MarForm MFU 200 – Reference form measuring machine

The close-to-production form measuring station –
ultraprecise and universal

Economical, low-emission motors, micromechanical elements from the optics and electronics sectors, high-performance hydraulics for the aerospace industry, medical diagnostic devices – all these applications require increasingly accurate, more reliable components. Not only should these components comply with the requisite dimensions, they should also have the required form. For companies to be able to produce these parts in a reliable and thus economical way, highly accurate form measurements are required. The more accurately a form measuring device measures actual deviations, the more economical the process will be: absolute and repeatable, close to production and resistant to external influences.

Especially when it comes to rotationally symmetrical parts with tolerances in the range of a thousandth of a millimeter, conventional measuring instruments are often incapable of meeting these requirements. At best, several expensive measuring instruments must be used to test the tools for a variety of features, which is very time-consuming. The MarForm MFU 200, on the other hand, uses technologies that enable the measurement of form and position characteristics as well as high-precision dimensional inspection close to production and at low cost.

Advantages of high-precision Mahr form metrology:

- Highly precise thanks to measurements accurate to the nanometer
- Versatile thanks to comprehensive workpiece assessment as per DIN ISO 1101
- Reliable thanks to high repeatability
- Economical thanks to the use of unique technologies
- Impervious to environmental and operator influences

Contents

Highly precise,
# universal measurement
of form and position

Mahr developed the highly precise and universal MarForm MFU 200 form measuring machine to test rotationally symmetrical components with tolerances below a thousandth of a millimeter quickly and close to production – all while excluding as many influencing factors as possible. The MarForm MFU 200 can also measure a number of features: Form and position tolerances, e.g. roundness, straightness, cylindricity, run-out as well as absolute measurement, i.e. diameter, taper angle, distances. It is equipped with the T7W probe system, featuring a motorized rotational axis. The magnetic holder makes it easy to change the probe arms. The proven Mahr software platform MarWin features intuitive, cascaded user guidance which offers extensive options for analyzing the measuring data using the Easy, Advanced or Professional modules.

Users benefit from the following advantages:

⬤ Optimized for use in the measuring room to achieve reference quality

⬤ High reproducibility of measuring results thanks to dynamic real-time compensation which measures and corrects even the smallest deviations in the measuring routine

⬤ Productivity thanks to high temperature stability over a long period of time – as a result, no calibration necessary, whether daily or several times a day

⬤ Maximum precision thanks to highly accurate rotational axis with Mahr precision guides: Roundness deviation of < 20 nm

⬤ Expandable with optical point sensor (IPS) for combined use as an optical and tactile measuring center

⬤ User-friendly operation for fast and easy access to the measuring record

MFU 200

Most reliable repeatability

With an absolute positioning accuracy of 0.001 mm within the space, this provides the best possible reproducibility and process capability.
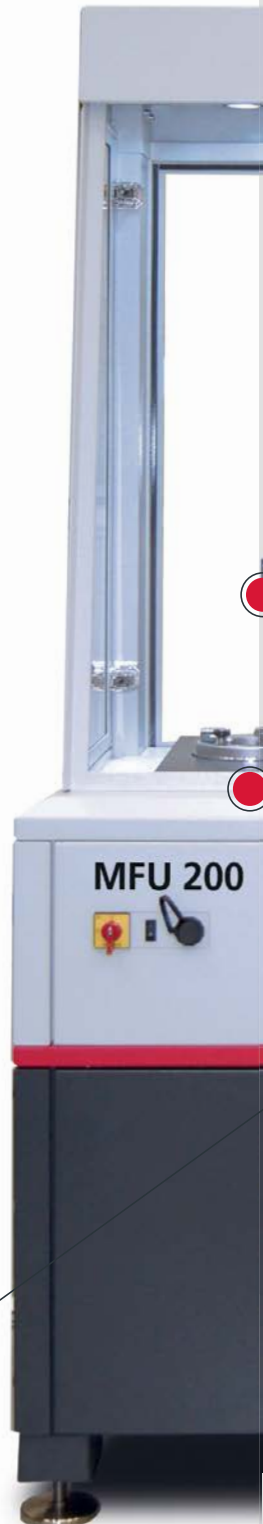
Z-axis with

320 mm

measuring path

Y-axis with

6 mm

measuring path
with motorized T7W

X-axis with

200 mm

measuring path

Centering and tilting table

0,5 µm

accuracy of alignment

Measurements without user intervention

The fully automated measuring process with motorized centering and tilting means that user intervention is no longer required, ensuring process stability.

C-axis with

200 rpm

rotational speed

Maximum precision

The MarForm MFU 200 concept ensures accuracy in the nanometer range, even for workpiece tolerances of 0.5 µm.

High-performance testing

The motorized probe and multi-point probe arms ensure automatic, flexible scanning.

Shorter measuring times

The quickly rotating C-axis features a stiff mechanical bearing. This accelerates the measurements considerably, increasing productivity.

Perfectly equipped for close-to-production form measurement

The MarForm MFU 200 allows users to benefit from Mahr's expertise and years of experience in form measurement. The machine is equipped so that customers can check their rotationally symmetrical workpieces extremely quickly and with high accuracy. Sophisticated functions and processes as well as the appropriate accessories ensure quick and reliable measurement, reduce user intervention as much as possible to attain reliable and reproducible measuring results.
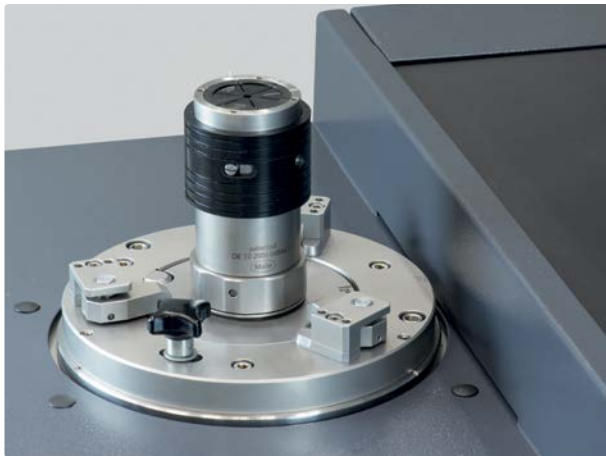

Centering and tilting table with quick clamping device

The MarForm MFU 200 features an automated centering and tilting table, here concealed by the base clamp, which sustainably reduces user interventions. The centering and tilting table and base clamp serve to position the workpieces quickly and automatically in the form tester, reducing set-up times and user intervention and ensuring reproducibility.

Mechanical bearings

Mahr's unique technology makes it possible to combine the robustness of mechanical bearings with the advantages of air bearings. This makes the mechanical bearings used in the MarForm MFU 200 up to 70 percent stiffer and thus more resistant to external influences like vibrations. They are produced by Mahr and result in outstanding radial runout properties.
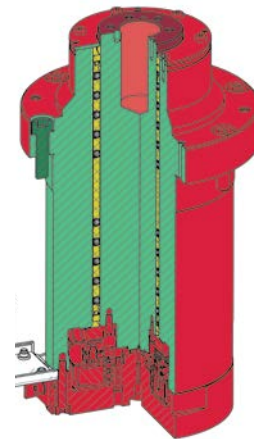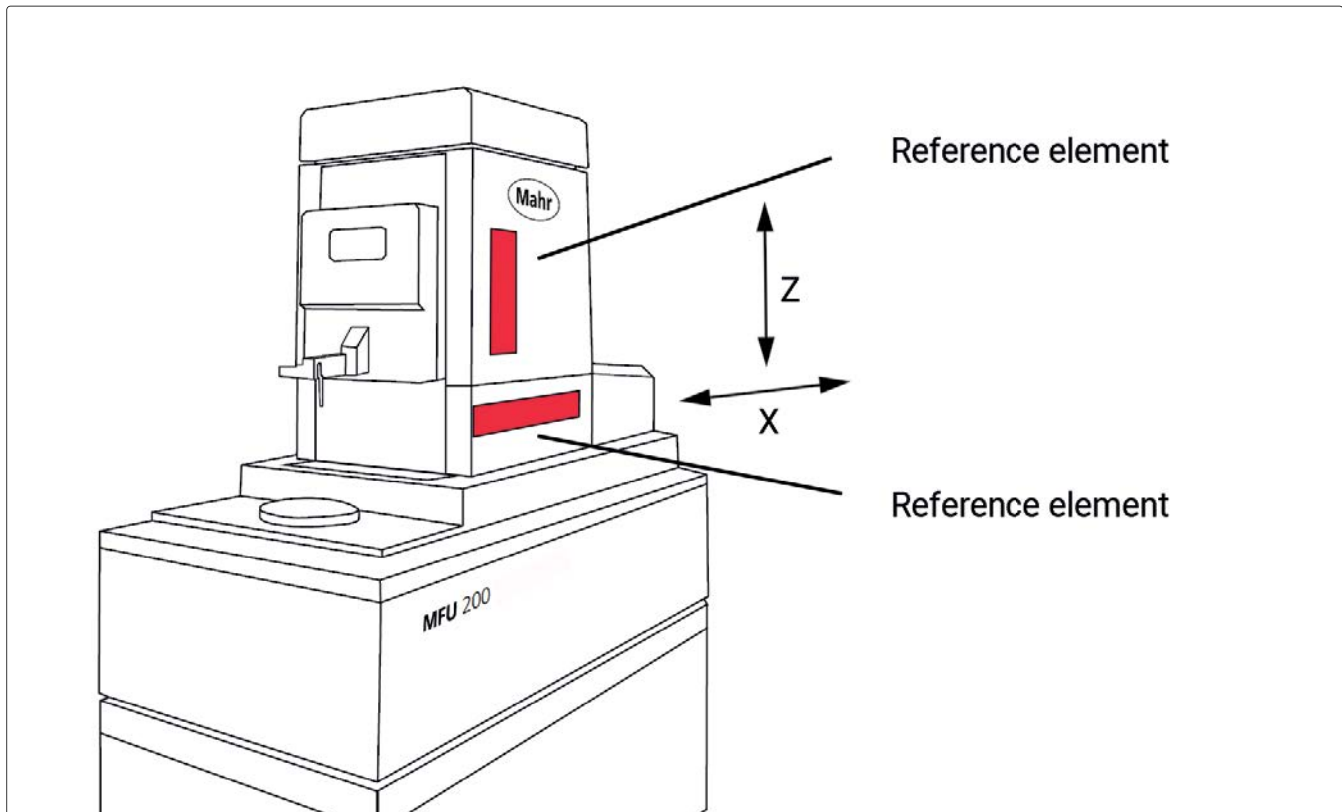
Dynamic real-time compensation

With the MarForm MFU 200, Mahr has integrated a real-time compensation of errors in the room. This provides the machine and measurements with maximum protection from external influences like temperature and vibrations. It measures and corrects even the smallest deviations in the measuring routine via reference rulers in the two measuring axes, X and Z. The machine thus offers extreme reproducibility, even in changing measuring conditions.

Measuring Y-axis

One innovative component is the tangential Y-axis, unique to reference form testers. This makes it possible to perform a zenith search anytime during the measuring routine: during calibration, position finding on small workpieces or diameter measurement. The result is 100 percent process accuracy and repeatability.
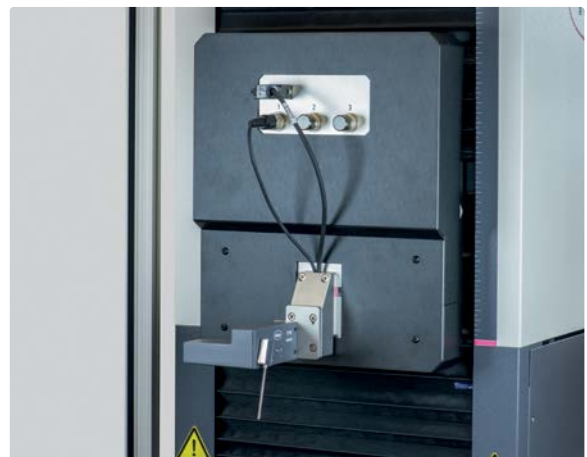
Mahr — MarWin 13.20-05

Applikation Center Sales
Carl-Mahr-Str. 1
37073 Göttingen

Part: JMR9N5
part: test cylinder
serial number: 1217
Comment:

Drawing no.: 4320196 - 1

Machining status: grinding
test reason: measurement capability
method: taktil T7W

Mahr

08.04.2022 9529
18:26:50
Inspector:
R. Pinkert-Wendt
Signature:

MFU200
measuring time: 4 min 25 sek
CG 6.0 SIGMA CGK 3.0 SIGMA
procedure 1: 1 part, 1 operator, 50 measurements/operator/part

feature		nominal	tol.	mean	syst.(Bi)	sigma	range	C_G	C_GK	%RE	Tmin µ"
cylindricity | M032											
roundness 40 mm 15wu | M023	µm	0.18000	3.00000	0.18955	0.00955	0.00512	0.02973	19.55	18.92	0.00	0.30
roundness 75 mm 15wu | M027	µm	0.05000	3.00000	0.02984	-0.02016	0.00116	0.00531	86.18	80.39	0.00	0.25
roundness 110 mm 15wu | M019	µm	0.08000	3.00000	0.03334	-0.04666	0.00351	0.01231	28.48	24.05	0.00	0.61
roundness 40 mm 50wu | M025	µm	0.06000	3.00000	0.03196	-0.02804	0.00156	0.00650	63.98	58.00	0.00	0.35
roundness 75 mm 50wu | M029	µm	0.08000	3.00000	0.04909	-0.03091	0.00307	0.01367	32.52	29.17	0.00	0.44
roundness 110 mm 50wu | M021	µm	0.08000	3.00000	0.05024	-0.02976	0.00547	0.01805	18.27	16.46	0.00	0.52
roundness 40 mm 150wu | M022	µm	0.07000	3.00000	0.05122	-0.01878	0.00382	0.01450	26.15	24.51	0.00	0.35
roundness 75 mm 150wu | M018	µm	0.12000	3.00000	0.09574	-0.02426	0.00915	0.03565	10.93	10.04	0.00	0.61
roundness 110 mm 150wu | M026	µm	0.12000	3.00000	0.08523	-0.03477	0.00420	0.01661	23.82	21.06	0.00	0.52
roundness 40 mm 500wu | M024	µm	0.09000	3.00000	0.08116	-0.00884	0.00528	0.02315	18.94	18.38	0.00	0.30
roundness 75 mm 500wu | M028	µm	0.19000	3.00000	0.14946	-0.04054	0.01229	0.04316	8.13	7.04	0.00	0.90
straightness 0° filter 0,8 | M020	µm	0.16000	3.00000	0.12753	-0.05247	0.00518	0.02348	19.30	15.92	0.00	0.74
straightness 90° filter 0,8 | M003	µm	0.13000	3.00000	0.12249	-0.00751	0.00922	0.04036	10.88	10.58	0.00	0.45
straightness 180° filter 0,8 | M009	µm	0.13000	3.00000	0.18624	0.05624	0.00274	0.01248	38.44	29.61	0.00	0.68
straightness 270° filter 0,8 | M005	µm	0.14000	3.00000	0.20327	0.06327	0.00267	0.01194	37.39	29.50	0.00	0.74
parallelism 0-180° filter 0,8 | M007	µm	0.12000	3.00000	0.18947	0.06947	0.00265	0.01276	37.81	29.05	0.00	0.81
parallelism 90-270° filter 0,8 | M015	µm	0.14000	3.00000	0.19559	0.05559	0.00333	0.01398	30.01	24.47	0.00	0.69
conicity 0-180° filter 0,8 | M017	µm	0.28000	3.00000	0.30361	0.02361	0.00420	0.02085	23.83	21.95	0.00	0.41
conicity 90-270° filter 0,8 | M011	µm	0.29000	3.00000	0.31889	0.02889	0.00429	0.01623	23.31	21.07	0.00	0.47
straightness 0° filter 0,25 | M013	µm	-0.28000	3.00000	-0.29544	-0.01544	0.00645	0.02920	15.51	14.71	0.00	0.42
straightness 90° filter 0,25 | M002	µm	-0.29000	3.00000	-0.31010	-0.02010	0.00595	0.02942	16.81	15.63	0.00	0.44
straightness 180° filter 0,25 | M008	µm	0.17000	3.00000	0.19051	0.02051	0.00312	0.01485	32.07	29.87	0.00	0.33
straightness 270° filter 0,25 | M004	µm	0.17000	3.00000	0.20900	0.03900	0.00297	0.01220	33.67	29.29	0.00	0.51
parallelism 0-180° filter 0,25 | M006	µm	0.15000	3.00000	0.19350	0.04350	0.00306	0.01525	32.68	27.94	0.00	0.56
parallelism 90-270° filter 0,25 | M014	µm	0.16000	3.00000	0.20131	0.04131	0.00360	0.01564	27.81	23.98	0.00	0.56
conicity 0-180° filter 0,25 | M016	µm	0.29600	3.00000	0.30772	0.01172	0.00429	0.01924	23.31	22.40	0.00	0.29
conicity 90-270° filter 0,25 | M010	µm	0.30400	3.00000	0.32235	0.01835	0.00414	0.01789	24.13	22.65	0.00	0.35
conicity 90-270° filter 0,25 | M012	µm	-0.28500	3.00000	-0.29539	-0.01039	0.00645	0.02918	15.51	14.97	0.00	0.37
	µm	-0.31100	3.00000	-0.31012	0.00088	0.00595	0.02944	16.80	16.75	0.00	0.25

Measuring equipment capability

The MarForm MFU 200 even achieves the required capability values below a tolerance of 1 µm. To ensure that the measuring process can handle a customer-specific workpiece, Mahr offers the option of testing the process capability with customer-specific standards or workpieces.

MarForm clamping concept

Measuring tasks with the narrowest of tolerances make it necessary to use appropriate and precise clamping devices to prevent deformations and to hold the workpiece to be tested firmly in place. That is why Mahr has developed its own concept with appropriate clamping devices. These devices not only hold the testpiece on the measuring device but they also use defined and constant force, are universally expandable and can still be individually adjusted to the testpiece and hold it in a specific position.

Rim chuck

Tactile measuring probe T7W

The T7W measuring probe is fitted with a motorized rotational axis. This allows you to move the probe arm gradually into any desired contacting position. It can be used for measurements on both cylindrical surfaces and end faces. As a zero position probe, the T7W can also switch between inner and outer measurements or between top and bottom end face measurements automatically, without operator intervention. Fully automatic measuring sequences on complex workpieces can be performed without operator intervention. The T7W probe arms are interchangeable. With its motorized rotational axis you can also create multi-point probe arms, i.e. probe arms with multiple contact elements, allowing you to switch between different stylus ball geometries within a measuring run.
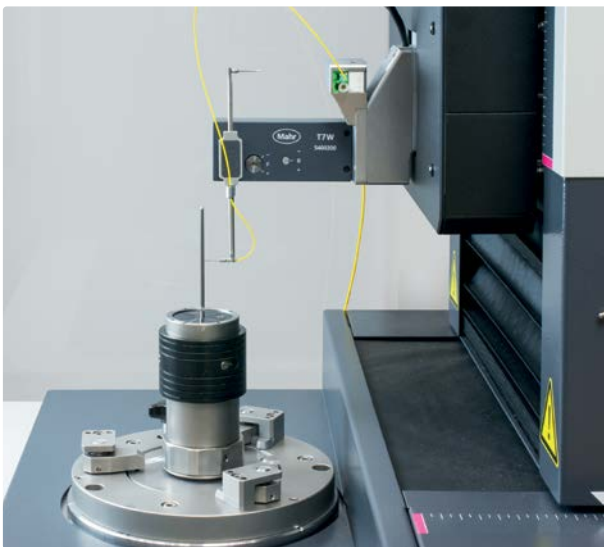
MarForm IPS 15 optical sensor

The optical MarForm IPS 15 (Interferometric Point Sensor) provides the option of measuring and analyzing workpiece surfaces extremely quickly at up to 200 rpm. Thanks to the resolution of the IPS sensor in the sub-nanometer range and the outstanding signal quality, even fine waviness can be tested without measuring again, which saves time and money. It is even possible to combine optical and tactile sensors in one T7W probe arm unit to further increase the versatility of the possible applications.

Powerful software for form measurement and more

The MarForm MFU 200 from Mahr not only provides universal hardware for form measuring tasks but also supplies the perfectly matched measurement and evaluation software based on the MarWin platform. MarWin has established itself in more than 60 countries and is used by many Mahr reference customers.

MarWin is the main software platform used to control various product ranges including the measuring machines in the MarForm range. Users will benefit from the intuitive, cascaded Easy, Advanced, and Professional user guidance and comprehensive options to analyze and further process the data. The user interface is clearly structured and easy to use in keeping with the motto: learn once, apply again and again.

In addition to the applications for form measurement, MarWin also offers other software options to significantly expand the performance range of the MarForm MFU 200.

Software option:
Roughness and contour measurementg

Combined measurement: The MarForm MFU 200 checks the form and position features of the workpiece surface with high-precision roundness and linear axes in accordance with ISO 1101. The machine uses a diamond tip to deliver the roughness parameters and measures the contour using a special probe tip to follow-up the high-resolution linear axes. Finally, the MarWin software analyzes and records the measuring data.

Software option: Contour measurement with path control (MCPC)

The new path control function MCPC (Mahr Continuous Path Control) on the MarForm MFU 200 is used for moving along a reference profile in space by simultaneous measurement with two axes. Measuring speeds of up to 5 mm/s are achieved, 10 times faster than with previous systems. The measuring data is continuously recorded as a 3D point cloud - the world's first implementation of this kind of coordinate measurement.
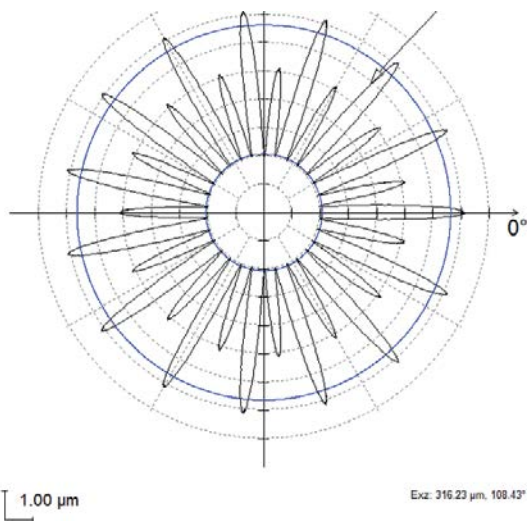

**Software option:
Cam evaluation**

Camshafts are measured using the T7W probe and a tactile contact element. One wizard (Quick & Easy) combines all camshaft types – standard, double cams, tripods, eccentric shafts, concave and convex cam forms - in the "Cam evaluation" software option.

Software option: QE QS-STAT data export

For users of the statistics software from Q-DAS, Mahr provides simple and convenient data export with the QE QS-STAT and QE QS-STAT Plus options, each of them tailored to the individual requirements of the user.

The QE QS-STAT option currently supports the following 30 AutoKeys:

AutoKey	Data
K0001	Values
K0002	Attribute
K0004	Time/Date
K0009	Text/Note
K0053	Order
K0100	Total number of features in the file
K1001	Part number
K1002	Part designation
K1053	Order
K1086	Machining operation/ operation

AutoKey	Data
K1103	Department/cost center
K1201	Testing setup number as text/number
K1202	Testing setup designation
K1221	Inspector's name
K1900	Text/Note
K2001	Feature number
K2002	Feature designation
K2009	Measurand, identifiers for the type of feature
K2022	Number of decimal places
K2101	Nominal size

AutoKey	Data
K2110	Lower limit
K2111	Upper limit
K2112	Lower allowance
K2113	Upper allowance
K2120	Type of lower limit
K2121	Type of upper limit
K2142	Unit designation
K2402	Testing setup designation
K2415	Gage serial number
K2900	Text/Note

1.00 µm

Exz: 316.23 µm, 108.43°

Software option: Dominant roundness waviness

This software option is based on the DAIMLER factory standard MBN 10 455. It measures periodically occurring waviness in roundness profiles. Following the dominant waviness evaluation of stylus profiles (VDA 2007), an evaluation method is described that identifies existing periodic dominant shape characteristics, evaluates them using a roundness waviness profile and derives parameters from them. This option evaluates RONWDc, RONWDt, RONWDmax and RONWDn.

Software option:
Diameter measurement

The DIAMETER_LIB software option measures the diameter of workpieces, mandrels, rings and spheres as well as the length for gage blocks, and evaluates them. MarWin Professional features the option with a collection of highly complex and thoroughly tested measurement, evaluation and calibration programs for diameter and length measurements.

Software option:
Lead measurement

The surface structure of the sealing surface of a shaft affects the flow behavior of the fluid in question and therefore has a major influence on the sealing function. The MarForm MFU 200 can analyze the macro lead in accordance with Mercedes Benz standard 31007-7.

MarForm MFU 200

Item no. 5440580

Roundness measuring device, C-axis	
Roundness deviation (µm+µm/mm measuring height)*	0.02 + 0.0004
Roundness deviation (µm+µm/mm measuring height)**	0.01 + 0.0002
Axial run-out deviation (µm+µm/mm measuring radius)*	0.04 + 0.0002
Axial run-out deviation (µm+µm/mm measuring radius)**	0.02 + 0.0001
Angle resolution interpolated (°)	0.0001
Measuring speed (rpm)	0.1 - 200
Positioning speed (rpm)	0.1 - 200
Position uncertainty P as per VDI 3441 (µm)	2
Position uncertainty P with probe feedback (µm)	1
Centering and tilting table	
Table diameter (mm)	180
Table load, centered *** (N)	200
Traverse path X,Y (mm)	± 1.8
Tilting angle A,B (°)	± 0.6
Vertical straightness measuring device, Z-axis	
Measuring path (mm)	320
Straightness deviation/320 mm measuring path (µm)*	0.1
Parallelism deviation Z/C-axis in tracing direction (µm)	0.5
Parallelism deviation Z/C-axis JMR9N5 testing cylinder (µm)	0.2
Measuring speed (mm/s)	0.1 - 50
Positioning speed (mm/s)	0.1 - 50
Position uncertainty P as per VDI 3441 (µm)	2
Position uncertainty P with probe feedback (µm)	1
Resolution interpolated (µm)	0.001
Horizontal straightness measuring device, X-axis	
Measuring path (mm)	200
Straightness deviation/200 mm measuring path (µm)*	0.075
Perpendicularity X/C-axis (µm)*	0.3
Measuring speed (mm/s)	0.1 - 50

Positioning speed (mm/s)	0.1 - 50
Position uncertainty P as per VDI 3441 (µm)	2
Position uncertainty P with probe feedback (µm)	0.5
Resolution interpolated (µm)	0.001
Horizontal straightness measuring device, Y-axis	
Measuring path (mm)	6
Straightness deviation (µm/5 mm), filter 0.25 mm	0.5
Perpendicularity Y/X-axis (µm/5 mm)	1
Resolution interpolated (µm)	0.005
Connection data	
Supply voltage (V)****	230
Frequency (Hz)	50
Nominal output (VA)	1800
Dimensions and weight	
Length x width x height (mm)	1400 x 800 x 2115
Machine weight (kg)	approx. 850
Ambient conditions	
Working temperature in measuring room	20°C ± 2 K
Temperature gradient	
temporal (K/h)	< 1
spatial (K/m)	< 1 - ceiling height
Storage/transport temperature range (°C)	-10 to +50
Humidity (rel. humidity, non-condensing)	30 % - 60 %
Air pressure (hPa)	1000 ± 200
Noise level/sound pressure (dB[A])	< 70

*   All values in accordance with DIN ISO 1101 at 20 °C ±1 K in a vibration neutral environment, filter 15 undulations/revolution LSC or 2.5 mm LSS at 5 rpm or 5 mm/s and standard probe arm with 3 mm sphere.

**   Values as max. deviation from LSC reference circle, filter 15 undulations/revolution. Proof at the standard using error separation techniques.

***   Workpiece diameter ≤ Table diameter, Hworkpiece≤ Zmeasuring path

**** Other voltages only using UPS/enhanced voltage generator

We would be pleased to provide you with more technical data for the MarForm MFU 200 on request.
We reserve the right to make changes to the technical data.

Mahr

Mahr GmbH
Carl-Mahr-Straße 1
37073 Göttingen
Germany

Phone: +49 551 7073 800
info@mahr.com
www.mahr.com