimum**	**maximum**
19.8684	19.8683	-0.0001	-0.0002	0.0000
99.9513	99.9509	-0.0003	-0.0004	-0.0003
219.9194	219.9193	-0.0001	-0.0002	0.0000
339.9034	339.9037	0.0003	0.0001	0.0004
419.9151	419.9154	0.0004	0.0003	0.0004

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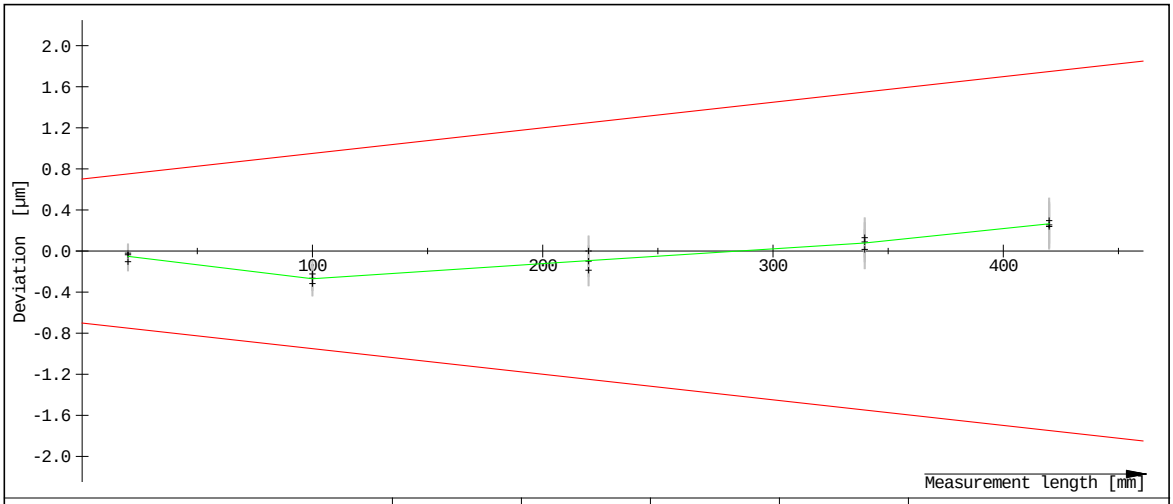
indication error in pos. 2 (X axis (top))



	X axis	Y axis	Z axis	test piece	Mon. factor = 0.33
temperature of material measure in °C	20.00	20.00	20.00	20.65	
position of test piece in mm	34	-231	-52	$E_{0,MPE} = 0.70 + L/400$	

Measuring length L in mm		Deviations in mm		
nominal value	**actual value**	**mean value**	**minimum**	**maximum**
19.8684	19.8683	-0.0001	-0.0001	0.0000
99.9513	99.9510	-0.0003	-0.0003	-0.0002
219.9194	219.9193	-0.0001	-0.0002	0.0000
339.9034	339.9035	0.0001	0.0000	0.0001
419.9151	419.9153	0.0003	0.0002	0.0003

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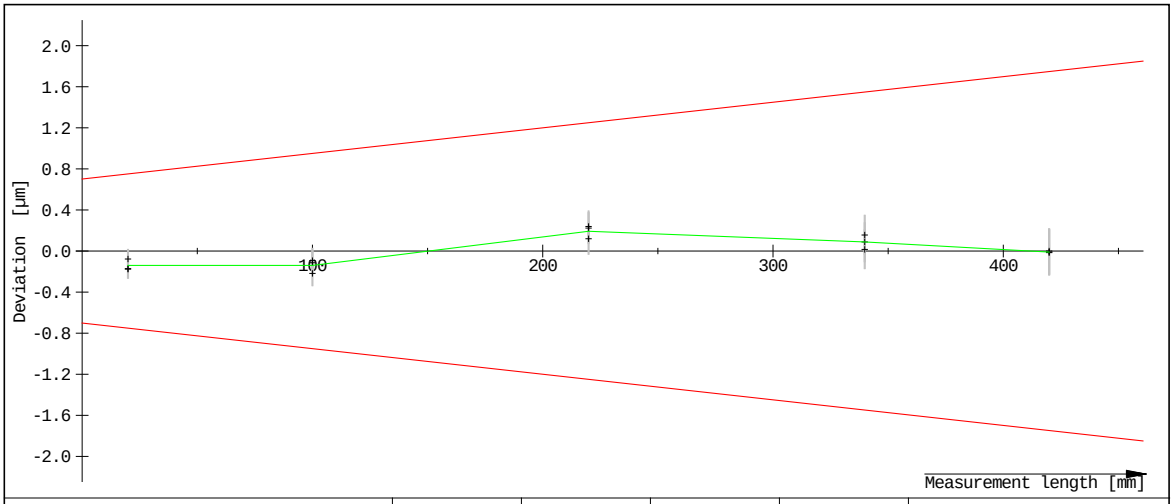
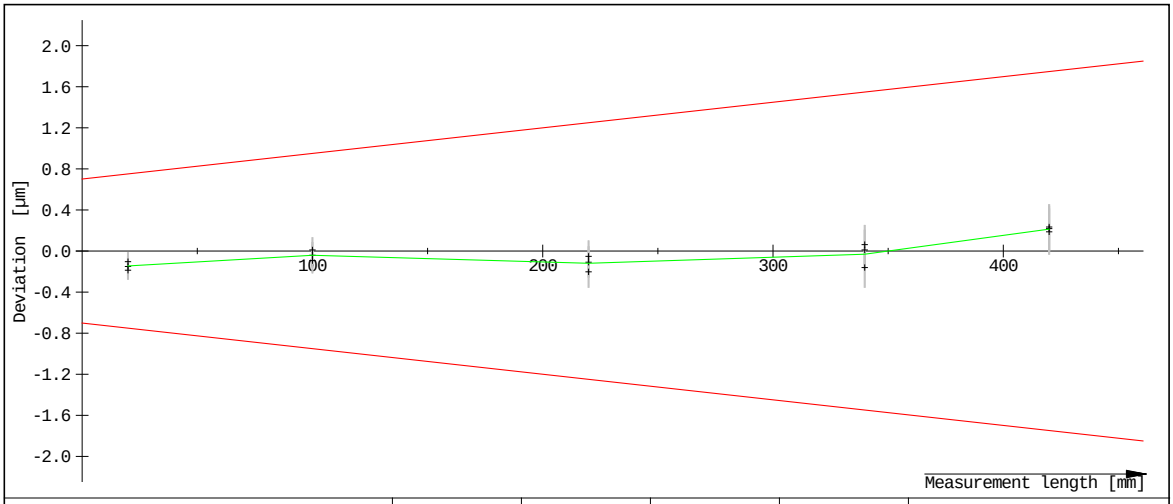
indication error in pos. 3 (Y axis (front-right))



	X axis	Y axis	Z axis	test piece	Mon. factor = 0.24
temperature of material measure in °C	20.00	20.00	20.00	20.57	
position of test piece in mm	444	-448	-137	$E_{0,MPE} = 0.70 + L/400$	

Measuring length L in mm		Deviations in mm		
nominal value	**actual value**	**mean value**	**minimum**	**maximum**
19.8684	19.8682	-0.0001	-0.0002	-0.0001
99.9513	99.9511	-0.0001	-0.0002	-0.0001
219.9194	219.9196	0.0002	0.0001	0.0002
339.9034	339.9035	0.0001	0.0000	0.0002
419.9151	419.9151	0.0000	0.0000	0.0000

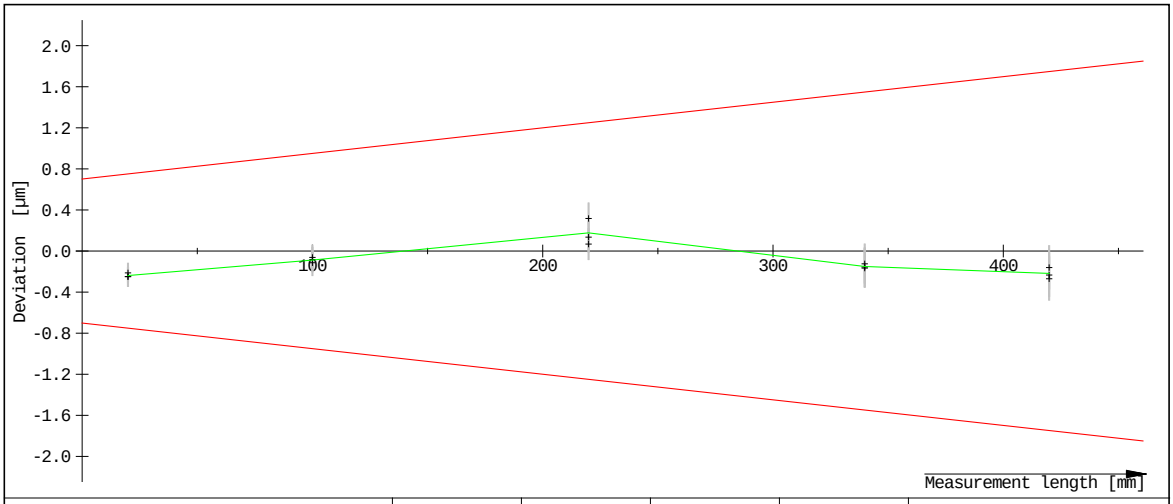
indication error in pos. 4 (Y axis (rear-left))



	X axis	Y axis	Z axis	test piece	Mon. factor = 0.25
temperature of material measure in °C	20.00	20.00	20.00	20.62	
position of test piece in mm	38	-42	-136	$E_{0,MPE}$ = 0.70 + L/400	

Measuring length L in mm		Deviations in mm		
nominal value	**actual value**	**mean value**	**minimum**	**maximum**
19.8684	19.8682	-0.0001	-0.0002	-0.0001
99.9513	99.9512	0.0000	-0.0001	0.0000
219.9194	219.9192	-0.0001	-0.0002	-0.0001
339.9034	339.9034	0.0000	-0.0002	0.0001
419.9151	419.9153	0.0002	0.0002	0.0002

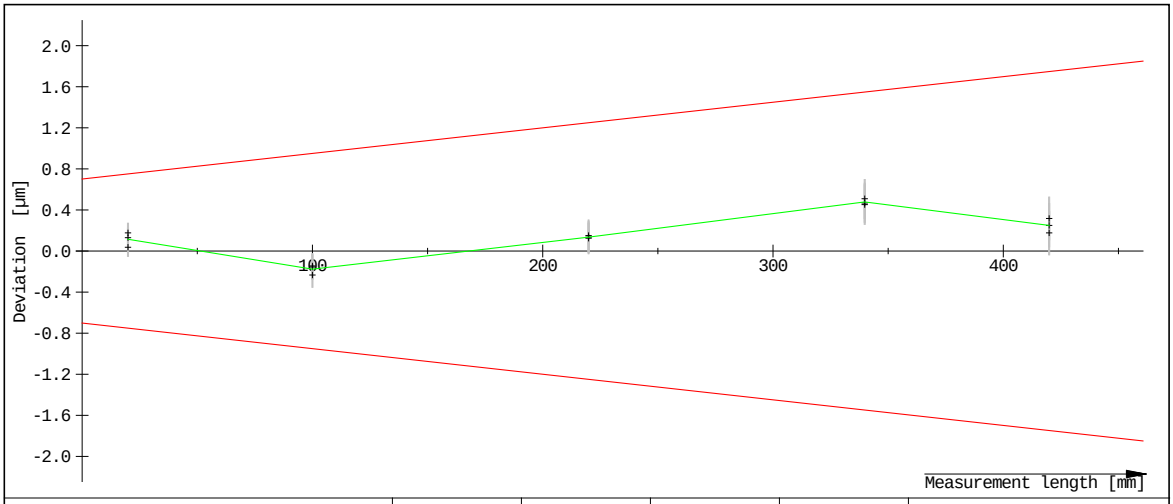
indication error in pos. 5 (Z axis)



	X axis	Y axis	Z axis	test piece	Mon. factor = 0.34
temperature of material measure in °C	20.00	20.00	20.00	20.41	
position of test piece in mm	131	-382	-399	$E_{0,MPE}$ = 0.70 + L/400	

Measuring length L in mm		Deviations in mm		
nominal value	**actual value**	**mean value**	**minimum**	**maximum**
19.8684	19.8681	-0.0002	-0.0003	-0.0002
99.9513	99.9512	-0.0001	-0.0001	-0.0001
219.9194	219.9195	0.0002	0.0001	0.0003
339.9034	339.9032	-0.0001	-0.0002	-0.0001
419.9151	419.9148	-0.0002	-0.0003	-0.0002

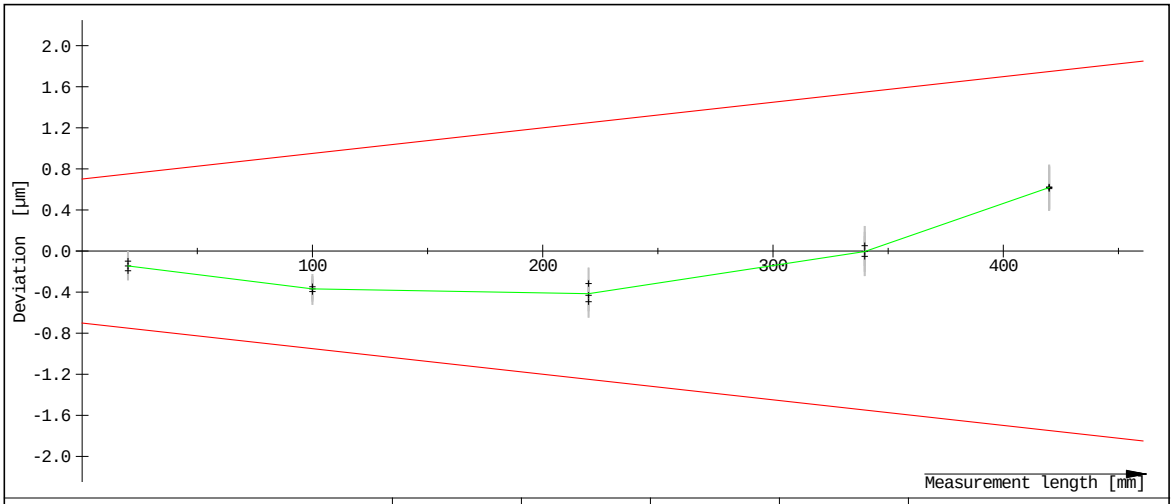
indication error in pos. 6 (Spatial (front-right))



	X axis	Y axis	Z axis	test piece	
temperature of material measure in °C	20.00	20.00	20.00	20.38	Mon. factor = 0.33
position of test piece in mm	397	-346	-308	$E_{0,MPE}$ = 0.70 + L/400	

Measuring length L in mm		Deviations in mm		
nominal value	**actual value**	**mean value**	**minimum**	**maximum**
19.8684	19.8685	0.0001	0.0000	0.0002
99.9513	99.9511	-0.0002	-0.0002	-0.0001
219.9194	219.9195	0.0001	0.0001	0.0001
339.9034	339.9039	0.0005	0.0005	0.0005
419.9151	419.9153	0.0002	0.0002	0.0003

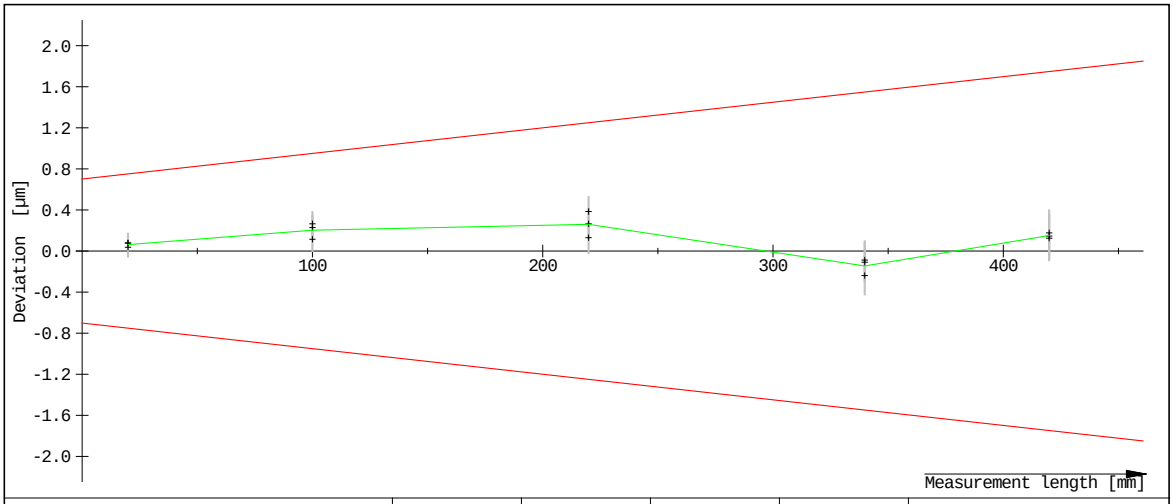
indication error in pos. 7 (Spatial (front-left))



	X axis	Y axis	Z axis	test piece	
temperature of material measure in °C	20.00	20.00	20.00	20.38	Mon. factor = 0.42
position of test piece in mm	69	-391	-308	$E_{0,MPE} = 0.70 + L/400$	

Measuring length L in mm		Deviations in mm		
nominal value	**actual value**	**mean value**	**minimum**	**maximum**
19.8684	19.8682	-0.0001	-0.0002	-0.0001
99.9513	99.9509	-0.0004	-0.0004	-0.0003
219.9194	219.9189	-0.0004	-0.0005	-0.0003
339.9034	339.9034	0.0000	-0.0001	0.0001
419.9151	419.9157	0.0006	0.0006	0.0006

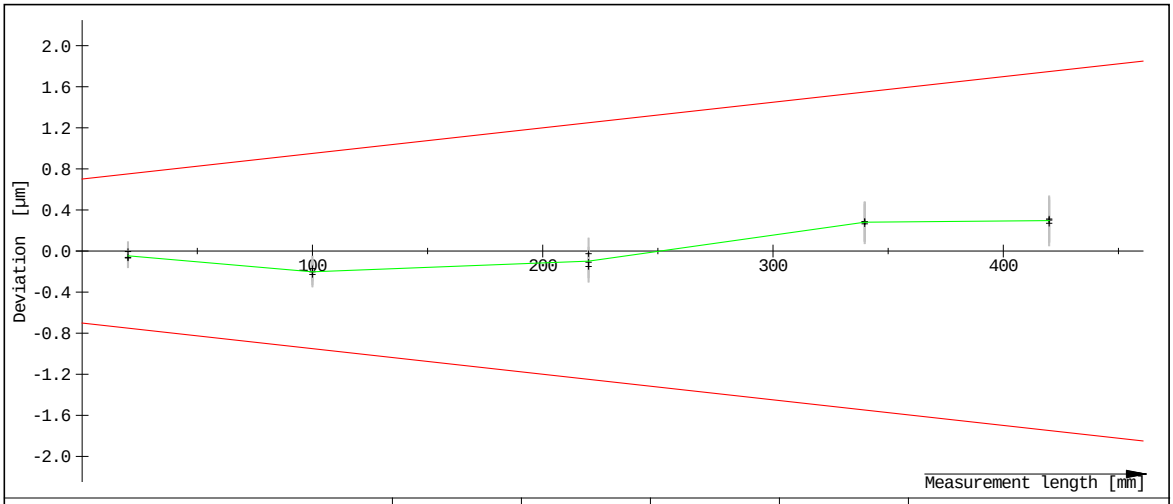
indication error in pos. 8 (Spatial (rear-left))



	X axis	Y axis	Z axis	test piece	Mon. factor = 0.31
temperature of material measure in °C	20.00	20.00	20.00	20.51	
position of test piece in mm	37	-161	-308	$E_{0,MPE}$ = 0.70 + L/400	

Measuring length L in mm		Deviations in mm		
nominal value	**actual value**	**mean value**	**minimum**	**maximum**
19.8684	19.8684	0.0001	0.0000	0.0001
99.9513	99.9515	0.0002	0.0001	0.0003
219.9194	219.9196	0.0003	0.0001	0.0004
339.9034	339.9032	-0.0001	-0.0002	-0.0001
419.9151	419.9152	0.0001	0.0001	0.0002

indication error in pos. 9 (Spatial (rear-right))



	X axis	Y axis	Z axis	test piece	Mon. factor = 0.24
temperature of material measure in °C	20.00	20.00	20.00	20.51	
position of test piece in mm	365	-116	-308	$E_{0,MPE} = 0.70 + L/400$	

Measuring length L in mm		Deviations in mm		
nominal value	**actual value**	**mean value**	**minimum**	**maximum**
19.8684	19.8683	0.0000	-0.0001	0.0000
99.9513	99.9510	-0.0002	-0.0002	-0.0002
219.9194	219.9193	-0.0001	-0.0002	0.0000
339.9034	339.9037	0.0003	0.0003	0.0003
419.9151	419.9154	0.0003	0.0003	0.0003

4.2 Probing error P_{FTU}

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

GCS number: E57 valid to 2021-06-12

The max. permissible value : **0.9 µm**

Measured value: **P_{FTU} = (0.5 ± 0.09) µm**

Position of test object: X = 88mm Y = -383mm Z = -273mm
Temperature of test object in °C: 20.39

The measured results were determined with a stylus L = 94 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 2021-06-12

The max. permissible value for scanning probing error THP: **1.3 µm**

The measured value of the : **THP = (0.7 ± 0.09) µm**

The max. permissible value for the scanning test duration is: **40 s** *)

The measured value : **= (34 ± 0.90) s** *)

Position of test object: X = 88mm Y = -383mm Z = -273mm
Temperature of test object in °C: 20.44
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: E11 valid to 2023-01-22

Max. permissible roundness error: t = **1.0 µm**

Measurement results:

In the X/Y plane: **t = (0.5 ± 0.14) µm** (*T* = 20.5°C; stylus L = 94mm and D = 12.0mm)
In the X/Z plane: **t = (0.5 ± 0.14) µm** (*T* = 20.5°C; stylus L = 94mm and D = 12.0mm)
In the Y/Z plane: **t = (0.4 ± 0.14) µm** (*T* = 20.6°C; stylus L = 94mm and D = 12.0mm)

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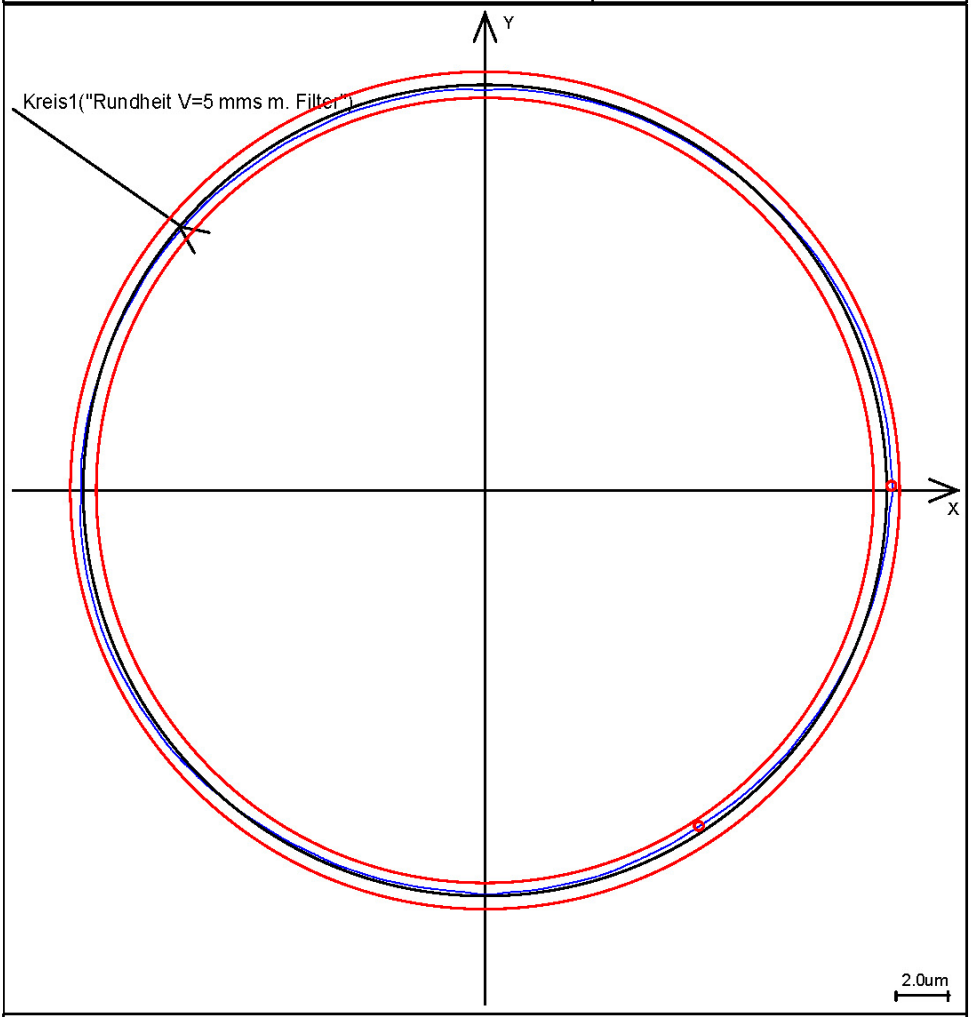
Roundness form measurement error RONt (MZCI) XY-Plane

ZEISS Calypso 6.8.16	Carl Zeiss		Date May 18, 2021 Order
Part Number 172	CMM Type MICURA	Drawing No. * drawingno *	Department: Operator Master Signature:
Measurement Plan Scanning_XY_CAL410_V1.0			Rundheit V=5 mms m. Filter

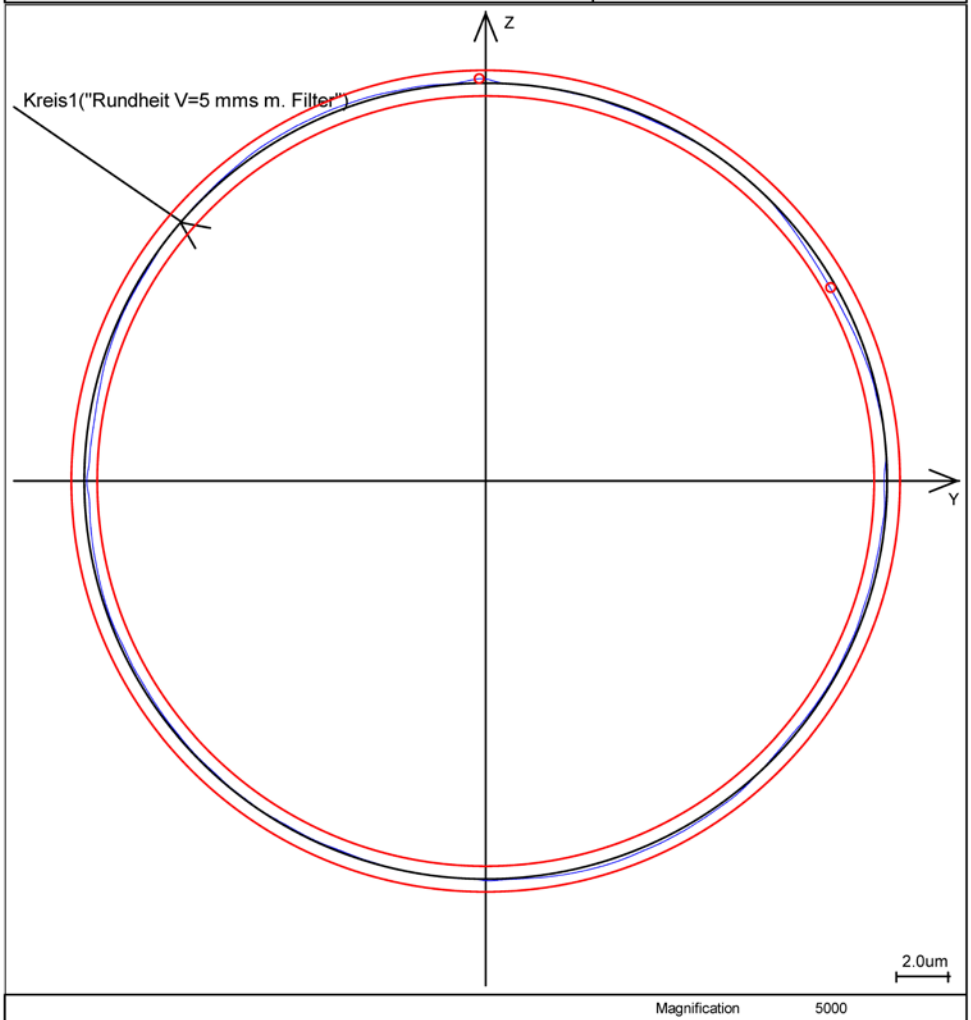


Magnification 5000

No	Identifier	Actual	Tol.	D-Act	D-Nom	Number d	Speed	Stylus Rad	F.Typ	L-C	UPR
1	Rundheit V=5 mms m. Filter	0.00047	0.00100	50.00038	50.00060	3266	5	6.00003	Gauss		50

Roundness form measurement error RONt (MZCI) YZ-Plane

ZEISS Calypso 6.8.16	Carl Zeiss		Date May 18, 2021 Order
Part Number 113	CMM Type MICURA	Drawing No. * drawingno *	Department: Operator Master Signature:
Measurement Plan Scanning_YZ_CAL410_V1.0			Rundheit V=5 mms m. Filter

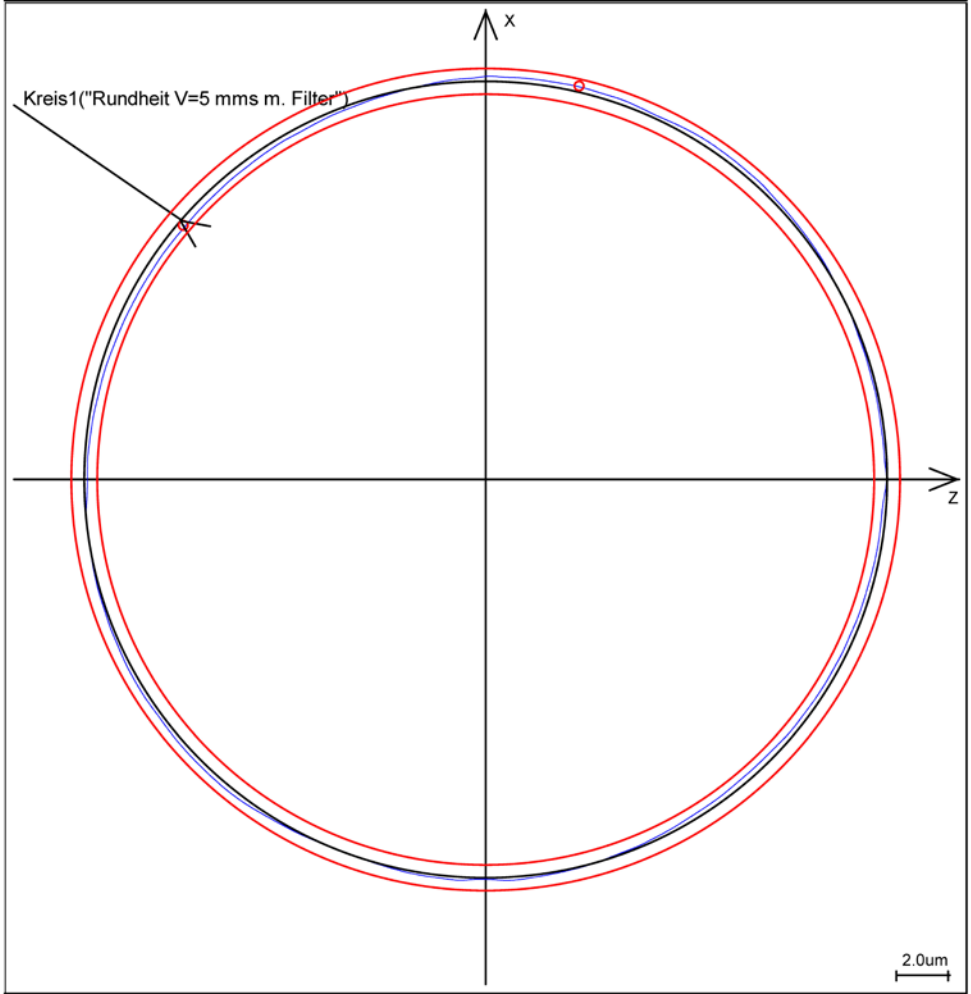


Magnification 5000

No	Identifier	Actual	Tol.	D-Act	D-Nom	Number o	Speed	Stylus Radi	F.Typ	L-C	UPR
1	Rundheit V=5 mms m. Filter	0.00038	0.00100	50.00009	50.00060	3266	5	5.99999	Gauss		50

Roundness form measurement error RONt (MZCI) XZ-Plane

ZEISS Calypso 6.8.16	Carl Zeiss		Date May 18, 2021 Order
Part Number 115	CMM Type MICURA	Drawing No. * drawingno *	Department: Operator Master Signature:
Measurement Plan Scanning_XZ_CAL410_V1.0			Rundheit V=5 mms m. Filter



Magnification 5000

No	Identifier	Actual	Tol.	D-Act	D-Nom	Number o	Speed	Stylus Radi	F.Typ	L-C	UPR
1	Rundheit V=5 mms m. Filter	0.00048	0.00100	50.00089	50.00060	3267	5	6.00006	Gauss		50

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 ident	n.a97
Department		Time/Date	5/18/2021 11:17 AM
CMM Type	MICURA	Run	All Characteristics
CMM No.	510093	No. measured values	37
Operator	Master	No. values: red	0
Text		Measurement Duration	00:01:36.0

Name	Measured value	Nominal value	+Tol	-Tol	Deviation	+/-
^Temperature Compensation	20.40					
Temperature AVG START	20.39570	0.00000			20.39570	
MPE-P Value	0.00046	0.00000	0.00070	-0.00070	0.00046	
X	88.15189	0.00000			88.15189	
Y	-383.30392	0.00000			-383.30392	
Z	-273.19571	0.00000			-273.19571	
Time	68.00000	68.00000			0.00000	
TimePerProbing	2.70000	2.70000			0.00000	
Minimaler Radius	12.49773	12.49798	0.00250	-0.00250	-0.00025	
Maximaler Radius	12.49818	12.49798	0.00250	-0.00250	0.00021	
Radii(1)	12.49818	12.49798	0.00070	-0.00070	0.00020	
Radii(2)	12.49789	12.49798	0.00070	-0.00070	-0.00008	
Radii(3)	12.49792	12.49798	0.00070	-0.00070	-0.00006	
Radii(4)	12.49773	12.49798	0.00070	-0.00070	-0.00025	
Radii(5)	12.49798	12.49798	0.00070	-0.00070	0.00000	
Radii(6)	12.49815	12.49798	0.00070	-0.00070	0.00018	
Radii(7)	12.49786	12.49798	0.00070	-0.00070	-0.00011	
Radii(8)	12.49788	12.49798	0.00070	-0.00070	-0.00009	
Radii(9)	12.49805	12.49798	0.00070	-0.00070	0.00008	
Radii(10)	12.49795	12.49798	0.00070	-0.00070	-0.00002	
Radii(11)	12.49795	12.49798	0.00070	-0.00070	-0.00003	
Radii(12)	12.49792	12.49798	0.00070	-0.00070	-0.00006	
Radii(13)	12.49807	12.49798	0.00070	-0.00070	0.00009	
Radii(14)	12.49796	12.49798	0.00070	-0.00070	-0.00001	

ZEISS CALYPSO
6.8.16

Part name	**MPE-P-C44-V070523-DuraMax**
Order number	Appendix A
Part ident	n.a97
Operator	Master
Time/Date	5/18/2021 11:17 AM

Name	Measured value	Nominal value	+Tol	-Tol	Deviation	+/-
Radii(15)	12.49798	12.49798	0.00070	-0.00070	0.00001	
Radii(16)	12.49813	12.49798	0.00070	-0.00070	0.00016	
Radii(17)	12.49818	12.49798	0.00070	-0.00070	0.00021	
Radii(18)	12.49792	12.49798	0.00070	-0.00070	-0.00006	
Radii(19)	12.49786	12.49798	0.00070	-0.00070	-0.00012	
Radii(20)	12.49800	12.49798	0.00070	-0.00070	0.00002	
Radii(21)	12.49784	12.49798	0.00070	-0.00070	-0.00013	
Radii(22)	12.49785	12.49798	0.00070	-0.00070	-0.00012	
Radii(23)	12.49804	12.49798	0.00070	-0.00070	0.00007	
Radii(24)	12.49792	12.49798	0.00070	-0.00070	-0.00005	
Radii(25)	12.49785	12.49798	0.00070	-0.00070	-0.00013	
Temperature AVG END	20.35190	0.00000			20.35190	
Roundness1	0.00038	0.00000	0.00070	0.00000	0.00038	

ZEISS CALYPSO

6.8.16

Part name	**MPE-THP-C46-V0804010-DuraMax**		
Drawing number	VAST __VAST Speed: 25/25		
Order number	Appendix B	Last 1 measurements ► Approval ≠ Blocked	
Variant			
Company		Part ident	279
Department		Time/Date	5/18/2021 11:21 AM
CMM Type	MICURA	Run	All Characteristics
CMM No.	510093	No. measured values	14
Operator	Master	No. values: red	0
Text		Measurement Duration	00:01:06.0

Name	Measured value	Nominal value	+Tol	-Tol	Deviation	+/-
^Temperature Compensation	20.42					
Temperature AVG START	20.44160	0.00000			20.44160	
DIN EN ISO 10360-4						
Result 1: MPE-THP	0.00067	0.00130	0.00000	-0.00130	-0.00063	
Result 2: MPTtau	34.00000	40.00000	0.00000	-40.00000	-6.00000	
DIN EN ISO 10360-4 ► Service Information						
Form error 'Sphere THP' filtered	0.00067	0.00000	0.00130	0.00000	0.00067	
Form error 'Sphere THP' unfiltered	0.00238	0.00000	1000.00000	0.00000	0.00238	
Rnom-Ract	0.00038	0.00000	1.30000		0.00038	
R_min	12.49759	12.49798	0.00130	-0.00130	-0.00038	
R_max	12.49834	12.49798	0.00130	-0.00130	0.00036	
Diameter Sphere THP	24.99579	24.99595			-0.00016	
X-Value 'Sphere THP'	88.15244	0.00000			88.15244	
Y-Value 'Sphere THP'	-383.30315	0.00000			-383.30315	
Z-Value 'Sphere THP'	-273.19464	0.00000			-273.19464	
Temperature AVG - END	20.47150	0.00000			20.47150	