Machine checking gauge (MCG) system user's guide

Documentation part number: H-1000-5080-05-D

General information

ORIGINAL LANGUAGE VERSION

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Care of equipment

Renishaw probes and associated systems are precision tools used for obtaining precise measurements and must therefore be treated with care.

Changes to Renishaw products

Renishaw reserves the right to improve, change or modify its hardware or software without incurring any obligations to make changes to Renishaw equipment previously sold.

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Packaging

To aid end user recycling and disposal the materials used in the different components of the packaging are stated here:

Packaging component	Material	94/62/EC code	94/62/EC number
Outer box	Corrugated fibreboard	PAP	20
Outer box	Polypropylene	PP	5
Packaging insert	Low density polyethylene	LDPE	4
Packing foam	Low density polyethylene	LDPE	4

Product compliance

REACH regulation

Information required by Article 33(1) of Regulation (EC) No. 1907/2006 (“REACH”) relating to products containing substances of very high concern (SVHCs) is available at:

www.renishaw.com/REACH

Introduction

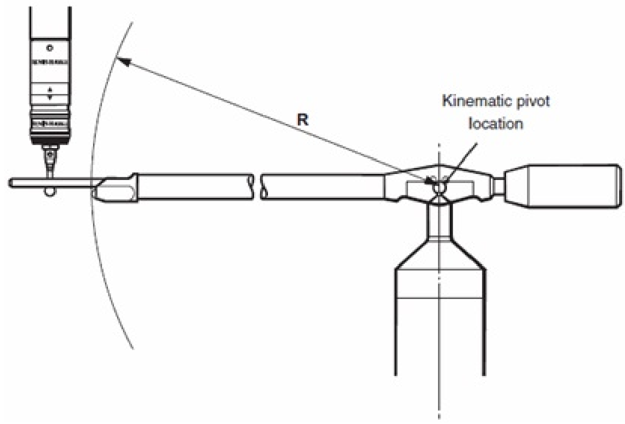
Renishaw's machine checking gauge (MCG) (as shown above) provides an easy way to monitor the volumetric measurement performance of your co-ordinate measuring machine (CMM). The MCG is an effective complement to existing standards for CMM verification and can be used as an interim checking gauge in accordance with international standards BS EN ISO 10360-2.

Based on a simple alternative to the ‘ballbar principle', the MCG provides fast, automatic machine evaluation (Go/No go checks) on a regular basis. The MCG can also be used for machine characterisation and, in some instances, software compensation of errors found.

Principle of the MCG operation

The counterbalanced arm, as shown below, has a kinematic seat which sits on a precision ruby ball located on an adjustable tower. The kinematic seat allows very accurate arm pivoting, both horizontally through 360° and vertically through ±45°. At the end of the counterbalanced arm is a second kinematic location which is formed by two rods, the tungsten carbide ball of the arm, and the probe stylus ball. The arm is able to sweep a truncated spherical outline of radius R about the kinematic pivot location.

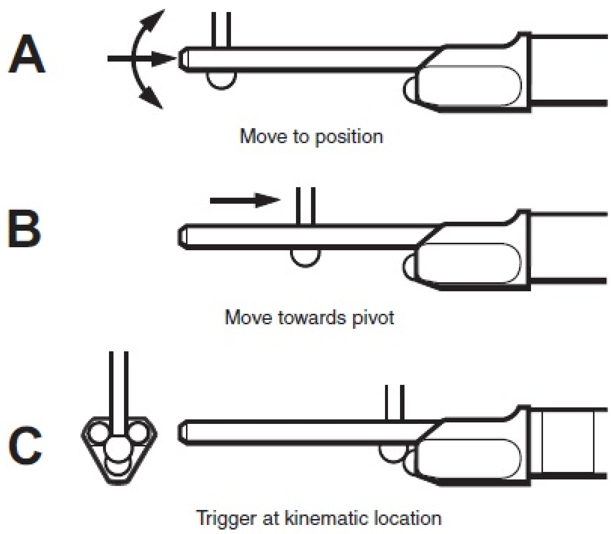
The counterbalanced arm is balanced to provide a downforce of 2 gm at the measuring end to allow arm movement without false triggering.



The probe is moved to its required position (position A) and then towards the pivot position (B) where it will trigger at the kinematic location (C) and the radius is measured.

Since the counterbalanced arm is of a constant radius R, any deviation from R is an indication of the volumetric measuring performance of the CMM for that volume swept by the arm. Repetition of a sequence of readings checks the system for repeatability. Volumetric measuring performance is the maximum error between any two points in any plane, over any distance within the full measuring volume.

On horizontal arm machines the probe is mounted at 90° to the arm.



MCG setting-up

MCG cleanliness

The pivot ball, probe stylus and arm forks must be scrupulously cleaned before assembly as even a fingerprint can give an error of 3 microns. Use a proprietary cleaner to clean the surfaces of these components.

MCG temperature

The components of the MCG are subject to distortion due to changes in temperature. It is therefore important that handling of the components is kept to a minimum and that, if handled, a five-minute temperature stabilisation period is observed once any handling is complete. It is also recommended that the MCG is left in the vicinity of the CMM prior to performing any checking.

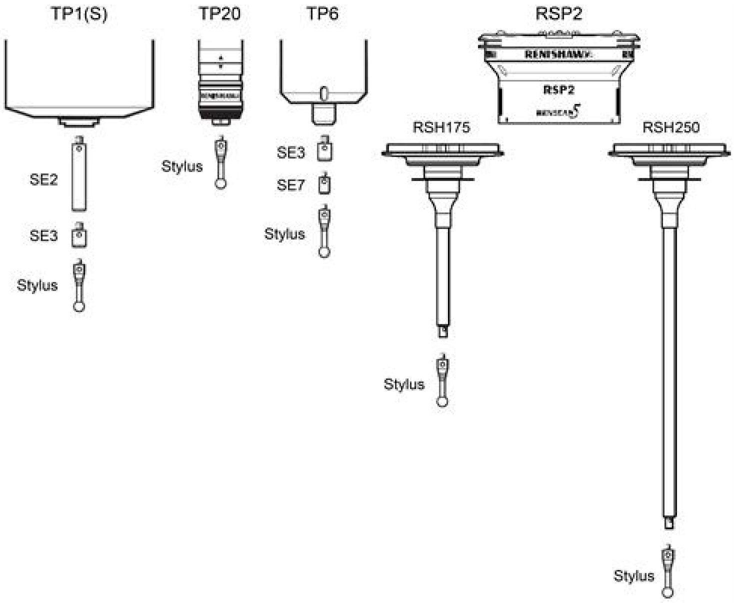
MCG mounting

For optimum performance, it is recommended that the MCG is clamped by its base to the table of the CMM prior to use. The recommended procedure is as follows:

NOTE: The MCG is not suitable for use with TP7M, SP600, SP80 or REVO RSP3 probes, and not recommended for use with TP200 probes. SP25M requires a TM25-20 and TP20 module. It is possible to use REVO with an RSP2 and RSH175 or RSH250 but only with the dedicated UCCassist-2 MCG routine.

1. Attach the special, calibrated stylus of the MCG (this can be readily identified by the two grooves cut within the stylus stem) to your touch-trigger probe. If necessary, use the extensions and adaptors supplied to allow the calibrated stylus to be fitted to the probe.

Adaptors and extensions:

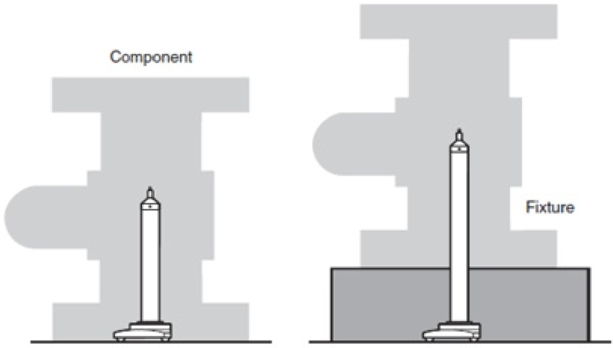


2. Visually inspect the stylus ball of the calibrated stylus for contamination and clean if required.

3. Inspect the probe head to ensure that it is securely located in the machine quill.

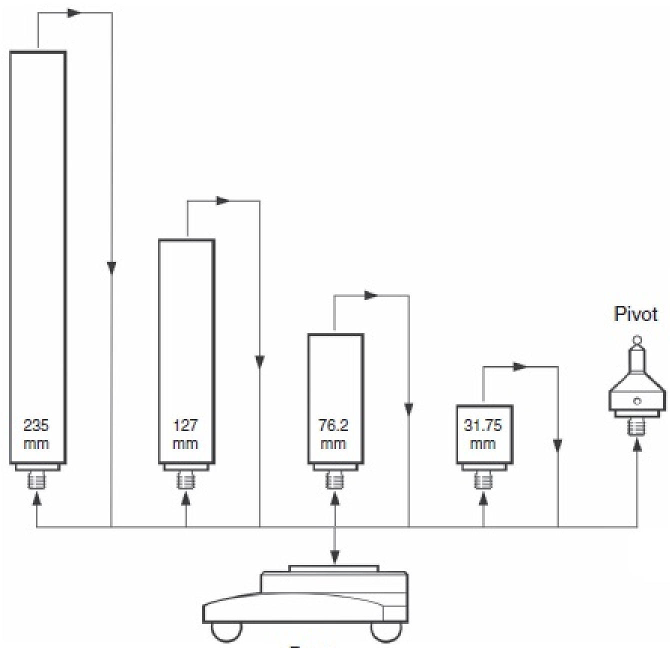
4. Construct a tower using the base, pillars and pivot. When building the tower, ensure that the pivot ball height will be approximately half the height of the component to be measured. If the component is mounted on a fixture, take any added height into account. Tighten the pillars by hand.

Building the tower:



5. Towers of varying heights are possible by using the pillars in combinations as required.

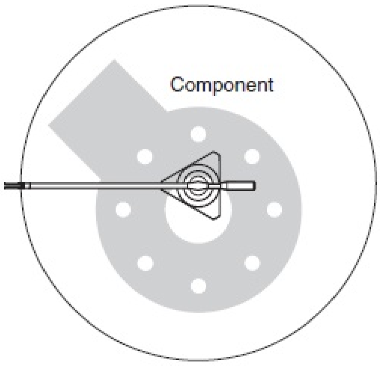
Available pillar extensions:



NOTE: It is recommended that when mounting the tower to the CMM table that the base of the tower is clamped on the central steel clamping ring.

6. Ensuring that base of the tower is approximately central to the component volume, position the tower on the table of your CMM.

Positioning the tower:

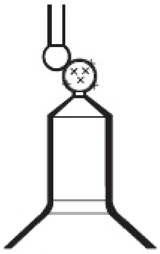


7. Ensure that the ball of the kinematic pivot location is perfectly clean.

8. Allow the assembly to thermally stabilise for 2 minutes.

9. Datum the ball of the kinematic pivot location using a minimum of (10) ten readings. Set the centre of the pivot ball to be the origin (i.e. X=0, Y=0, Z=0).

Datuming the ball of the kinematic pivot location:

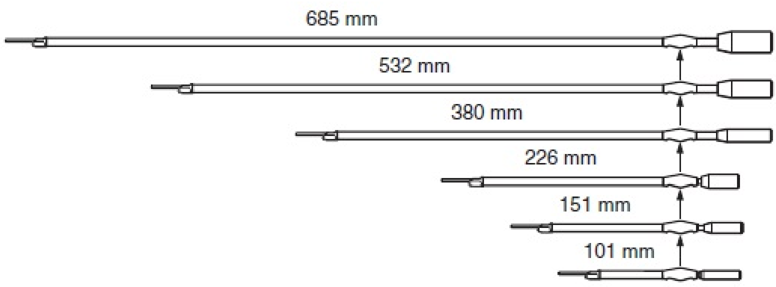


10. Select an arm radius R to suit the component. Use the following table to choose the correct arm for your component.

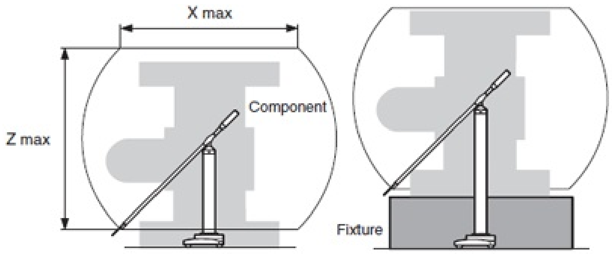
Arm	Radius	X maximum	Z maximum
1	101 mm (4 in)	143 mm (5.6 in)	143 mm (5.6 in)
2	151 mm (6 in)	213 mm (8.4 in)	213 mm (8.4 in)
3	226 mm (9 in)	320 mm (12.7 in)	320 mm (12.7 in)
4	380 mm (15 in)	537 mm (21.2 in)	537 mm (21.2 in)
5	532 mm (21 in)	752 mm (29.6 in)	752 mm (29.6 in)
6	685 mm (27 in)	986 mm (38.1 in)	986 mm (38.1 in)

11. Visually inspect the chosen counterbalanced arm for cleanliness. Make sure that the stylus guide rods and ball of the measuring location and the three ball pivot location are perfectly clean. If necessary, clean the parts with a suitable proprietary cleaner.

Arm length selections:



Angle of rotation:



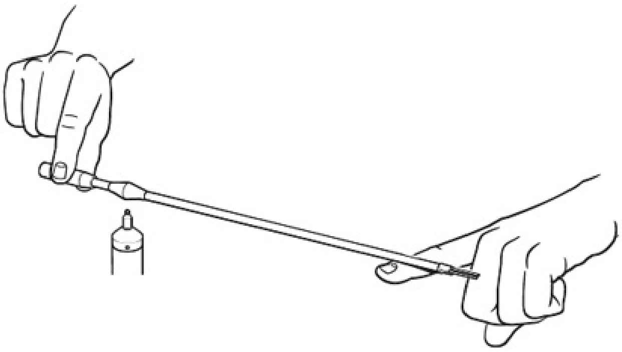
NOTE: When position the counterbalanced arm on the pivot ball, it is important to ensure that handling of the arm is kept to an absolute minimum to avoid thermal distortion.

12. Locate the counterbalanced arm on the pivot ball.

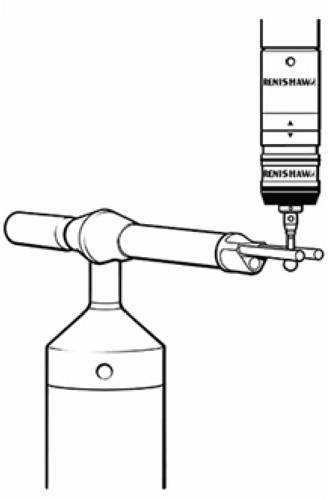
13. Locate the stylus ball between the stylus guide rods.

14. Allow the assembly to thermally stabilise for a minimum period of 5 minutes.

Mounting the counterbalance arm:



Locating the stylus ball between the stylus guide rods:



Additional weights

Each counterbalanced arm is set to provide a downforce on the stylus ball which is sufficient to allow the probe and the arm to be moved without causing false triggers.

If required, the downforce may be increased by attaching additional weights to the counterbalanced arm to allow greater speeds and / or acceleration to be used.

Taking measurements with MCG

Taking measurements when using MCG Tools

Renishaw have simplified the implementation of using an MCG by providing on-line MCG Tools on the Renishaw website:

www.renishaw.com/mcg

Using the MCG has never been easier with Renishaw's online MCG service. In three easy steps, we help you to measure, analyse and track the volumetric performance of your CMM:

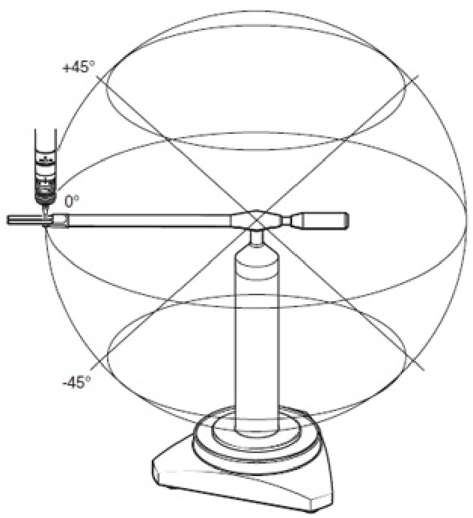
1. **Create an MCG test program to run on your CMM** - a DMIS program is generated for you from a set of parameters that you specify. You can run this on your CMM to generate a set of measurement results.
2. **Analyse your MCG test results** - the MCG test generates a set of measurement results, again in DMIS format. You can upload these and have them analysed online. We provide guidance to help you interpret the data.
3. **Store and retrieve previous results to spot trends** - you can store your MCG test results online and retrieve them at a later date, allowing you to identify changes in the performance of your CMM over time.

Taking measurements when not using MCG Tools

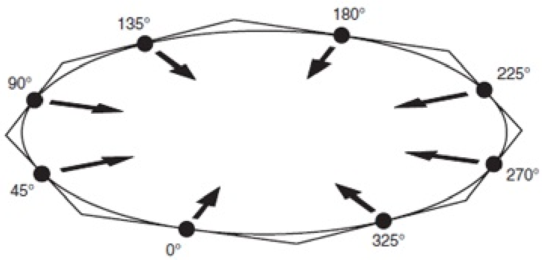
1. Arm elevation 0° - measure the arm radius R at 45° intervals in the horizontal plane (a total of eight measurements).
2. Arm elevation -45° - measure the arm radius R at 45° intervals in the horizontal plane (a total of eight measurements).
3. Arm elevation +45° - measure the arm radius R at 45° intervals in the horizontal plane (a total of eight measurements).
4. Repeat steps 1 to 3 twice to obtain repeatability measurements. This provides a total of 72 (3 × 24) measurements for evaluation of volumetric measuring performance and system repeatability.
5. Remove the counterbalanced arm carefully and re-datum the pivot ball using a minimum of ten readings (refer to the 'Setting-up' section). If the pivot ball centre has moved significantly more than the maximum measured repeatability, re-datum the pivot ball ensuring that:

- The seating faces between the pivot , pillars and baseplates are perfectly clean and that these parts are firmly tightened.
- The stated pillar thermal stabilising period (2 minutes minimum) is observed.
- The utmost care is taken when placing the counterbalanced arm of the pivot.

Arm elevation:



Eight points of measurement:



Evaluating the results

1. Evaluate the average measured arm radius, RAV as follows:

$$R_{AV} = \frac{\sum_{i=1}^{i=n} R_i}{n}$$

Where n = total number of readings

2. Evaluate each measured arm radius for its deviation from the average measured radius as follows:

$$\Delta R_i = R_{AV} - R_i$$

3. Evaluate the range of deviation for each run, known as the 'span'.

4. Evaluate the range deviations over all three runs, i.e. the maximum deviation in the + and - directions. This is the VOLUMETRIC MEASURING PERFORMANCE (VMP) for the volume swept by the arm radius R as follows:

$$VMP = \Delta R_{i(max)} - \Delta R_{i(min)}$$

5. Evaluate the range of deviations for each measuring position. This is the SYSTEM REPEATABILITY at that POSITION. A suggested layout is shown overleaf.

6. When the MCG indicates an unacceptable performance of your CMM, contact the OEM to service the machine (please note that this service cannot normally be undertaken by the user).

REPEATABILITY →

MACHINE REFERENCE: 101-6 DATE: 27-05-85
VARIATIONS FROM MEAN RADIUS (△Ri) – MICRONS

ELEVATION	ANGLE	RUN 1	RUN 2	RUN 3	REPEATABILITY
0	0	−3.0	−3.0	−3.0	0.0
	45	0.0	−0.5	0.5	1.0
	90	2.5	2.5	2.0	0.5
	135	3.5	4.0	4.0	0.5
	180	3.5	3.5	3.5	0.0
	225	1.5	2.0	2.0	0.5
	270	−2.5	−2.0	−1.5	1.0
	315	−5.5	−5.0	−5.0	0.5
+45	0	−2.0	−2.0	−2.0	0.0
	45	−1.5	−2.0	−1.5	0.5
	90	−1.0	−1.0	−1.5	0.5
	135	1.5	1.0	0.5	1.0
	180	4.0	3.5	3.5	0.5
	225	6.0	**6.5**	5.5	1.0
	270	1.5	1.0	2.0	1.0
	315	−3.0	−4.0	−3.5	1.0
−45	0	−1.5	−1.5	−2.0	0.5
	45	−4.5	−5.0	−5.5	1.0
	90	−6.0	−6.0	**−7.0**	1.0
	135	−3.0	−3.5	−4.0	1.0
	180	1.5	1.5	1.0	0.5
	225	6.0	6.0	6.0	0.0
	270	4.0	4.5	4.5	0.5
	315	0.0	1.0	0.5	0.5
SPAN		12.0	12.5	13.0	

VOLUMETRIC MEASURING PERFORMANCE ↓

HIGHEST 6.5 LOWEST −7.0 SPAN (3 RUNS) 13.5
VOLUMETRIC MEASURING PERFORMANCE 13.5 MICRONS

Calibration procedures for MCG

A calibration report and calibration traces are supplied with each MCG kit. The traces supplied are as follows:

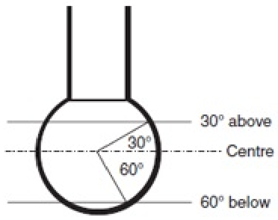
- Probe stylus ball roundness
- Pivot ball roundness
- Bearing runout - arm horizontal
- Bearing runout - arm at +45°

These results are summarised on the outside of the calibration report wallet.

Probe stylus ball

A trace is made to simulate the action encountered during probing with a stylus.

Probe stylus ball trace:

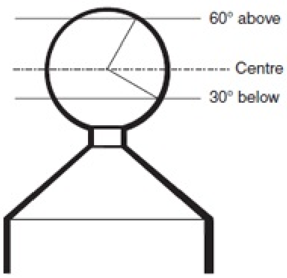


Pivot ball

The pivot ball roundness is a major influence on bearing runout. The trace is therefore included for reference.

The trace is made to simulate the action encountered when the arm revolves about the pivot.

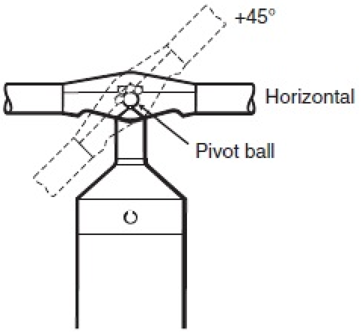
Pivot ball trace:



Bearing runout

Traces of bearing runout are made for all counterbalanced arms, at +45° incline and horizontally. This simulates the action encountered during measurement.

Bearing runout trace:



Total gauge error

The total gauge error comprises the following components:

Stylus ball roundness + bearing runout = total gauging error

Therefore:

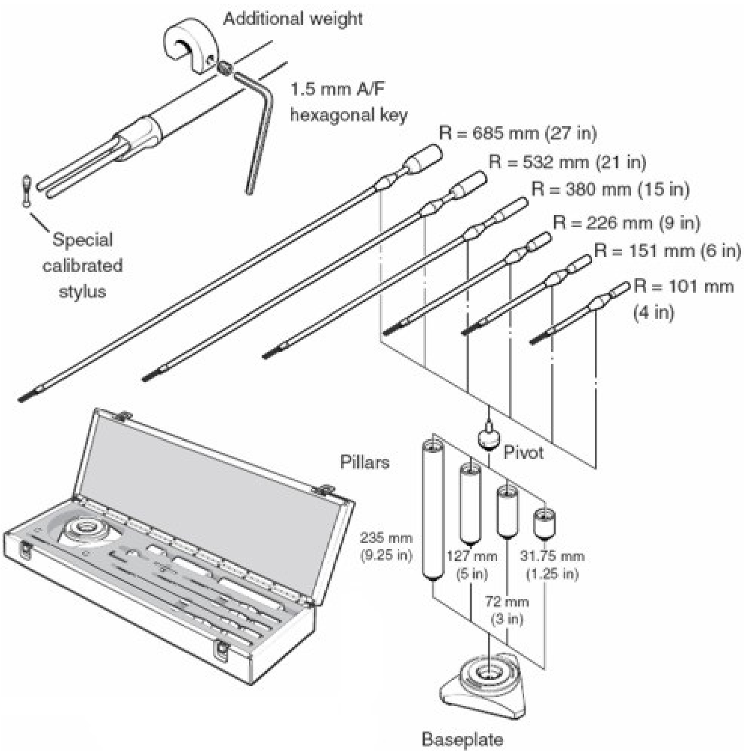
0.25 µm maximum + 0.25 µm maximum = 0.50 µm maximum

MCG parts list

Part	Part number (replacement only)	MCG1 (small kit)	MCG2 (comprehensive kit)
Baseplate	A-1007-0016	✓	✓
Pillar (31.75 mm)	M-1007-0158	✓	X
Pillar (76.2 mm)	M-1007-0023	✓	✓
Pillar (127 mm)	M-1007-0024	✓	✓
Pillar (235 mm)	M-1007-0025	X	✓
Pivot	A-1007-0017	✓	✓
Arm (101 mm)	A-1007-0007	✓	✓
Arm (151 mm)	A-1007-0008	✓	✓
Arm (226 mm)	A-1007-0009	✓	✓
Arm (380 mm)	A-1007-0010	✓	✓
Arm (532 mm)	A-1007-0011	X	✓
Arm (685 mm)	A-1007-0012	X	✓
Stylus	A-5000-7650	✓	✓
Weights (2)	A-1007-0018	✓	✓
1.5 mm AF hexagonal key	P-TL01-0150	✓	✓
Mahogany box	M-1015-7646	✓	X
Mahogany box	M-1015-7704	X	✓

Machine checking gauge (MCG) system user's guide

For part identification please refer to the following figure.



Each kit includes:

- Stylus and pivot ball roundness trace
- System dynamic test certificate

Maintenance

Care of equipment

Renishaw probes and associated systems are precision tools used for obtaining precise measurements and must therefore be treated with care.

The Renishaw recommended recalibration period for MCG is 12 months.

Recalibration periods are purely a recommendation, under normal service conditions. However, there are several factors that may generate the need for more or less frequent recalibrations including:-

- Environmental conditions
- Frequency and duration of use
- Harsh treatment of the MCG system, during storage, transportation or use
- Level of accuracy required by the user
- The requirements of company QA procedures an / or national / local regulations

Ultimately it is for the user to determine the appropriate calibration period given his operational environment and performance requirements.

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