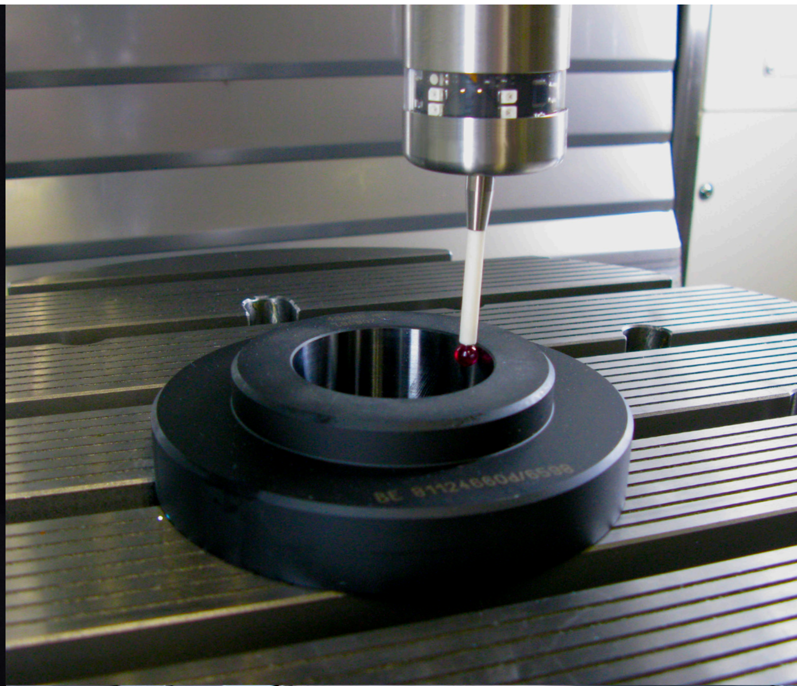
TE415

RENISHAW
apply innovation™



Machine tool probe calibration

Introduction

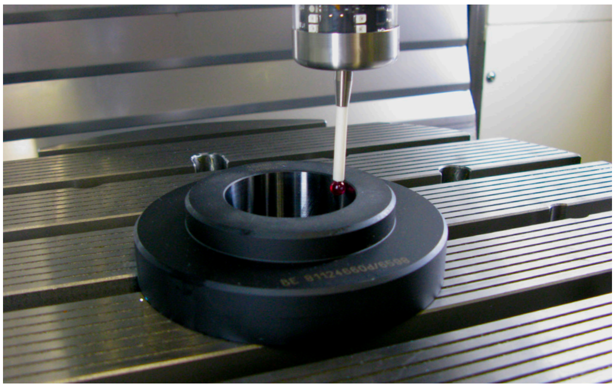
Upon first use and at intervals thereafter it is necessary to establish the characteristics of each individual probe installation. This will allow the accompanying software running on the CNC to make accurate calculations of such things as tool and work offsets, while compensating for characteristics inherent within the measurement system.

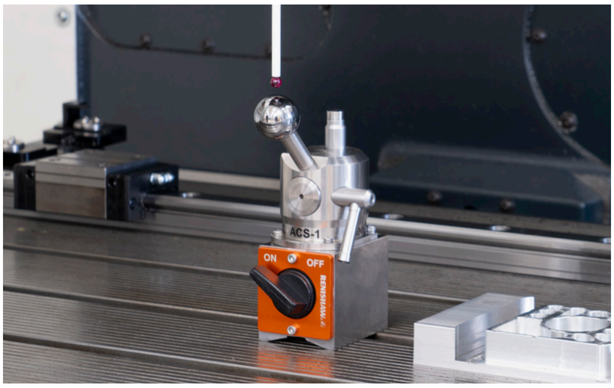
Within the industry this type of characterisation is commonly referred to as probe calibration.

www.renishaw.com/machinetool

#renishaw

RENISHAW
apply innovation™





The importance of accurate probe calibration cannot be overstated as all subsequent measurements are based on the values established here and any errors introduced will be present until the system is recalibrated.

For a typical spindle probe, the characteristics considered by a calibration routine may be as follows:

- **Electronic length** of the probe includes the pre-travel and is stored in the machine variables. Following calibration this pre-travel is compensated for in all subsequent measurements. For more information on pre-travel, see TE411, Innovations in touch trigger probe sensor technology.
- **Physical length** of the probe is stored in the tool offsets.
- **Electronic stylus ball radius** (this differs from the physical size of the stylus ball as it includes pre-travel, which is subsequently always compensated for).
- **Offset** of the stylus ball from spindle centre line. The distance in the X and Y axes between the centre of the stylus ball and the machine spindle centre line. Typically this distance is compensated for in all future measurements. However, on some machines this is not possible, so the offset must be mechanically minimised.

Note: This document is intended to provide an overview of the sequence and importance of correctly calibrating a workpiece inspection probe. For full detail of implementing the calibration process, please refer to the manuals provided with the probe application software.

Calibration methods

Although a variety of probe calibration methods are available, the routines remain similar for each, however, it is actually the reference features that are chosen and set-up differently.

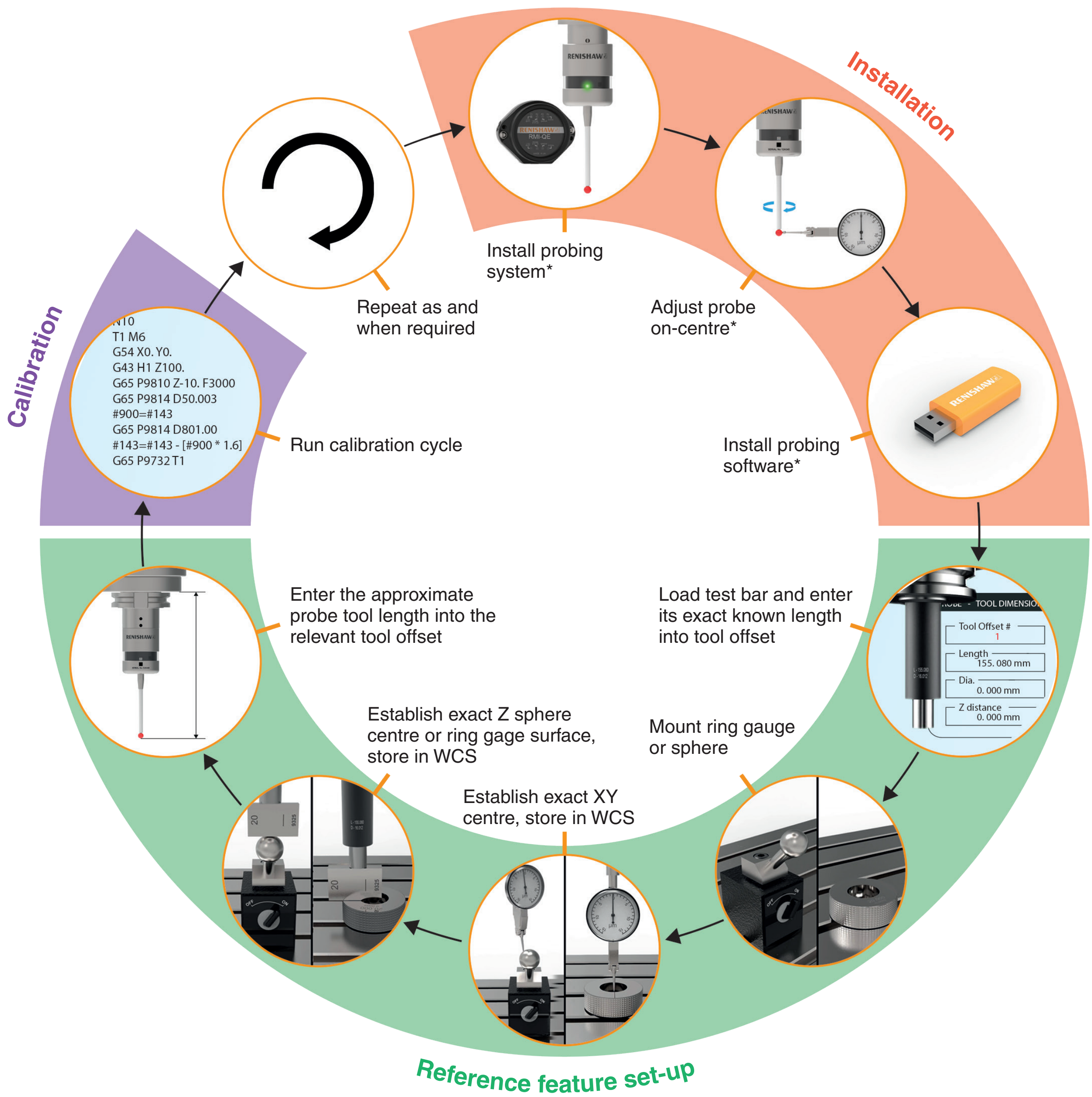
This document covers the following methods for probe calibration:

In addition to the calibration conducted when a probing system is first used, it will be necessary to occasionally repeat calibration, particularly in the following circumstances:

- Where the probe stylus is replaced (even with another stylus of the same specification).
- Following a machine or probe collision or where the machine has undergone major service.
- As part of any periodic healthcheck or maintenance regime, or if you have any concerns regarding the measurement performance of your probe.

RENISHAW
apply innovation™

Using a ring gauge or sphere, without 180° spindle orientation function



* not covered in this document

Installation

- A probing system requiring calibration should be installed and operational in accordance with the manufacturer's recommendations.
- Before starting it is good practice to mechanically adjust the tip of the stylus in-line with the spindle axis (on-centre adjustment). For machines without spindle orientation (Fanuc reference M19) it is vitally important that on-centre adjustment is optimised (i.e. the run-out of the stylus ball is minimised when the spindle is rotated). Run-out is typically measured using a low force dial test indicator in contact with the probe stylus ball, and adjusted for using a series of screws on the shank mounting face. For details of stylus on-centre adjustment refer to the installation guide for the relevant probe type.
- Where probing (macro) software cycles are not already installed on the CNC, these should be loaded in accordance with their instructions.

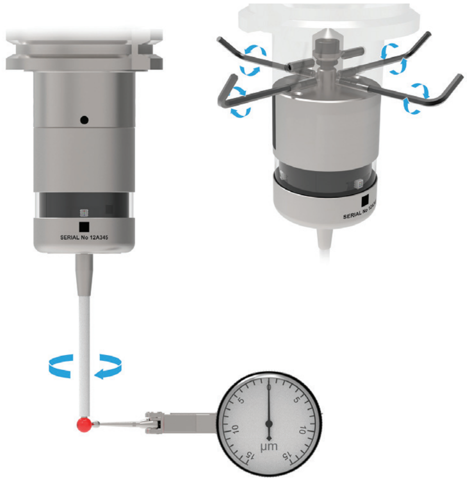


Figure 1: on-centre adjustment

Reference feature set-up

- A test bar (length bar) of exact known length is required and should be loaded to the machine. Its length, which is usually etched on the bar and confirmed on a calibration certificate should be entered into the relevant tool offset registry.
- A ring gauge or sphere of exact known diameter is required and should be securely mounted to the machine table. The diameter of the ring gauge/sphere will be an input into the calibration software cycle.
- The centre of the ring gauge/sphere must now be established accurately in the X-Y plane. This step may be skipped if the accompanying calibration software offers an automatic centre find function using spindle-orientation. Otherwise a dial test indicator (DTI or clock) is used, mounted onto the spindle nose and slowly rotated until a constant reading is achieved over 360°. The current work offset should then be set to this XY centre.
- A reference surface in the Z-axis is now required. The position of this should be accurately established using the test bar. Methods vary according to user preference and machine specific issues (see also "Alternative methods" on page 15). Typically the test bar is moved slowly to make contact with a slip or feeler placed on the top surface of the ring gauge/sphere. By considering the known length of the test bar and the thickness of the slip or feeler and sphere radius when applicable, it is possible to accurate establish this Z position of the ring gauge top surface or sphere centre and set it in the current work coordinate system. The actual calculation of this depends on the tool offset system active on the machine.

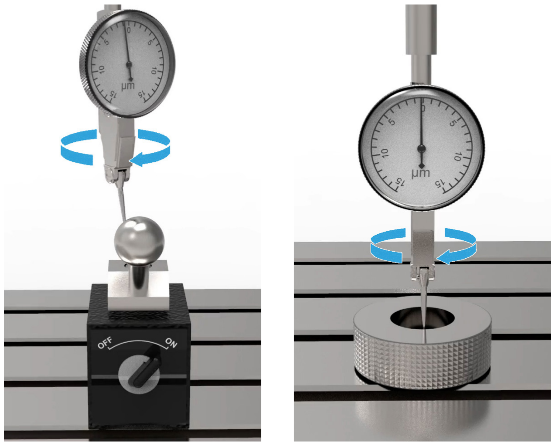


Figure 2: Establish XY centre

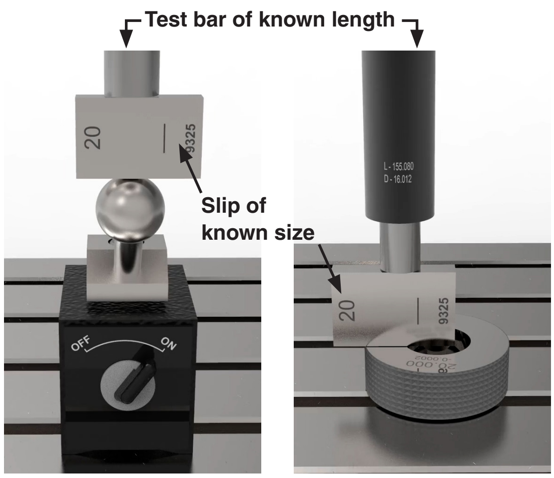


Figure 3: Setting work offset in Z

RENISHAW
apply innovation™

Calibration

As shown in figure 4, the current work offset is now set for X, Y, Z being zero at the centre top face of the ring gauge or sphere centre.

The probe calibration routine in the accompanying software is now run on the CNC. No matter which methods have been used to establish the X, Y and Z references (relevant work offset), the sequence of operation will remain the same.

- The Z-reference surface (either the sphere or the top surface of the ring gauge) will be measured by the probe, the distance between the electronic length and the physical length is stored in the macro variable and the physical length is store in the tool registry.

- The X-Y reference surfaces (either the circumference of the sphere or the internal diameter of the ring gauge) will be measured, establishing the electronic stylus ball radius and X, Y offsets. The results will be stored in macro variables (e.g. #500 - #503 Fanuc).

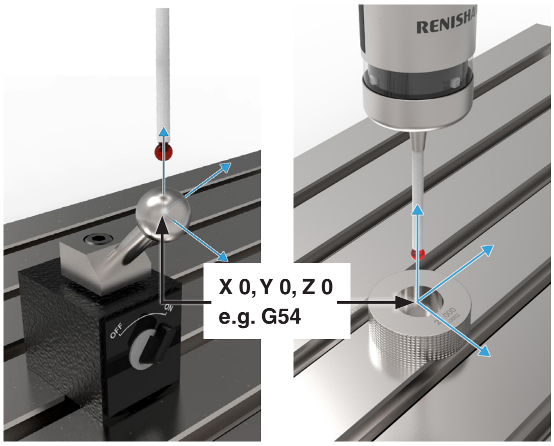
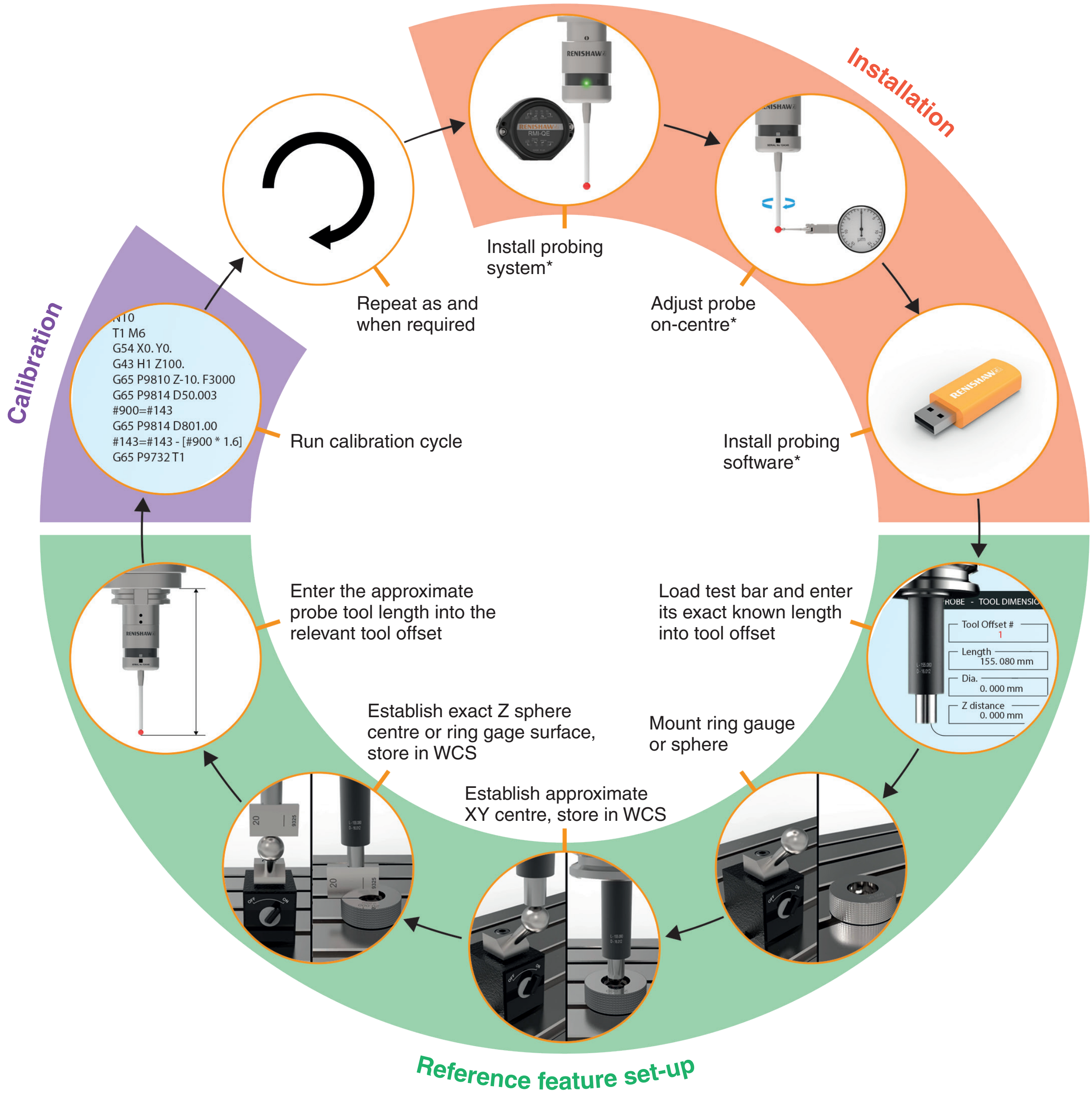


Figure 4: Calibrating XY offset

RENISHAW apply innovation™

Using a ring gauge or sphere, with 180° spindle orientation function



* not covered in this document

RENISHAW
apply innovation™

Installation

- A probing system requiring calibration should be installed and operational in accordance with the manufacturer's recommendations.
- Before starting it is good practice to mechanically adjust the tip of the stylus in-line with the spindle axis (on-centre adjustment) to reduce run-out. Run-out is typically measured using a low force dial test indicator in contact with the probe stylus ball, and adjusted for using a series of screws on the shank mounting face. For details of stylus on-centre adjustment refer to the installation guide for the relevant probe type.
- Where probing (macro) software cycles are not already installed on the CNC, these should be loaded in accordance with their instructions.

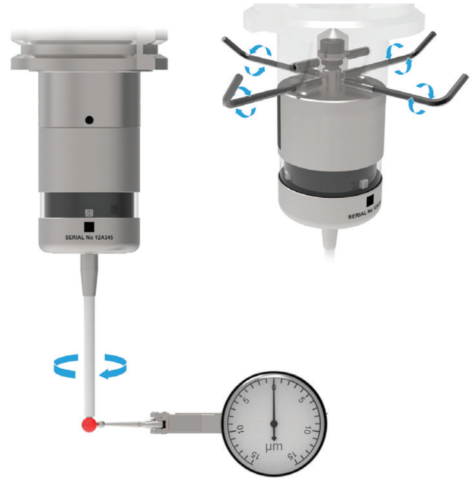


Figure 1: on-centre adjustment

Reference feature set-up

- A test bar (length bar) of exact known length is required and should be loaded to the machine. Its length, which is usually etched on the bar and confirmed on a calibration certificate should be entered into the relevant tool offset registry.
- A ring gauge or sphere of exact known diameter is required and should be securely mounted to the machine table. The diameter of the ring gauge/sphere will be an input into the calibration software cycle.
- The test bar should be jogged into the approximate centre of the ring gauge in the X-Y plane. The accompanying calibration software offers an automatic centre find function using spindle-orientation. The current work offset should then be set to this approximate XY centre.
- A reference surface in the Z-axis is now required. The position of this should be accurately established using the test bar. Methods vary according to user preference and machine specific issues (see also "Alternative methods" on page 15). Typically the test bar is moved slowly to make contact with a slip or feeler placed on the top surface of the ring gauge/sphere. By considering the known length of the test bar and the thickness of the slip or feeler, it is possible to accurate establish this Z position of the ring gauge top surface or sphere centre and set it in the current work coordinate system. The actual calculation of this depends on the tool offset system active on the machine.

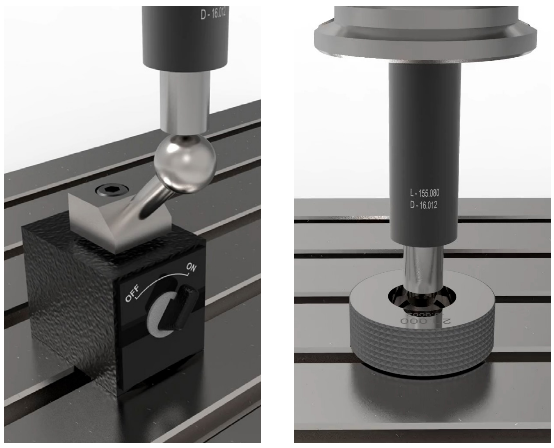


Figure 2: Approximate XY centre

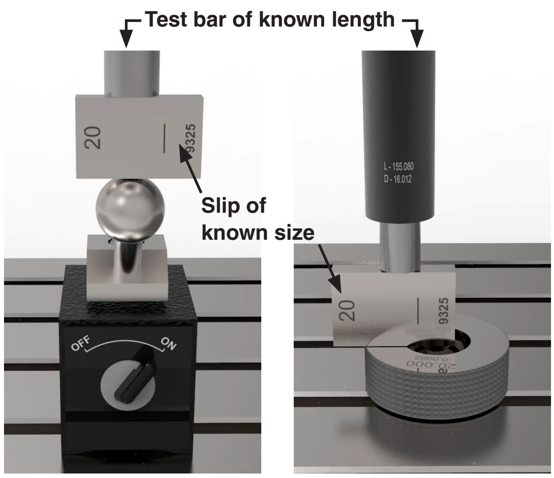


Figure 3: Setting work offset in Z

Calibration

As shown in figure 4, the current work offset is now set for X, Y, Z being zero at the centre top face of the ring gauge or sphere centre.

The probe calibration routine in the accompanying software is now run on the CNC. No matter which methods have been used to establish the X, Y and Z references (relevant work offset), the sequence of operation will remain the same.

- The Z-reference surface (either the sphere or the top surface of the ring gauge) will be measured by the probe, the distance between the electronic length and the physical length is stored in the macro variable and the physical length is store in the tool registry.

- The X-Y reference surfaces (either the circumference of the sphere or the internal diameter of the ring gauge) will be measured, establishing the electronic stylus ball radius and X, Y offsets. The results will be stored in macro variables (e.g. #500 - #503 Fanuc).

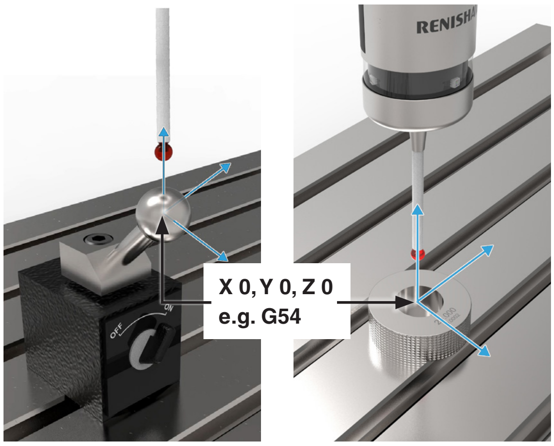
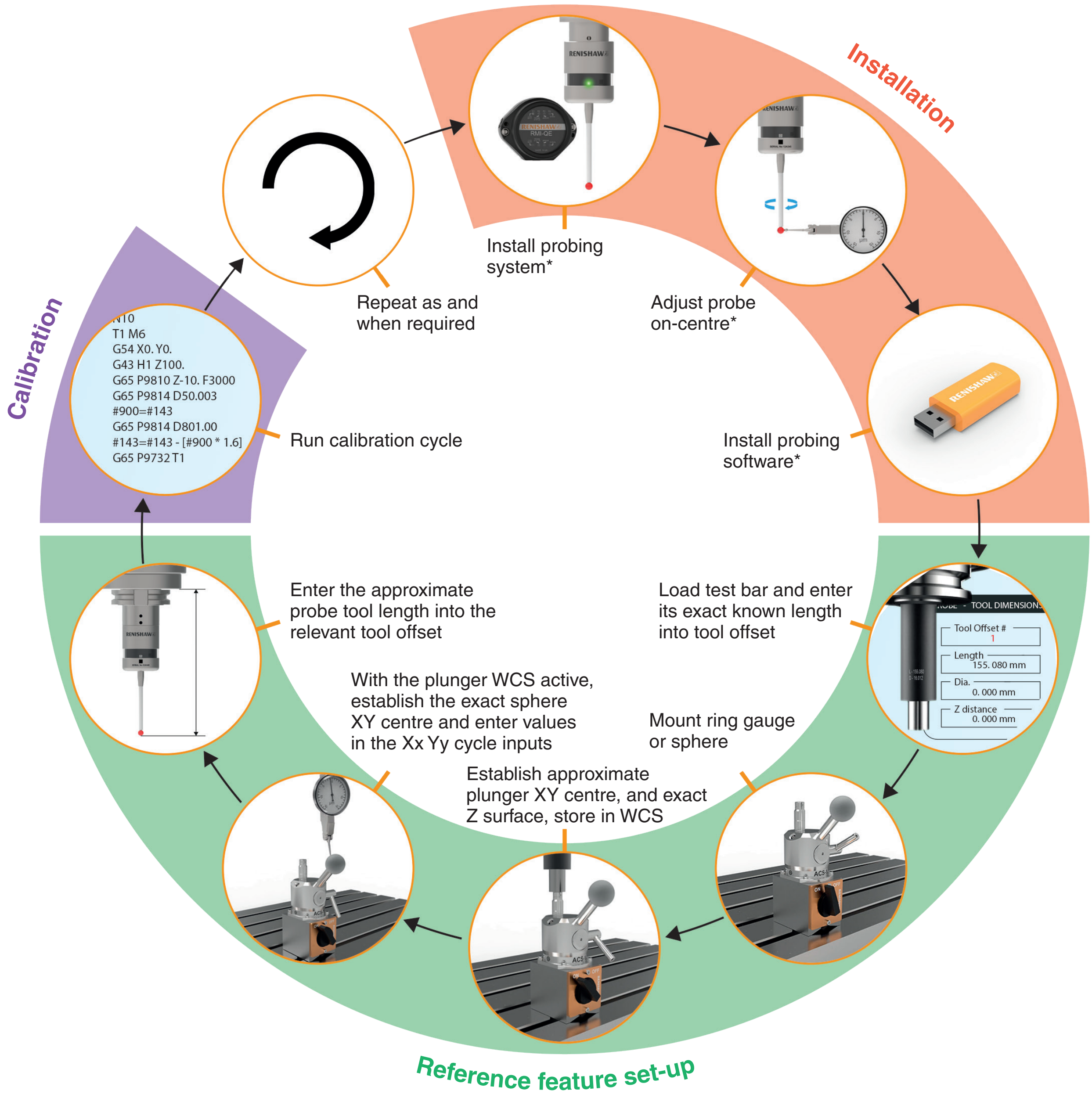


Figure 4: Calibrating XY offset

Using an ACS-1 (Advanced Calibration Sphere), without 180° spindle orientation function



* not covered in this document

RENISHAW apply innovation™

Installation

- A probing system requiring calibration should be installed and operational in accordance with the manufacturer's recommendations.
- Before starting it is good practice to mechanically adjust the tip of the stylus in-line with the spindle axis (on-centre adjustment). For machines without spindle orientation (Fanuc reference M19) it is vitally important that on-centre adjustment is optimised (i.e. the run-out of the stylus ball is minimised when the spindle is rotated). Run-out is typically measured using a low force dial test indicator in contact with the probe stylus ball, and adjusted for using a series of screws on the shank mounting face. For details of stylus on-centre adjustment refer to the installation guide for the relevant probe type.
- Where probing (macro) software cycles are not already installed on the CNC, these should be loaded in accordance with their instructions.

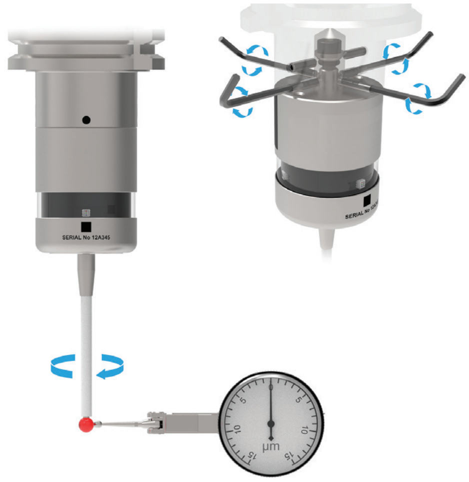


Figure 1: on-centre adjustment

Reference feature set-up

- A test bar (length bar) of exact known length is required and should be loaded to the machine. Its length, which is usually etched on the bar and confirmed on a calibration certificate should be entered into the relevant tool offset registry.
- An ACS-1 with a sphere of exact known diameter is required and should be securely mounted to the machine table. The diameter of the sphere will be an input into the calibration software cycle.
- A reference surface (ACS-1 plunger) in the Z-axis is now required. The position of this should be accurately established using the test bar. With the ACS-1 in the unlocked state, position the test bar centrally above plunger, store in WCS, approximate values are acceptable. Depress the plunger ensuring the maximum travel is not exceeded. The lever can now be locked and the Z WCS be set.
- The centre of the ACS-1's sphere must now be established accurately in the X-Y plane. A dial test indicator (DTI or clock) is used, mounted onto the spindle nose and slowly rotated until a constant reading is achieved over 360°. With the plunger WCS active, enter values in Xx Yy cycle inputs.

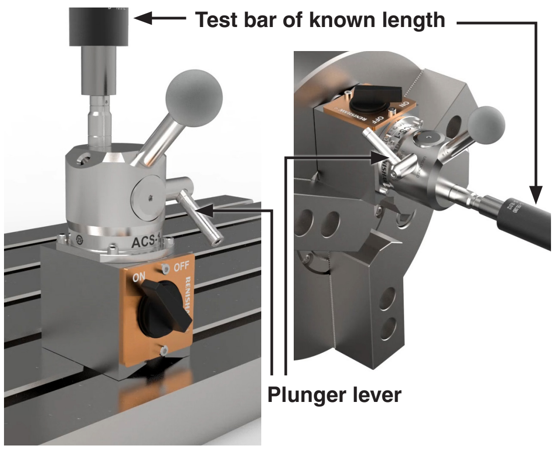


Figure 2: Setting work offset in Z

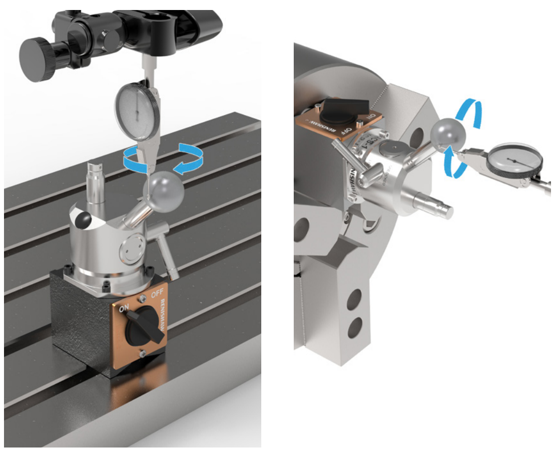


Figure 2: Establish XY centre

Calibration

As shown in figure 4, the current work offset is now set for X, Y, Z being zero at the centre top face of the plunger.

The probe calibration routine in the accompanying software is now run on the CNC.

- The Z-reference surface (in this example the top of the plunger) will be measured by the probe, establishing its electronic length and storing this result in the tool offset registry.
- The X-Y reference surfaces (in this example the diameter of the sphere) will be measured, establishing the electronic stylus ball radius and X, Y offsets. The results will be stored in macro variables (e.g. #500 - #503 Fanuc).

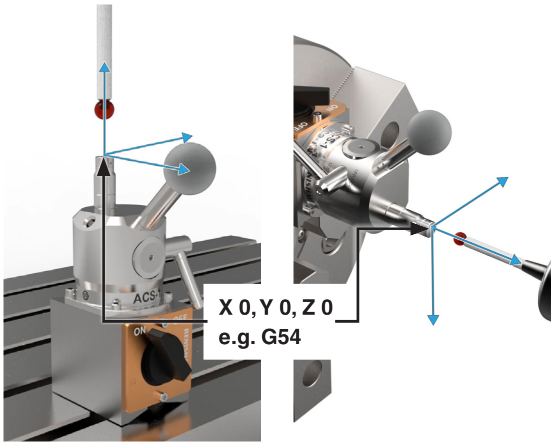
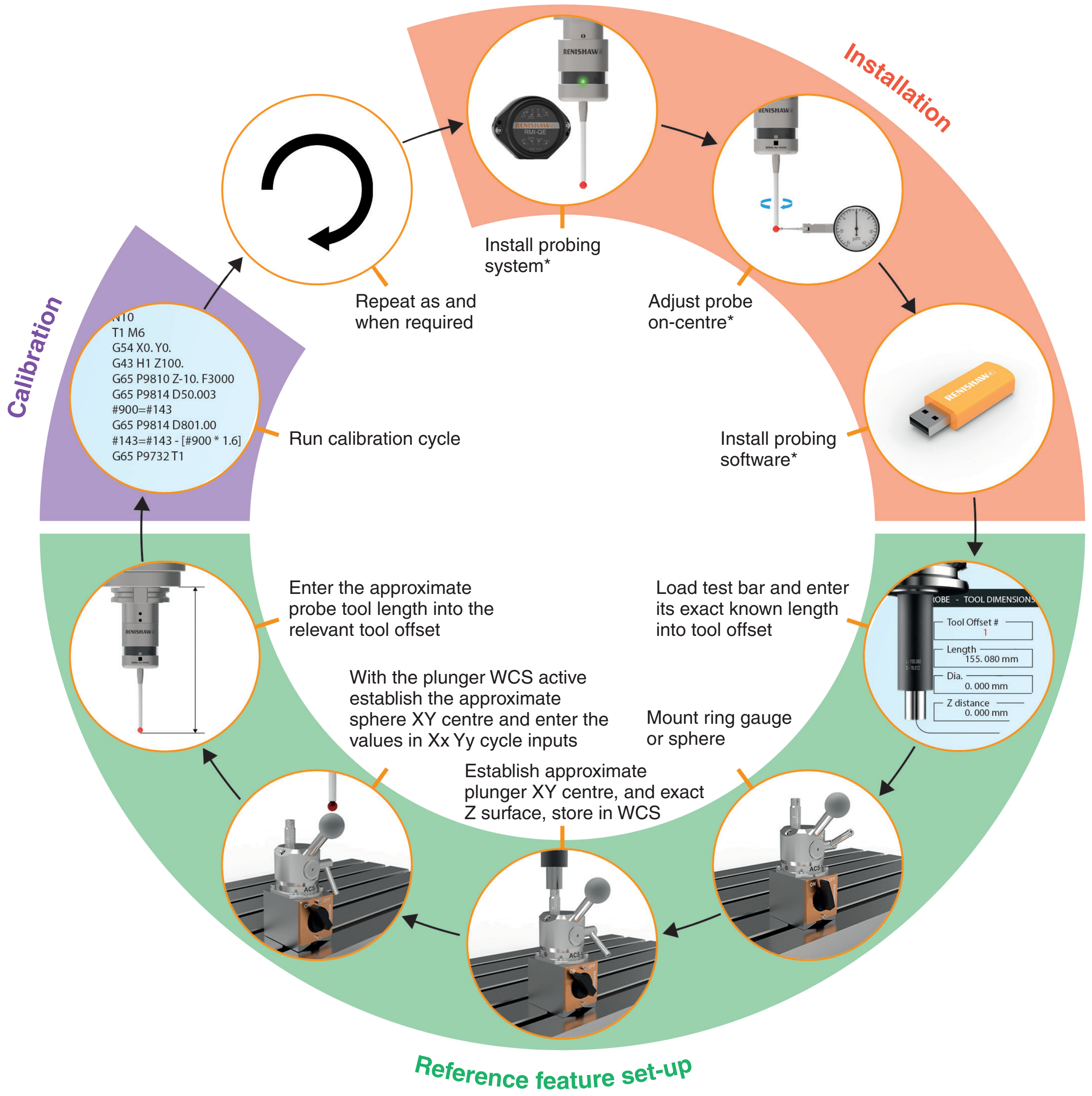


Figure 4: Calibrating XY offset

RENISHAW
apply innovation™

Using an ACS-1 (Advanced Calibration Sphere), with 180° spindle orientation function



* not covered in this document

Installation

- A probing system requiring calibration should be installed and operational in accordance with the manufacturer's recommendations.
- Before starting it is good practice to mechanically adjust the tip of the stylus in-line with the spindle axis (on-centre adjustment) to reduce run-out. Run-out is typically measured using a low force dial test indicator in contact with the probe stylus ball, and adjusted for using a series of screws on the shank mounting face. For details of stylus on-centre adjustment refer to the installation guide for the relevant probe type.
- Where probing (macro) software cycles are not already installed on the CNC, these should be loaded in accordance with their instructions.

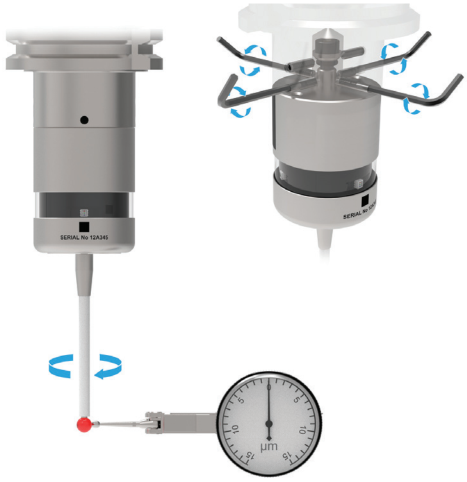


Figure 1: on-centre adjustment

Reference feature set-up

- A test bar (length bar) of exact known length is required and should be loaded to the machine. Its length, which is usually etched on the bar and confirmed on a calibration certificate should be entered into the relevant tool offset registry.
- An ACS-1 with a sphere of exact known diameter is required and should be securely mounted to the machine table. The diameter of the sphere will be an input into the calibration software cycle.
- A reference surface (ACS-1 plunger) in the Z-axis is now required. The position of this should be accurately established using the test bar. With the ACS-1 in the unlocked state, position the test bar centrally above plunger, store in WCS, approximate values are acceptable. Depress the plunger ensuring the maximum travel is not exceeded. The lever can now be locked and the Z WCS be set.
- The centre of the ACS-1's sphere must now be established approximately in the X-Y plane. With the plunger WCS active, enter values in Xx Yy cycle inputs.

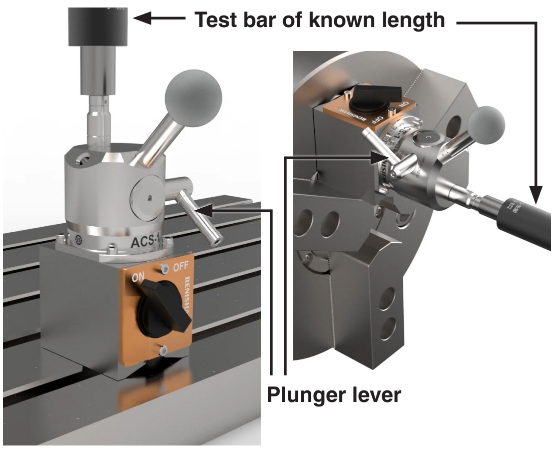


Figure 2: Setting work offset in Z

Calibration

As shown in figure 4, the current work offset is now set for X, Y, Z being zero at the centre top face of the plunger.

The probe calibration routine in the accompanying software is now run on the CNC.

- The Z-reference surface (in this example the top of the plunger) will be measured by the probe, establishing its electronic and physical length and storing this result in the tool offset registry.

- The X-Y reference surfaces (in this example the diameter of the sphere) will be measured, establishing the electronic stylus ball radius and X, Y offsets. The results will be stored in macro variables (e.g. #500 - #503 Fanuc).

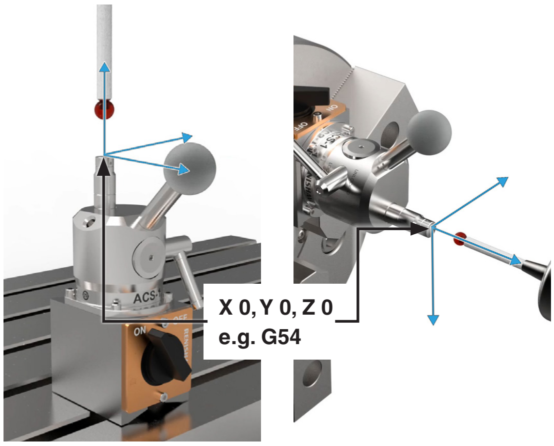


Figure 4: Calibrating XY offset

RENISHAW
apply innovation™

Alternative methods

Reference feature set-up

In common with the development of machine tools themselves a range of methods for setting up probe calibration have been used and many still have merit:

- **Bored hole for establishing X, Y offsets:** rather than using a dial test indicator to establish the centre of the ring gauge, with its inherent human and measurement errors, a hole is bored in a part already loaded to the machine. The centre of this hole is therefore known very accurately and may then be used by the calibration routine to calculate the X,Y offset of the stylus ball. With these values established the ring gauge is used only for the purposing of calculating the electronic stylus ball radius, for which it is unnecessary to know the centre position accurately.
- **Machined surface (Z-reference) for establishing the electronic and physical probe length:** rather than using a test bar of exact known length, it is possible to choose a milling tool known by the operator to be cutting accurately. A surface is machined using this cutter and considered as the Z-reference for electronic probe length calibration. This avoids errors inherent in the manual use of a feeler gauge. However, it should be stressed that this method is not traceable and that it is only suitable for use on machines without rotary axes.

www.renishaw.com/machinetool

#renishaw

+44 (0) 1453 524 524 uk@renishaw.com

Part no.: H-5650-2014-02-A