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ISO 10791-6 using QC20 ballbar

Introduction

This document details the Renishaw solution for capturing data according to the ISO 10791-6 standard using a QC20 ballbar, associated software and hardware.

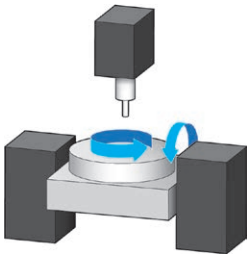
ISO 10791-6 details tests which can be carried out using a QC20 ballbar to verify the performance of 4-axis or 5-axis machine tool centres.

Testing is carried out using the tool centre point style function within the machine controller. The tool centre point function allows the machine to contour effectively between two set positions. When contouring, the machine tool will maintain a constant separation between the tool tip and workpiece using multi-axis movements. This makes the QC20 ballbar the ideal tool for verifying the contouring performance of a machine tool by measuring any deviation along the specified tool paths.

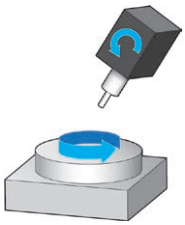
Machine requirements

The tests described in the ISO 10791-6 standard can be performed for machine tools with construction as below:

ISO 10791-6 reference = **'AK'**
Head - Head machines
2 rotary axes in the spindle head



ISO 10791-6 reference = **'BK'**
Table -Table machines
2 rotary axes in the workpiece side of the machine



ISO 10791-6 reference = **'CK'**
CK: **Head - Table** machines
Swivel head and/or rotary table

The function of enabling and disabling tool centre point in machine tool controllers will vary depending on the manufacturer. The table below lists some common manufacturers and the enable/disable codes for part program generation.

CAUTION: In the part program, it is critical that the tool length offset is applied when the tool centre point function is enabled. Failure to do so could result in damage to the QC20 ballbar or to the machine tool.

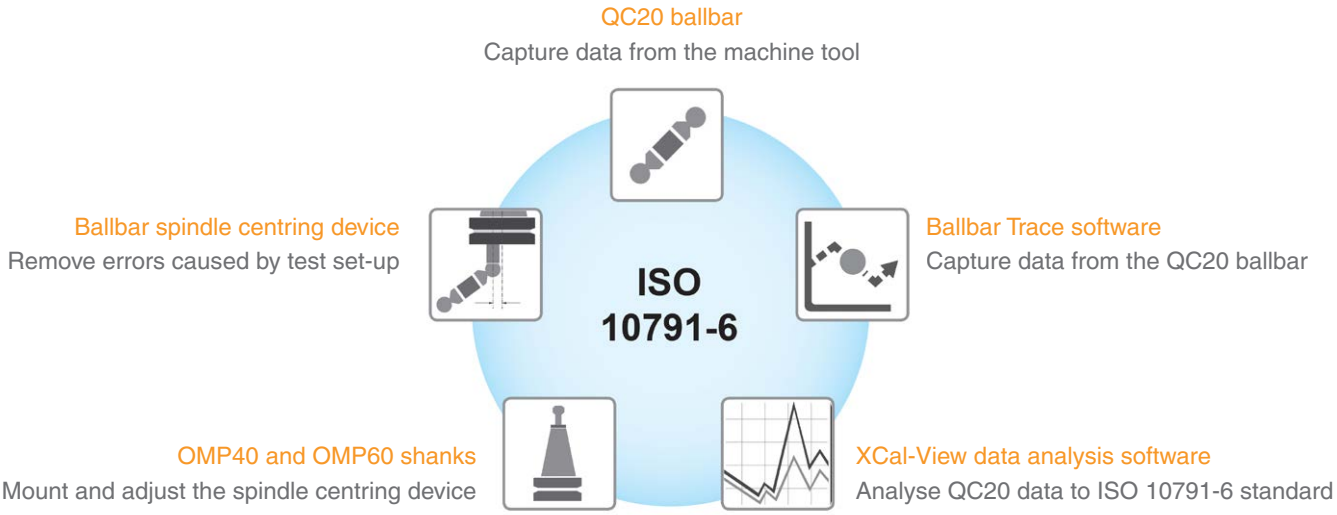
Control type	TCP control function	Enable	Disable
Fanuc 30 series	Tool Centre Point (TCP)	G43.4	G49
Siemens 840D	TRAORI	TRAORI	TRAFOOF
Mazak Matrix 2	Tool Tip Point Control (TTPC)	G43.4	G49
Heidenhain TNC640	Tool Centre Point Management (TCPM)	M128	M129
Haas UMC-750	Tool Centre Point Management (TCPC)	G234	G49

CAUTION: If you are using a part program or error correction parameters generated by the Renishaw software, it is your responsibility to validate these at low feedrates and be prepared to operate the emergency stop button if necessary.

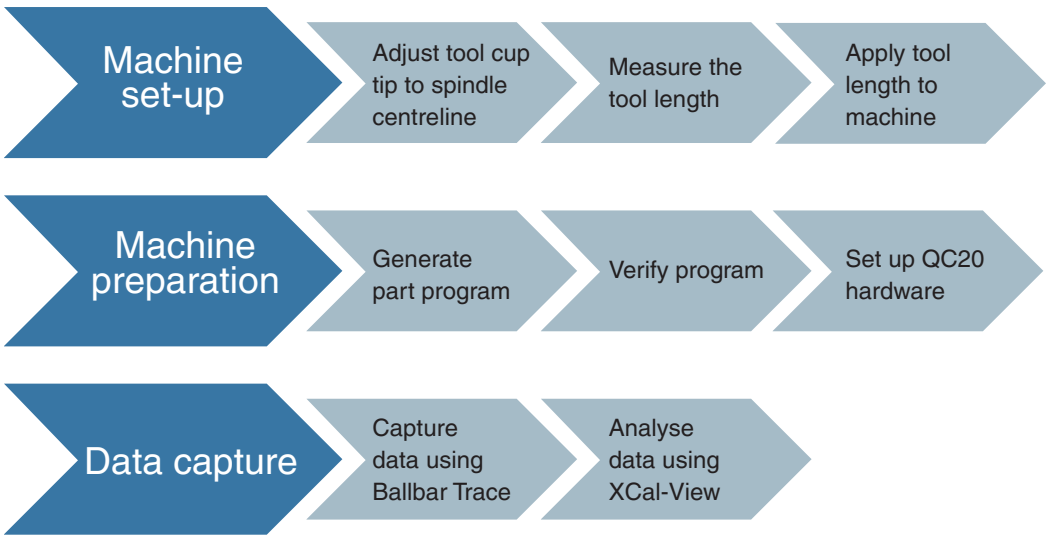
Hardware and software requirements

The following hardware and software will be required to carry out testing for all the machine variants detailed on page 1.

Further information on all the hardware below, as well as software downloads, can be found at:
www.renishaw.com/ballbar-ISO-testing



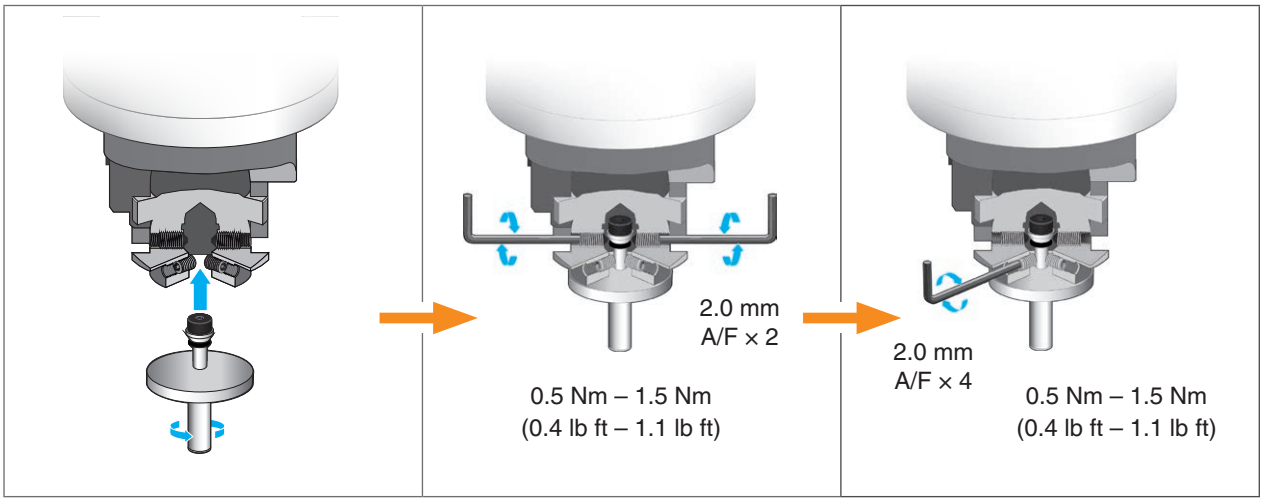
Test process



1 Machine set-up

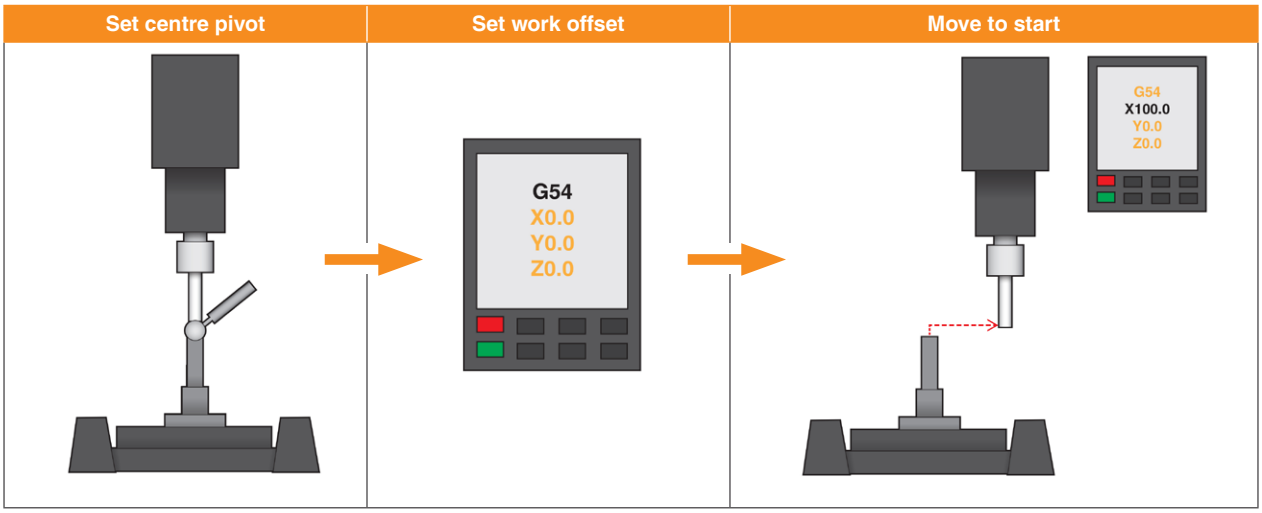
Assemble the ballbar spindle centring device/shank

Insert the ballbar spindle centring device into the shank and hold in place by tightening the screws in the shank.

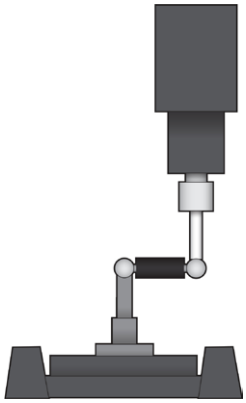
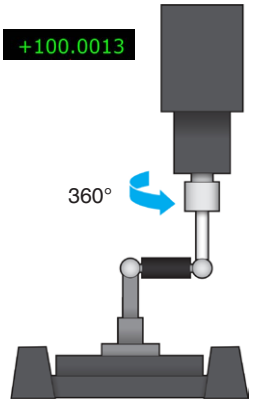


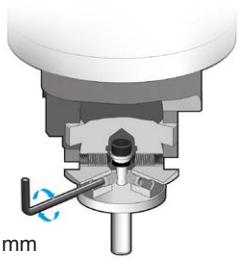
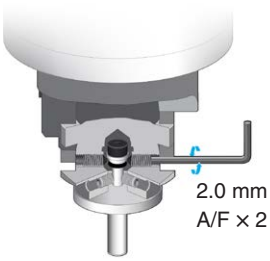
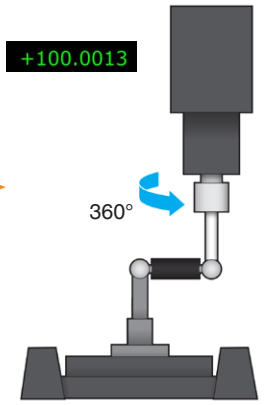
2 Prepare the machine

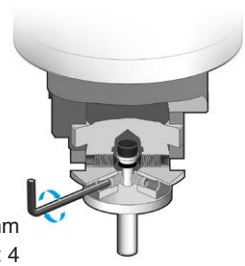
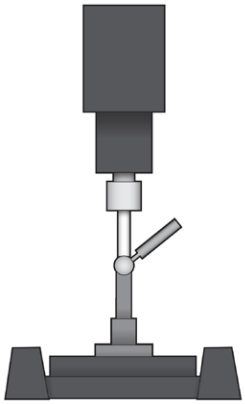
Using the setting ball, align the centre pivot and tool cup and set a work offset.



3 Adjust tool cup to spindle centreline

Insert QC20 ballbar	Start Ballbar 20 software	Alignment check
		

Coarse adjust	Tighten	Alignment check
100 mm ±10 µm 	 1.5 Nm – 2.2 Nm (1.1 lb ft – 1.6 lb ft)	

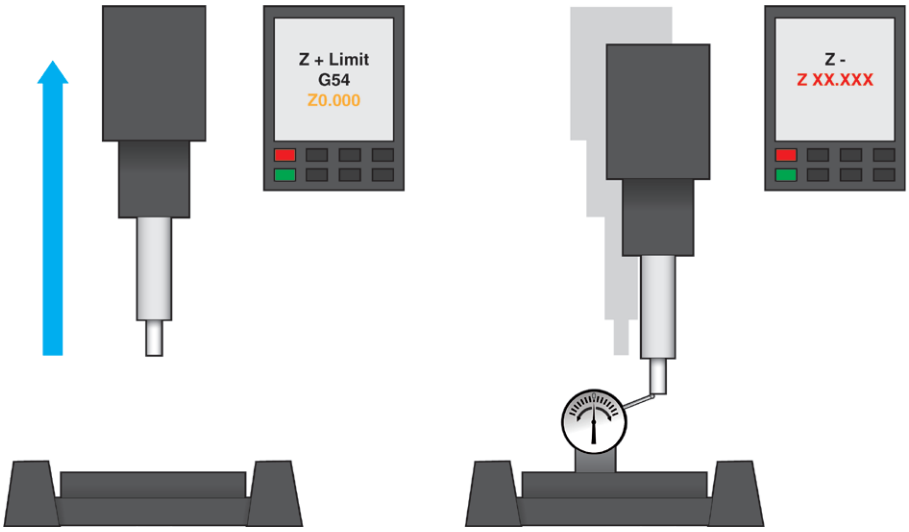
Fine adjust	Move to centre	Reset work offset
100 mm ± 1 µm  1.5 Nm – 2.2 Nm (1.1 lb ft – 1.6 lb ft)		

Measure the tool length

Before carrying out any tool centre point function, it is critical that the tool length is accurately known. The tool length is defined as the distance from the gauge line to the centre of the setting ball from the QC20 ballbar kit.

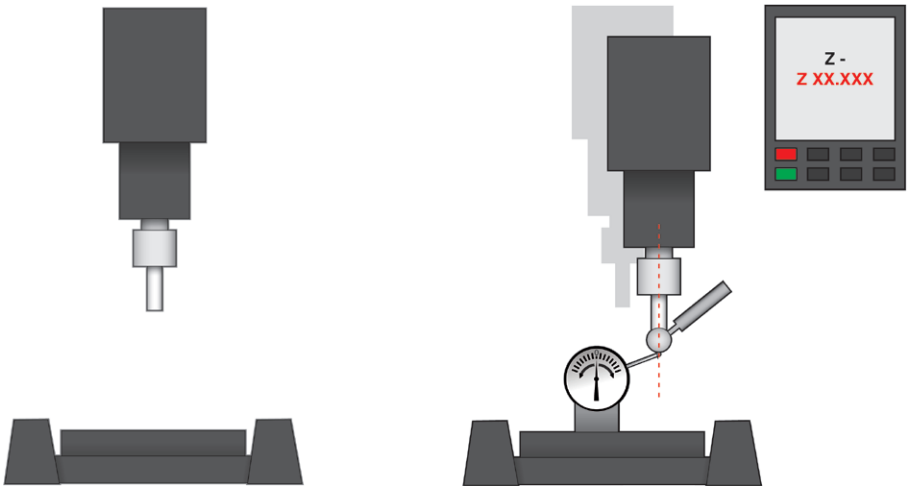
Manual method

- Measure a reference position using a calibrated length bar



Overall length (1) =
Z position from machine controller – Calibrated length bar

- Measure the same reference position with the centred tool cup and setting ball



Overall length with tool cup =
Overall length (1) – new Z position from machine controller

- Subtract the radius of the ball from the measured length (6.35 mm)

Apply tool length to machine

CAUTION: Applying the tool length will vary depending on the control manufacturer for your machine. Please refer to the user guides for exact details. The instructions below are for guidance only.

FANUC 30 series

- To access the tool page, press ***'Offset setting'*** hard key > ***'Offset'*** soft key.
- Select the tool number with the centred tool and enter the tool length.
- The options for Tool length wear, Radius geometry and Radius wear do not need to be populated.

Siemens 840D

- To access the tool page, press ***'Offset'*** hard key > ***'Tool list'*** soft key.
- Select the tool name or tool number with the centred tool and enter the tool length.
- The options for Tool diameter and Tool type do not need to be edited.

Mazak Matrix 2

- Press '←' (left arrow) > ***'Position'*** > ***'Tool data'*** soft keys.
- Select the relevant tool to display the tool details on the right-hand side of the screen.
- Press '**Edit**' > '**Length**', enter the length and press '**Input**'.

Heidenhain iTNC 640

- In manual or hand mode, navigate right and select '**Tool Table**' to access the tool page.
- Enable Edit mode by pressing '**Edit Off/On***',* then select the tool name or tool number with the centred tool and enter the tool length (L).
- The option for Tool Radius (R) does not need to be edited.

HAAS UMC-750

- Press '**Offset**' hard key and navigate to the ***'Tool tab'*** (if not the default tab).
- Select the correct tool number, type in the tool length and press '**Write/Enter**' hard key.
- Other tool geometries do not need to be populated.

Machine preparation

Generating a part program

Ballbar Trace software does not currently produce a part program. Programs which can be edited to suit all test details in the standard can be downloaded from **www.renishaw.com/ballbar-ISO-testing**

CAUTION: Each program contains variables which must be edited to suit your machine before running. On the first run of the program, it is recommended that the ballbar is not inserted.

NOTE: Ballbar Trace data capture is activated and deactivated by a linear Feed-in and Feed-out move of the ballbar. This can lead to a spike in the data plot at Feed-in and Feed-out which is not representative of the 5-axis error in the machine tool.

XCal-View overcomes this by allowing the Start/End of the data to be manually 'cropped' by the user.

To identify a clear difference between Feed-in and 5 axis moves, it is recommended that you add a machine dwell after the Feed-in and before activating tool centre point function.

- A simple example of a part program is shown below:

G-code	Description
X101.5	Liner start position from G54
X100.0	Feed-in 1.5 mm
G04X2	Dwell 2 seconds
G43.4H1	Enable TCP and call tool length
B90	Rotate B axis 90 degrees
G49	Disable TCP
G04X2	Dwell 2 seconds

Test set-up

The set-up for each test should be as recommended in the ISO 10791-6 standard. The guidelines outlined in this document are as follows:

- Feedrate
- Minimum stroke of rotary axis
- Clockwise and counter clockwise data capture
- The offset of the sphere from the rotary axis
- Ballbar length (diameter of test)

For further information of any of the above, refer to the latest edition of the ISO 10791-6 standard.

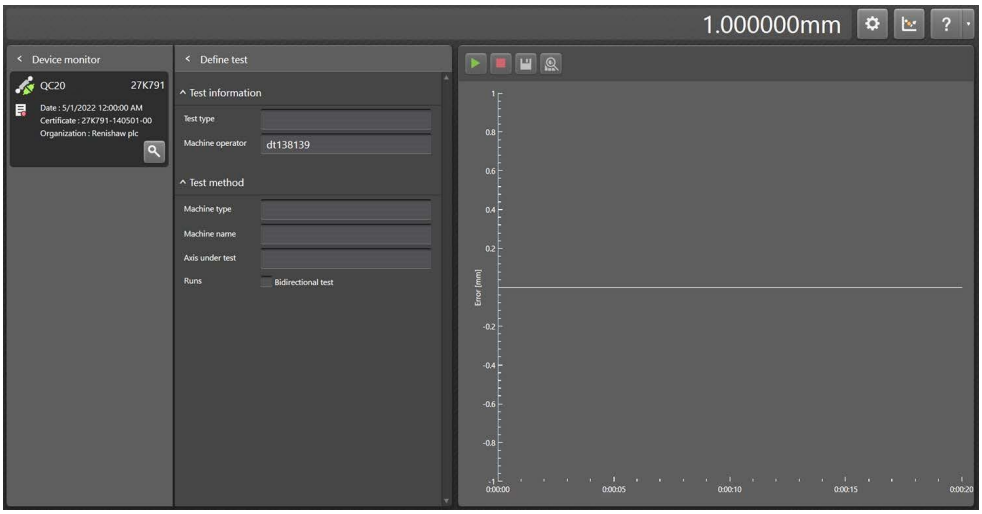
Machine precautions

- Ensure that the rotation of an A or B axis does not cause a collision with the machine spindle - more likely to occur on a ‘trunnion’ style machine.
- Be aware that the feedrate with TCP enabled is often the feedrate of the rotary axis. As a result linear moves can be much higher than expected.

Data capture (Ballbar Trace)

Ballbar Trace software allows a 'free-run' method of data capture using a simple feed-in/feed-out move of the ballbar to start and stop data capture.

Full details of the software functionality can be found in the **Ballbar Trace** *user guide*.

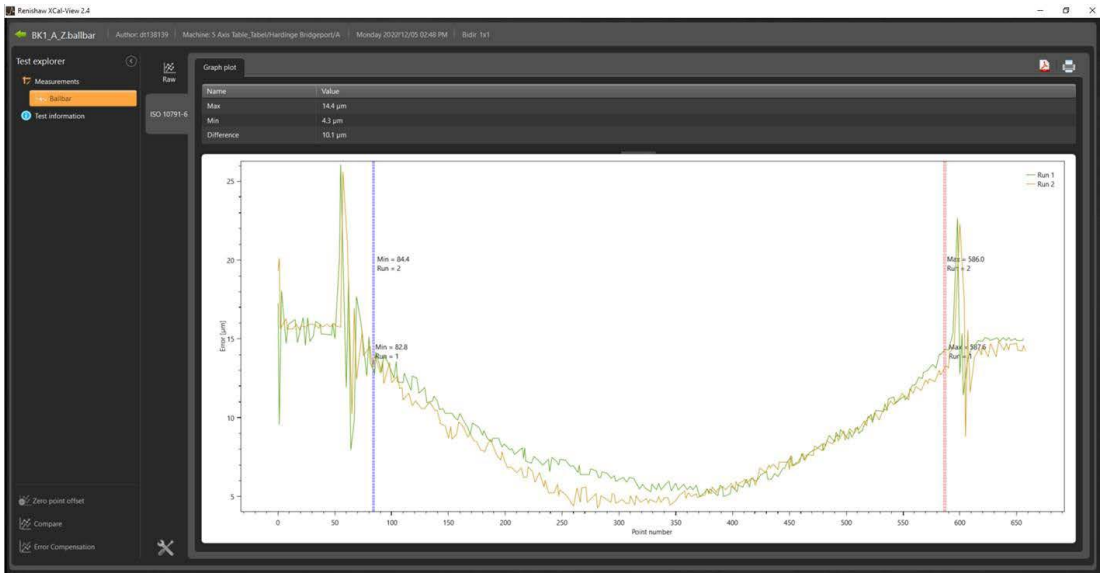


Data analysis (XCal-View)

Ballbar Trace software saves data in a **`.ballbar`** file format. The files can only be analysed to the ISO 10791-6 standard using XCal-View software.

Data in **`.ballbar`** format can be analysed in ISO 10791-6 or in its raw format using the tabs to the left of the main plot. When ISO 10791-6 is selected, data can be manually cropped by the user to remove any spikes as a result of feed-in/feed-out move (see page 6).

Full details of the software functionality can be found in the **XCal-View help manual.**



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Factors affecting accuracy

CAUTION: Care must be taken in following areas when carrying out the initial set-up of the hardware. These areas can influence the data captured directly and give a result that does not reflect that of the machine performance.

- Tool tip misalignment: the tool cup tip is not aligned to the centre of the spindle
  - This will cause a direct maximum to minimum deviation error caused by the set-up, not an error in the machine tool.
  - The level of this affect will vary depending on which test is being carried out.
- Incorrect tool length applied: the tool length value in the controller is incorrect
  - This can cause the tool path to increase or decrease.
  - In extreme circumstances, this can lead to the QC20 being dropped.
- Damage to tool cup/centre cup kinematic mounts
  - This will result in a loose fit of the ball into the cup, giving a test error.
- Loose tool cup/centre cup
  - This will cause the ballbar to change length during the tool path, resulting in a test error.

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