SIEMENS

SINUMERIK

SINUMERIK 840D sl / 828D
Measuring cycles

Programming Manual

Valid for:

Control system
SINUMERIK 840D sl / 840DE sl / 828D
Software
CNC software version 4.8 SP3

08/2018
6FC5398-4BP40-6BA2

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

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Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

Siemens AG
Division Digital Factory
Postfach 48 48
90026 NÜRNBERG
GERMANY

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Preface

SINUMERIK documentation

The SINUMERIK documentation is organized into the following categories:

- General documentation/catalogs
- User documentation
- Manufacturer/service documentation

Additional information

You can find information on the following topics at the following address (https://support.industry.siemens.com/cs/de/en/view/108464614):

- Ordering documentation/overview of documentation
- Additional links to download documents
- Using documentation online (find and search in manuals/information)

If you have any questions regarding the technical documentation (e.g. suggestions, corrections), please send an e-mail to the following address (mailto:docu.motioncontrol@siemens.com).

mySupport/Documentation

At the following address (https://support.industry.siemens.com/My/ww/en/documentation), you can find information on how to create your own individual documentation based on Siemens' content, and adapt it for your own machine documentation.

Training

At the following address (http://www.siemens.com/sitrain), you can find information about SITRAIN (Siemens training on products, systems and solutions for automation and drives).

FAQs

You can find Frequently Asked Questions in the Service&Support pages under Product Support (https://support.industry.siemens.com/cs/de/en/ps/faq).

SINUMERIK

You can find information about SINUMERIK at the following address (http://www.siemens.com/sinumerik).

Target group

This programming manual is intended for machine tool programmers for the SINUMERIK Operate software.

Benefits

With the programming manual, the target group can develop, write, test, and debug programs and software user interfaces.

Standard scope

This documentation only describes the functionality of the standard version. Additions or revisions made by the machine manufacturer are documented by the machine manufacturer.

Other functions not described in this documentation might be executable in the control. This does not, however, represent an obligation to supply such functions with a new control or when servicing.

For the sake of simplicity, this documentation does not contain all detailed information about all types of the product and cannot cover every conceivable case of installation, operation, or maintenance.

Technical Support

Country-specific telephone numbers for technical support are provided in the Internet at the following address (https://support.industry.siemens.com/sc/ww/en/sc/2090) in the "Contact" area.

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1 Fundamental safety instructions

1.1 General safety instructions

WARNING

Danger to life if the safety instructions and residual risks are not observed

If the safety instructions and residual risks in the associated hardware documentation are not observed, accidents involving severe injuries or death can occur.

- Observe the safety instructions given in the hardware documentation.
- Consider the residual risks for the risk evaluation.

WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameterization (parameter assignments) against unauthorized access.
- Handle possible malfunctions by taking suitable measures, e.g. emergency stop or emergency off.

1.2 Warranty and liability for application examples

Application examples are not binding and do not claim to be complete regarding configuration, equipment or any eventuality which may arise. Application examples do not represent specific customer solutions, but are only intended to provide support for typical tasks.

As the user you yourself are responsible for ensuring that the products described are operated correctly. Application examples do not relieve you of your responsibility for safe handling when using, installing, operating and maintaining the equipment.

1.3 Industrial security

Note

Industrial security

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the Internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit:

Industrial security (http://www.siemens.com/industrialsecurity)

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed at:

Industrial security (http://www.siemens.com/industrialsecurity)

Further information is provided on the Internet:

Industrial Security Configuration Manual (https://support.industry.siemens.com/cs/ww/en/view/108862708)

⚠ WARNING

Unsafe operating states resulting from software manipulation

Software manipulations (e.g. viruses, trojans, malware or worms) can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a holistic, state-of-the-art industrial security concept for the installation or machine.
- Make sure that you include all installed products into the holistic industrial security concept.
- Protect files stored on exchangeable storage media from malicious software by with suitable protection measures, e.g. virus scanners.
- Protect the drive against unauthorized changes by activating the "know-how protection" drive function.

Description 2

2.1 Basics

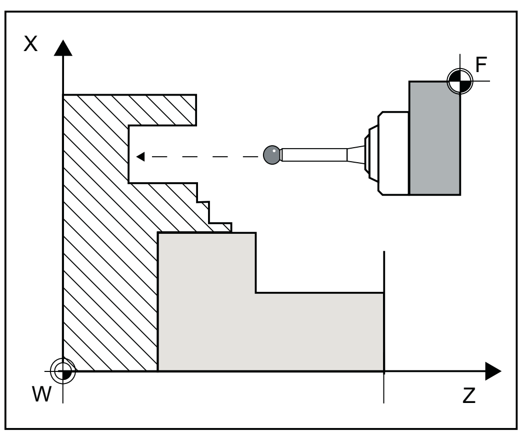
General information

Measuring cycles are general subroutines designed to solve specific measurement tasks. They can be adapted to specific problems via parameter settings.

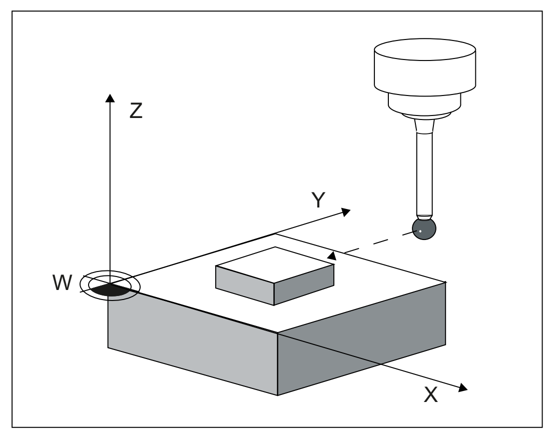
When taking general measurements, a distinction is made between

- **Tool measurement** and
- **Workpiece measurement**.

Workpiece measurement



Workpiece measurement, turning example



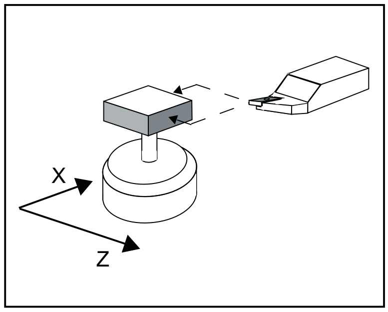
Workpiece measurement, milling example

In workpiece measurement, a probe is moved up to the clamped workpiece in the same way as a tool and the measured values are acquired. The flexibility of measuring cycles makes it possible to perform nearly all measurements required on a milling or turning machine.

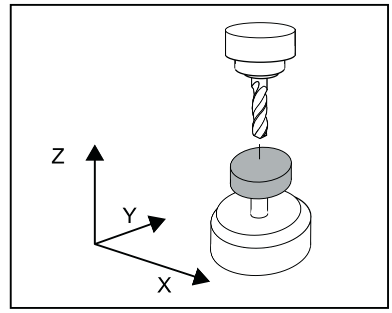
The result of the workpiece measurement can be optionally used as follows:

- Compensation in the work offset
- Automatic tool offset
- Measurement without offset

Tool measurement



Tool measurement, turning tool example



Tool measurement, drill example

In tool measurement, the selected tool is moved up to the probe and the measured values are acquired. The probe is either in a fixed position or is swung into the working area with a mechanism. The tool geometry measured is entered in the appropriate tool offset data set.

2.2 General prerequisites

Certain preconditions must be met before measuring cycles can be used. These are described in detail in the *SINUMERIK 840D sl Base Software and Operating Software*.

Check the preconditions using the following checklist:

- **Machine**
  - All machine axes are designed in accordance with DIN 66217.
  - Machine data has been adapted.
- **Starting position**
  - The reference points have been approached.
  - The starting position can be reached by linear interpolation without collision.
- **Display functions of the measuring cycles**
  A HMI/PCU or HMI/TCU is required for showing the measuring result displays and for measuring cycle support.
- **Please observe the following when programming:**
  - Tool radius compensation is deselected before it is called (G40).
  - The cycle is called no later than at the 5th program level.
  - The measurement is also possible in a system of units that differs from the basic system (with technology data that has been switched over).
    For **metric** dimension system with active G70, G700.
    For **inch** dimension system with active G71, G710.

References

Supplementary information for this documentation is provided in the following manuals:

- Commissioning Manual *SINUMERIK 840D sl Base Software and Operating Software*
  - /IM9/ SINUMERIK Operate
- /PG/, Programming Manual *SINUMERIK 840D sl / 828D Fundamentals*
- /FB1/, Function Manual *Basic Functions*
- /FB2/, Function Manual *Expanded Functions*
- /FB3/, Function Manual *Special Functions*

2.3 Behavior on block search, dry run, program testing, simulation

Function

The measuring cycles are skipped during execution if one of the following execution modes is active:

- "Trial run" ($P_DRYRUN=1)
- "Program test" ($P_ISTEST=1)
- "Block search" ($P_SEARCH=1), only if $A_PROTO=0.

Simulation and simultaneous recording

Setting the measuring cycles under a simulated environment

Setting data SD55618 $SCS_MEA_SIM_ENABLE

= 0: The measuring cycles are exited without any function.

= 1: The measuring cycles are executed.
A distinction is made between the following simulation versions:

-Simulation in the HMI Operate editor
Traversing motion is visualized.
Measurement results and measurement result display are not available.

-SinuTrain
Measurement results and measurement result display are available.
Traversing motion can be visualized using the simultaneous recording function.

-For systems that exclusively operate with simulated axes (e.g. virtual machines, NCU in a test rack application)
Measurement results and measurement result display are available.
Traversing motion can be visualized using the simultaneous recording function.

The following parameters should be observed for simulation in Sinutrain and systems with simulated axes:

If MD13230 $MN_MEAS_PROBE_SOURCE = 1 to 8,
then set MD10360 $MN_FASTIO_DIG_NUM_OUTPUTS >= 1!

SD55619 $SCS_MEA_SIM_MEASURE_DIFF = input of simulated measurement difference

Measuring cycles and measurement results under a simulated environment (SinuTrain) are used for programming for training purposes if a real machine is not available. The measurement results also involve "simulated" values, which can also deviate from the setting in MD13231 MEAS_PROBE_OFFSET, but which are influenced by these.

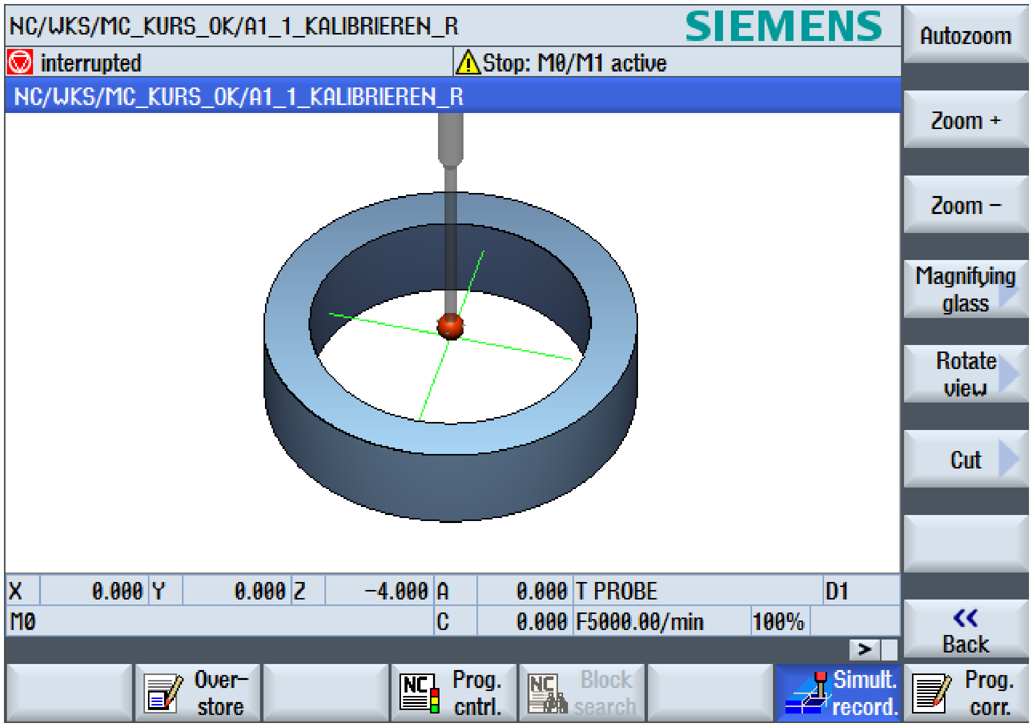


Figure 2-1 Measuring - simulation

2.4 Reference points on the machine and workpiece

General information

Depending on the measuring task, measured values may be required in the machine coordinate system (MCS) or in the workpiece coordinate system (WCS).

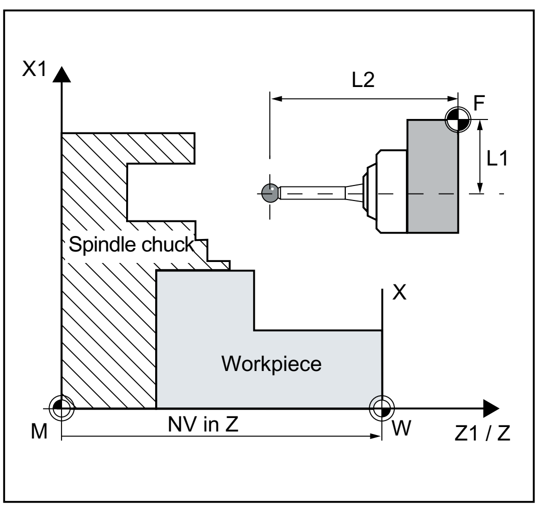
For example: It may be easier to ascertain the tool length in the machine coordinate system.

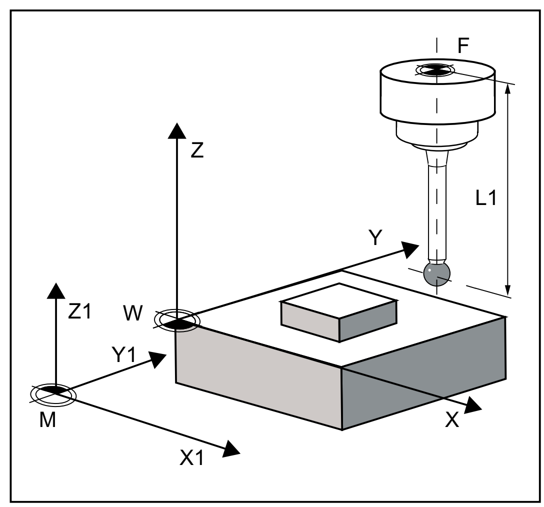
Workpiece dimensions are measured in the workpiece coordinate system.

Where:

- M = machine zero in the machine coordinate system
- W = workpiece zero in the workpiece coordinate system
- F = tool reference point

Reference points





The position of tool reference point F in the machine coordinate system is defined with machine zero M as the **machine actual value**.

The position of the tip/cutting edge of the active tool in the workpiece coordinate system is displayed with the workpiece zero W as **workpiece actual value**. For a workpiece probe, the center or the end of the probe ball can be defined as the tool tip.

The **work offset** (WO) characterizes the position of the workpiece zero W in the machine coordinate system.

Work offsets (WO) comprise the components offset, rotation, mirroring and scaling factor (only the global basic work offset does not contain any rotation).

A distinction is made between the basic, work offset (G54 ... G599) and programmable work offset. The basic area contains further subsections – such as the basic work offset, channel-specific basic work offset and configuration-dependent work offsets (e.g. rotary table reference or basic reference).

The specified work offsets are effective together as a chain and result in the workpiece coordinate system.

For "Correction in a work offset", in conjunction with measuring cycles, a distinction is made between two different cases.

Correction to the coarse offset:
An absolute offset value is determined between the machine zero and the measured workpieces zero. This offset is written into the coarse component of the selected work offset and deleted in the fine component.

Correction to the fine offset:
The measured difference is written as offset to the fine component of the selected work offset and is added to the course component.

The input window work offset coarse/fine in the automatic measuring cycle screens is activated using SD54760 $SNS_MEA_FUNCTION_MASK_PIECE, bit 10 = 1.

Note

Scale factors with a scaling value unequal to "1" are not supported by the measuring cycles! Mirroring functions are only permitted in conjunction with counterspindles on turning machines.

The machine and workpiece coordinate system can be set and programmed separately in the "inch" or "metric" measuring system.

Note

Transformation

- Measure workpiece
  Workpiece measurements are always performed in the workpiece coordinate system. All descriptions relating to workpiece measurement refer to it!
- Measure tool
  When measuring tools with kinematic transformation active, a distinction is made between **basic coordinate system** and **machine coordinate system**.
  If kinematic transformation is deactivated, this distinction is made.
  All subsequent descriptions relating to tool measurement assume that kinematic transformation is disabled and therefore refer to the machine coordinate system.

2.5 Definition of the planes, tool types

When measuring under milling, machining planes G17, G18 or G19 can be selected.

When measuring under turning, machining plane G18 must be selected.

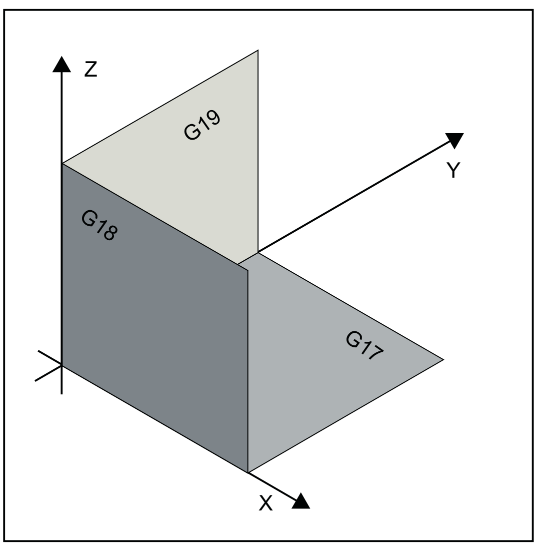
For tool measurement, the following tool types are permitted:

- Milling, type 1..
- Drill, type 2 ...
- Turning tools, type 5 ...

For workpiece measurement, the following tool types are permitted:

- Workpiece probe, milling: Probe types 710, 712, 713, 714
- Workpiece probe, turning: Probe type 580 for turning machines without extended milling technology, otherwise 710
  See "Measuring the workpiece on a machine with combined technologies (Page 250)".

Milling



Depending on the tool type, the tool lengths are assigned to the axes as follows:

	Acts in ...	G17 plane	G18 plane	G19 plane
	Tool type:		1xy / 2xy / 710	
Length 1	1st axis of the plane:	Z	Y	X
Length 2	2nd axis of the plane:	Y	X	Z
Length 3	3rd axis of the plane:	X	Z	Y

Note

In the assignment of the tool lengths, note the settings in the following setting data

- SD42940 $SC_TOOL_LENGTH_CONST
- SD42942 $SC_TOOL_LENGTH_CONST_T
- SD42950 $SC_TOOL_LENGTH_TYPE

Example of plane definition for milling

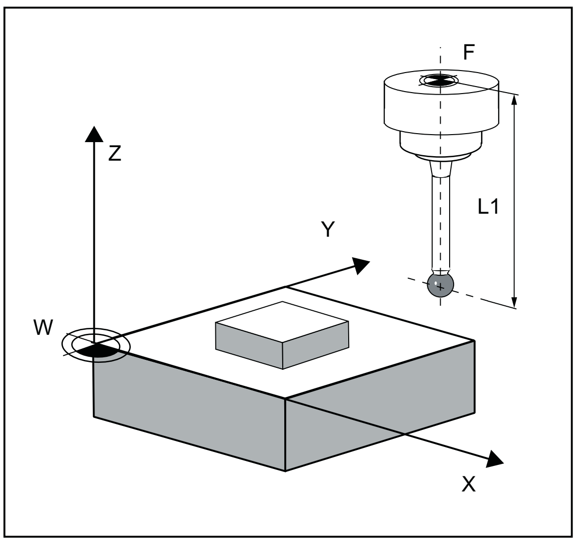
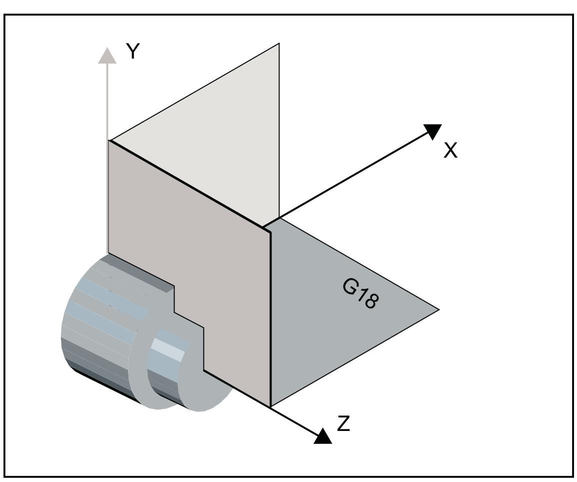


Figure 2-2 Example: Milling machine with G17

Turning



Turning machines generally only use axes Z and X and therefore:

G18 plane

Tool type	5xy (turning tool, workpiece probe)
Length 1	Acts in X (2nd axis of the plane)
Length 2	Acts in Z (1st axis of the plane)

G17 and G19 are used for milling on a turning machine. If there is no machine axis Y, milling can be implemented with the following kinematic transformations.

- TRANSMIT
- TRACYL

In principle, measuring cycles support kinematic transformations. This is stated more clearly in the individual cycles and measuring variants. Information about kinematic transformation can be found in the Programming Manual *SINUMERIK 840D sl / 828D Fundamentals* or in the documentation of the machine manufacturer.

Note

If a drill or milling cutter is measured on a lathe, in most cases, the channel-specific SD 42950 $SC_TOOL_LENGTH_TYPE = 2 is set: These tools are then length-compensated like a turning tool.

SINUMERIK controls have other machine and setting data that can influence the calculation of a tool.

References:

- /FB1/, Function Manual *Basic Functions*
- /FB2/, Function Manual *Expanded Functions*
- /FB3/, Function Manual *Special Functions*

Example of plane definition for turning

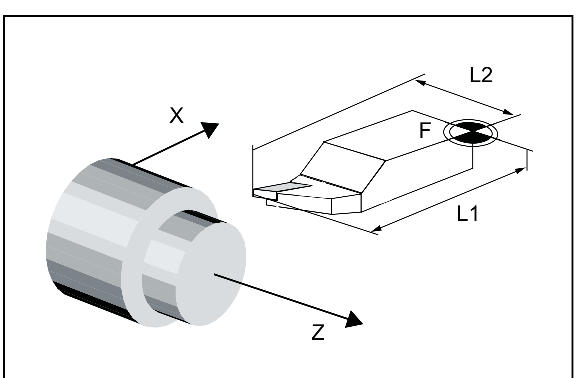


Figure 2-3 Example: Lathe with G18

2.6 Probes that can be used

General information

To measure tool and workpiece dimensions, an electronic touch-trigger probe is required that provides a signal change (edge) when deflected with the required repeat accuracy.

The probe must operate virtually bounce-free.

Different types of probe are offered by different manufacturers.

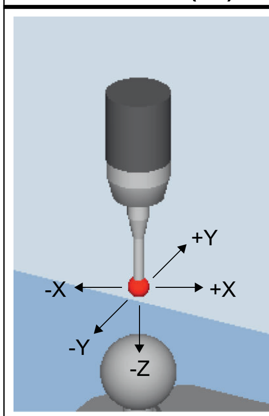
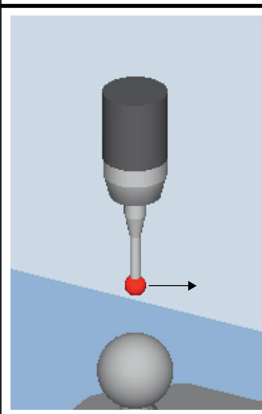
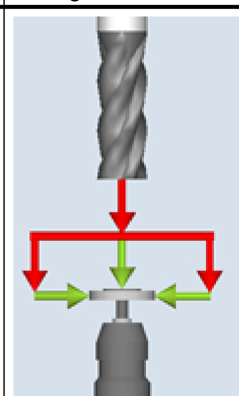
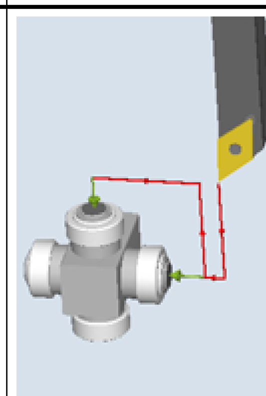
Note

Please observe the information provided by the manufacturers of electronic probes and/or the machine manufacturer's instructions on the following points:

- Electrical connection
- Mechanical calibration of the probe
- If a workpiece probe is used, both the direction of deflection and transmission of switching signal to the machine column (radio, infrared or cable) must be taken into account. In some versions, transmission is only possible in particular spindle positions or in particular ranges. This can restrict the use of the probe.

Probes are distinguished according to the number of measuring directions.

- Multi-directional (multi probe)
- Mono-directional (mono probe)

Workpiece probe		Tool probe	
Multi-directional (3D)	**Mono-directional**	**Milling machines**	**Lathes**
			

The probes also differ in the form of the stylus tip:
The measuring cycles support pin, L and star probes as autonomous tool types. The use of the probe types is referenced in the individual measuring cycles. The multi probe is universally applicable.

For a mono probe, the switching direction is tracked for each measurement by turning the spindle. This can lead to a longer program runtime.

Workpiece probe types

The following workpiece measuring probe types – as well as a calibration tool for calibrating tool probes – are provided in the tool management:

710	-	3D milling probe
711	-	Edge finder
712	-	Mono probe
713	-	L probe
714	-	Star probe
725	-	Calibrating tool

Figure 2-4 Probe types in the tool management

Tool data from probes

The probes differ as a result of the tool type and their special attributes, e.g. switching directions.

A probe can encompass several tool types. For this purpose, several cutting edges (D1, D2, ...) should be created for the probe.

Example: Multi probe with a boom

D1	3D_PROBE	Type 710
D2	L_PROBE	Type 713

The user must take into account the geometry of the probe when pre-positioning. To do this, you can read out individual tool data in the user program:

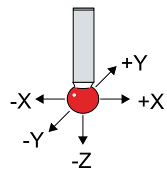
Example:

```
IF (($P_TOOLNO>0) AND ($P_TOOL>0))
     R1= ($P_AD[6]) ; Reading: tool radius of the current tool
ENDIF
```

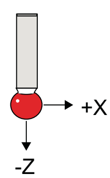
Correction angle

"The probe is aligned in the +X direction using tool parameter "correction angle" .

3D probe (multi probe)

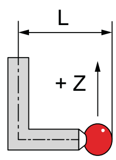
Display	Properties	Characteristic
	Application:	Universal
	Type:	$TC_DP1 = 710
	Tool length:	in Z (for G17) [1)]
	Radius of the probe sphere	$TC_DP6
1) Workpiece measurement, length reference of the 3D probe The tool length in the direction of the infeed axis (for G17: Z axis) is defined as the distance between the tool reference point in the tool adapter and a parameterized reference point on the probe sphere. The reference point can be set to the center of the sphere or the surface of the sphere using the following machine data: MD51740 $MN_MEA_FUNCTION_MASK, bit 1		

Mono probe

Display	Properties	Characteristic
	Application:	Alignment of the switching direction when measuring
	Type:	$TC_DP1 = 712
	Tool length:	in Z (for G17) [1)]
	Correction angle:	$TC_DP10 = 0.0° to 359.9°
	Radius of the probe sphere	$TC_DP6
1) Workpiece measurement, length reference of mono probe The tool length in the direction of the infeed axis (for G17: Z axis) is defined as the distance between the tool reference point in the tool adapter and a parameterized reference point on the probe sphere. The reference point can be set to the center of the sphere or the surface of the sphere using the following machine data: MD51740 $MN_MEA_FUNCTION_MASK, bit 1		

As initial state for the measuring cycles it is defined that at spindle position 0° the switching direction of the mono probe in the machining plane is aligned in the axis direction +X. If an angular offset is required, then the value should be entered into tool parameter "Correction angle" ($TC_DP10).

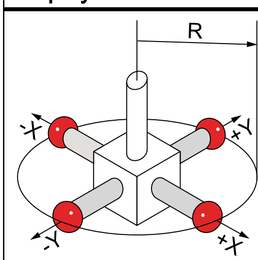
L probe

Display	Properties	Characteristic
	Application:	Towing measurement in +Z
	Type:	$TC_DP1 = 713
	Tool length:	in Z (for G17) [1)]
	Correction angle:	$TC_DP10 = 0.0° to 359.9°
	Radius of the probe sphere:	$TC_DP6
	Length L of the boom:	$TC_DP7
1) Workpiece measurement, length reference The tool length is defined as the distance between the tool reference point in the tool adapter and the probing point of the probe sphere in the +Z direction.		

The initial position of the L probe referred to the measuring cycles is defined so that at spindle position 0°, the boom and therefore the switching direction in the machining plane, are aligned in the axis direction +X.

If an angular offset of the tool spindle is required, then the value should be entered into tool parameter "Correction angle" ($TC_DP10).

Star probe

Display	Properties	Characteristic
	Application:	Measure: Hole parallel to the axis [1)]
	Type:	$TC_DP1 = 714
	Tool length:	in Z (for G17) [2)]
	Correction angle:	$TC_DP10 = 0.0° to 359.9°
	External radius R of the star element:	$TC_DP6
	Radius of a probe sphere:	$TC_DP7
1) The application only refers to measurements in the plane (for G17: XY plane). Measurement in the tool direction (for G17: Z direction) is not permitted using a star probe. If a measurement is to be made in the tool direction, a star element (boom) must be parameterized as an L probe ($TC_DP1 = 713).		
2) Workpiece measurement, length reference of star probe The tool length is defined as the distance between the tool reference point in the tool adapter and the center point of one of the probe spheres.		

The booms of the star probe should be aligned parallel to the geometry axes of the machining plane. If an angular offset is required, then the value should be entered into tool parameter "Correction angle" ($TC_DP10).

2.7 Probe, calibration body, calibration tool

2.7.1 Measuring workpieces on milling machines, machining centers

Probe calibration

All probes must be mechanically correctly adjusted before use. The switching directions must be calibrated before they are used in the measuring cycles for first-time. This also applies when changing the stylus tip of the probe.

When being calibrated, the trigger points (switching points), position deviation (skew), and active ball radius of the workpiece probe are determined and entered into the data fields of the general setting data SD 54600 $SNS_MEA_WP_BALL_DIAM . There are 40 data fields.

Calibration can be realized in a calibration ring (known bore), on a calibration ball or on workpiece surfaces, which have an appropriate geometrical precision and low surface roughness.

Use the same measuring velocity for calibrating and measuring. This applies in particular to the feedrate overide. If, in MD51740 $MNS_MEA_FUNCTION_MASK, bit 6 is set =1, then 100% feed rate override traversing velocity is used for the measuring blocks (MEAS) in the measuring cycles if the feedrate override is set > 0. If calibration is performed more than once on a calibration data set, the same measuring velocity must be set, otherwise the previous calibration will be declared as being invalid.

Measuring cycle CYCLE976 with different measuring variants is available to calibrate the probe.

Measuring

All probe types can be used in conjunction with a spindle capable of positioning. This ensures that all milling measuring variants can be applied.

When positioning the probe, the measuring cycles always refer to the active master spindle. If several spindles exist, then this condition must be satisfied by the user. During the program runtime, this is possible using the SETMS NC command.

Example: SETMS(3); the third spindle is defined as master spindle.

If probes are used in conjunction with spindles that are not capable of positioning, restrictions are obtained regarding the measuring variants and probe types. For illegal measuring variants, alarms can be displayed during the cycle time.

At the calibration and measurement instant, the user must guarantee an identical orientation (spindle position) of the probe, for example by clamping or indexing.

If probes are fixed in a system, restrictions are obtained regarding the measuring variants and probe types. For illegal measuring variants, alarms can be displayed during the cycle time.

When the probe is mounted in the machine at a fixed position, a mechanical offset can exist in the three geometry axes between the center point of the probe ball (tool tip) and the tool reference point.

This offset should be entered in the adapter dimension (basis dimension) of the tool data of the workpiece probe.

See also

Calibrate probe - radius in ring (CYCLE976) (Page 112)

Calibrate probe - radius on edge (CYCLE976) (Page 117)

Calibrate probe - calibrate on ball (CYCLE976) (Page 124)

2.7.2 Measuring tools on milling machines, machining centers

Tool probe

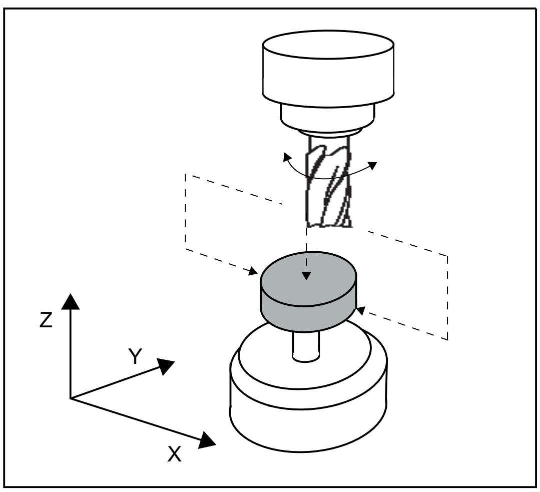


Figure 2-5 Measuring a milling cutter

Parameters of the tool probe

Setting data

- For machine-related measurement/calibration:
  - SD 54625 $SNS_MEA_TP_TRIG_MINUS_DIR_AX1
  - SD 54626 $SNS_MEA_TP_TRIG_PLUS_DIR_AX1
  - SD 54627 $SNS_MEA_TP_TRIG_MINUS_DIR_AX2
  - SD 54628 $SNS_MEA_TP_TRIG_PLUS_DIR_AX2
  - SD 54629 $SNS_MEA_TP_TRIG_MINUS_DIR_AX3
  - SD 54630 $SNS_MEA_TP_TRIG_PLUS_DIR_AX3
- For machine-related measurement/calibration:
  - SD 54640 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX1
  - SD 54641 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX1
  - SD 54642 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX2
  - SD 54643 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX2
  - SD 54644 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX3
  - SD 54645 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX3

The default setting has data fields for 6 probes.

Calibration, calibration tool

A probe must be calibrated before it can be used. To do this, when using measuring cycles in the AUTOMATIC mode, **before** calibration, the approximate values must be entered into the setting data listed above for the corresponding probe. Only then can the approximate position of the probe be identified in the measuring cycle.

Calibration involves precisely determining the trigger points (switching points) of the tool probe, and entering them in the corresponding parameters.

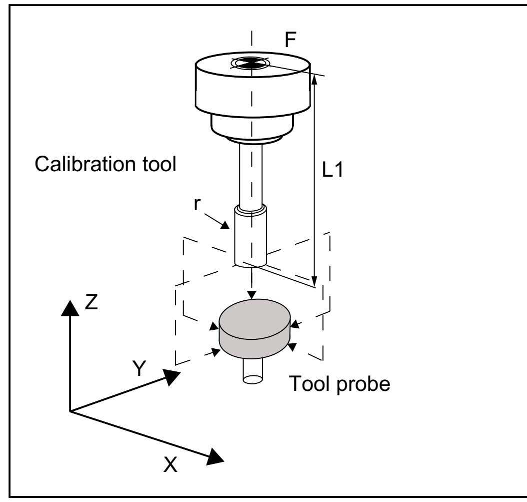
Calibration tool (type 725), milling (type 1xy) or drilling tool (2xy) can be used for calibration. The precise dimensions of the tool are known.

Measurement version Calibrate probe (CYCLE971) (Page 281) is provided for calibration.

Note

Measuring velocities

It is recommended that the same measuring velocities are used for calibrating and measuring.

Tool parameters		Calibrating tool probes
Tool type ($TC_DP1[ ]):	725, 1xy or 2xy	
Length 1 - geometry ($TC_DP3[ ]):	L1	
Radius ($TC_DP6[ ]):	r	
Length 1 - basic dimension ($TC_DP21[ ]):	only if required	

All other tool parameters, such as wear, must be assigned a value of zero.

2.7.3 Measuring workpieces at the turning machines

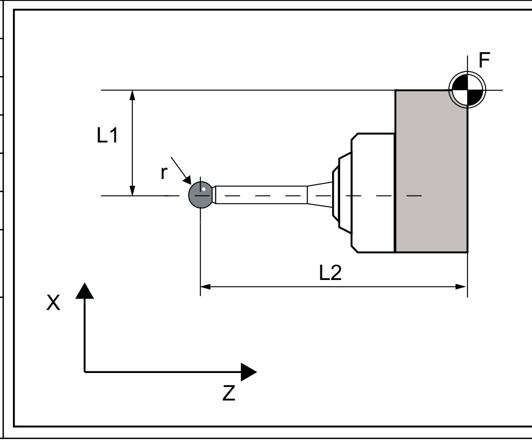
Workpiece probe

On turning machines, the workpiece probes are treated as tool type 580 with permissible cutting edge positions (SL) 5 to 8 and must be entered in the tool memory accordingly.

Lengths specified for turning tools always refer to the tool tip, except in the case of workpiece probes on turning machines where they refer to the probe center.

Probes are classified according to their position:

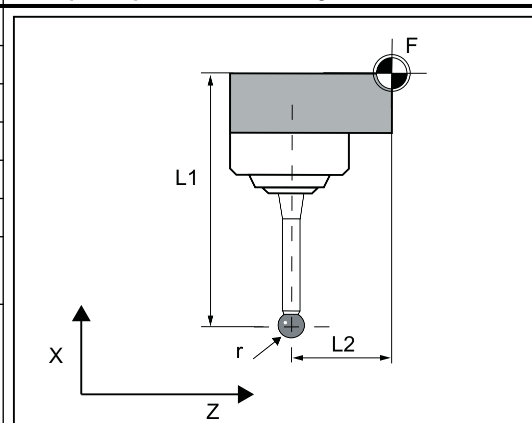
Workpiece probe SL 7

Entry in tool memory		Workpiece probe for a turning machine
Tool type ($TC_DP1[ ]):	580	
	710[1)]	
Cutting edge ($TC_DP2[ ]):	7	
Length 1 - geometry:	L1	
Length 2 - geometry:	L2	
Radius ($TC_DP6[ ]):	r	
Length 1 - basic dimension ($TC_DP21[ ]):	only if required	
Length 2 - basic dimension ($TC_DP22[ ]):	only if required	

1) For turning-milling combination technology (1st technology is turning, 2nd technology is milling) with the requirements, setting data SD 42940 $SC_TOOL_LENGTH_CONST = 18 (or -18) and setting data SD 42950 $SC_TOOL_LENGTH_TYPE = 2

The wear and other tool parameters must be assigned the value 0.

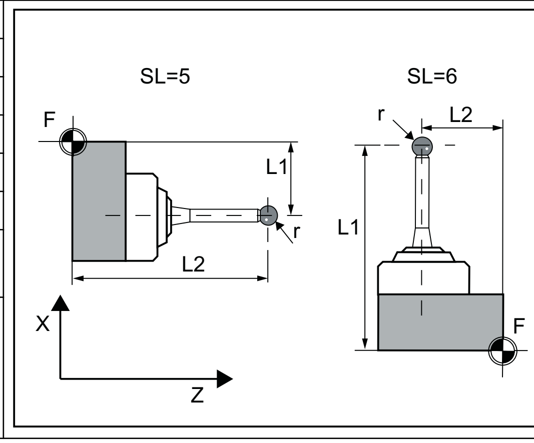
Workpiece probe SL 8

Entry in tool memory		Workpiece probe for a turning machine
Tool type ($TC_DP1[ ]):	580	
	710[1)]	
Cutting edge ($TC_DP2[ ]):	8	
Length 1 - geometry:	L1	
Length 2 - geometry:	L2	
Radius ($TC_DP6[ ]):	r	
Length 1 - basic dimension ($TC_DP21[ ]):	only if required	
Length 2 - basic dimension ($TC_DP22[ ]):	only if required	

1) For turning-milling combination technology (1st technology is turning, 2nd technology is milling) with the requirements, setting data SD 42940 $SC_TOOL_LENGTH_CONST = 18 (or -18) and setting data SD 42950 $SC_TOOL_LENGTH_TYPE = 2

The wear and other tool parameters must be assigned the value 0.

Workpiece probe SL 5 or SL 6

<table>
<tr><th colspan="2">Entry in tool memory</th><th>Workpiece probe for a turning machine</th></tr>
<tr><td rowspan="2">Tool type ($TC_DP1[ ]):</td><td>580</td><td rowspan="9">
</td></tr>
<tr><td>710[1)]</td></tr>
<tr><td>Cutting edge ($TC_DP2[ ]):</td><td>5 or 6</td></tr>
<tr><td>Length 1 - geometry:</td><td>L1</td></tr>
<tr><td>Length 2 - geometry:</td><td>L2</td></tr>
<tr><td>Radius ($TC_DP6[ ]):</td><td>r</td></tr>
<tr><td>Length 1 - basic dimension ($TC_DP21[ ]):</td><td>only if required</td></tr>
<tr><td>Length 2 - basic dimension ($TC_DP22[ ]):</td><td>only if required</td></tr>
<tr><td></td><td></td></tr>
</table>

[1)] For turning-milling combination technology (1st technology is turning, 2nd technology is milling) with the requirements, setting data SD 42940 $SC_TOOL_LENGTH_CONST = 18 (or -18) and setting data SD 42950 $SC_TOOL_LENGTH_TYPE = 2

The wear and other tool parameters must be assigned the value 0.

Calibration, gauging block

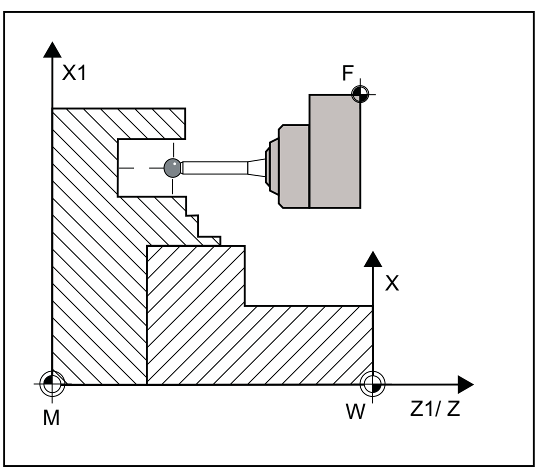


Figure 2-6 Calibrating a workpiece probe, example: Calibrating in the reference groove

A probe must be calibrated before it can be used. When being calibrated, the trigger points (switching points), position deviation (skew), and precise ball radius of the workpiece probe are determined and entered into the corresponding data fields of the general setting data SD 54600 $SNS_MEA_WP_BALL_DIAM .

The default setting has data fields for 40 probes.

Calibration of the workpiece probe on turning machines is usually performed with gauging blocks (reference grooves). The precise dimensions of the reference groove are known and entered in the associated data fields of the following general setting data:

- SD54615 $SNS_MEA_CAL_EDGE_BASE_AX1
- SD54616 $SNS_MEA_CAL_EDGE_UPPER_AX1
- SD54617 $SNS_MEA_CAL_EDGE_PLUS_DIR_AX1
- SD54618 $SNS_MEA_CAL_EDGE_MINUS_DIR_AX1
- SD54619 $SNS_MEA_CAL_EDGE_BASE_AX2
- SD54620 $SNS_MEA_CAL_EDGE_UPPER_AX2
- SD54621 $SNS_MEA_CAL_EDGE_PLUS_DIR_AX2
- SD54622 $SNS_MEA_CAL_EDGE_MINUS_DIR_AX2

The default setting has data fields for three gauging blocks. In the measuring cycle program, the selection is made using the number of the gauging block (S_CALNUM).

It is also possible to calibrate on a known surface.

Measuring cycle CYCLE973 with various measuring variants is ready for calibration.

See also

Calibrate probe - length (CYCLE973) (Page 82)

Calibrate probe - radius on surface (CYCLE973) (Page 85)

Calibrate probe - calibrate in groove (CYCLE973) (Page 88)

2.7.4 Measuring tools at lathes

Tool probe

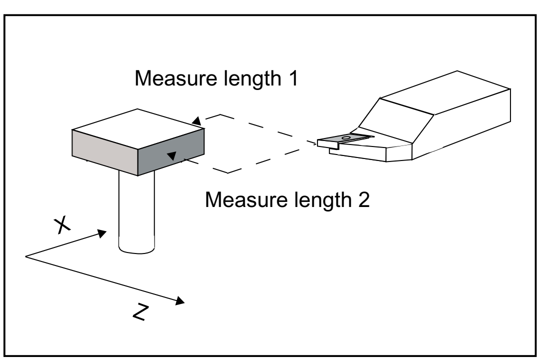


Figure 2-7 Measuring a turning tool

Parameters of the tool probe

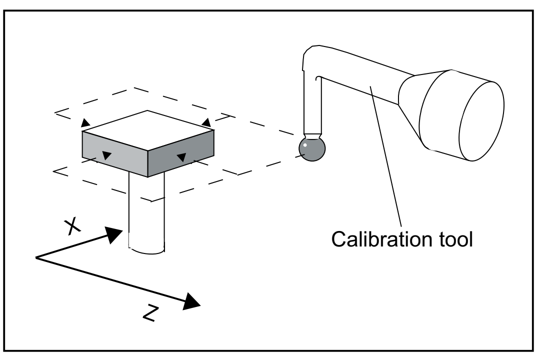
Setting data:

- For machine-related measurement/calibration:
  - SD 54626 $SNS_MEA_TP_TRIG_PLUS_DIR_AX1
  - SD 54625 $SNS_MEA_TP_TRIG_MINUS_DIR_AX1
  - SD 54627 $SNS_MEA_TP_TRIG_MINUS_DIR_AX2
  - SD 54628 $SNS_MEA_TP_TRIG_PLUS_DIR_AX2
- For workpiece-related measurement/calibration:
  - SD 54641 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX1
  - SD 54640 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX1
  - SD 54642 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX2
  - SD 54643 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX2

The default setting has data fields for 6 probes.

In addition to turning tools, drills and mills can also be measured.

Calibration, gauging block



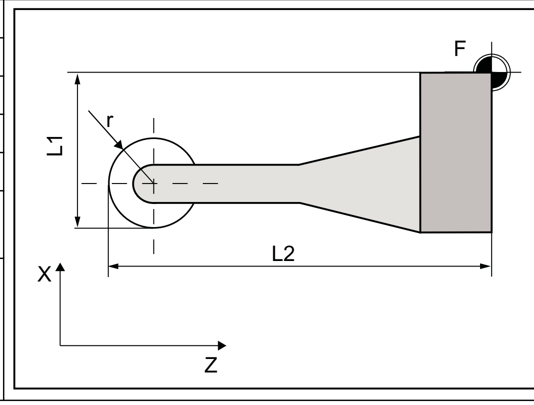
A probe must be calibrated before it can be used. To do this, when using measuring cycles in the AUTOMATIC mode, **before** calibration, the approximate values must be entered into the setting data listed above for the corresponding probe. Only then can the approximate position of the probe be identified in the measuring cycle.

Calibration involves precisely determining the trigger points (switching points) of the tool probe, and entering them in the corresponding parameters.

Calibration tool (type 585 or type 725) or turning tool (type 5xy) can be used for calibration. The precise dimensions of the tool are known.

Measurement version Calibrate probe (CYCLE982) (Page 255) is provided for calibration.

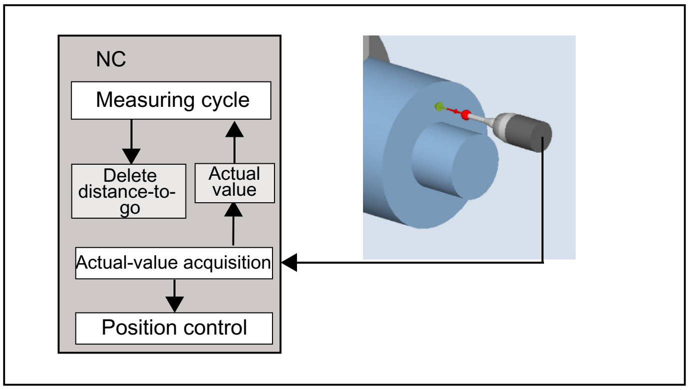
For lathes, the calibration tool is treated like a turning tool. Cutting edge positions 1 - 4 can be used for calibration. The lengths refer to the sphere equator, not to the sphere center.

Entry in tool memory		Calibration tool for a tool probe on a lathe
Tool type ($TC_DP1[ ]):	585, 725 or 5xy	
Cutting edge ($TC_DP2[ ]):	3	
Length 1 - geometry:	L1	
Length 2 - geometry:	L2	
Radius ($TC_DP6[ ]):	r	
Length 1 - basic dimension ($TC_DP21[ ]):	only if required	
Length 2 - basic dimension ($TC_DP22[ ]):	only if required	

All other parameters, such as wear, must be assigned a value of zero.

2.8 Measurement principle

Flying measurement



The principle of "flying measurement" is implemented in the SINUMERIK control. The probe signal is processed directly on the NC so that the delay when acquiring measured values is minimal. This permits a higher measuring speed for the prescribed measuring precision and time needed for measuring is reduced.

Connecting probes

Two inputs for connecting touch trigger probes are provided on the I/O device interface of the SINUMERIK control systems.

Machine manufacturer

Please observe the machine manufacturer's instructions.

Measurement operation sequence using the example set edge (CYCLE978)

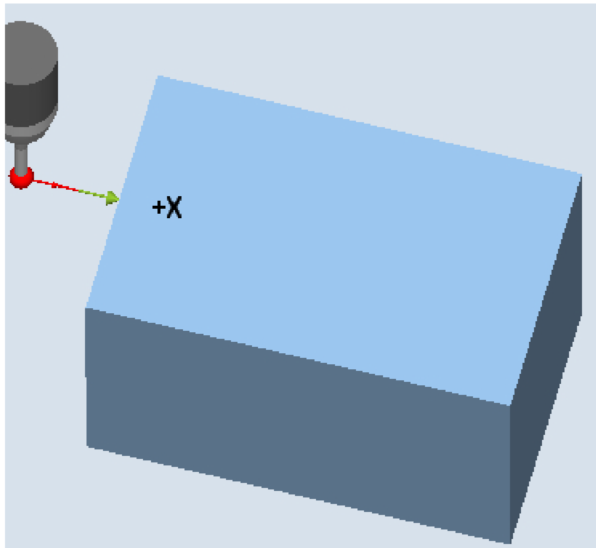


Figure 2-8 Measurement operation sequence, example set edge (CYCLE978)

The sequence is described using the measuring version, set edge (CYCLE978). The sequence is essentially the same for the other measuring cycles.

The **starting position** for the measuring procedure is the position **DFA** in front of the specified **set position** (expected contour).

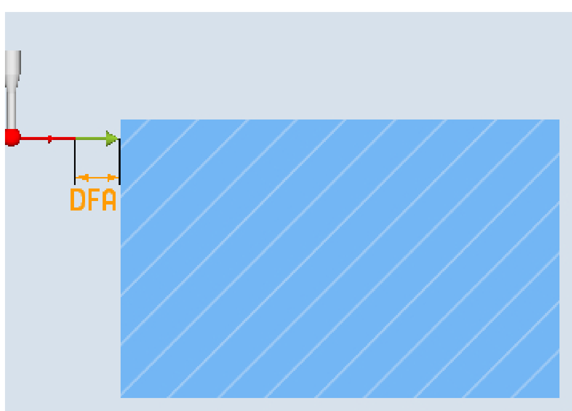


Figure 2-9 Starting position

The starting position is calculated in the cycle based on parameter entries and probe data. The traversing distance from the pre-position, defined by the user program, to the starting position of the measuring distance is either traversed with rapid traverse G0 or with positioning speed G1 (depending on the parameter). From the starting position, the **measuring velocity** is effective, which is saved in the calibration data.

The switching signal is expected along path 2 · DFA as from the starting position. Otherwise, an alarm will be triggered or the measurement repeated.

The resulting **maximum measuring position** is available in the result parameters _OVR[ ] and _OVI[ ] of the measuring cycle.

At the instant the switching signal is output by the probe, the current **actual position** is stored internally "on-the-fly" as the actual value, the measuring axis is stopped and then the "**Delete distance-to-go**" function is executed.

The distance-to-go is the path not yet covered in the measuring block. After deletion, the next block in the cycle can be processed. The measuring axis travels back to the starting position. Any measurement repetitions selected are restarted from this point.

Measurement path DFA

Measurement path DFA defines the distance between the starting position and the expected switching position (setpoint) of the probe.

Measuring velocity

As measuring feedrate, all of the measuring cycles use the value saved in the general setting data SD54611 after the calibration of the workpiece probe. A different measuring feedrate can be assigned for each calibration field [n].

To calibrate the measuring probe, either the measuring feedrate from the channel-specific setting data SD55630 $SCS_MEA_FEED_MEASURE is used (default value: 300 mm/min) or the measuring feedrate can be overridden in the input screen form at the calibration instant. To do this, bit 4 must be set to 1 in the general setting data SD54760 $SNS_MEA_FUNCTION_MASK_PIECE .

The **maximum permissible measuring velocity** is derived from:

- The deceleration behavior of the axis.
- The permissible deflection of the probe.
- The signal processing delay.

Deceleration distance, deflection of probe

NOTICE
Safe braking of the measuring axis Safe deceleration of the measuring axis to standstill within the permissible deflection path of the probe must always be ensured. Otherwise damage will occur!

A delay **t**, typical for the control, is taken into account in signal processing (IPO cycle) for the time between detection of the switching signal and output of the deceleration command to the measuring axis: general machine data MD10050 $MN_SYSCLOCK_CYCLE_TIME and MD10070 $MN_IPO_SYSCLOCK_TIME_RATIO). This gives the braking distance component.

The following error of the measuring axis is reduced. The following error is velocity dependent and at the same time dependent on the control factor of the measuring axis (servo gain of the associated machine axis: servo gain factor).

The deceleration rate of the axis must also be taken into account.

Together they produce an axis-specific velocity-dependent deceleration distance.

The Kv factor is the axis MD 32200 $MA_POSCTRL_GAIN.

The maximum axis acceleration / deceleration rate a is saved in axis MD 32300 $MA_MAX_AX_ACCEL . It may have a lesser effect due to other influences.

Always use the lowest values of the axes involved in the measurement.

Measuring accuracy

A delay occurs between detection of the switching signal from the probe and transfer of the measured value to the control. This is caused by signal transmission from the probe and is defined by the control hardware. In this time a path is traversed that falsifies the measured value. This influence can be minimized by reducing the measuring speed.

The rotation when measuring a milling tool on a rotating spindle has an additional influence. This can be compensated using compensation tables.

The measurement accuracy that can be obtained is dependent on the following factors:

- Repeat accuracy of the machine
- Repeat accuracy of the probe
- Resolution of the measuring system

Note

Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane, orientation of the spindle in the plane and measuring velocity are the same for both measurement and calibration. Deviations result in measurement errors. If, in MD51740 $MNS_MEA_FUNCTION_MASK, bit 6 is set =1, then 100% feed rate override traversing velocity is used for the measuring blocks (MEAS) in the measuring cycles if the feedrate override is set > 0.

Calculating the deceleration distance

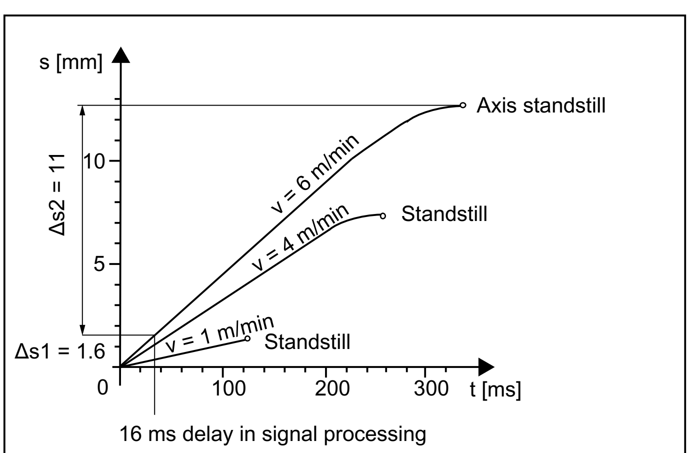


Figure 2-10 Distance-time diagram at different measuring velocities according to the calculation example

The deceleration path to be considered is calculated as follows:

$$sb = \underbrace{v \cdot t}_{\Delta s1} + \underbrace{\frac{v2}{2a}}_{\Delta s2} + \Delta s$$

s_b	Braking distance	in mm
v	Measuring velocity	in m/s
t	Delay signal	in s
a	Deceleration	in m/s^2
Δs	Following error	in mm
Δs = v / Kv		v here in m/min
Kv	Servo gain	in (m/min)/mm

Example of calculation:

- v = 6 m/min = 0.1 m/s measuring velocity
- a = 1 m/s^2 deceleration
- t = 16 ms signal delay
- Kv = 1 in (m/min)/mm

Intermediate steps:

Δs = v / Kv	= 6[m/min] / 1[(m/min)/mm]	= 6 mm	Following error
$\Delta s_2 = v^2/2a$	= 0,1 $[m/s]^2$ / 2 · 1 $[m/s^2]$	= 5 mm	Axis-specific component
$\Delta s_1 = v \cdot t$	= 0,1 [m/s] · 0,016 [s]	= 1,6 mm	Percentage due to signal delay

Overall result:

s_b **=** $\Delta s_1 + \Delta s_2 + \Delta s$	= 6 mm + 5 mm + 1,6 mm	**= 12,6 mm**	Braking distance

The deflection of the probe = braking distance to zero speed of the axis is **12.6 mm**.

2.9 Measuring strategy for measuring workpieces with tool offset

The actual workpiece dimensions must be measured exactly and compared with the setpoint values to be able to determine and compensate the actual dimensional deviations on the workpiece. An offset value can then be ascertained for the tool used for machining.

Function

When taking measurements on the machine, the actual dimensions are derived from the path measuring systems of the position-controlled feed axes. For each dimensional deviation determined from the set and actual workpiece dimensions there are many causes which essentially fall into three categories:

- **Dimensional deviations with causes that are n o t subject to a particular trend**, e.g. positioning scatter of the feed axes or differences in measurement between the internal measurement (probe) and the external measuring device (micrometer, measuring machine, etc.).
  In this case, it is possible to apply **empirical values**, which are stored in separate memories. The set/actual difference determined is automatically compensated by the empirical value.
- **Dimensional deviations with causes that a r e subject to a particular trend**, e.g. tool wear or thermal expansion of the leadscrew.
- **Accidental dimensional deviations**, e.g. due to temperature fluctuations, coolant or slightly soiled measuring points.
  Assuming the ideal case, only those dimensional deviations that are subject to a trend can be taken into account for compensation value calculation. Since, however, it is hardly ever known to what extent and in which direction accidental dimensional deviations influence the measurement result, a strategy (sliding averaging) is needed that derives a compensation value from the actual/set difference measured.

Mean value calculation

Mean value calculation in conjunction with measurement weighting has proven a suitable method.

When correcting a tool, it can be selected whether a correction is made based on the actual measurement, or whether an average value of the measurement differences should be generated over several measurements which is then used to make the correction.

The formula of the mean value generation chosen is:

$$Mv_{new} = Mv_{old} - \frac{Mv_{old} - D_i}{k}$$

Mv_{new}	Mean value new = amount of compensation
Mv_{old}	Mean value prior to last measurement
k	Weighting factor for mean value calculation
D_i	Actual/set difference measured (minus any empirical value)

The mean value calculation takes account of the trend of the dimensional deviations of a machining series. The **weighting factor k** from which the mean value is derived is selectable.

A new measurement result affected by accidental dimensional deviations only influences the new tool offset to some extent, depending on the weighting factor.

Computational characteristic of the mean value with different weightings k

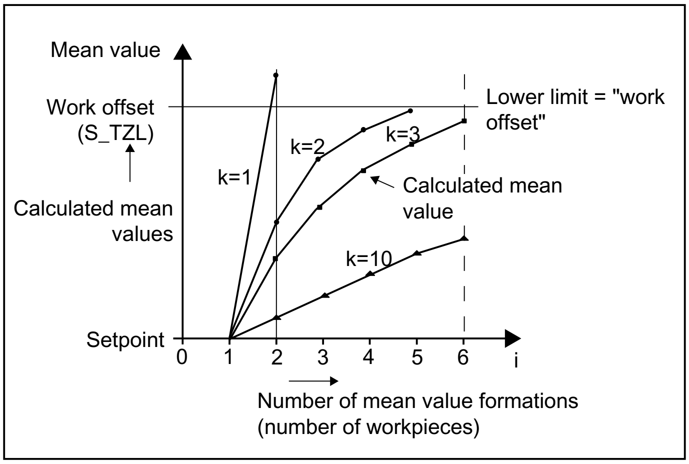
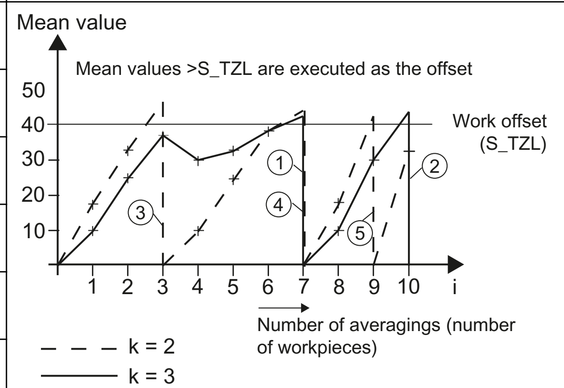


Figure 2-11 Mean value generation with influence of weighting k

- The greater the value of k, the slower the formula will respond when major deviations occur in computation or counter compensation. At the same time, however, accidental scatter will be reduced as k increases.
- The lower the value of k, the faster the formula will react when major deviations occur in computation or counter compensation. However, the effect of accidental variations will be that much greater.
- The mean value Mv is calculated starting at 0 over the number of workpieces i, until the calculated mean value exceeds the work offset range (`S_TZL`). From this limit on, the calculated mean value is applied as an offset.
- Once the mean value has been used for the offset, it is deleted from the memory. The next measurement then starts again with $Mv_{old} = 0$.

Table 2-1 Example of mean value calculation and offset

	Lower limit = 40 µm (S_TZL = 0.04)			**Characteristic of the mean value for two different weighting factors**
i	Di [µm]	Mv k = 3 [µm]	Mv k = 2 [µm]	
1. measurement	30	10	15	
2. Measurement	50	23,3	32,5	
3. Measurement	60	35,5	46,2 ③	
4. Measurement	20	30,3	10	
5. Measurement	40	32,6	25	
6. Measurement	50	38,4	37,5	
7. Measurement	50	42,3 ①	43,75 ④	
8. Measurement	30	10	15	
9. Measurement	70	30	42,5 ⑤	
10. Measurement	70	43,3 ②	35	

For the measurements with marked fields, tool offset is performed with the mean value (calculated mean value >S_TZL):

- If k=3 in the 7th and 10th measurement (① and ②),
- If k=2 in the 3rd, 7th, and 9th measurement (③, ④ and ⑤).

2.10 Parameters for checking the measurement result and offset

For constant deviations not subject to a trend, the dimensional deviation measured can be compensated by an empirical value in certain measuring variants.

For other compensations resulting from dimensional deviations, symmetrical tolerance bands are assigned to the set dimension which result in different responses.

Empirical value / mean value EVN (S_EVNUM)

The empirical values are used to suppress dimensional deviations that are **not subject to a trend**.

Note

If empirical values are not to be applied, then S_EVNUM = 0 must be set.

The empirical values themselves are saved in channel-specific SD 55623 $SCS_MEA_EMPIRIC_VALUE .

EVN specifies the number of the empirical value memory. The actual/set difference determined by the measuring cycle is corrected by this value **before** any further correction measures are taken.

This is the case:

- For workpiece measurement with automatic tool offset.
- For single-point measurement with automatic work offset.
- For tool measurement.

The mean value only refers to the workpiece measurement with automatic tool offset.

For an automatic tool offset, the mean value is generated from the measured difference of the previous and the actual measurement. This functionality has special significance within a machining series with measurements performed at the same measuring location.

The function does not have to be activated.

The mean values are stored in the channel-specific SD 55625 $SCS_MEA_AVERAGE_VALUE . The number of the mean value memory is transferred in the measuring cycle using variable S_EVNUM.

Safe area TSA (S_TSA)

The safe area is effective for almost all measuring variants and does not affect the offset value; it is used for diagnostics.

If this limit is reached then the following can be assumed:

- A probe defect, or
- An incorrect setpoint position, or
- An illegal deviation from the setpoint position.

Note

AUTOMATIC mode

AUTOMATIC operation is interrupted and the program cannot continue. An alarm text appears to warn the user.

Dimension difference check DIF (S_TDIF)

DIF is active only for workpiece measurement with automatic tool offset and for tool measurement.

This limit has no effect on generation of the compensation value either. When it is reached, the tool is probably worn and needs to be replaced.

Note

An alarm text is displayed to warn the operator and the program can be continued by means of an NC start.

This tolerance limit is generally used by the PLC for tool management purposes (twin tools, wear monitoring).

Tolerance of workpiece: Lower limit TLL (S_TLL), upper limit TUL (S_TUL)

When measuring workpieces, both parameters are only effective regarding tool offsets.

If, for tolerance parameters TLL, TUL, asymmetrical values are selected, then in the cycles, setpoint ∅S is adapted so that it lies at the center of a new internally generated symmetrical tolerance bandwidth. These modified values are saved to the following result parameters:

- _OVR[0] - setpoint
- _OVR[8] - upper tolerance limit
- _OVR[12] - lower tolerance limit

Parameters entered by the user TLL,TUL, ∅S remain unchanged.

Example: TUL= 0.0, TLL= -0.004, ∅S= 10

The following is obtained in the result: _OVR[8] = 0.002, _OVR[12] = -0.002, _OVR[0] = 9.998

If, mean value generation is used for the tool offset, and the measurement difference lies in the range between "2/3 tolerance of the workpiece" (S_TMV) and the "dimensional difference monitoring" (S_TDIF), then 100 % of the measurement difference is incorporated as tool offset and the previous mean value is deleted. This enables a fast response to major dimensional deviations.

Note

If the measurement difference exceeds one of the tolerance limits of the workpiece, then this is displayed depending on the tolerance position "oversize" or "undersize". In CYCLE995, TUL stands for the upper tolerance limit of the angular deviation.

2/3 tolerance of workpiece TMV (S_TMV)

TMV is active only for workpiece measurement with automatic tool offset.

Within the range of "Lower limit" and "2/3 workpiece tolerance" the mean value is calculated according to the formula described in Section "Measuring strategy".

Note

Mv_{new} is compared with the work offset range:

- If Mv_{new} is **greater** than this range, compensation is corrected by Mv_{new} and the associated mean value memory is cleared.
- If Mv_{new} is **less** than this range, no compensation is carried out. This prevents excessively abrupt compensations.

Weighting factor for mean value generation FW (S_K)

FW is active only for workpiece measurement with automatic tool offset. The weighting factor can be used to give a different weighting for each measurement.

A new measurement result thus has only a limited effect on the new tool offset as a function of FW.

Work offset range TZL (S_TZL)

TZL active for

- Workpiece measurement with automatic tool offset
- Tool measurement and calibration for milling tools and workpiece probes

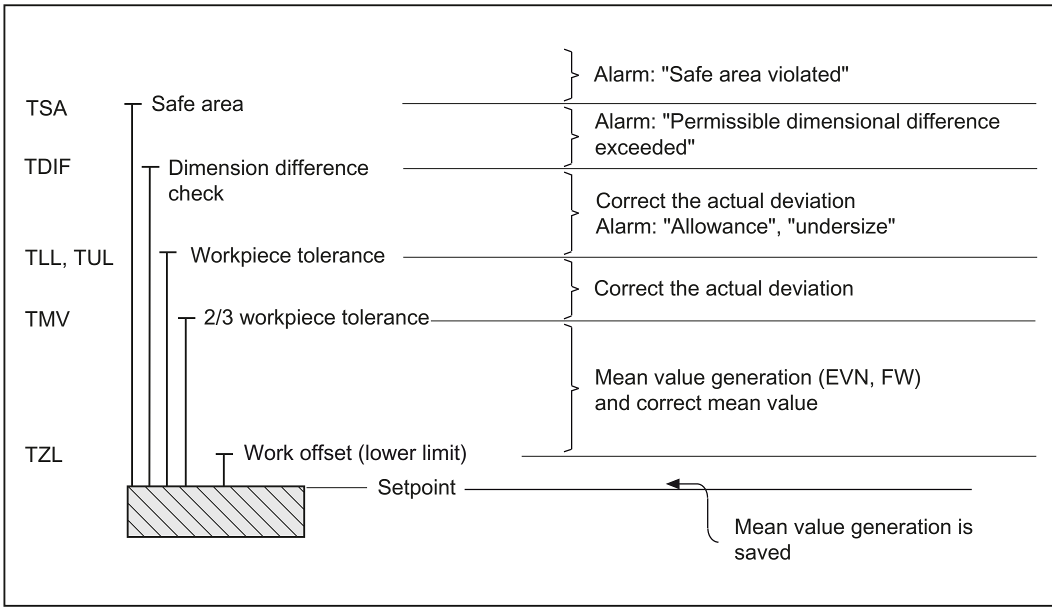
This tolerance range corresponds to the amount of maximum accidental dimensional deviations. It has to be determined for each machine.

No tool compensation is made within these limits.

In workpiece measurement with automatic tool offset, however, the mean value of this measuring point is updated and re-stored with the measured actual/set difference, possibly compensated by an empirical value.

The tolerance bands (range of permissible dimensional tolerance) and the responses derived from them are as follows:

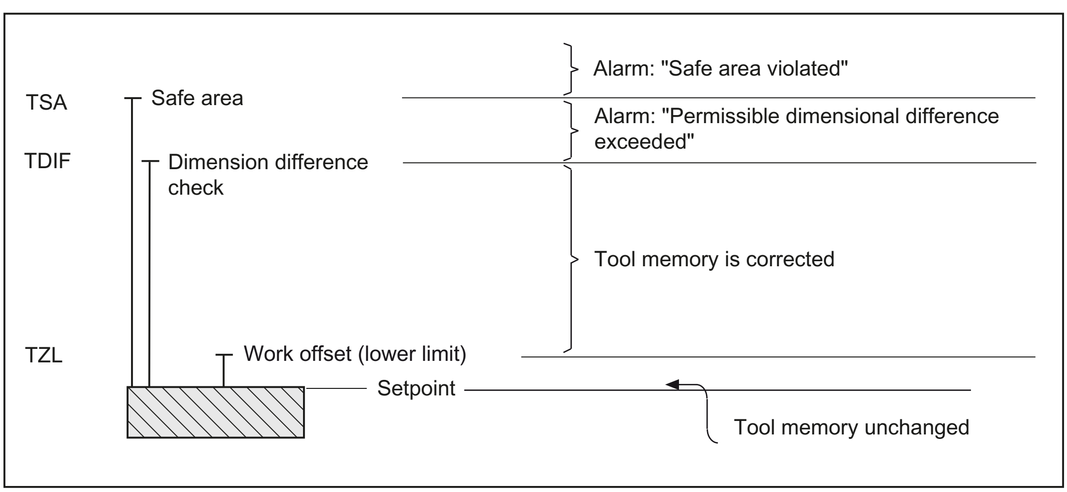
- **For workpiece measurement with automatic tool offset**



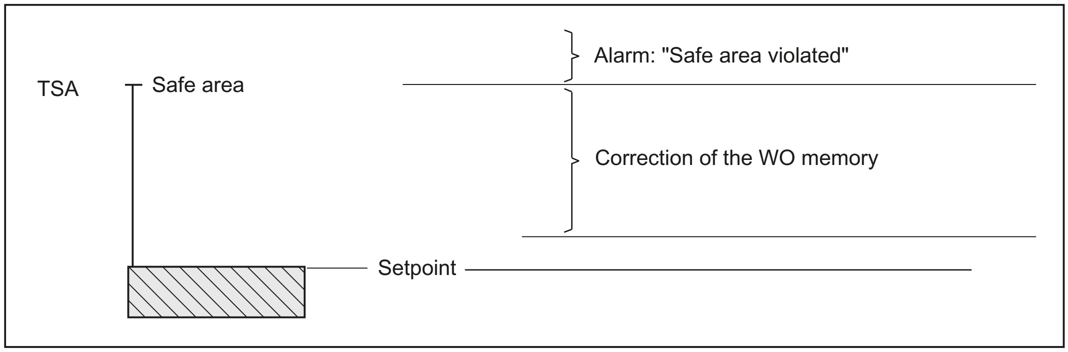
Note

In measuring cycles, the workpiece setpoint dimension is placed in the middle of the permitted ± tolerance limit for reasons associated with symmetry.

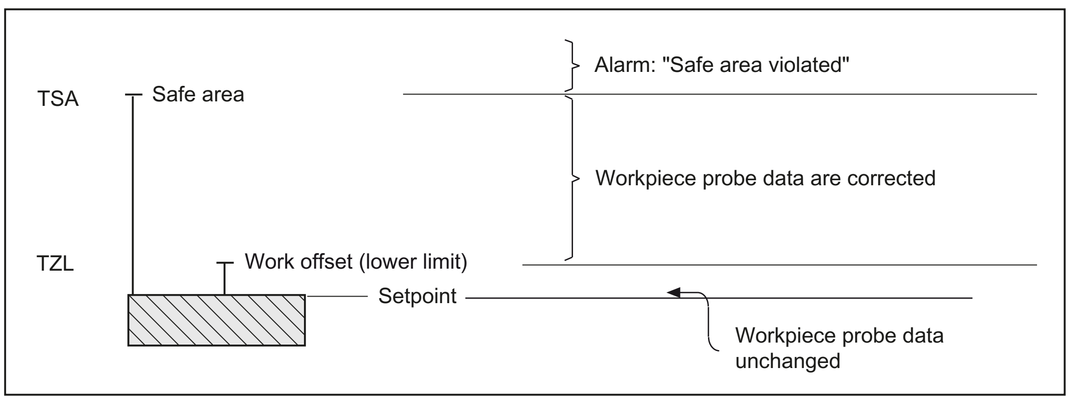
- **For tool measurement**



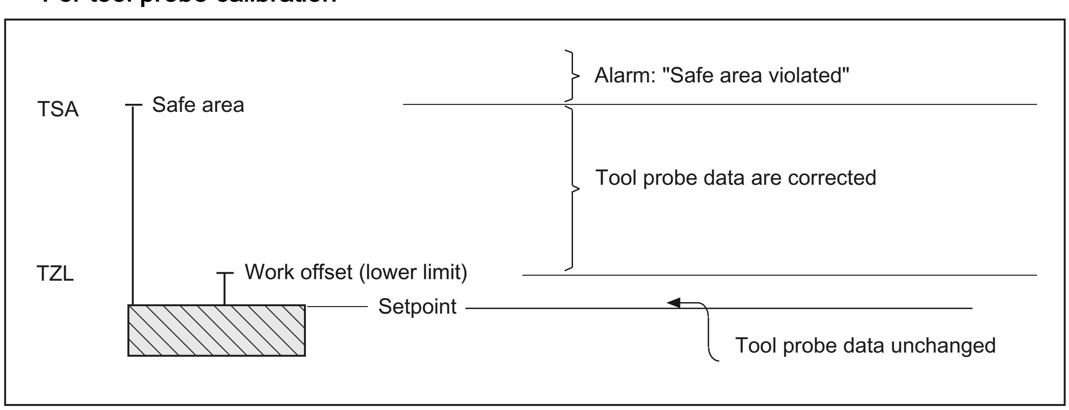
- **For workpiece measurement with WO correction**



- **For workpiece probe calibration**

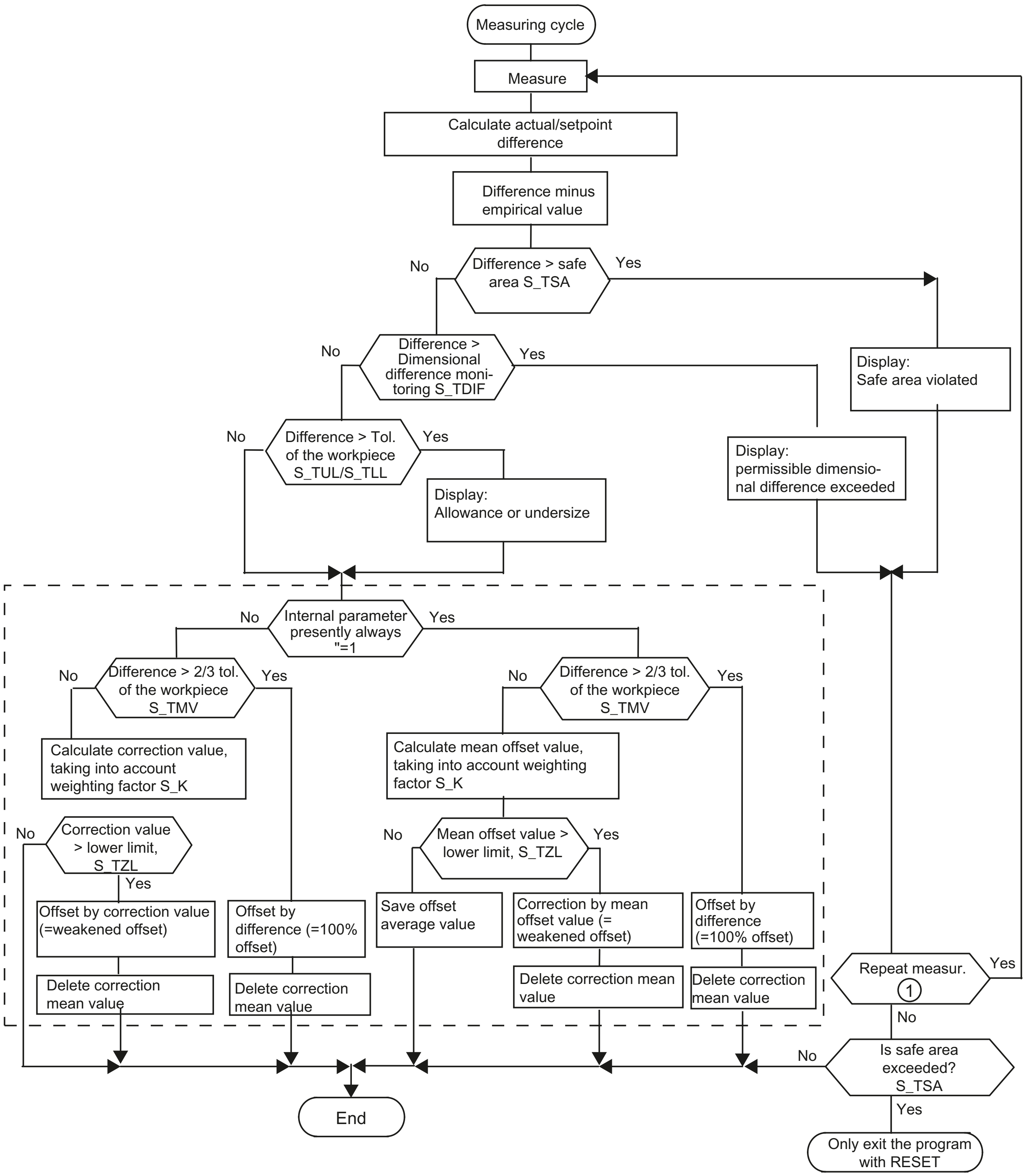


- **For tool probe calibration**



2.11 Effect of empirical value, mean value, and tolerance parameters

The following flowchart shows the effect of empirical value, mean value, and tolerance parameters on workpiece measurement with automatic tool offset.



① SD 54740 $SNS_MEA_FUNCTION_MASK, Bit 0

2.12 Tool offset strategy

2.12.1 Correction strategy for tool offsets when measuring tools regarding tool groups (replacement tools)

For tool offset after measuring the workpiece, the measuring cycles always check the following status of the tool:

- "Tool active" and
- "Tool has been in use"

Only tools with this status will be corrected, assuming that they are not locked.

Individual behavior of the measuring cycles

State	Correction behavior
Precisely one tool of a tool group has the status • "Tool active" and • "Tool has been in use"	This tool is corrected. If the tool has the "locked" status, cycle alarm 61404 "Tool correction not executed" is output.
No tool was found associated with the tool name.	A correction is not made, instead cycle alarm 61343 "Tool does not exist" is output.
No tool with the status mentioned above was found in the tool group.	The tool is not corrected, but instead, cycle alarm 61404 "Tool correction not executed" is output.
Several tools with the status mentioned above were found in the tool group.	A correction is not made, instead cycle alarm 61344 "Several tools are active" is output.

2.13 Measuring cycle help programs

2.13.1 CYCLE116: Calculation of center point and radius of a circle

Function

This cycle calculates from three or four points positioned on one plane the circle they inscribe with center point and radius.

To allow this cycle to be used as universally as possible, its data is transferred via a parameter list.

An array of REAL variables of length 13 must be transferred as the parameter.

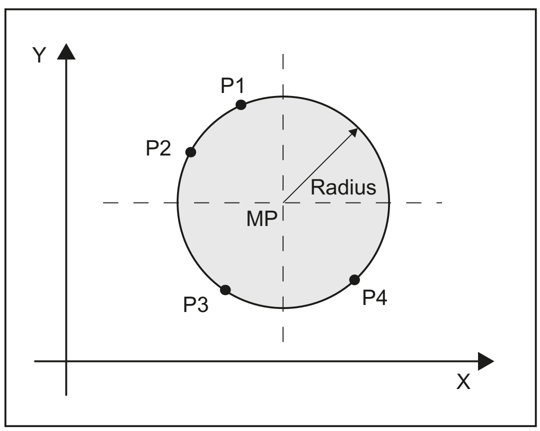


Figure 2-12 Calculation of circle data from 4 points

Programming

```
CYCLE116 (_CAL[ ], _MODE)
```

Transfer parameters

- **Input data**

Parameters	Data type	Meaning
_CAL [0]	REAL	Number of points for calculation (3 or 4)
_CAL [1]	REAL	1st axis of the plane of the first point
_CAL [2]	REAL	2nd axis of the plane of the first point
_CAL [3]	REAL	1st axis of the plane of the second point
_CAL [4]	REAL	2nd axis of the plane of the second point
_CAL [5]	REAL	1st axis of the plane of the third point
_CAL [6]	REAL	2nd axis of the plane of the third point
_CAL [7]	REAL	1st axis of the plane of the fourth point
_CAL [8]	REAL	2nd axis of the plane of the fourth point

- **Output data**

Parameters	Data type	Meaning
_CAL [9]	REAL	1st axis of the plane of the circle center point
_CAL [10]	REAL	2nd axis of the plane of the circle center point
_CAL [11]	REAL	Circle radius
_CAL [12]	REAL	Status for the calculation 0 = Calculation in progress 1 = Error occurred
_MODE	INTEGER	Error number (61316 or 61317 possible)

Note

This cycle is called as a subroutine by, for example, measuring cycle CYCLE979.

Example

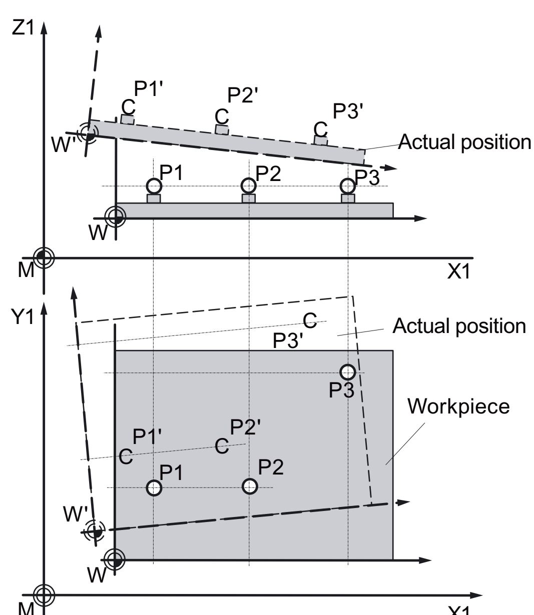
```
%_N_Circle_MPF

DEF INT _MODE

DEF REAL _CAL[13]= (3,0,10,-10,0,0,-10,0,0,0,0,0,0)          ;3 points specified
                                                              P1: 0.10
                                                              P2: -10.0
                                                              P3: 0,-10
```

CYCLE116(_CAL, _MODE)	;Result: _CAL[9]=0 _CAL[10]=0 _CAL[11]=10 _CAL[12]=0 _ALM=0
M0	
STOPRE	
M30	

2.13.2 CYCLE119: Arithmetic cycle for determining position in space

Function

This help cycle calculates, from three spatial setpoint positions (reference triangle), three spatial actual positions as well as the positional and angular deviation to the active frame. The offset is applied in the direction of the selected frame.



3 connected points P1 to P3 (triangle) are spatially offset, and can be arranged, rotated: P1', P2', P3'

Cycle119 is separately called from measuring cycle CYCLE997 as subprogram or from a user program.

To universally use this cycle, its data are transferred via a parameter interface.

Programming

```
CYCLE119 (_SETPOINT, _MEASPOINT, _ALARM, _RES, _REFRAME,_COR,
_RESLIM)
```

Parameter

Input data	Data type	Meaning	
_SETPOINT[3,3]	REAL	Field for 3 setpoint positions in the sequence 1st, 2nd, 3rd, geometry axis (X, Y, Z). These points are the reference triangle.	
_MEASPOINT[3,3]	REAL	Field for 3 setpoint positions measured in the sequence 1st, 2nd, 3rd, geometry axis (X, Y, Z). This is really the spatial position of the defined triangle.	
_COR	INTEGER	Compensation	
		Values:	0: No compensation
			1...99: WO compensation in G54...G57, G505..G599
			1000: WO compensation in last active channel basic frame according to MD 28081
			1011 to 1026: WO compensation in channel basic frame
			2000: WO compensation in system frame for scratching and setting actual value ($P_SETFR).
			9999: WO compensation in active frame, settable frame G54 to G57, G505...G599 and/or with G500 in last active basic frame according to $P_CHBFRMASK
_RESLIM	REAL	Limit value for distortion (only relevant, if _COR >0). If _RES is below this value, then WO is compensated, otherwise an alarm is output.	

The results of the calculation are stored in these transfer parameters.

Output data	Data type	Meaning	
_ALARM	INTEGER	Cycle alarm number for feedback signal. (for cycle call, transfer value must be = 0.)	
_RES	REAL	Calculation result	
		Values:	< 0: No frame was able to be calculated. Alarm (_ALARM > 0) is returned
			>= 0: The calculation was successful. The size of the value a measure of the distortion of the triangle, for example, due to measurement inaccuracies. It is the sum of the deviations of the individual points in mm.
_REFRAME	FRAME	Result frame, difference to the active frame. If this result frame is linked with the active frame, the measured triangle position is given the desired setpoint position (workpiece coordinates).	

Note

For correction

The frame to be corrected must not include any mirroring or scale factors. If there is no channel basic frame for G500, then a cyclic alarm (_ALARM>0) is output.

If cycle 119 is called by cycle 997, then the corrected frame is automatically activated.

If cycle 119 is separately called in a user program, the new data of the frame are activated outside the cycle when the G command of the associated adjustable frame (G500, G54 up to ...) is reprogrammed.

2.13.3 CUST_MEACYC: User program before/after measurements are performed

Function

The CUST_MEACYC cycle is called in every measuring cycle before and after the measurement.

It can be used by users to program sequences necessary before starting a measurement (e.g. to activate the probe).

In the as-delivered state, this cycle contains a CASE statement that executes a jump to a label with subsequent M17 (end of subprogram) for each measuring cycle.

Example

_M977:	;before workpiece probe with CYCLE977 (measure hole/shaft/groove/spigot)
GOTOF _AM_WP_MES	
;	
.....	
;	
_AM_WP_MES:	;before workpiece general
;	
;	
M17	;end of cycle

From the jump labels, actions can be programmed, which should be executed at each CYCLE977 call (label _M977) or for general workpiece measurements (label _AM_WP_MES).

References

Commissioning manual *SINUMERIK 840D sl Basesoftware and Operating Software*.

2.14 Miscellaneous functions

2.14.1 Measuring cycle support in the program editor

The program editor offers extended measuring cycle support for inserting measuring cycle calls into the program.

Prerequisite

Hardware TCU or PCU.

Function

This measuring cycle support provides the following functionality:

- Measuring cycle selection via softkeys
- Input screen forms for parameter assignment with help displays
- Retranslatable program code is generated from the individual screen forms.

2.14.2 Measuring result screens

Function

Measurement result displays can be shown automatically during a measuring cycle. The measuring result display can be turned on/off and configured in the program using cycle CYCLE150, which also controls the logging function.

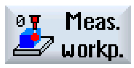
Note

CYCLE150 must be programmed before the first relevant measuring cycle call. For compatibility reasons, the previous option of controlling the measuring result display using setting data 55613 $SCS_MEA_RESULT_DISPLAY has been retained.

Measuring result screens

Procedure

The part program or ShopMill program to be processed has been created and is opened in the editor.



1. Press the "Meas. workpiece" or "Meas. tool" softkey.
2. Press the "Meas. result" softkey. The "Measurement result" input window opens.

3. Make the required selection in the toggle fields.

The display mode can be selected as follows in the screen for the measurement result display "on":

- "automatically 8 s" ...	The measurement result screen remains for a fixed time of 8 s
- "NC Start" ...	With the measurement result screen, the cycle is stopped using M0, the measuring cycle is continued with NC Start and the measurement result screen deselected
- "for alarm" ...	The measuring results screen is only displayed for cycle alarms 61303, 61304, 61305 and 61306.

These selection options correspond to the options that were previously available using SD55613 $SCS_MEA_RESULT_DISPLAY.

Measuring result display and logging function can be separately activated and deactivated. An additional CYCLE150 call should be programmed.

At the end of the program (channel RESET), the function is deactivated automatically, explicit programming is not required.

Note

For compatibility reasons, the previous option of controlling the measuring result display using setting data 55613 $SCS_MEA_RESULT_DISPLAY has been retained.

The measuring cycles can display different measuring result screens depending on the measuring variant:

- Calibrating tool probes
- Tool measurement
- Calibrating workpiece probes
- Workpiece measurement

Content of measuring result screens

The measuring results screens contain the following data:

Calibrating tool probes

- Measuring cycle and measuring variant
- Trigger values of axis directions and differences
- Probe number
- Safe area

Tool measurement

- Measuring cycle and measuring variant
- Actual values and differences for tool offsets
- Safe area and permissible dimensional difference
- T name, D number

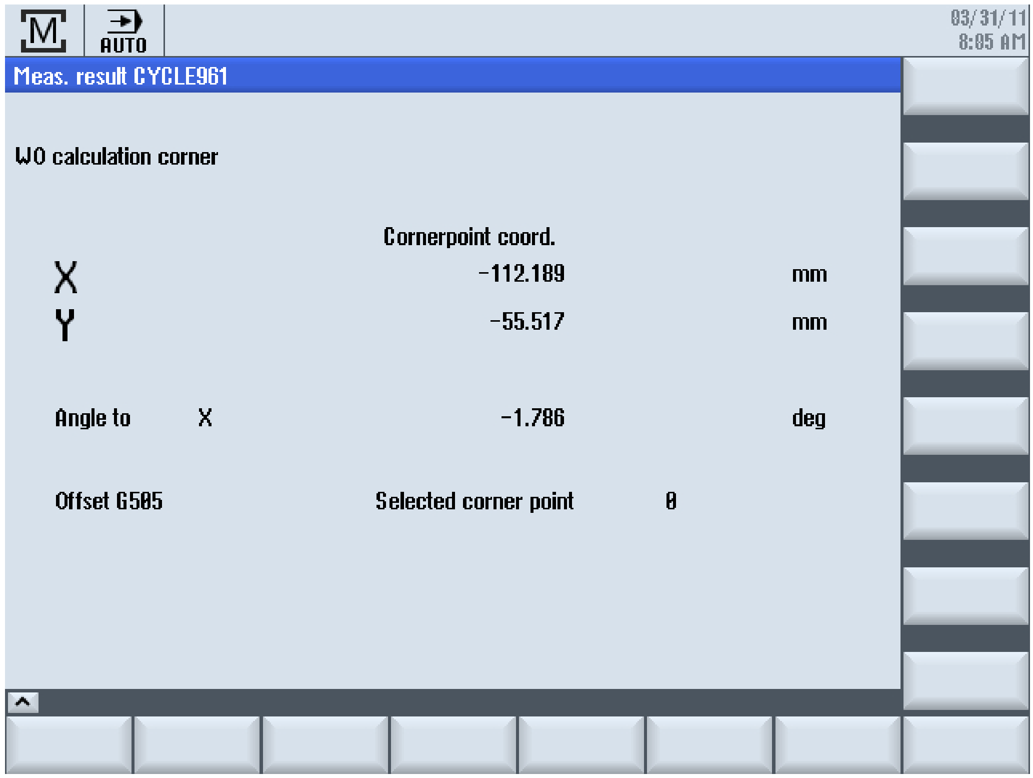
Calibrating workpiece probes

- Measuring cycle and measuring variant
- Trigger values of axis directions and differences
- Position deviation (probe skew) when calibrating in the plane
- Probe number
- Safe area

Workpiece measurement

- Measuring cycle and measuring variant
- Setpoints, actual values and their differences
- Tolerance upper and lower limits (for tool offset)
- Offset value
- Probe number
- Safe area and permissible dimensional difference
- T name, D number and DL number or WO memory number for automatic offset

Example of measurement result display



Program control for displaying and shutting down the measuring result displays

Using the program control MRD "Display measurement result", programmed measuring result display calls can be simply activated or deactivated. To do this, the program does not have to be changed!

The program control MRD acts on all measuring result display calls, irrespective of whether these are implemented using CYCLE150 calls or by programming setting data 55613 $SCS_MEA_RESULT_DISPLAY in the program.

2.14.3 Logging

2.14.3.1 General

Function

- Standard log
  Output of the measurement results from the automatic measuring cycles in a log file. Each measuring method of the standard measuring cycles is assigned a fixed standard log with regard to the contents. The contents correspond to the measurement result display on the screen. User entries for the log contents are not required.
- User log
  Output of user-relevant data as a separate log or supplement to the measurement log. The contents and format are the sole responsibility of the user. A predefined variable field is available which can take the contents of the log.

It is possible to log to external media, if they are available, on local drives, USB or in the part program memory. The log output can be in text format or in tabular format (column separator ";") for further processing in spreadsheet programs.

Requirements

If the data is to be saved to external media, such as USB or network drives, then the "EES" option is required (see "Commissioning Manual Sinumerik Operate (IM9)").

Contents of a standard log

- Date/time (when the log was written), log name with path
- Measuring method
- The most important input values (that were entered in the screen form before measuring)
- Correction target
- Setpoints, measured values and differences

As many decimal places are logged as displayed on the screen. The terms and axis identifiers also correspond to those displayed on the screen – but are written out (without abbreviations). The measurement unit mm/inch depends on the system of units active during the measurement.

2.14.3.2 Control cycle CYCLE150

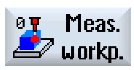
Function

The activation of the logging function is performed by simply programming the CYCLE150 call. The result display and logging can be selected separately and can be controlled independently. Parameters in CYCLE150 have a modal effect until the end of the program or reset, or until the cycle is called again.

Procedure

The logging is activated and deactivated via the program through the appropriate parameterization of CYCLE150. This must be programmed once at the start of the measuring program. Only when the input parameters are changed must the programming be performed again before the respective measuring cycle call. At the end of the program (channel RESET), the functions are deactivated automatically, explicit programming is not required.

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" or "Meas. tool" softkey.

2. Press the "Meas. result" softkey. The "Measurement Result" input window opens.

3. Make the required selection in the toggle fields (see following table).

The screen form contains a selection field for activating and deactivating the measurement result display with the toggle states "Off"/"On". It also contains a selection field for activating and deactivating the logging with the toggle states "Off"/"On"/"Last measurement".

If both selections fields have the toggle state "Off", all the following input fields for the respective function are hidden.

Parameter

Parameter	Description
Measurement result display	Off/On
Display mode	autom. 8 s / NC start / for alarm
Log	
Log type	Standard log / User log
Log format (for standard)	Text format / Tabular format (file extension TXT/CSV)
Log data	New/Append
Log storage	Directory / As part program / Variable
Name of log file	File type set according to selection of log format

Log type

The existing infrastructure for the logging of the measurement results should also be made accessible to users for their own purposes - output of user logs. A distinction is therefore made between the standard log and the user log.

Log format

Standard logs can be output in two log formats, in text format and in tabular format. The text format is based on the display of the measurement results on the screen. The tabular format is a format that can be imported by Excel (or other spreadsheet programs). This allows the measurement result logs to be statistically processed.

The Text format / Tabular format selection is only available for standard logs. With user logs, the user is responsible for the formatting, i.e. the selection field is hidden for the user log.

Log data

A new log file can be created or an existing file appended. This is selected via Log data "New" or "Append". With "New", the existing file with the same name is deleted and a new file created during logging.

Log storage

The path can be specified explicitly or implicitly for the log storage, i.e. "Directory", "As part program" or "Variable" can be selected.

With "As part program", the path of the higher-level NC program is automatically determined by the logging cycles and the log file is stored there. The following input field for the path is hidden. With "Directory", there is an additional input field in which the path is entered. The path does not have to be entered, it can be selected via a dialog which is opened via the additional VSK1 "Select directory".

The name of the variable is entered for "Variable" in the following field. The name of the log file is then programmed via this variable. It is possible, but not necessary, to specify a path. The log file is then located in the same path as the higher-level NC program.

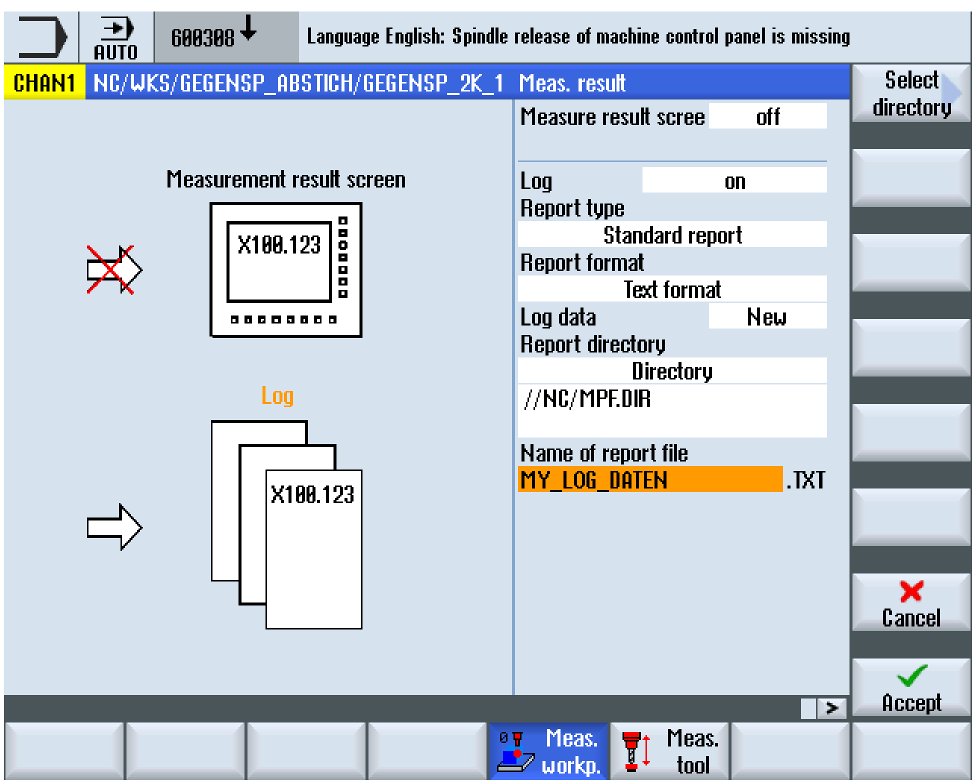


Figure 2-13 Entry level in the selection dialog for log storage

This softkey "Select directory" only appears when "Directory" is set in the Log storage selection field.

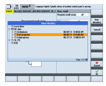


Figure 2-14 Selection dialog for log storage

All drives and paths available in the program manager can be selected.

- Local drive
- NC data (part program memory)
- Network drive(s), if connected
- USB (if available)

Only a path or an available file can be selected in the dialog.

If only a path is selected, the selection with the complete path is transferred to the screen form with the Accept softkey, but can be changed. The name of the log file is entered. If a file is selected, the full path and file name are transferred to the screen form, but can be changed.

Alternatively, the storage location can be entered.

Examples of the selected storage location:

1. NC data -> Workpiece -> Workpiece "Logs"
   //NC:/WKS.DIR/PROTOKOLLE.WPD
2. Network drive logs
   //d:/Logs
3. USB -> measuring_cycle_logs
   //USB:/01/measuring_cycle_logs

Name of log file

The log file name can be freely selected. It must comply with the rules for program names in the NC, or for program names when writing to external drives.

File type

The following file types are supported:

- Text file - type TXT
- Tabular format – type CSV

These file types depend on the selected log format.

The file type cannot be changed, it is only displayed.

2.14.3.3 Log "Last measurement"

Function

The "Log last measurement" function is programmed by calling the logging CYCLE150 once. Measuring is not performed, instead the values of the last measurement which are still available in the result parameters of the measuring cycles (GUD variables) are used, and only a subcycle is called for the logging. This function only makes sense when log "Off" was selected during the measurement.

Requirement

A standard log can only be output when a measuring cycle was previously active in automatic mode.

Procedure

A part program for logging "Last measurement" is created and is in the editor.

1. Select Log "Last measurement" in the input field.
2. Supply additional parameters as described above.
3. Press the "Accept" softkey. The generated cycle call appears in the editor.

Programming example:

```
CYCLE150(30,11012,"//NC/MPF.DIR/LAST_MEASURE.TXT")
M30
```

2.14.3.4 Standard log

Function

Standard logs display the results from measuring cycles in a clear log structure. The output is possible in text or tabular format. Contents and structure are predefined.

Requirement

Standard logs are only possible in conjunction with measuring cycle calls.

Log contents

The logs are generally created with fixed English texts. (The measurement result displays appear in the language that has been set for Operate.)

Logs of the measuring cycles have the following structures and contents:

- Header block - log header
  - Date/time (when the log was created)
  - Name and path of the log file
  - Name of the part program from which the measuring function was called
  - Workpiece number
- Value block - results per measuring point
  - Number of the measuring point, measuring variant as programmed, time of the measurement
    Measuring variant as text (e.g. "1 hole")
  - Specification of the correction target, either
    measure only – no correction – or
    for measuring variants with WO correction: Specification of the corrected WO, correction target (WO / fine offset) – or
    for measuring variants with tool offset: Tool name, D number, tool type, correction target (length/radius, geometry/wear)
  - Setpoints, measured values, differences with specification of the respective axis name or measurement objects (e.g. "Diameter") and the measurement unit

Procedure

The call of the control CYCLE150 is always at the start of the program. The respective measuring cycle calls are then programmed. If a different parameterization of CYCLE150 is required, it must be called again at the appropriate program position.

Programming example

`N10 G54`	
`N20 T710 D1 M6`	; Probe call
...	; Positioning, etc.
`N50 CYCLE150(10,1001,"MESSPROT.TXT")`	; Activate logging
`N60 CYCLE997(109,1,1,10,1,5,0,45,0,0,0,5,5,5,10,10,10,0,1,,0,)`	; 1st measurement
...	; Positioning, etc.
`N90 CYCLE978(200,,4000001,1,77,2,8,1,1,1,"END_MILL_D8",,0,1.01,0.1,0.1,0.34,1,10001,,1,0)`	; 2nd measurement
...	; Positioning, etc.
`N120 CYCLE998(100105,10004,0,1,1,1,,1,5,201,1,10,,,,,1,,1,)`	; 3. measurement
`N140 M30`	

Log in tabular format

"Tabular format" must be selected at "Log format" in the CYCLE150 screen form. This format can be imported into spreadsheet programs and processed further.

The "Tabular format" is defined by the following default settings:

Separation of the data fields:	Semicolon
Decimal character:	Point
Date format:	yyyy-MM-dd
Number of decimal places:	As on the screen
Time format:	hh:mm:ss

A log in tabular format contains the same information as in text format. For the statistical evaluation of measurement series, these logs require post processing in the respective spreadsheet programs.

2.14.3.5 User log

Function

With this function, the user freely defines the contents of the log lines and stores them in an array of string variables (string length 200).

The contents of the string array are logged when a new CYCLE160 is called. The logging always begins with array index 0 and continues until an empty string (i.e. string length 0) is found.

For simple applications, an NCK-global array of string variables is predefined in the PGUD block:

DEF NCK STRING[200] S_LOGTXT[10]

This means that 10 lines can be immediately logged.

If this is not sufficient, the user can alternatively create a second string array of any length with the predefined name S_USERTXT[n] in a separate GUD block (e.g. MGUD or UGUD):

DEF NCK STRING[200] S_USERTXT[n]

The logging function checks whether the S_USERTXT array is available. If it is available, the contents of this array are logged, if not, the contents of S_LOGTXT.

At the program position where CYCLE160 is called, the logging is performed according to the logging destination set by the CYCLE150 call – exactly the same as the logging of measurement results.

This function can be used to output a complete user-specific log (without any reference to the measuring) or to insert additional lines in standard logs.

If additional lines are to be written in standard logs in tabular format, the user must ensure the column formatting in these strings (insert separators ";").

Procedure

"User log" is selected in the CYCLE150 screen form for the log control.

There is no difference between text format and tabular format – the user determines the contents. The corresponding selection field is hidden for the user log.

If the path is entered, it is performed with the same dialog as for the standard log.

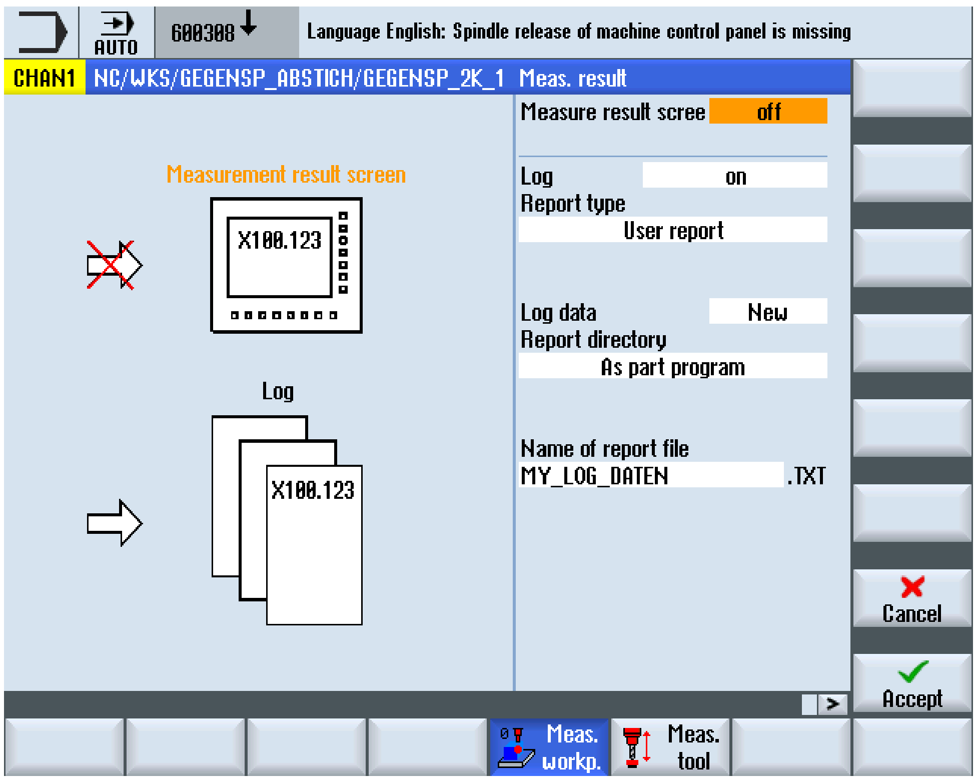


Figure 2-15 User log screen form

The following must be written in the part program:

- CYCLE150 call to activate the user log
- Assignment of the log contents to the predefined string variables
- CYCLE160 for the output of the log contents

CYCLE160 has no transfer parameters. The user must program it without a screen form.

Freely-definable user log

Programming example:

...	
`N50 CYCLE150(10,1111, "MY_PROT.TXT")`	; Logging ON
`N51 S_USERTXT[0]=REP("")`	; Delete old data array
`N52 S_USERTXT[0]="MACHINE: ABC_12345"`	; Compile log contents

```
N53 S_USERTXT[1]="LOGFILE COMPENSATION DATA"
N54 S_USERTXT[2]=" "                ; Programming of empty line: 1 x blank
N55 S_USERTXT[3]="VALUE1 = "<<R101
N56 S_USERTXT[4]="VALUE2 = "<<R102
N60 CYCLE160                        ; Write user log
...
M30
```

Log extract:

```
MACHINE: ABC_12345
LOGFILE COMPENSATION DATA

VALUE1 = 123.456
VALUE2 = 789.333
```

Explanations:

- N50 … Logging is switched on
  - Destination: In the same path as the calling program
  - The log is appended
  - Log type: User log
  - Logging "on"
- N52 - N56 log content
- N60 … CYCLE160 call: Data is now written
- Value 1 and value 2 mirror the contents of the R-parameters R101 and R102 at the time of the log output.

Standard log with additional user data

Programming example:

```
---
N50 CYCLE150(10,1001,…)             ; Logging ON, write header
N51 S_LOGTXT[0]=REP("")             ; Delete old data array
N52 S_LOGTXT[0]="HOLE DM 20H7"      ; Write user data
N53 S_LOGTXT[1]="LARGESTDIMENSION:
20.021"
N54
S_LOGTXT[2]="SMALLESTDIMENSION:
20.000"
N55 S_LOGTXT[3]="SPINDLETEMPERATURE:"<<R99<<" DEG"
N60 CYCLE160                        ; Write user data to log
T="3D_PROBE_FR" D1 M6
```

```
G0 X0 Y0 Z5
N70 CYCLE977(201,,4000001,1,24,,,2,8,0,1,1,,,1," ",,
0,1.01,1.01,-1.01,0.34,1,0,,1,1)
...
M30
```

Log extract:

```
****************************************************************************************************
Date     :  2013-08-05              Time:  11:59:10
Protocol: /_N_WKS_DIR/_N_WP1_WPD/_PROT_TE_977_BOHR_TXT
Program : _N_TE_977_BOHR_MPF
Workpiece no.: 123
****************************************************************************************************

HOLE DM 20H7

LARGESTDIMENSION:20.021

SMALLESTDIMENSION:20.000

SPINDLETEMPERATURE:68.7 DEG

------------------------------------------------------------------------------------------------------------
1                      : 977 / 101          Time: 11:58:10
Results measure: 1 Hole / CYCLE977
------------------------------------------------------------------------------------------------------------
Correction into: Work offset, coarse
                       G508
                       Coarse [mm]             Rotation [deg]
                       ------------------------------------------------------------------------
X                      -0.0200                  0.0000
Y                       0.0300                 45.0000
Z                      -0.0128                  0.0000
                       ------------------------------------------------------------------------


Results:          Setpoint          Measured          Difference
X                 12.9900           12.9700           -0.0200  mm
Y                  7.5000            7.5300            0.0300  mm
Diameter          24.0000           23.8400           -0.1600  mm
-----------------------------------------------------------------------------------------------------------
```

2.14.3.6 Displaying a user log in the form of a measurement results screen

A user log is displayed on the screen in the form of a measurement results screen if the following conditions are fulfilled:

- CYCE150: Measurement result screen "on"
  - "User log" log type OR
  - log "off"
- Calling CYCLE160
  When selecting "last measurement" log, CYCLE160 should not be called!

If "MRD" is activated using the program control, the content of variable field "S_PROTTXT" or "S_USERTXT" is displayed in the form of a measurement results screen. The content of the results screen corresponds to that of the log. The program is continued with "Start" or "Automatic" depending on the selection in CYCLE150. For log "off", only the result screen is displayed. The "For alarm" display mode is only active in measuring cycles.

Programming example 1

If user log lines with the same column distribution are to be output just like a standard log in the text format, then the format definition can be taken from GUD variables _PROTVAL[35], [36]. The program should be written as follows, using the keyword "SPRINT":

```
%_N_TEST_3.MPF

CYCLE150(31,11,"MEAS_PROTOCOL.TXT")

S_PROTTXT[0]=REP("",10)

S_PROTTXT[0]="SPRINT(_PROTVAL[35],'"'Axis'"','"'Setpoint'"','"'Measu
rd'"','"'Difference'"','"'Unit'"')"

S_PROTTXT[1]="SPRINT(_PROTVAL[36],'"'Z'"',R11,R12,R13,S_TXT[3])"

CYCLE160

M30
```

Explanation

The measured values are output line by line in the standard measurement log, subdivided into 5 standard columns. The format string is the formatting rule to be applied to the values for each of these columns, separated by a comma.

_PROTVAL[35] = format string to display the column headers (only text)

_PROTVAL[36] = format string to display the column content (only text, values)

S_TXT[3] = length dimension in the active system (mm or inch)

The start and end of the string should be identified with " ("…") - including keyword SPRINT. If the particular column only contains text, then the string identifier should be placed in inverted commas (e.g.: ‘ “ ‘NAME‘ “ ‘).

Programming example 2

When calling CYCLE150 with the "Last measurement" function, the actual content of the variable field is logged and displayed (if MRD is active).

```
%_N_LASTMEAS_MPF

CYCLE150(31,12,"MEAS_PROTOCOL_LAST.TXT")

M30
```

2.14.3.7 Behavior during block search, simulation and for several channels

Block search

If during the block search, a cycle call for logging "On" is executed, this state is saved. The following measuring cycle calls that are run through in the block search mode do not log anything (because there are no measuring results). Logging is started as of the program start when the search target is reached.

Similarly, the state is also saved for a cycle call for logging "Off" during the block search, and then nothing logged as of the program start.

Simulation

The following behavior applies in the simulation of Operate:

Programs with calls for the logging function can be executed, but no logs are created.

During simulation, measuring cycles do not return any measurement results, they only show the traversing to the measuring points – and therefore there is nothing to log.

Several channels

In principle, measuring programs with logging can run in two channels.

However, the user must ensure that the measuring and logging functions run in succession from channel to channel and do not overlap. This also applies to user logs.

Measuring variants

3

3.1 General requirements

3.1.1 Overview of the measuring cycles

Function of the measuring cycles

The following table describes all the measuring cycle functions for the turning and milling technologies.

Table 3-1 Measuring cycles

Measuring cycle	Description	Measuring versions
CYCLE973 [2)]	This measuring cycle can be used to calibrate a workpiece probe on a surface on the workpiece or in a groove.	• Calibrate probe - length • Calibrate probe - radius on surface • Calibrate probe - probe in groove
CYCLE974 [2)]	This measuring cycle can be used to determine the workpiece zero in the selected measuring axis or a tool offset with 1-point measurement.	• Turning measurement - front edge • Turning measurement - inside diameter • Turning measurement - outside diameter
CYCLE994 [2)]	This measuring cycle can be used to determine the workpiece zero in the selected measuring axis with 2-point measurement. To do this, two opposite measuring points on the diameter are approached automatically in succession	• Turning measurement - inside diameter • Turning measurement - outside diameter
CYCLE976	Using this measuring cycle, a workpiece probe can be calibrated in a calibration ring or on a calibration ball completely in the working plane or at an edge for a particular axis and direction.	• Calibrate probe - length on surface • Calibrate probe - radius in ring • Calibrate probe - radius on edge • Calibrate probe - calibration on sphere
CYCLE961	This measuring cycle can be used to determine the position of a workpiece corner (inner or outer) and use this as work offset.	• Corner - right-angled corner • Corner - any corner
CYCLE977	This measuring cycle can be used to determine the center point in the plane as well as the width or the diameter.	• Edge distance - groove • Edge distance - rib • Hole - rectangular pocket • Hole - 1 hole • Spigot - rectangular spigot • Spigot - 1 circular spigot
CYCLE978	This measuring cycle can be used to measure the position of an edge in the workpiece coordinate system.	• Edge distance - set edge

Measuring cycle	Description	Measuring versions
CYCLE979	This measuring cycle can be used to measure the center point in the plane and the radius of circle segments.	• Hole - inner circle segment • Spigot - outer circle segment
CYCLE995	With this measuring cycle the angularity of the spindle on a machine tool can be measured.	• 3D - angular deviation spindle
CYCLE996	This measuring cycle can be used to determine transformation-relevant data for kinematic transformations with contained rotary axes.	• 3D - kinematics
CYCLE997	This measuring cycle can be used to determine the center point and diameter of a ball. Furthermore, the center points of three distributed balls can be measured. The plane formed through the three ball center points, regarding its angular position, is determined referred to the working plane in the workpiece coordinate system.	• 3D - sphere • 3D - 3 spheres
CYCLE998	This measuring cycle can be used to determine the angular position of a surface (plane) referred to the working plane and the angle of edges in the workpiece coordinate system.	• Edge distance - align edge • 3D - align plane
CYCLE971 [1)]	This measuring cycle can be used to calibrate a tool probe and measure the tool length and/or tool radius for milling tools.	• Calibrate probe • Measure tool
CYCLE982 [2)]	This measuring cycle can be used to calibrate a tool probe and measure turning, drilling and milling tools on turning machines.	• Calibrate probe • Turning tool • Milling tool • Drill

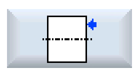
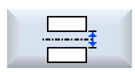
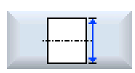
[1)] Only for milling technology

[2)] Only for turning technology

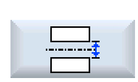
3.1.2 Selection of the measuring variants via softkeys (turning)

The following shows the measuring variants of the turning technology as a menu tree in the program editor. All of the measuring variants available in the control are shown in the display. However, on a specific system, only those steps can be selected that are possible for the set extended technology.

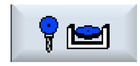
Turning technology menu tree

Meas. workp.	→	Calibrate probe	→	Length	Length (CYCLE973) (Page 214)
				Radius on face	Radius on face (CYCLE973) (Page 85)
				Calibr. in slot	Calibrate in slot (CYCLE973) (Page 88)
					Front edge (CYCLE974) (Page 92)
					Inner diameter (CYCLE974, CYCLE994) (Page 95)
					Outer diameter (CYCLE974, CYCLE994) (Page 99)
Meas. tool	→	Calibrate probe			Calibrate probe (CYCLE982) (Page 255)
		Turning tool			Turning tool (CYCLE982) (Page 261)
		Drill			Drill (CYCLE982) (Page 272)

The following softkeys are **only** displayed if the "Milling" extended technology is set (channel-specific MD52201 $MCS_TECHNOLOGY_EXTENSION = 2).

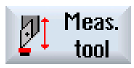
Meas. workp.	→	Calibrate probe	→	Length	Length at edge (CYCLE976) (Page 112)
				Radius in ring	Radius in ring (CYCLE976) (Page 112)
				Radius at edge	Radius at edge (CYCLE976) (Page 117)
				Comp. to sphere	Compare to sphere (CYCLE976) (Page 124)
		Measurem. turning			Inner diameter (CYCLE974, CYCLE994) (Page 95)

Edge distanc	→	Set edge (CYCLE978) (Page 128)
		Align edge (CYCLE998) (Page 134)
		Groove (CYCLE977) (Page 141)
		Rib (CYCLE977) (Page 146)
Corner	→	Right-angled corner (CYCLE961) (Page 152)
		Any corner (CYCLE961) (Page 157)
Hole	→	Rectangular pocket (CYCLE977) (Page 163)
		1 hole (CYCLE977) (Page 168)
		Inner circle segment (CYCLE979) (Page 173)
Spigot	→	Rectangular spigot (CYCLE977) (Page 179)
		1 circular spigot (CYCLE977) (Page 184)
		Outer circle segment (CYCLE979) (Page 190)
3D	→	Align plane (CYCLE998) (Page 195) The "3D" softkey is displayed if bit 1 = 1 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE.
		Sphere (CYCLE997) (Page 200)
		3 spheres (CYCLE997) (Page 205)
		Spindle angular displacement (CYCLE995) (Page 210) The "Angular deviation spindle" softkey is only displayed in the G code program.



3D kinematics (CYCLE996) (Page 214)

The "Kinematics" softkey is only displayed in the G code program if the "Measure kinematics" option is set.



→

Milling tool (CYCLE982) (Page 265)

See also

Calibrate probe - length (CYCLE973) (Page 82)

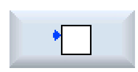
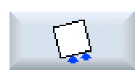
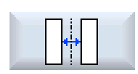
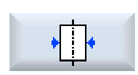
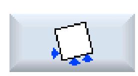
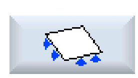
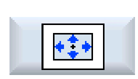
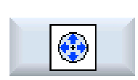
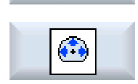
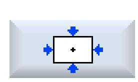
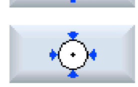
Measuring the workpiece on a machine with combined technologies (Page 250)

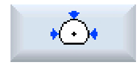
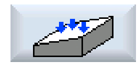
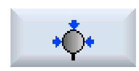
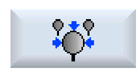
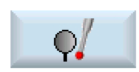
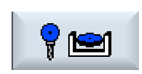
3.1.3 Selection of the measuring variants via softkeys (milling)

The following shows the measuring variants for the milling technology as a menu tree in the program editor.

All of the measuring variants available in the control are shown in the display. However, on a specific system, only those steps can be selected that are possible for the set extended technology.

Milling technology menu tree

Meas. workp.	→	Calibrate probe	→	Length	Length (CYCLE976)
				Radius in ring	Radius in ring (CYCLE976) (Page 112)
				Radius at edge	Radius at edge (CYCLE976) (Page 117)
				Comp. to sphere	Calibrate on sphere (CYCLE976) (Page 124)
		Edge distanc	→		Set edge (CYCLE978) (Page 128)
					Align edge (CYCLE998) (Page 134)
					Groove (CYCLE977) (Page 141)
					Rib (CYCLE977) (Page 146)
		Corner	→		Right-angled corner (CYCLE961) (Page 152)
					Any corner (CYCLE961) (Page 157)
		Hole	→		Rectangular pocket (CYCLE977) (Page 163)
					1 hole (CYCLE977) (Page 168)
					Inner circle segment (CYCLE979) (Page 173)
		Spigot	→		Rectangular spigot (CYCLE977) (Page 179)
					1 circular spigot (CYCLE977) (Page 184)

				Outer circle segment (CYCLE979) (Page 190)
The "3D" softkey is displayed if bit 1 = 1 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE.	3D	→		Align plane (CYCLE998) (Page 195)
				Sphere (CYCLE997) (Page 200)
				3 spheres (CYCLE997) (Page 205)
				Spindle angular displacement (CYCLE995) (Page 210) The "Angular deviation spindle" softkey is only displayed in the G code program.
				3D - kinematics (CYLE996) (Page 214) The "Kinematics" softkey is only displayed in the G code program if the "Measure kinematics" option is set.
Meas. tool	→	Calibrate probe		Calibrate probe (CYCLE971) (Page 281)
		Milling tool		Milling tool or drill (CYCLE971) (Page 287)
		Drill		Milling tool or drill (CYCLE971) (Page 287)

The following softkeys are only displayed if the "Turning" extended technology is set (channel-specific MD52201 $MCS_TECHNOLOGY_EXTENSION = 1).

Meas. tool	→		Turning tool	Turning tool (CYCLE982) (Page 261)

See also

Calibrate probe - calibrate in groove (CYCLE973) (Page 88)

Turning measurement - front edge (CYCLE974) (Page 92)

Turning measurement - inside diameter (CYCLE974, CYCLE994) (Page 95)

Turning measurement - outside diameter (CYCLE974, CYCLE994) (Page 99)

3.1.4 Result parameters

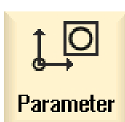
Definition

Result parameters are measurement results provided by the measuring cycles.

Parameters	Type	Meaning
_OVR[ ]	REAL	Result parameter - real number: Setpoint values, actual values, differences, offset values, etc.
_OVI[ ]	INTEGER	Result parameter - integer

Call

The result parameters of the measuring cycles are saved in the channel-specific user variables. These can be called from the operating area as follows:



1. Press the "Parameter" softkey.

3. Press the "User variable" softkey.

The result parameters _OVR[ ] and _OVI[ ] are displayed in the "Channel-specific user variables" window.

2. Press the "Channel GUD" softkey.

Note

If not only SGUD variables exist, the "GUD selection" softkey must be used to select "SGUD".

Measuring variants

Which result parameters are output from the measuring cycles, is described in the individual measuring variants.

For workpiece measurement with tool offset or offset in the WO, several measuring variants also supply result parameters, see Section Additional result parameters (Page 342).

3.2 Measure workpiece (turning)

3.2.1 General information

The measuring cycles below are intended for use on turning machines.

Note

Spindle

Spindle commands in the measuring cycles always refer to the active master spindle of the control.

When using the measuring cycles at machines with several spindles, then the spindle involved must be defined as master spindle before the cycle call.

Note

Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane and measuring velocity are the same for both measurement and calibration.

If the probe is used in the spindle for a driven tool, the spindle orientation must also be considered. Deviations can cause measuring errors.

References: /PG/ Programming Manual *SINUMERIK 840D sl / 828D Fundamentals*

Diameter programming, measuring system

The measuring cycles used in turning work with the current plane G18.

Value specifications of the transverse axis (X) of the measuring cycles used in turning are performed in the diameter (DIAMON). The measuring cycles used in turning *(CYCLE973, CYCLE974* and *CYCLE994*) also work internally with active diameter programming (DIAMON).

The measuring system (basic system) of the machine and the workpiece can be different.

The G700 command should be used when measuring the workpiece in INCHES on a metric machine.

The G710 command should be used when measuring the workpiece in mm on an "INCH" machine.

For information regarding measurement in conjunction with a 3rd axis, see Chapter Extended measurement (Page 105).

Note

A correspondence/assignment list of the measuring cycle parameters, machine and setting data used with regard to the measuring cycle versions 7.5, 2.6 and 4.4 can be found in the Appendix Changes from cycle version SW4.4 and higher (Page 345)!

3.2.2 Calibrate probe - length (CYCLE973)

Function

Only applies on a turning machine without the milling technology.

With this measuring version, a workpiece probe with cutting edge positions SL=5 to 8 can be calibrated on a known surface (workpiece-related). The trigger points of the probe are determined.

Optionally, the actual length can be entered in the tool offset memory via the "Adapt tool length" parameter.

Measuring principle

The switching position of the workpiece probe in an axis is calculated into the measuring probe length. The calculated trigger point is determined in the corresponding axis and axis direction, and entered in the selected calibration data set (calibration data field) of the workpiece probe.

The probe travels in the measuring direction to the calibration edge (e.g. workpiece)

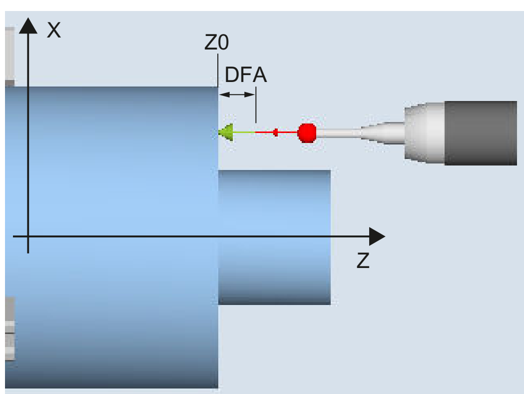


Figure 3-1 Calibrate: Length on the surface (CYCLE973), example G18, SL=7

Requirements

- The surface must be in parallel to an axis of the workpiece coordinate system (WCS).
- The calibration surface must have a low surface roughness.
- The workpiece probe is called as tool with tool offset.
- 580 must be declared as the probe type.
- Calibrating the probe length does not represent measuring the tool. The deviation between the physical probe length and the values in the tool data must be less than 5 mm / 0.2 inch.

Starting position before the measurement

The probe must be positioned opposite to the calibration surface.

Position after the end of the measuring cycle

The probe is at the distance of the selected measurement path (DFA) away from the calibration surface.

See also

Measuring the workpiece on a machine with combined technologies (Page 250)

Procedure

The part program or ShopTurn program to be processed has been created and you are in the editor.

1. Press the "Meas. workpiece" softkey.
2. Press the "Calibrate probe" softkey.
3. Press the "Length" softkey.
   The input window "Calibrate: Length at surface" opens.

Parameters

G code program				ShopTurn program		
Parameters	**Description**	**Unit**		**Parameters**	**Description**	**Unit**
	Calibration data set (1 - 40)	-		T	Name of the probe	-
F	Calibration and measuring feedrate	Distance/ min		D	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				β	Tool alignment with swivel axis • ← (0 degrees) • ↓ (90 degrees) • Value input	Degrees
				F	Calibration and measuring feedrate	mm/min
				CP	Positioning angle for the measuring range	Degrees
				Z	Start point Z of the measurement	mm
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm

Parameters	Description	Unit
Adapt tool length	Adapt the probe length and trigger point: • Yes • No (adapt trigger point only)	-
Measuring direction	Measuring axis (for G18): • +/- Z • +/- X	-
Z0 / X0	Reference point Z/X (corresponding to the measuring direction)	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

Note

When the calibration is performed for the first time, the default setting in the data field of the probe is still "0". For this reason, the **TSA** parameter must be programmed > probe ball radius to avoid the alarm "Safe area exceeded".

List of the result parameters

The measuring version "Length" provides the following result parameters:

Table 3-2 "Length" result parameters

Parameters	Description	Unit
_OVR [4]	Actual value probe ball diameter	mm
_OVR [5]	Difference probe ball diameter	mm
_OVR [8]	Trigger point in minus direction, actual value of 1st axis of the plane	mm
_OVR [10]	Trigger point in plus direction, actual value of 1st axis of the plane	mm
_OVR [12]	Trigger point in minus direction, actual value of 2nd axis of the plane	mm
_OVR [14]	Trigger point in plus direction, actual value of 2nd axis of the plane	mm
_OVR [9]	Trigger point in minus direction, difference of 1st axis of the plane	mm
_OVR [11]	Trigger point in plus direction, difference of 1st axis of the plane	mm
_OVR [13]	Trigger point in minus direction, difference of 2nd axis of the plane	mm
_OVR [15]	Trigger point in plus direction, difference of 2nd axis of the plane	mm
_OVR [20]	Positional deviation of the 1st axis of the plane (probe skew)	mm
_OVR [21]	Positional deviation of the 2nd axis of the plane (probe skew)	mm
_OVR [27]	Work offset range	mm
_OVR [28]	Safe area	mm
_OVI [2]	Measuring cycle number	-
_OVI [5]	Probe number	-
_OVI [9]	Alarm number	-

3.2.3 Calibrate probe - radius on surface (CYCLE973)

Function

Only applies on turning machines without the milling technology.

With this measuring version, the radius of a workpiece probe with cutting edge positions SL=5 to 8 can be calibrated on a surface. The trigger points of the probe are determined.

The calibration surface is workpiece-related. It is only possible to calibrate in the selected axis and direction, which are perpendicular to this calibration surface.

Measuring principle

The determined switching position of the workpiece probe in the parameterized axis and direction, is calculated with the setpoint of the reference surface and from this the corresponding trigger point determined.

If no alarms occur, the trigger values are entered into the selected calibration data set of the workpiece probe.

The probe travels in the measuring direction to the reference surface (e.g. workpiece)

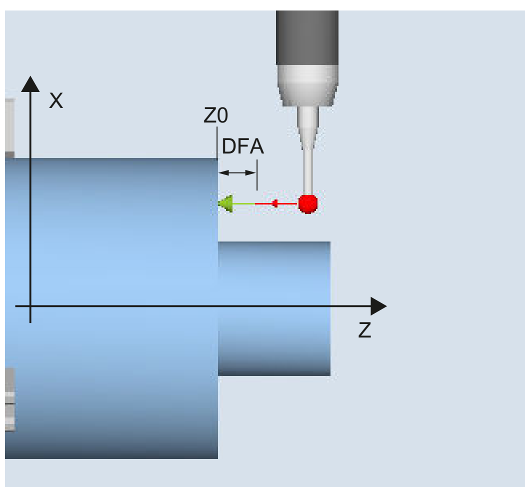


Figure 3-2 Calibrate: radius at the surface (CYCLE973), example G18, SL=8

Requirements

- The surface must be in parallel to an axis of the workpiece coordinate system (WCS).
- The calibration surface must have a low surface roughness.
- The workpiece probe is called as tool with tool offset.
- 580 must be declared as the probe type.

Starting position before the measurement

The probe must be positioned opposite to the calibration surface.

Position after the end of the measuring cycle

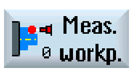
The probe (ball radius) is the distance of the measurement path away from the calibration surface.

See also

Measuring the workpiece on a machine with combined technologies (Page 250)

Procedure

The part program or ShopTurn program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Calibrate probe" softkey.

3. Press the "Radius on surface" softkey.
   The input window "Calibrate: Radius at surface" opens.

Parameters

G code program				ShopTurn program		
Parameter	Description	Unit		Parameter	Description	Unit
	Calibration data set (1 - 40)	-		T	Name of the probe	-
F	Calibration and measuring feedrate	Distance/ min		D	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				F	Calibration and measuring feedrate	mm/min
				β	Tool alignment with swivel axis • ← (0 degrees) • ↓ (90 degrees) • Value input	Degrees
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameters	Description	Unit
Measuring direction	Measuring axis (for measuring plane G18) • +/- Z • +/- X	-
Z0 / X0	Reference point Z/X (corresponding to the measuring direction)	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

Note

When the calibration is performed for the first time, the default setting in the data field of the probe is still "0". For this reason, the **TSA** parameter must be programmed > probe ball radius to avoid the alarm "Safe area exceeded".

List of the result parameters

The measuring variant "Radius on surface" provides the following result parameters:

Table 3-3 "Radius on surface" result parameters

Parameters	Description	Unit
_OVR [4]	Actual value probe ball diameter	mm
_OVR [5]	Difference probe ball diameter	mm
_OVR [8]	Trigger point in minus direction, actual value of 1st axis of the plane	mm
_OVR [10]	Trigger point in plus direction, actual value of 1st axis of the plane	mm
_OVR [12]	Trigger point in minus direction, actual value of 2nd axis of the plane	mm
_OVR [14]	Trigger point in plus direction, actual value of 2nd axis of the plane	mm
_OVR [9]	Trigger point in minus direction, difference of 1st axis of the plane	mm
_OVR [11]	Trigger point in plus direction, difference of 1st axis of the plane	mm
_OVR [13]	Trigger point in minus direction, difference of 2nd axis of the plane	mm
_OVR [15]	Trigger point in plus direction, difference of 2nd axis of the plane	mm
_OVR [20]	Positional deviation of the 1st axis of the plane (probe skew)	mm
_OVR [21]	Positional deviation of the 2nd axis of the plane (probe skew)	mm
_OVR [27]	Zero offset area	mm
_OVR [28]	Safe area	mm
_OVI [2]	Measuring cycle number	-
_OVI [5]	Probe number	-
_OVI [9]	Alarm number	-

3.2.4 Calibrate probe - calibrate in groove (CYCLE973)

Function

Only applies on turning machines without the milling technology.

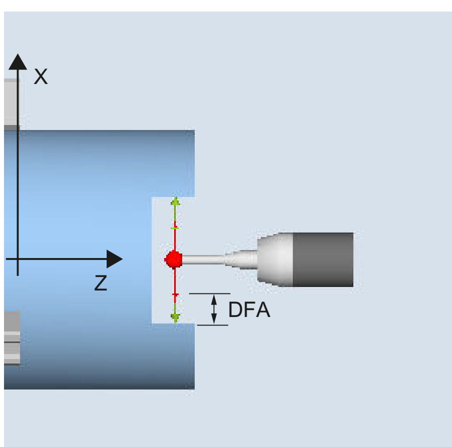
Using this measuring version, a workpiece probe with cutting edge position SL=7 or SL=8 can be calibrated in a reference groove machine-related in the axes of the plane. The measuring probe length or the probe sphere radius can be determined with the calibration.

With the radius determination, a calibration is possible in one direction or in opposite directions of an axis. It is also possible to determine the positional deviation (skew) of the probe and the effective diameter of the probe sphere during calibration in opposite directions.

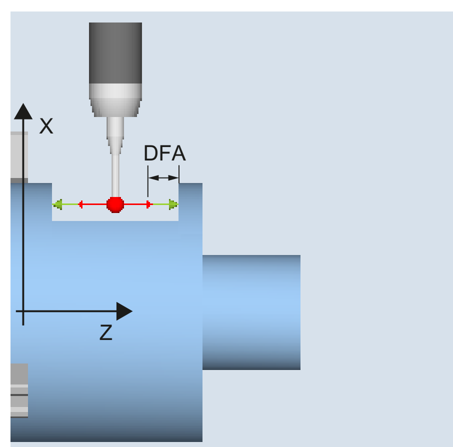
Measuring principle

The measured switching positions of the workpiece probe in the parameterized axis are taken into account together with the machine-related data of the selected calibration groove. From this data, the trigger points are calculated in the positive and negative directions as well as the position deviation in this axis and the effective probe sphere diameter. The trigger points always refer to the center of the probe sphere (TCP).

The probe moves in the selected measuring axis in both directions in the calibration groove.



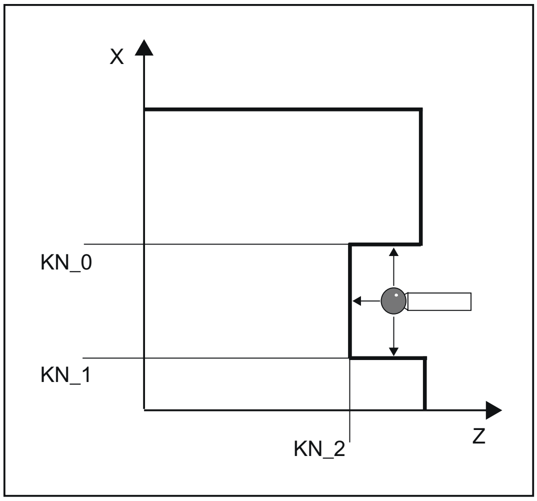
Calibrate: Probe in groove (CYCLE973), example G18, SL=7



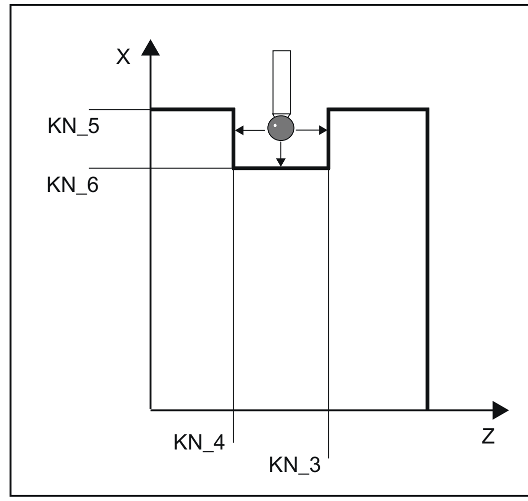
Calibrate: Probe in groove (CYCLE973), example G18, SL=8

Requirements

- The workpiece probe must be called as tool with the associated tool offset.
- The machine-related geometrical dimensions of the selected calibration group must be saved before calibration in the corresponding general setting data.



Geometry of the calibration groove, example G18, SL=7



Geometry of the calibration groove, example G18, SL=8

Table 3-4 General setting data for dimensions of the calibration groove

Calibration groove	General setting data	Description
KN_0	SD 54621 $SNS_MEA_CAL_EDGE_PLUS_DIR_AX2	Calibration slot edge in the positive direction of the 2nd measuring axis
KN_1	SD 54622 $SNS_MEA_CAL_EDGE_MINUS_DIR_AX2	Calibration slot edge in the negative direction of the 2nd measuring axis
KN_2	SD 54615 $SNS_MEA_CAL_EDGE_BASE_AX1	Calibration slot base of the 1st measuring axis
KN_3	SD 54617 $SNS_MEA_CAL_EDGE_PLUS_DIR_AX1	Calibration slot edge in the positive direction of the 1st measuring axis
KN_4	SD 54618 $SNS_MEA_CAL_EDGE_MINUS_DIR_AX1	Calibration slot edge in the negative direction of the 1st measuring axis
KN_5	SD 54620 $SNS_MEA_CAL_EDGE_UPPER_AX2	Upper calibration slot edge of the 2nd measuring axis
KN_6	SD 54619 $SNS_MEA_CAL_EDGE_BASE_AX2	Calibration slot base of the 2nd measuring axis

References: Commissioning Manual *SINUMERIK Operate (IM9) / SINUMERIK 840D sl*, Chapter "Measuring workpieces when turning".

Starting position before the measurement

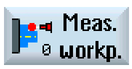
The starting position should be selected so that the selected workpiece probe can be positioned in the shortest possible distance, collision-free, with paraxial movements, in the reference groove corresponding to the active cutting edge position.

Position after the end of the measuring cycle

When calibration with one calibration direction has been completed, the probe is positioned at the measurement distance (DFA) from the calibration surface. For calibration with two calibration directions, the probe is located at the start position after completion of the measuring operation.

Procedure

The part program or ShopTurn program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Calibrate probe" softkey.

3. Press the "Calibrate in groove" softkey.
   The input window "Calibrate: Probe in groove" opens.

Parameter

G code program				ShopTurn program		
Parameter	Description	Unit		Parameter	Description	Unit
PL	Measuring plane (G17 - G19)	-		T	Name of the probe	-
	Calibration data set (1 - 40)	-		D	Cutting edge number (1 - 9)	-
F	Calibration and measuring feedrate	Distance/ min			Calibration data set (1 - 40)	-
				β	Tool alignment with swivel axis • ← (0 degrees) • ↓ (90 degrees) • Value input	Degrees
				F	Calibration and measuring feedrate	mm/min
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Calibrate	• Length (calibrate probe length) • Radius (calibrate probe radius)	-
Calibration directions (only for "Radius" calibration)	• 1: Calibration in one direction • 2: Calibration in opposite directions	-
Measuring direction	Measuring axis (corresponding to the measuring plane): • (+/-) Z • (+/-) X	-

Parameter	Description	Unit
Adapt tool length (only for "Length" calibration)	• No (adapt trigger point only) • Yes (adapt probe length and trigger point)	-
Calibration groove data set	• 1 • 2 • 3	-
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

Note

When the calibration is performed for the first time, the default setting in the data field of the probe is still "0". For this reason, the **TSA** parameter must be programmed > probe ball radius to avoid the alarm "Safe area exceeded".

List of the result parameters

The measuring variant "Calibrate in groove" provides the following result parameters:

Table 3-5 "Calibrate in groove" result parameters

Parameters	Description	Unit
_OVR [4]	Actual value probe ball diameter	mm
_OVR [5]	Difference probe ball diameter	mm
_OVR [8]	Trigger point in minus direction, actual value of 1st axis of the plane	mm
_OVR [10]	Trigger point in plus direction, actual value of 1st axis of the plane	mm
_OVR [12]	Trigger point in minus direction, actual value of 2nd axis of the plane	mm
_OVR [14]	Trigger point in plus direction, actual value of 2nd axis of the plane	mm
_OVR [9]	Trigger point in minus direction, difference of 1st axis of the plane	mm
_OVR [11]	Trigger point in plus direction, difference of 1st axis of the plane	mm
_OVR [13]	Trigger point in minus direction, difference of 2nd axis of the plane	mm
_OVR [15]	Trigger point in plus direction, difference of 2nd axis of the plane	mm
_OVR [20]	Positional deviation of the 1st axis of the plane (probe skew)	mm
_OVR [21]	Positional deviation of the 2nd axis of the plane (probe skew)	mm
_OVR [27]	Work offset range	mm
_OVR [28]	Safe area	mm
_OVI [2]	Measuring cycle number	-
_OVI [5]	Probe number	-
_OVI [9]	Alarm number	-

3.2.5 Turning measurement - front edge (CYCLE974)

Function

With this measuring variant, workpiece dimensions can be measured at edges in the direction of the infeed axis and offsets derived from these.

The measurement result and the measurement difference can be used for:

- Correction of a work offset
- Offset of a tool
- Measurement without offset

Note

Extended measurement

Information on measurement in conjunction with a third axis can be found in ChapterExtended measurement (Page 105).

Measuring principle

The measuring cycle determines the actual value of a measuring point at an edge of the turned part, relative to the workpiece zero.

The difference between the actual value (measured value) and a specified setpoint in the 1st axis of the plane is calculated (for G18: Z).

An extended tool offset in the summed and setup offsets is possible.

For the tool offset, generally empirical values can be included in the calculation.

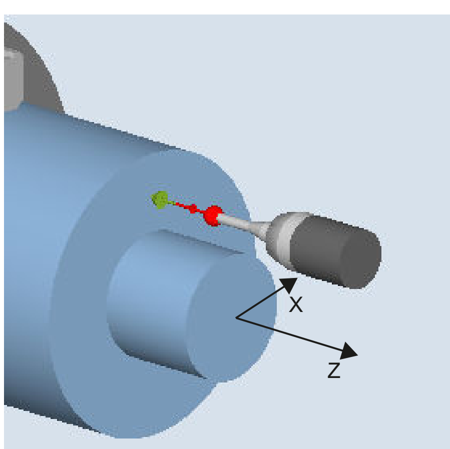


Figure 3-3 Measure: Front edge (CYCLE974)

Requirements

- The probe must be calibrated in the measuring direction and active as tool. The probe type is 710 or 580.
- The cutting edge position can be 5 to 8 and must be suitable for the measurement task.
- If necessary, the workpiece must be positioned in the correct angular spindle position using spindle positioning (SPOS).

Starting position before the measurement

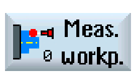
The probe must be positioned opposite to the surface/edge to be measured. Starting from this position, the measuring cycle always traverses the measuring axis in the direction of the setpoint.

Position after the end of the measuring cycle

When the measuring process has been completed, the probe is positioned at the distance of the measurement path (DFA) from the measuring surface.

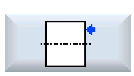
Procedure

The part program or ShopTurn program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Turning measurement" softkey.



3. Press the "Set front edge" softkey.
   The input window "Measure: Front edge" opens.

Parameter

G code program				ShopTurn program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
	Calibration data set (1 - 40)	-		T	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				β	Tool alignment with swivel axis • ← (0 degrees) • ↓ (90 degrees) • Value input	Degrees
				Z	Start point Z of the measurement	mm
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) 1) • Tool offset (save measured value in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected	-
Z0	Reference point Z	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Dimensional tolerance	Use dimensional tolerance (only for the "Tool offset" correction target) • Yes • No	-
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm

1) Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

Machine manufacturer

Please observe the information provided by the machine manufacturer.

List of the result parameters

The measuring variant "Front edge" provides the following result parameters:

Table 3-6 "Front edge" result parameters

Parameters	Description	Unit
_OVR [0]	Setpoint value for measuring axis	mm
_OVR [1]	Setpoint in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [2]	Setpoint in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [3]	Setpoint in 3rd axis of the plane → only for `S_MA=3`	mm
_OVR [4]	Actual value for measuring axis	mm
_OVR [5]	Actual value in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [6]	Actual value in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [7]	Actual value in 3rd axis of the plane → only for `S_MA=3`	mm
_OVR [16]	Difference for measuring axis	mm
_OVR [17]	Difference in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [18]	Difference in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [19]	Difference in 3rd axis of the plane → only for `S_MA=3`	mm
_OVI [0]	D number or WO number	-
_OVI [2]	Measuring cycle number	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, see Additional result parameters (Page 342).

3.2.6 Turning measurement - inside diameter (CYCLE974, CYCLE994)

Function

With this measuring variant, the inside diameter of cylindrical workpieces can be measured. The diameter and radius programming are supported.

The measurement result (measurement difference) can be used as follows:

- Correction in the work offset (only for 1-point measurements)
- Offset of a tool
- Measurement without offset

Note

Extended measurement

Information on measurement in conjunction with a third axis can be found in Section Extended measurement (Page 105).

Measuring principle

The measuring cycle determines the actual value of an inside diameter using a 1-point measurement or 2-point measurement symmetrically around the workpiece zero (center of rotation). The 2-point measurement is performed by reversing the spindle through 180 degrees of the workpiece or by making measurements above and below the center of rotation.

An extended tool offset in the summed and setup offsets is possible.

For the tool offset, generally empirical values can be included in the calculation.

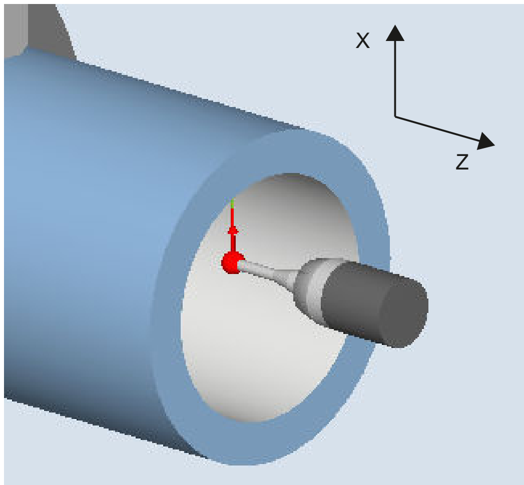


Figure 3-4 Measure: Inside diameter (CYCLE974)

Positioning "Travel below the center" (CYCLE994)

For "Travel below the center", the inside diameter of the workpiece is measured using a 2-point measurement with the measuring cycle `CYCLE994` . Two opposite measuring points symmetrical to the workpiece zero (center of rotation) are approached at a distance of the setpoint specified by the user.

A protection zone can be programmed, which should be taken into account when traversing. The user must take into account the ball radius of the probe when dimensioning the protection zone.

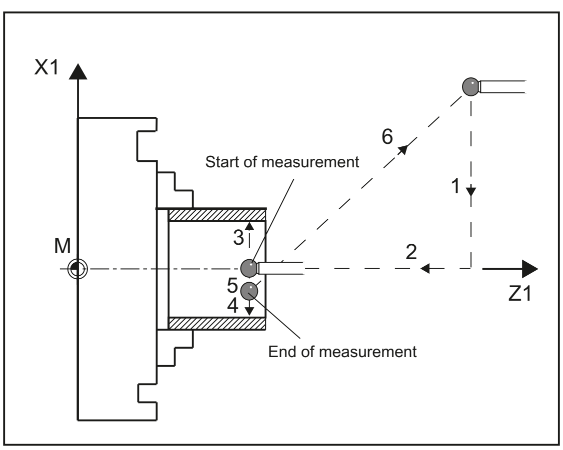


Figure 3-5 Positions of the probe when measuring the inside diameter using 2-point measurement (CYCLE994)

Measuring with reversal of the workpiece (CYCLE974)

With this measuring variant, the actual value of a workpiece with reference to the workpiece zero in the measuring axis is determined by acquiring two opposite points on the diameter.

The workpiece is positioned by the cycle before the first measurement at the angular position programmed in parameter **α0**. After the 1st measurement, the cycle also automatically generates the 180 degrees reversal before the second measurement. The mean value is calculated from both measured values.

A correction of the work offset (WO) is only possible when measuring without reversal (1-point measurement).

Requirements

- The probe must be calibrated in the measuring direction.
- The probe of type 710 or 580 must be active.
- The cutting edge position can be 5 to 8 and must be suitable for the measurement task.

Starting position before the measurement

The probe should be positioned opposite the surface to be measured, above the turning center.

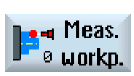
Position after the end of the measuring cycle

The probe is at a distance of the measuring path (DFA) from the measuring surface, above the turning center.

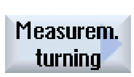
When "Travel under the center of rotation" is selected, after the end of the measuring cycle, the probe is at a distance of the measuring path (DFA) from the measuring surface, below the center of rotation.

Procedure

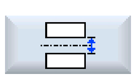
The part program or ShopTurn program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.



2. Press the "Turning measurement" softkey.



3. Press the "Inside diameter" softkey.
   The input window "Measure: Inside diameter" opens.

Parameter

G code program				ShopTurn program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
	Calibration data set (1 - 40)	-		T	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				β	Tool alignment with swivel axis • ← (0 degrees) • ↓ (90 degrees) • Value input	Degrees
				Z	Start point Z of the measurement	mm
				X	Start point X of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured value in a settable WO) [1), 2)] • Tool offset (save measured value in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected	-
Ø	Inside diameter	mm
Positioning	• Measuring without reversal of the workpiece • Measuring with reversal of the workpiece (180°) [3)] • Travel below center (measuring above and below the center of rotation)	-
α0	Starting angle for spindle reversal (only for positioning "with reversal")	Degrees
XR	Retraction in X (diameter)	mm
ZR (for G18)	Retraction in Z	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Dimensional toler-ance	Use dimensional tolerance (only for the "Tool offset" correction target) • Yes • No	-
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm

1) Only for positioning "without reversal"

2) Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

3) The "Measurement with reversal of the workpiece" function is displayed if bit 0 is set in the general SD 54764 $SNS_MEA_FUNCTION_MASK_TURN.

Machine manufacturer
Please observe the information provided by the machine manufacturer.

List of the result parameters

The measuring variant "Inside diameter" provides the following result parameters:

Table 3-7 "Inside diameter" result parameters

Parameters	Description	Unit
_OVR [0]	Diameter setpoint (note measuring axis `S_MA`)	mm
_OVR [1]	Diameter setpoint in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [2]	Diameter setpoint in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [3]	Diameter setpoint in 3rd axis of the plane → only for `S_MA=3`	mm
_OVR [4]	Diameter actual value	mm
_OVR [5]	Diameter actual value in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [6]	Diameter actual value in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [7]	Diameter actual value in 3rd axis of the plane → only for `S_MA=3`	mm
_OVR [16]	Diameter difference	mm
_OVR [17]	Diameter difference in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [18]	Diameter difference in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [19]	Diameter difference in 3rd axis of the plane → only for `S_MA=3`	mm
_OVI [0]	D number	-
_OVI [2]	Measuring cycle number	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, seeAdditional result parameters (Page 342).

3.2.7 Turning measurement - outside diameter (CYCLE974, CYCLE994)

Function

With this measuring variant, the outer diameter of cylindrical workpieces can be measured. The diameter and radius programming are supported.

The measurement result (measurement difference) can be used as follows:

- Correction in the work offset (only for measuring without reversal, 1-point measurement)
- Offset of a tool
- Measurement without offset

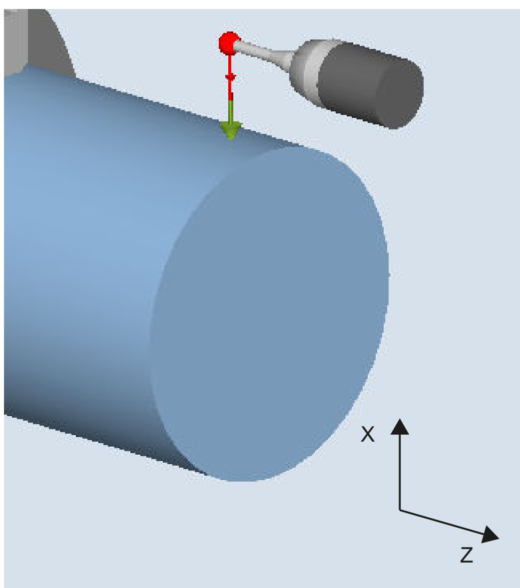
Note

Extended measurement

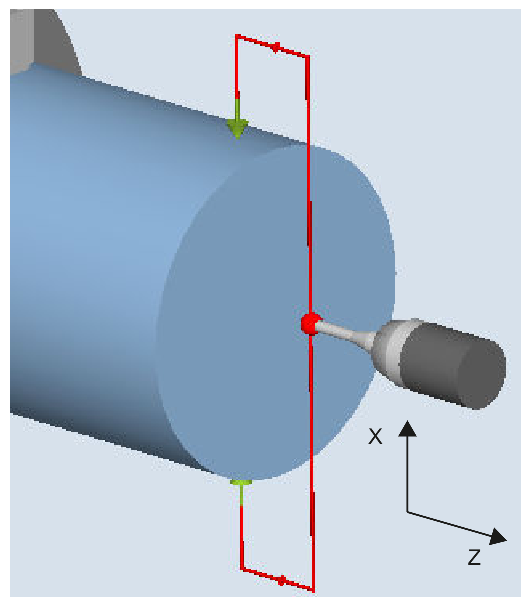
Information on measurement in conjunction with a third axis can be found in Section Extended measurement (Page 105).

Measuring principle

The measuring cycle determines the actual value of an outer diameter using a 1-point measurement or 2-point measurement symmetrically around the workpiece zero (center of rotation). The 2-point measurement is performed by reversing the spindle through 180 degrees of the workpiece or by making measurements above and below the center of rotation.



Measure: Outside diameter (CYCLE974) with/without reversal of the workpiece



Measure: Diameter, outside (CYCLE994) above and below the turning center

Positioning "Travel below the center" (CYCLE994)

For "Travel below the center", the outer diameter of the workpiece is measured using a 2-point measurement with the measuring cycle `CYCLE994` . Two opposite measuring points symmetrical to the workpiece zero (center of rotation) are approached at a distance of the setpoint specified by the user. When traversing, a safety zone is taken into account. The user must take into account the ball radius of the probe when dimensioning the protection zone.

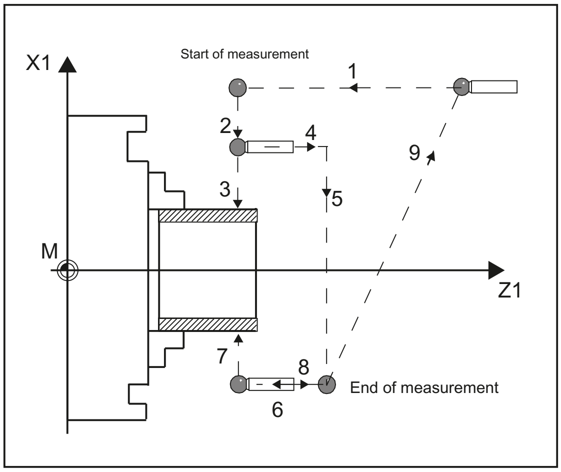


Figure 3-6 Positions of the probe when measuring the outer diameter (CYCLE994) with retraction path in X and Z

Measuring with reversal of the workpiece (CYCLE974)

With this measuring variant, the actual value of a workpiece with reference to the workpiece zero in the measuring axis is determined by acquiring two opposite points on the diameter.

The workpiece is positioned by the cycle before the first measurement at the angular position programmed in parameter **α0**. After the first measurement, the cycle also automatically generates the 180 degrees reversal before the second measurement. The mean value is calculated from both measured values.

A correction of the work offset (WO) is only possible when measuring without reversal (1-point measurement).

Requirements

- The probe must be calibrated in the measuring directions.
- The probe of type 710 or 580 must be active.
- The cutting edge position can be 5 to 8 and must be suitable for the measurement task.

Note

For the measuring variant "Travel below the center of rotation", measurements can also be performed without previous calibration if, in the user program, before calling CYCLE 994, the _CHBIT[7] is set (compatibility to previous releases).

Starting position before the measurement

The probe should be positioned opposite the surface to be measured, above the turning center.

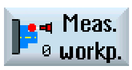
Position after the end of the measuring cycle

The probe is at a distance of the measuring path (DFA) from the measuring surface, above the turning center.

If "Travel under the center of rotation" was selected, after the end of the measuring cycle, the probe is at a distance of the measuring path (DFA) from the measuring surface, below the center of rotation.

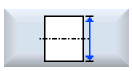
Procedure

The part program or ShopTurn program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Turning measurement" softkey.



3. Press the "Outside diameter" softkey.
   The input window "Measure: Outer diameter" opens.

Parameter

G code program				ShopTurn program		
Parameter	Description	Unit		Parameter	Description	Unit
	Calibration data set (1 - 40)	-		T	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				β	Tool alignment with swivel axis • ← (0 degrees) • ↓ (90 degrees) • Value input	Degrees
				Z	Start point Z of the measurement	mm
				X	Start point X of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured value in a settable WO) 1), 2) • Tool offset (save measured value in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected	-
Ø	Outer diameter	mm
Positioning	• Measuring without reversal of the workpiece • Measuring with reversal of the workpiece 3) • Travel below center (measuring above and below the center of rotation)	-

Parameter	Description	Unit
α0	Starting angle for spindle reversal (only for positioning "Measuring with reversal")	Degrees
ZR (for G18)	Retraction in Z	mm
XR	Retraction in X (in the diameter)	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Dimensional tolerance	Use dimensional tolerance (only for the "Tool offset" correction target) • Yes • No	-
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm

1) Only for positioning "Measuring without reversal"

2) Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

3) The "Measurement with reversal of the workpiece" function is displayed if bit 0 is set in the general SD 54764 $SNS_MEA_FUNCTION_MASK_TURN .

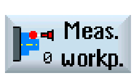
Machine manufacturer

Please observe the information provided by the machine manufacturer.

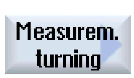
Measuring variant, milling on a turning machine

Procedure

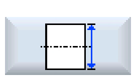
The part program or ShopMill program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.



2. Press the "Turning measurement" softkey.



3. Press the "Outside diameter" softkey.
   The input window "Measure: Outer diameter" opens.

Parameter

ShopMill program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 40)	-

ShopMill program		
Parameter	Description	Unit
β	Tool alignment with swivel axis • ← (0 degrees) • ↓ (90 degrees) • Value input	Degrees
Z	Start point Z of the measurement	mm
X	Start point X of the measurement	mm

List of the result parameters

The measuring variant "Outside diameter" provides the following result parameters:

Table 3-8 "Outside diameter" result parameters

Parameters	Description	Unit
_OVR [0]	Diameter setpoint (note measuring axis `S_MA`)	mm
_OVR [1]	Diameter setpoint in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [2]	Diameter setpoint in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [3]	Diameter setpoint in 3rd axis of the plane → only for `S_MA=3`	mm
_OVR [4]	Diameter actual value	mm
_OVR [5]	Diameter actual value in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [6]	Diameter actual value in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [7]	Diameter actual value in 3rd axis of the plane → only for `S_MA=3`	mm
_OVR [16]	Diameter difference	mm
_OVR [17]	Diameter difference in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [18]	Diameter difference in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [19]	Diameter difference in 3rd axis of the plane → only for `S_MA=3`	mm
_OVI [0]	D number	-
_OVI [2]	Measuring cycle number	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, seeAdditional result parameters (Page 342).

3.2.8 Extended measurement

Measuring in conjunction with a 3rd axis (Y)

If a turning machine has a 3rd axis, for technological reasons it can make sense to also use this as a measuring axis. In this case, pre-positioning and the measuring operation are performed in the 3rd axis (Y axis); however, the measuring result correction is entered in the tool and WO components of the 2nd geometry axis (X axis). The 3rd axis supports the radius and diameter programming according to the relationships of the 2nd geometry axis (X).

Note

The function of including the 3rd axis for turning machines refers to the measuring cycles CYCLE974 and CYCLE994! This function must be enabled, see

References: Commissioning Manual *SINUMERIK Operate (IM9) / SINUMERIK 840D sl*, Section "Measuring workpieces when turning".

Extended bypass options for 2-point measurement (CYCLE994)

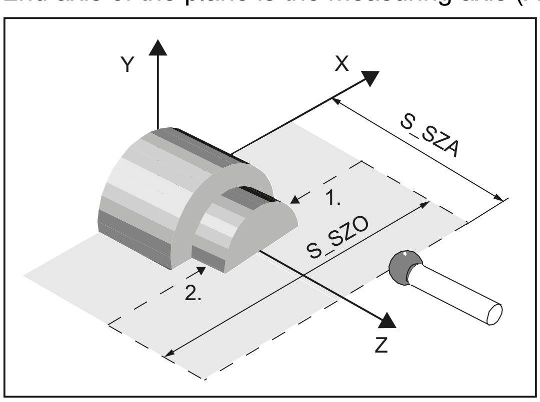
If a turning machine has a 3rd axis, then it can also be optionally used as a bypass axis.

The bypass strategies discussed in the following can be realized using the parameter assignment screen forms or the number of the measuring axis (Parameter S_MA).

Basis for the extended bypass strategy is that the 3rd axis has been enabled for measuring cycles.

S_MA, multi-digit = 102

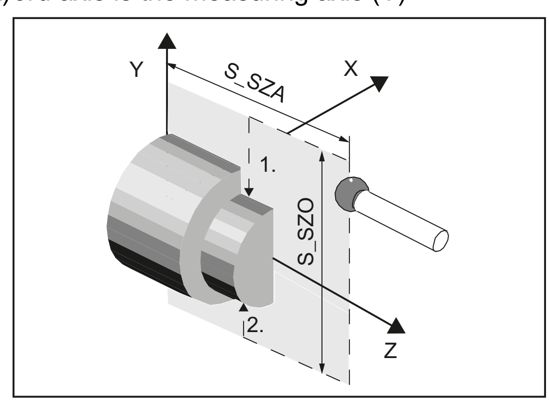
1st axis of the plane is the bypass axis (Z)
2nd axis of the plane is the measuring axis (X)



Probe with cutting edge position (SL)=7

S_MA, multi-digit = 103

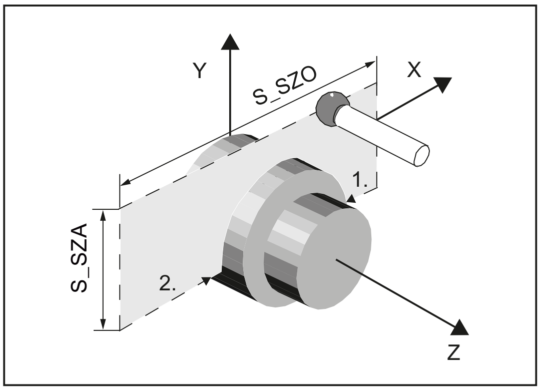
1st axis of the plane is the bypass axis (Z)
3rd axis is the measuring axis (Y)



Probe with SL=7

S_MA, multi-digit = 302

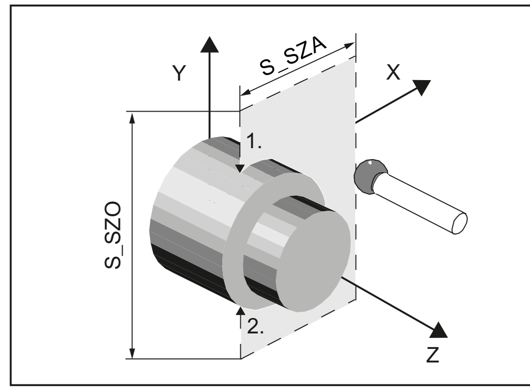
3rd axis is the bypass axis (Y)
2nd axis of the plane is the measuring axis (X)



Probe with SL=7

S_MA, multi-digit = 203

2nd axis of the plane is the bypass axis (X)
3rd axis is the measuring axis (Y)



Probe with SL=7

3.3 Measure workpiece (milling)

3.3.1 General information

Milling machines

The measuring cycles below are intended for use on milling machines.

Note

Spindle

Spindle commands in the measuring cycles always refer to the active master spindle of the control.

When using the measuring cycles at machines with several spindles, then the spindle involved must be defined as master spindle before the cycle call.

Note

Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane and measuring velocity are the same for both measurement and calibration.

If the probe is used in the spindle for a driven tool, the spindle orientation must also be considered. Deviations can cause measuring errors.

References: */PG/* Programming Manual *SINUMERIK 840D sl / 828D Fundamentals*

Plane definition, measuring system

The measuring cycles under milling work with the active planes G17, G18 or G19.

The measuring system (basic system) of the machine and the workpiece can be different.

The G700 command should be used when measuring the workpiece in INCHES on a metric machine.

The G710 command should be used when measuring the workpiece in mm on an "INCH" machine.

3.3.2 Calibrate probe - length (CYCLE976)

3.3.2.1 Function

Note

Note about all calibration methods

For precise measurements in conjunction with the functions swivel/Cycle800 or Traori, ensure that the probe is calibrated in the same way as measurement will subsequently be performed.

In other words, the probe should be calibrated in the mechanical constellation of rotary and linear axes that corresponds to the measurement!

Function

Using this measuring variant, the length of a workpiece probe can be calibrated in the tool axis on a known surface (reference area). This can be done, for example, on a workpiece.

Measuring principle

The probe travels in the measuring direction on the edge (e.g. workpiece)

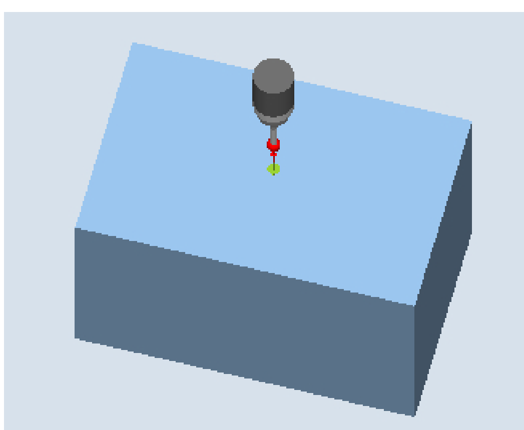


Figure 3-7 Calibrate: Length at edge (CYCLE976)

The length of the probe is determined corresponding to the setting in general MD 51740 $MNS_MEA_FUNCTION_MASK, bit 1. The setting determines whether the tool length refers to the probe sphere center or the probe sphere circumference.

In the "Tool length to sphere center" variant, a trigger value is entered in the calibration data according to the calibration direction.

References: Commissioning Manual *SINUMERIK Operate (IM9) / SINUMERIK 840D sl*, Chapter "Measuring cycles and measurement functions".

Requirements

- The probe must be active as tool.
- Probe type:
  - 3D multi probe (type 710)
  - Mono probe (type 712)
  - L probe (type 713)

  Note

  L probe application (type 713)

  Calibration in +Z (for towing measurement) is possible with the L probe.

  The basic alignment of the L probe boom is toward +X (offset angle = 0). If the probe boom is to be aligned in a different direction in the measuring program, this can be performed through a rotation around the tool axis (e.g. ROT Z = 90).

- The probe length must be known in the program for collision-free positioning of the workpiece probe and entered in the tool offset memory.
- The sphere radius must be known exactly and entered in the tool data. For example, this can be implemented using a previous calibration in the ring or on the sphere (valid for type 710, 712).
- The calibration surface is perpendicular to the measuring axis or tool axis.

Starting position before the measurement

The probe must be positioned opposite to the calibration surface.

The distance between the probe and calibration surface should be approximately the same as the selected measurement path (DFA).

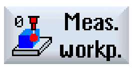
Position after the end of the measuring cycle

According to the measuring direction (X, Y, Z), the distance between the probe in AUTOMATIC operation and the calibration surface is the same as the distance of the selected measurement path (DFA). In JOG operation, the start position is approached again.

3.3.2.2 Calling the measuring version

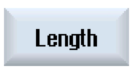
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Calibrate probe" softkey.



3. Press the "Length" softkey.
   The input window "Calibrate: Length at edge" opens.

3.3.2.3 Parameters

Parameters

G code program				ShopMill program		
Parameters	**Description**	**Unit**		**Parameters**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		T	Name of the probe	-
	Calibration data set (1 - 40)	-		D	Cutting edge number (1 - 9)	-
F	Calibration and measuring feedrate	Distance/ min			Calibration data set (1 - 40)	-
				F	Calibration and measuring feedrate	mm/min
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameters	Description	Unit
Adapt tool length	• Yes (adapt probe length and trigger point) [1)] • No (adapt trigger point only)	-
Measuring direction	Measuring axis (+/-) Z (for measuring plane G17)	-
Z0	Reference point Z (for measuring plane G17)	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Measurements	Number of measurements at the same location (1-9)	-

[1)] The "Adapt tool length" parameter is only available when this field has been enabled via SD 54780 $SNS_J_MEA_FUNCTION_MASK_PIECE bit 28.

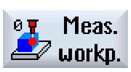
Note

When the calibration is performed for the first time, the default setting in the data field of the probe is still "0". For this reason, the **TSA** parameter must be programmed > probe ball radius to avoid the alarm "Safe area exceeded".

Measuring variant, turning on a milling machine (only 840D sl)

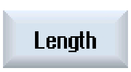
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Calibrate probe" softkey.



3. Press the "Length" softkey.
   The input window "Calibrate: Length at edge" opens.

Parameters

ShopTurn program		
Parameters	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 40)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

3.3.2.4 Result parameters

List of the result parameters

The measuring version "Length" provides the following result parameters:

Table 3-9 "Length" result parameters

Parameters	Description	Unit
_OVR [4]	Actual value probe ball diameter	mm
_OVR [5]	Difference probe ball diameter	mm
_OVR [16]	Trigger point in minus direction, actual value of 3rd axis of the plane	mm
_OVR [17]	Trigger point in minus direction, difference of 3rd axis of the plane	mm
_OVR [18]	Trigger point in plus direction, actual value of 3rd axis of the plane	mm
_OVR [19]	Trigger point in plus direction, difference of 3rd axis of the plane	mm
_OVR [22]	Probe length of the workpiece probe	mm
_OVR [27]	Work offset range	mm
_OVR [28]	Safe area	mm
_OVI [2]	Measuring cycle number	-
_OVI [5]	Probe number	-
_OVI [9]	Alarm number	-

3.3.3 Calibrate probe - radius in ring (CYCLE976)

Function

Using this measurement version, the following data can be calibrated:

- Inclined position of the workpiece probe
- Trigger values
- Radius of the probe in a calibration ring (in axes of the plane)

The probe calibration in the ring can be on the basis of an unknown or known center point in the ring. With known center point, this corresponds to the starting position.

Calibration is also possible taking into account a starting angle when using the "Start at ring center" calibration method. Any obstacles in the measuring path or at the measuring point can be avoided when using a starting angle.

Measuring principle

Calibration always starts in the positive direction of the 1st axis of the actual machining plane. Eight calibration positions are to be acquired, divided into two passes. Depending on the probe type, the passes are made with a uniform spindle position or a reversal of 180 degrees.

During the calibration process, the center point of the calibration ring (corresponding to the calibration method) and its distance to the starting position are determined.

The calibration data / trigger values are significantly influenced in the result by the following variables:

- Physical probe ball radius
- Design of the probe
- Measuring velocity
- Calibration ring with corresponding accuracy
- Correct mounting of the calibrating ring

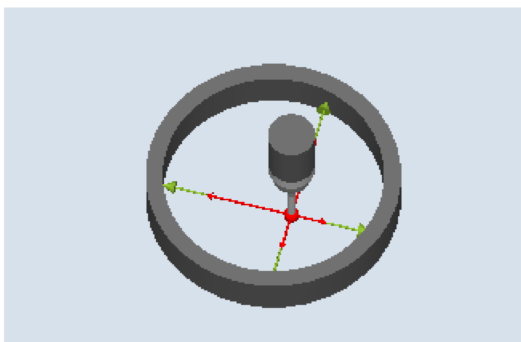


Figure 3-8 Calibrate: Radius in ring (CYCLE976)

Preconditions

The following requirements must be fulfilled for calibration in the ring:

- The probe must be active as tool.
- Probe type:
  - 3D multi probe (type 710)
  - Mono probe (type 712)
  - Star-type probe (type 714)
  -
    Note

    In connection with mono probes, star-type probes and the calibration method "Start point in ring center "NO"", an SPOS-capable spindle is required.
- Note: The arms of a star-type probe (type 714) must be positioned at 90 degree angle to each other.
- The exact diameter of the calibration ring is known.

Starting position before the measurement

If the measuring cycle is not started at the center of the ring, the workpiece probe sphere center must be positioned close to the center of the ring as well as to a calibration height within the calibration ring.

When starting the measuring cycle at the center of the ring, the workpiece probe sphere center must be positioned precisely at the ring center point as well as at a calibration height within the calibration ring.

Position after the end of the measuring cycle

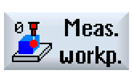
When calibration is complete, the probe center is at calibration height in the center of the ring.

Note

For extremely high demands placed on the measuring accuracy, it makes sense to accept the distance between the center point and starting position in the work offset and to perform an additional calibration using this optimization.

Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Calibrate probe" softkey.

3. Press the "Radius in ring" softkey.
   The input window "Calibrate: Radius in ring" opens.

Parameter

G code program				ShopMill program		
Parameter	Description	Unit		Parameter	Description	Unit
PL	Measuring plane (G17 - G19)	-		T	Name of the probe	-
	Calibration data set (1 - 40)	-		D	Cutting edge number (1 - 9)	-
F	Calibration and measuring feedrate	Distance/ min			Calibration data set (1 - 40)	-
				F	Calibration and measuring feedrate	mm/min
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Starting point at the center of the ring	• Yes (adapt calibration directions and measuring direction) • No (determine position deviation)	-
Calibration directions	• 1 (calibrate in one direction) • 2 (calibrate in opposite directions) • 4 (calibrate in opposite directions of the plane)	-
Determine position deviation	• Yes (determine position deviation of the probe) • No (do not determine position deviation of the probe)	-
Measuring axis	Measuring axis (X, Y)	-
Measuring direction	Measuring direction (+/-), measuring axis (X, Y)	-
∅	Ring diameter	mm
α0	Contact angle	Degrees
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Measurements	Number of measurements at the same location (1-9)	-

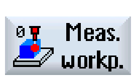
Note

When the calibration is performed for the first time, the default setting in the data field of the probe is still "0". For this reason, the **TSA** parameter must be programmed > probe ball radius to avoid the alarm "Safe area exceeded".

Measuring variant, turning on a milling machine (only 840D sl)

Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Calibrate probe" softkey.

3. Press the "Radius in ring" softkey.
   The input window "Calibrate: Radius in ring" opens.

Parameters

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-

ShopTurn program		
Parameter	**Description**	**Unit**
	Calibration data set (1 - 40)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Radius in Ring" provides the following result parameters:

Table 3-10 "Radius in ring" result parameters

Parameters	Description	Unit
_OVR [4]	Actual value probe ball diameter	mm
_OVR [5]	Difference probe ball diameter	mm
_OVR [6]	Center point of calibration ring in 1st axis of the plane	mm
_OVR [7]	Center point of calibration ring in 2nd axis of the plane	mm
_OVR [8]	Trigger point in minus direction, actual value of 1st axis of the plane	mm
_OVR [9]	Trigger point in minus direction, difference of 1st axis of the plane	mm
_OVR [10]	Trigger point in plus direction, actual value of 1st axis of the plane	mm
_OVR [11]	Trigger point in plus direction, difference of 1st axis of the plane	mm
_OVR [12]	Trigger point in minus direction, actual value of 2nd axis of the plane	mm
_OVR [13]	Trigger point in minus direction, difference of 2nd axis of the plane	mm
_OVR [14]	Trigger point in plus direction, actual value of 2nd axis of the plane	mm
_OVR [15]	Trigger point in plus direction, difference of 2nd axis of the plane	mm
_OVR [20]	Positional deviation of the 1st axis of the plane (probe skew)	mm
_OVR [21]	Positional deviation of the 2nd axis of the plane (probe skew)	mm
_OVR [24]	Angle at which the trigger points were determined	Degrees
_OVR [27]	Zero offset area	mm
_OVR [28]	Safe area	mm
_OVI [2]	Measuring cycle number	-
_OVI [5]	Probe number	-
_OVI [9]	Alarm number	-

3.3.4 Calibrate probe - radius on edge (CYCLE976)

Function

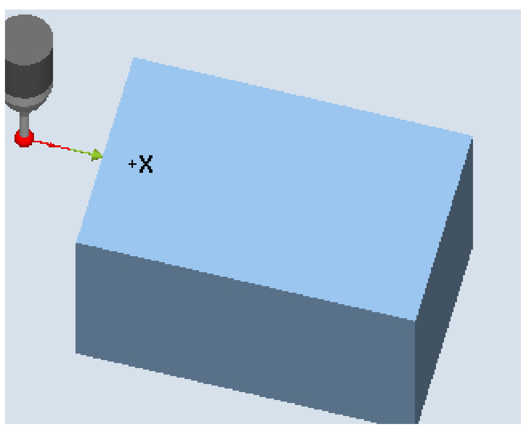
With this measuring method, a workpiece probe can be calibrated in an axis and the direction selected by the user at a reference surface perpendicular to this. This can be done, for example, on a workpiece.

The determined trigger point is taken into the addressed calibration data field.

Measuring principle

The probe approaches the reference surface in the selected axis and direction.

The determined calibration value (trigger point + position deviation) and probe ball radius are transferred into the addressed calibration data fields.



Calibrate: Radius at edge (CYCLE976), calibration direction

Preconditions

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)
  - Star-type probe (type 714)
  - L probe (type 713)

Starting position before the measurement

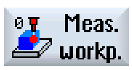
The probe is positioned in the measuring height, approximately at the distance of the measurement path (DFA) opposite to the edge.

Position after the end of the measuring cycle

The probe ball center is located in front of the reference edge by the distance of the measuring path.

Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Calibrate probe" softkey.

3. Press the "Radius at edge" softkey.
   The input window "Calibrate: Radius at edge" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		T	Name of the probe	-
	Calibration data set (1 - 40)	-		D	Cutting edge number (1 - 9)	-
F	Calibration and measuring feedrate	Distance/min			Calibration data set (1 - 40)	-
				F	Calibration and measuring feedrate	mm/min
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Calibration directions	• 1: Calibration in one direction • 2: Calibrations in opposite directions	-
Determine position deviation	• Yes (determine position deviation of the probe) • No (do not determine position deviation of the probe)	-
Measuring axis	• X (for G17) • Y (for G17 and G19) • Z (for G19)	-

Parameter	Description	Unit
Measuring direction	Measuring axis: • (+/-) X (for G17) • (+/-) Y (for G17 and G19) • (+/-) Z (for G19)	-
X0 / Y0 / Z0	Reference point	mm
X1/ Y1 / Z1	Position 2. Edge referred to X0 / Y0 / Z0	inc
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Measurements	Number of measurements at the same location (1-9)	-

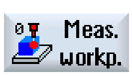
Note

When the calibration is performed for the first time, the default setting in the data field of the probe is still "0". For this reason, the **TSA** parameter must be programmed > probe ball radius to avoid the alarm "Safe area exceeded".

Measuring variant, turning on a milling machine (only 840D sl)

Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Calibrate probe" softkey.

3. Press the "Radius at edge" softkey.
   The input window "Calibrate: Radius at edge" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 40)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Radius on edge" provides the following result parameters:

Table 3-11 "Radius on edge" result parameters

Parameters	Description	Unit
_OVR [4]	Actual value probe ball diameter	mm
_OVR [5]	Difference probe ball diameter	mm
_OVR [8]	Trigger point in minus direction, actual value of 1st axis of the plane	mm
_OVR [10]	Trigger point in plus direction, actual value of 1st axis of the plane	mm
_OVR [40]	Trigger point in minus direction, actual value of 2nd axis of the plane	mm
_OVR [14]	Trigger point in plus direction, actual value of 2nd axis of the plane	mm
_OVR [9]	Trigger point in minus direction, difference of 1st axis of the plane	mm
_OVR [11]	Trigger point in plus direction, difference of 1st axis of the plane	mm
_OVR [13]	Trigger point in minus direction, difference of 2nd axis of the plane	mm
_OVR [15]	Trigger point in plus direction, difference of 2nd axis of the plane	mm
_OVR [20]	Positional deviation of 1st axis of the plane (probe skew)	mm
_OVR [21]	Positional deviation of 2nd axis of the plane (probe skew)	mm
_OVR [24]	Angle at which the trigger points were determined	Degrees
_OVR [27]	Work offset range	mm
_OVR [28]	Safe area	mm
_OVI [2]	Measuring cycle number	-
_OVI [5]	Probe number	-
_OVI [9]	Alarm number	-

3.3.5 Calibrate probe - radius between 2 edges (Cycle976)

3.3.5.1 Function

Function

With this measuring version, a workpiece probe can be calibrated in an axis of the machining plane selected by the user, between two reference surfaces parallel to one another.

Measuring principle

The probe traverses with constant spindle alignment in the selected axis, between the reference surfaces. The traversing path must be at right angles to the reference surfaces.

The determined calibration value (trigger point + position deviation) and probe ball radius are transferred into the addressed calibration data fields.

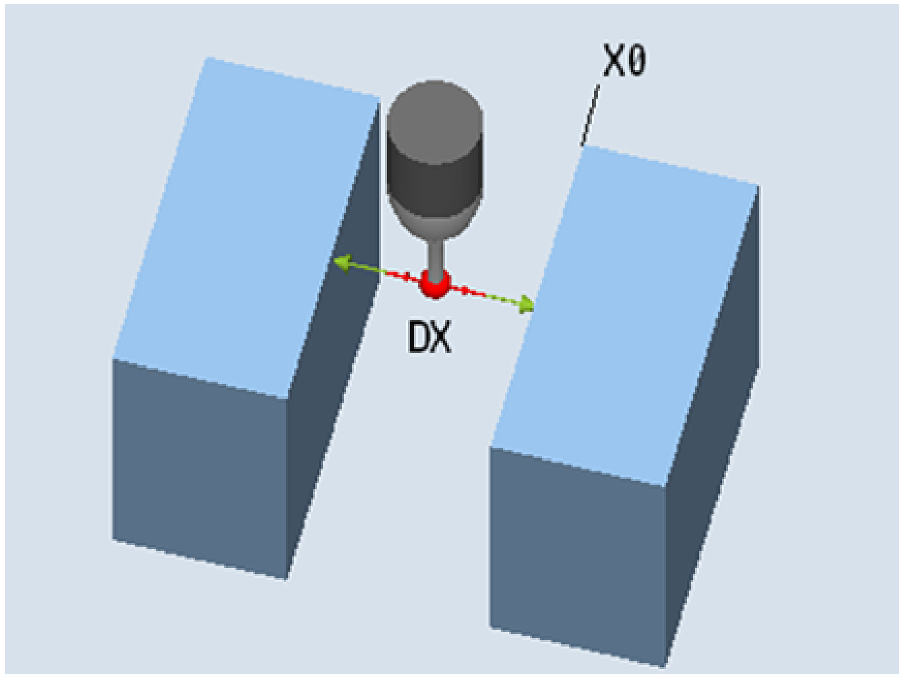


Figure 3-9 Calibrate: Radius between 2 edges (CYCLE976)

Preconditions

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)

Starting position before the measurement

The probe must be positioned at the calibration height, approximately in the middle between the two edges.

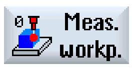
Position after the end of the measuring cycle

The center of the probe is located in the middle between the two reference surfaces.

3.3.5.2 Calling the measuring version

Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Calibrate probe" softkey.

3. Press the "Radius at edge" softkey.
   The input window "Calibrate: Radius at edge" opens.
4. In the selection field, Calibrate directions, select, "2".

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		T	Name of the probe	-
	Calibration data set (1 - 40)	-		D	Cutting edge number (1 - 9)	-
F	Calibration and measuring feedrate	Distance/min			Calibration data set (1 - 40)	-
				F	Calibration and measuring feedrate	mm/min
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Calibration directions	• 1: Calibration in one direction • 2: Calibrations in opposite directions	-
Determine position deviation	• Yes (determine position deviation of the probe) • No (do not determine position deviation of the probe)	-
Measuring axis	• X (for G17) • Y (for G17 and G19) • Z (for G19)	-
Measuring direction	Measuring axis: • (+/-) X (for G17) • (+/-) Y (for G17 and G19) • (+/-) Z (for G19)	-

Parameter	Description	Unit
X0 / Y0 / Z0	Reference point	mm
X1/ Y1 / Z1	Position 2. Edge referred to X0 / Y0 / Z0	inc
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Measurements	Number of measurements at the same location (1-9)	-

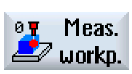
Note

When the calibration is performed for the first time, the default setting in the data field of the probe is still "0". For this reason, the **TSA** parameter must be programmed > probe ball radius to avoid the alarm "Safe area exceeded".

Measuring variant, turning on a milling machine (only 840D sl)

Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Calibrate probe" softkey.

3. Press the "Radius at edge" softkey.
   The input window "Calibrate: Radius at edge" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 40)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

3.3.5.3 Result parameters

List of the result parameters

The measuring version "Radius between two edges" provides the following result parameters:

Table 3-12 "Radius between two edges" result parameters

Parameter	Description	Unit
_OVR [4]	Actual value probe ball diameter	mm
_OVR [5]	Difference probe ball diameter	mm
_OVR [8]	Trigger point in minus direction, actual value of 1st axis of the plane	mm
_OVR [10]	Trigger point in plus direction, actual value of 1st axis of the plane	mm
_OVR [12]	Trigger point in minus direction, actual value of 2nd axis of the plane	mm
_OVR [14]	Trigger point in plus direction, actual value of 2nd axis of the plane	mm
_OVR [9]	Trigger point in minus direction, difference of 1st axis of the plane	mm
_OVR[11]	Trigger point in plus direction, difference of 1st axis of the plane	mm
_OVR[13]	Trigger point in minus direction, difference of 2nd axis of the plane	mm
_OVR[15]	Trigger point in plus direction, difference of 2nd axis of the plane	mm
_OVR[20]	Positional deviation of the 1st axis of the plane (probe skew)	mm
_OVR[21]	Positional deviation of the 2nd axis of the plane (probe skew)	mm
_OVR[27]	Work offset range	mm
_OVR[28]	Safe area	mm
_OVI[2]	Measuring cycle number	-
_OVI[5]	Probe number	-
_OVI[9]	Alarm number	-

The result parameters are written to, which correspond to the selected axis.

3.3.6 Calibrate probe - calibrate on ball (CYCLE976)

Function

Using this measuring method, a workpiece probe can be calibrated at any position in space. This has a special meaning in conjunction with swivel functions and transformations.

The same calibration data is generated as for calibration in the ring:

- Inclined position of the workpiece probe
- Trigger values
- Radius of the probe ball

In addition, the probe length in the tool axis can be determined based on the machine data.

MD51740 $MNS_MEA_FUNCTION_MASK, bit 1 (probe ball center or ball circumference)

The calibration sphere center is determined as supplementary result.

Note

For the version "Positioning on circular path", positioning through 90° is always in the mathematical positive direction.

Measuring principle

The measurement sequence is divided into the following steps:

1. Determining the center point coordinates of the reference sphere
2. Determining the calibration data

This procedure can be made parallel to the axis by passing or moving around the reference sphere.

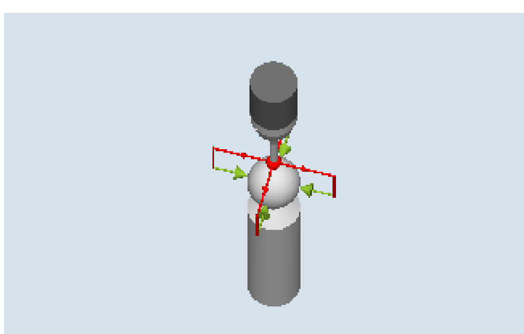


Figure 3-10 Calibration at the sphere (CYCLE976), example of overtravel (intermediate positioning parallel to the axis)

Requirements

- The diameter of the reference sphere must be known.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)
- SPOS-capable spindle required.

Starting position before the measurement

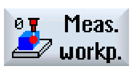
The workpiece probe must be positioned above the reference sphere so that it can be approached collision-free from above and at the circumference.

Position after the end of the measuring cycle

The workpiece probe is located above the sphere center.

Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Calibrate probe" softkey.

3. Press the "Calibrate on ball" softkey.
   The input window "Calibrate: Probe on ball" opens.

Parameter

G code program				ShopMill program		
Parameter	Description	Unit		Parameter	Description	Unit
PL	Measuring plane (G17 - G19)	-		T	Name of the probe	-
	Calibration data set (1 - 40)	-		D	Cutting edge number (1 - 9)	-
F	Calibration and measuring feedrate	Distance/ min			Calibration data set (1 - 40)	-
				F	Calibration and measuring feedrate	mm/min
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Positioning	Travel around sphere • Parallel to the axis • Moving around on a circular path	-
Determine position deviation	• Yes (determine position deviation of the probe) • No (do not determine position deviation of the probe)	-
Calibration in the infeed axis	• Yes (calibrate probe in the plane and infeed axis) • No (calibrate probe in the plane)	-

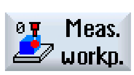
Parameter	Description	Unit
Adapt tool length	• Yes (adapt probe length and trigger point) • No (adapt trigger point only)	-
ZS (for G17)	Upper edge of the calibration sphere (only for adapt tool length "Yes")	mm
∅	Sphere diameter	mm
α0	Contact angle 1)	Degrees
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Measurements	Number of measurements at the same location (1-9)	-

1) The contact angle always refers to the positive direction of the 1st axis of the active coordinate system, e.g. for G17 to +X, G18/+Z, G19/+Y

Measuring variant, turning on a milling machine (only 840D sl)

Procedure

The part program or ShopTurn program to be processed has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Calibrate probe" softkey.

3. Press the "Comp. to sphere" softkey.
   The input window "Calibr.: probe on sphere" opens.

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 40)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Radius on sphere" provides the following result parameters:

Table 3-13 "Radius on sphere" result parameters

Parameters	Description	Unit
_OVR [4]	Actual value probe ball diameter	mm
_OVR [5]	Difference probe ball diameter	mm
_OVR [8]	Trigger point in minus direction, actual value of 1st axis of the plane	mm
_OVR [10]	Trigger point in plus direction, actual value of 1st axis of the plane	mm
_OVR [12]	Trigger point in minus direction, actual value of 2nd axis of the plane	mm
_OVR [14]	Trigger point in plus direction, actual value of 2nd axis of the plane	mm
_OVR [16]	Trigger point in minus direction, actual value of 3rd axis of the plane	mm
_OVR [18]	Trigger point in plus direction, actual value of 3rd axis of the plane	mm
_OVR [9]	Trigger point in minus direction, difference of 1st axis of the plane	mm
_OVR [11]	Trigger point in plus direction, difference of 1st axis of the plane	mm
_OVR [13]	Trigger point in minus direction, difference of 2nd axis of the plane	mm
_OVR [15]	Trigger point in plus direction, difference of 2nd axis of the plane	mm
_OVR [17]	Trigger point in minus direction, difference of 3rd axis of the plane	mm
_OVR [19]	Trigger point in plus direction, difference of 3rd axis of the plane	mm
_OVR [20]	Positional deviation of the 1st axis of the plane (probe skew)	mm
_OVR [21]	Positional deviation of the 2nd axis of the plane (probe skew)	mm
_OVR [22]	Probe length of the workpiece probe	mm
_OVR [24]	Angle at which the trigger points were determined	Degrees
_OVR [27]	Work offset range	mm
_OVR [28]	Safe area	mm
_OVI [2]	Measuring cycle number	-
_OVI [5]	Probe number	-
_OVI [9]	Alarm number	-

3.3.7 Edge distance - set edge (CYCLE978)

Function

This measuring method determines the position of a paraxial edge in the workpiece coordinate system through 1-point measurement.

When using probes with side boom (L probe, type 713), towing measurement is possible in the positive direction of the tool axis.

With the "3D probe with spindle reversal" measuring method, measurement is performed in the axes of the plane as differential measurement. Two measurements are automatically carried out one after the other, one with a spindle position of 180 degrees, and one with 0 degrees. The special procedure for this measurement permits the use of an uncalibrated multi-directional probe. However, the correct tool radius of the probe must be determined once by calibrating the probe. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

With the "Align 3D probe" measuring method, the switching direction of the probe is always aligned to the current measuring direction. This function is recommended when high demands are placed on the measuring accuracy. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

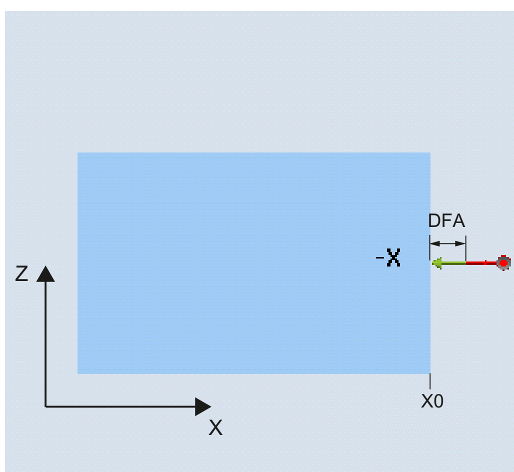
The measurement result (measurement difference) can be used as follows:

- Correction of a work offset
- Offset of a tool
- Measurement without offset

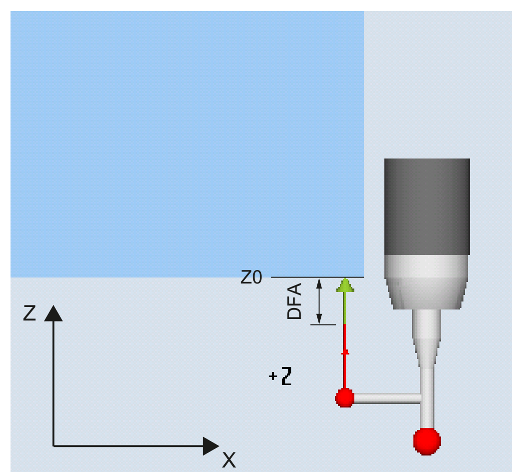
Measuring principle

The measuring cycle determines the actual value of a measuring point, taking into account the calibration values at one edge of the workpiece referred to its zero point.

The difference between the actual value (measured value) and a specified setpoint in the parameterized measuring axis is calculated.



Measure: Edge (CYCLE978)
measuring direction: -X



Measure: Edge (CYCLE978)
measuring direction: +Z (towing measurement)

Preconditions

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)
  - L probe (type 713)

    Note

    L probe application (type 713)

    Measurement in +Z (for towing measurement) is possible with the L probe.

    The basic alignment of the L probe boom is toward +X (offset angle = 0). If the probe boom is to be aligned in a different direction in the measuring program, this can performed through a rotation around the tool axis (e.g. ROT Z = 90).

  - Star-type probe (type 714)

When using the measuring version on lathes:

- Use probe type 710 or 580
- Set the length reference of the workpiece probe to the center of the probe ball: MD51740 $MNS_MEA_FUNCTION_MASK, bit 1 = 0

Note

The following measuring methods are only possible in the axes of the plane:

- 3D probe with spindle reversal (differential measurement)
- Align 3D probe

The probe types 712, 713 and 714 generally **cannot** be used for these measuring methods.

Starting position before the measurement

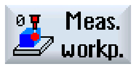
The probe should be positioned at a distance that is somewhat greater than the measurement path (DFA) with respect to the surface to be measured.

Position after the end of the measuring cycle

After the measurement has been completed, the probe ball with its circumference is at a distance of the measuring path DFA with respect to the measuring surface.

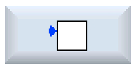
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Edge distance" softkey.



3. Press the "Set edge" softkey.
   The input window "Measure: Edge" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-		**T**	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
PL	Measuring plane (G17 - G19)	-		**Measuring method**	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-			Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
				X	Start point X of the measure-ment	mm
				Y	Start point Y of the measure-ment	mm
				Z	Start point Z of the measure-ment	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured value in a settable WO) 3) – Save measured values in adjustable work offset (active WO, G54, G55, G56, G57, G505, G506) – Coarse/fine (save measured value in coarse offset/save measured value in fine offset) • Tool offset (save measured value in the basis reference) – Coarse/fine (save measured value in coarse offset/save measured value in fine offset) • Channel-specific basis – Save measured values in frame number (1-4) – Coarse/fine (save measured value in coarse offset/save measured value in fine offset) • Tool offset (save measured value in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected (1-9)	-
	• Geometry: Save measured values in the tool geometry • Wear: Save measured values in the tool wear	-
	• Automatic: Automatic selection of the tool length or tool radius • Length L1-L3: Correct tool length L1-L3 • Radius: Correct tool radius	-
Calculation	• Not inverted (tool offset is not calculated inverted) • Inverted (tool offset is calculated inverted)	-
Measuring direction	Measuring axis • +/- X • +/- Y • +/- Z	-
X0 / Y0 / Z0	Setpoint (corresponding to the measuring direction)	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
TDIF	Tolerance range for dimensional difference monitoring	mm
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TZL	Tolerance range for work offset	mm
Data set empirical value	• Without (do not use empirical values) • 1-20 (data set for empirical value)	-
Data set average value	Without (do not generate average value) 1-20 (data set for average value generation)	-
TMV	Range for correction with average value generation	-
FW	Weighting factor for averaging	-
Measurements	Number of measurements at the same location (1-9)	-

1) The "3D probe with spindle reversal" function is shown if bit 16 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

2) The "Align 3D probe" function is shown if bit 17 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

3) Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

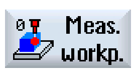
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

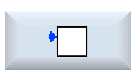
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Edge distance" softkey.



3. Press the "Set edge" softkey.
   The input window "Measure: Edge" opens.

Parameter

ShopTurn program		
Parameters	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1] • Align 3D probe[2]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Set edge" provides the following result parameters:

Table 3-14 "Set edge" result parameters

Parameters	Description	Unit
_OVR [0]	Setpoint value for measuring axis	mm
_OVR [1]	Setpoint in 1st axis of the plane → only for `S_MA=1`	mm

Parameters	Description	Unit
_OVR [2]	Setpoint in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [3]	Setpoint in 3rd axis of the plane → only for `S_MA=3`	mm
_OVR [4]	Actual value for measuring axis	mm
_OVR [5]	Actual value in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [6]	Actual value in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [7]	Actual value in 3rd axis of the plane → only for `S_MA=3`	mm
_OVR [16]	Difference for measuring axis	mm
_OVR [17]	Difference in 1st axis of the plane → only for `S_MA=1`	mm
_OVR [18]	Difference in 2nd axis of the plane → only for `S_MA=2`	mm
_OVR [19]	Difference in 3rd axis of the plane → only for `S_MA=3`	mm
_OVR [21]	Mean value	mm
_OVI [0]	D number or WO number	-
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring variant	-
_OVS_TNAME	Tool name	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, see Additional result parameters (Page 342).

3.3.8 Edge distance - align edge (CYCLE998)

Function

The workpiece lies in any direction, i.e. not parallel to the workpiece coordinate system (WCS) on the work table. By measuring two points on the workpiece reference edge that you have selected, you determine the angle to the active coordinate system. You can correct this angle as a rotation either in a geometry axis or as translatory offset in a rotary axis (rotary table) in any WO or in the active WO.

Note

Maximum measured angle

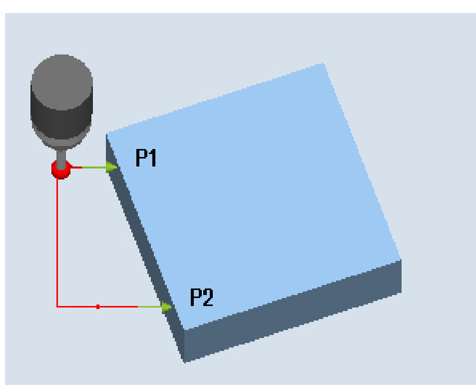
Using the "Align edge" measuring variant, a maximum angle of +/- 45 degrees can be measured.

Measuring principle

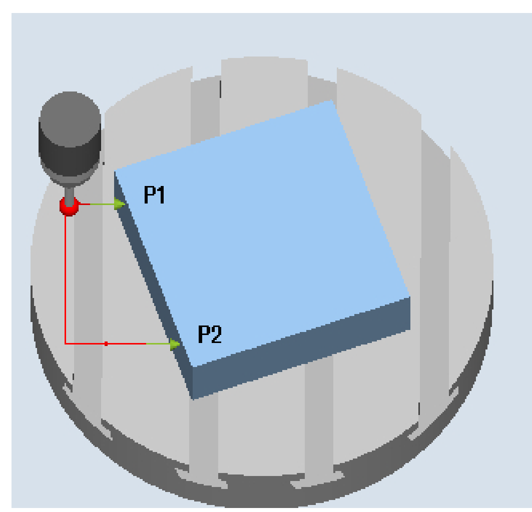
The Align edge measuring variant is performed according to the 1-angle measurement principle:

- For a clamped workpiece that is rotated in the plane, the angular offset is in the rotary part of the geometry axis that is located perpendicular to the measuring plane.
  Example of G17 plane: Measuring axis X, offset axis Y
  - Angular offset is realized in the Z rotation
  - The rotation offset in the WO is performed so that the actual position of the edge (actual value) and the desired setpoint angle (α) in the workpiece coordinate system must be taken into account.
- For a workpiece on a rotary table, the angular offset is added to the translatory offset of the rotary axis (table axis). The correction only makes sense if the rotary axis rotates around the geometry axis that is located perpendicular to the measuring plane.
  Example of G17 plane: Measuring axis X, offset axis Y
  - Angular offset is realized in the C axis. Rotary axis C rotates a rotary table around the Z axis.
  - After the measurement, the rotary axis should be repositioned to align the workpiece.
  - Example: G55 G0 C0.

For both correction variants, the translatory components of the WO remain unchanged and should be redetermined after the edge has been aligned. This can be realized in a subsequent measuring program using the function "Set edge".



Measure: Align edge (CYCLE998), workpiece clamped in the plane



Measure: Align edge (CYCLE998), workpiece clamped on rotary table C axis

Measuring without spindle reversal

Precise measurement is only possible with a calibrated probe, i.e. machining plane, orientation of the spindle in the plane and measuring velocity are the same for both measurement and calibration. Deviations can cause additional measuring errors.

Measuring with spindle reversal

With measuring method "3D probe with spindle reversal", measuring point P1 is measured twice each with 180 degrees spindle reversal (probe rotated through 180 degrees) and 0 degrees. This means that the trigger points for the corresponding axis direction are currently being newly determined for this measurement (it is not necessary to calibrate the probe in the measuring direction). The measuring method "3D probe with spindle reversal" only makes sense for align edge of the axes in the working plane (for G17 XY).

The special procedure for this measurement permits the use of an uncalibrated multi-directional probe. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

Requirements

- The probe must be called as a tool with a tool length compensation.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)

Note

Precisely determining the angle requires the corresponding surface quality at least at one of the measuring points. The distances between the measuring points should be selected as high as possible.

Note

The "3D probe with spindle reversal" function (differential measurement) is only possible in the axes of the plane. The probe types 712, 713 and 714 generally **cannot** be used for this measuring method.

Starting position before the measurement

Measuring axis and positioning axis (offset axis) can be preselected as required; however, they may not be the same.

Positioning taking into account a protection zone

- Protection zone = no
  The probe is positioned in the measuring axis, as a maximum at the distance of measurement path DFA with respect to the surface to be measured in front of measuring point P1 at the measuring height.
- Protection zone = yes
  The probe is positioned in the measuring axis as a maximum the distance from the measuring path DFA and the absolute value in parameter DX (for G17 and measuring axis X) with respect to the surface to be measured in front of measuring point P1 at the measuring height.

In both cases, when making the measurement, measuring point P1 must be able to be safely reached.

If the distances from the reference edge are selected too large for the 1st measurement, then a measurement is not made.

Intermediate positioning from measuring point P1 to measuring point P2

Intermediate positioning "parallel to the edge"

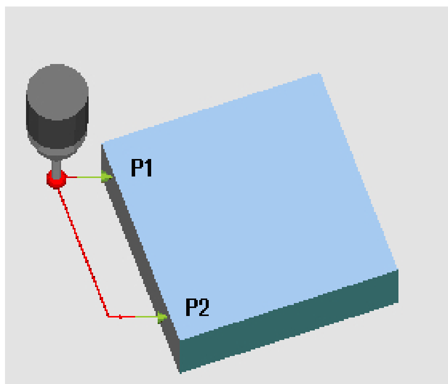


Figure 3-11 Aligning the edge (CYCLE998), intermediate positioning "parallel to the edge"

The probe travels parallel to the reference edge at the distance of parameter L2 in front of measuring point P2. In so doing, the angle from parameters **α** and **TSA** is taken into account. TSA contains the value for the maximum permissible angular deviation.

Intermediate positioning "parallel to the axis"

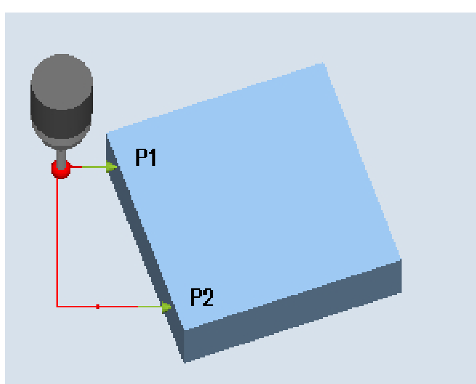


Figure 3-12 Aligning the edge (CYCLE998), intermediate positioning "parallel to the axis"

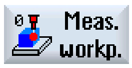
The probe travels parallel to the positioning axis (offset axis) at a distance of parameter L2 in front of measuring point P2.

Position after the end of the measuring cycle

After the end of measurement, the probe is at measuring point P2 at the distance of the measurement path DFA with respect to the measuring surface.

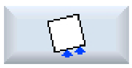
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Edge distance" softkey.



3. Press the "Align edge" softkey.
   The input window "Measure: Align edge" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal 1)	-		**T**	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
PL	Measuring plane (G17 - G19)	-		**Measuring method**	• Standard measuring method • 3D probe with spindle reversal 1)	-
	Calibration data set (1 - 40) (only for standard measuring method)	-			Calibration data set (1 - 40) (only for standard measuring method)	-
				X	Start point X of the measure-ment	mm
				Y	Start point Y of the measure-ment	mm
				Z	Start point Z of the measure-ment	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) 2) • Basis reference • Channel-specific basis (save measured values in frame numbers 1-4)	-
Angular offset (only for "work offset")	Offset results in: • Coordinate system rotation • Rotary axis rotation C 3)	-
Positioning	Position probe: • Parallel to the axis • Parallel to the edge	-

Parameter	Description	Unit
Measuring direction	Measuring axis • (+/-) X • (+/-) Y • (+/-) Z	-
Positioning axis	Offset axis (**Note:** Measuring axis and offset axis may not be the same!) • X • Y • Z	-
α	Angle between positioning axis and edge [4]	Degrees
L2	Distance to the 2nd measuring point [5]	mm
Protection zone	Use protection zone • Yes • No	-
DX / DY / DZ (corresponding to the measuring direction)	Distance to the edge for measuring point 1 (only for protection zone "Yes")	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	Degrees
Data set empirical value	• Without (do not use empirical values) • 1-20 (data set for empirical value)	-
Measurements	Number of measurements at the same location (1-9)	-

1) The "3D probe with spindle reversal" function is shown if bit 16 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

2) Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

3) To display the corresponding rotary axis as offset target, bit 6 must be set to 1 in the channel-specific MD 52207 $MCS_AXIS_USAGE_ATTRIB.

If the offset (correction) involves more than one rotation around one of the geometry axes, then this offset cannot be executed by a rotary axis. Alarm 61403 "Correction of the work offset not executed" is output.

4) By specifying the measuring axis in parameter **measuring direction**, then all three measuring planes are possible. Setpoint angle **α** therefore refers to the positive direction of the offset axis and is negative in the clockwise sense, positive in the counter-clockwise sense.
Setpoint angle **α** specifies the required angle between the edge and the positive direction of the offset axis. For **α**=0 (`S_STA=0`) , after correction, regarding the offset axis, the edge is parallel to the axis.
When positioning "Parallel to the edge", angle **α** is also used for positioning. The positioning angle is generated together with parameter **TSA**. Parameter **α** should therefore only deviate a small amount from the measured angle!

5) With parameter **L2** (`S_ID`) the distance in the offset axis between P1 and P2 is defined. Only positive values are permissible for **L2**. Accordingly, P1 should be selected in the offset axis at the beginning of the cycle.

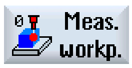
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

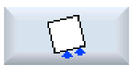
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Edge distance" softkey.



3. Press the "Align edge" softkey.
   The input window "Measure: Align edge" opens.

Parameter

ShopTurn program		
Parameters	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)]	-
	Calibration data set (1 - 40) (only for standard measuring method)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Align edge" provides the following result parameters:

Table 3-15 "Align edge" result parameters

Parameters	Description	Unit
_OVR [0]	Angle setpoint	Degrees
_OVR [4]	Angle actual value	Degrees
_OVR [16]	Angle difference	Degrees
_OVR [20]	Angle offset value	Degrees
_OVR [28]	Safe area	Degrees
_OVR [30]	Empirical value	Degrees
_OVI [0]	WO number	-
_OVI [2]	Measuring cycle number	-
_OVI [5]	Probe number	-
_OVI [7]	Empirical value memory number	-
_OVI [9]	Alarm number	-

3.3.9 Edge distance - groove (CYCLE977)

Function

This measuring variant can be used to measure a groove in a workpiece. The groove width is measured and the groove center point determined. Measurements at an inclined groove are also possible. To do this, an angle corresponding to the actual angularity of the groove position should be entered into the parameterizing screen form. Probing at the groove edge always takes place at right angles. A protection zone can be defined in the groove.

With the "3D probe with spindle reversal" measuring method, measurement is performed in the axes of the plane as differential measurement. Two complete measurements of the groove are automatically carried out one after the other, one with a spindle position of 180 degrees, and one with 0 degrees. The special procedure for this measurement permits the use of an uncalibrated multi-directional probe. However, the correct tool radius of the probe must be determined once by calibrating the probe. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

With the "Align 3D probe" measuring method, the switching direction of the probe is always aligned to the current measuring direction. This function is recommended when high demands are placed on the measuring accuracy. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

The measurement result (measurement difference) can be used as follows:

- Correction of a WO so that the workpiece zero is in relation to the groove center point.
- Offset of a tool
- Measurement without offset

Measuring principle

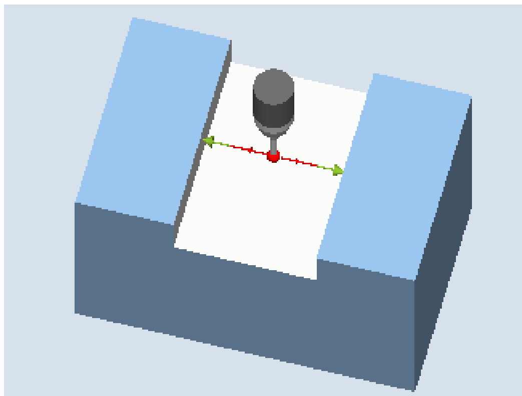
One point at each of the opposite edges of the slot are measured based on the selected measuring axis. The positive direction of the geometry axis is measured first.

From the two actual positions, taking into account the calibration values, the groove width is calculated.

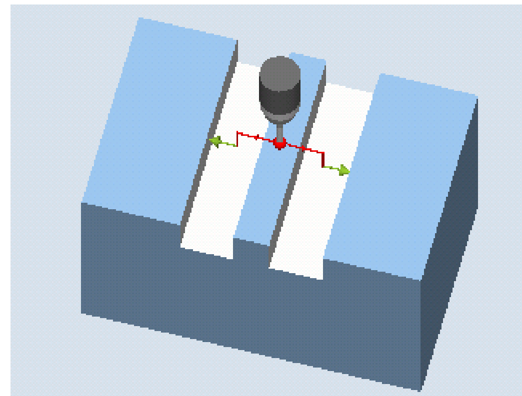
The position of the groove center as workpiece zero is determined corresponding to the work offset selected to be corrected.

With the selection Setpoint center point "YES", the position of the groove center can be defined as workpiece zero through setpoint specifications.

The measured difference of the groove width is used as basic variable for a tool offset, the position of groove zero point, as basis of a work offset.



Measure: Groove (CYCLE977)



Measure: Groove with protection zone (CY-CLE977)

Requirements

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)

Note

The following measuring methods are only possible in the axes of the plane:

- 3D probe with spindle reversal (differential measurement)
- Align 3D probe

The probe types 712, 713 and 714 generally **cannot** be used for these measuring methods.

Starting position before the measurement

The probe should be positioned with the probe ball center in the measuring axis approximately at the center of the groove and at the measuring height. For a protection zone, the probe ball should be positioned in the measuring axis approximately centered to the groove and at a height above the protection zone. With the infeed path that has been entered, it must be guaranteed that from this height the desired measuring height in the groove can be reached.

Note

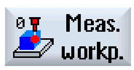
If too large a measurement path DFA has been selected so that the protection zone is violated, then the distance is reduced automatically in the cycle. However, there must be sufficient room for the probe ball.

Position after the end of the measuring cycle

Without activated protection zone, the probe ball is at the measuring height in the center of the groove. With protection zone, the probe ball is centered with respect to the groove over the protection zone at the starting position of the measuring cycles.

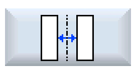
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Edge distance" softkey.



3. Press the "Groove" softkey.
   The input window "Measure: Groove" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-		**T**	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
PL	Measuring plane (G17 - G19)	-		**Measuring method**	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-			Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [3)] – Save measured values in adjustable work offset (active WO, G54, G55, G56, G57, G505, G506) – Coarse/fine (save measured value in coarse offset/save measured value in fine offset) • Basis reference – Coarse/fine (save measured value in coarse offset/save measured value in fine offset) • Channel-specific basis – Save measured values in frame number (1-4) – Coarse/fine (save measured value in coarse offset/save measured value in fine offset) • Tool offset (save measured values in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected (1-9)	-
	• Geometry: Save measured values in the tool geometry • Wear: Save measured values in the tool wear	
	• Automatic: Automatic selection of the tool length or tool radius • Length L1-L3: Correct tool length L1-L3 • Radius: Correct tool radius	
Calculation	• Not inverted (tool offset is not calculated inverted) • Inverted (tool offset is calculated inverted)	
Measuring axis	Measuring axis (for G17): • X • Y	-
W	Groove width setpoint	mm
XM, YM	Setpoint value specification for the for the center point of the groove, corresponding to the measuring axis (only for setpoint center point "Yes")	mm
α0	Angle between measuring axis and workpiece	Degrees
Protection zone	Use protection zone • Yes • No	-
WS	Width of the protection zone (only for protection zone "Yes")	mm
DZ	Infeed distance at measuring height (for G17) (only for protection zone "Yes")	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
TDIF	Tolerance range for dimensional difference monitoring	mm
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TZL	Tolerance range for work offset	mm

Parameter	Description	Unit
Data set empirical value	• Without (do not use empirical values) • 1-20 (data set for empirical value)	-
Data set average value	Without (do not generate average value) 1-20 (data set for average value generation)	-
TMV	Range for correction with average value generation	-
FW	Weighting factor for averaging	-
Measurements	Number of measurements at the same location	-

1) The "3D probe with spindle reversal" function is shown if bit 16 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

2) The "Align 3D probe" function is shown if bit 17 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

3) Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

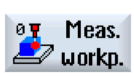
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

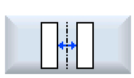
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Edge distance" softkey.



3. Press the "Groove" softkey. The input window "Measure: Groove" opens.

Parameter

ShopTurn program		
Parameters	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1] • Align 3D probe[2]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Groove" provides the following result parameters:

Table 3-16 "Groove" result parameters

Parameters	Description	Unit
_OVR [0]	Groove width setpoint	mm
_OVR [1]	Groove center setpoint in the 1st axis of the plane	mm
_OVR [2]	Groove center setpoint in the 2nd axis of the plane	mm
_OVR [4]	Groove width actual value	mm
_OVR [5]	Groove center actual value in the 1st axis of the plane	mm
_OVR [6]	Groove center actual value in the 2nd axis of the plane	mm
_OVR [16]	Groove width difference	mm
_OVR [17]	Groove center difference in the 1st axis of the plane	mm
_OVR [18]	Groove center difference in the 2nd axis of the plane	mm
_OVI [0]	D number or WO number	-
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring variant	-
_OVS_TNAME	Tool name	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, see Additional result parameters (Page 342).

3.3.10 Edge distance - rib (CYCLE977)

Function

This measuring variant can be used to measure a rib on a workpiece. The rib width is measured and the rib center point is determined.

Measurements at an inclined rib are also possible. To do this, an angle corresponding to the actual angularity of the rib position should be entered into the parameterizing screen form. Probing at the rib edge always takes place at right angles. A protection zone can be defined at the side of the rib.

With the "3D probe with spindle reversal" measuring method, measurement is performed in the axes of the plane as differential measurement. Two complete measurements of the rib are automatically carried out one after the other, one with a spindle position of 180 degrees, and one with 0 degrees. The special procedure for this measurement permits the use of an uncalibrated multi-directional probe. However, the correct tool radius of the probe must be determined once by calibrating the probe. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

With the "Align 3D probe" measuring method, the switching direction of the probe is always aligned to the current measuring direction. This function is recommended when high demands are placed on the measuring accuracy. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

The measurement result (measurement difference) can be used as follows:

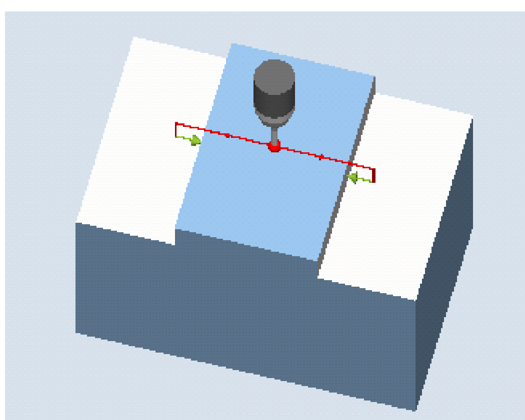
- Correction of a WO so that the workpiece zero is in relation to the rib center point.
- Offset of a tool
- Measurement without offset

Measuring principle

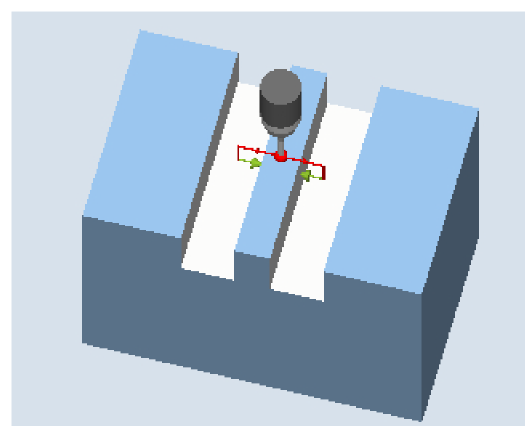
One point at each of the opposite edges of the rib are measured based on the selected measuring axis. The positive direction of the geometry axis is measured first. From the two actual positions, taking into account the calibration values, the rib width is calculated. The position of the rib center as workpiece zero is determined corresponding to the work offset selected to be corrected.

With the selection Setpoint center point "YES", the position of the rib center can be defined as workpiece zero through setpoint specifications.

The measured difference of the rib width is used as basic variable for a tool offset, the position of rib zero point, as basis of a work offset.



Measure: Rib (CYCLE977)



Measure: Rib with a protection zone (CYCLE977)

Requirements

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)

Note

The following measuring methods are only possible in the axes of the plane:

- 3D probe with spindle reversal (differential measurement)
- Align 3D probe

The probe types 712, 713 and 714 generally **cannot** be used for these measuring methods.

Starting position before the measurement

The probe should be positioned with the probe ball center in the measuring axis approximately above the center of the rib. With the entered infeed path, it must be ensured that from the starting height the required measuring height at the rib is reached.

Note

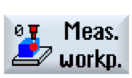
If too large a measurement path DFA has been selected so that the protection zone is violated, then the distance is reduced automatically in the cycle. However, there must be sufficient room for the probe ball.

Position after the end of the measuring cycle

The probe ball is centered above the rib at the height of the starting position of the measuring cycles.

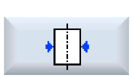
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Edge distance" softkey.



3. Press the "Rib" softkey.
   The input window "Measure: Rib" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-		**T**	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
PL	Measuring plane (G17 - G19)	-		**Measuring method**	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-			Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [3)] – Save measured values in a settable work offset (active WO, G54, G55, G56, G57, G505, G506) – Coarse/fine (save measured value in coarse offset/save measured value in fine offset) • Basis reference – Coarse/fine (save measured value in coarse offset/save measured value in fine offset) • Channel-specific basis – Save measured values in frame number (1-4) – Coarse/fine (save measured value in coarse offset/save measured value in fine offset) • Tool offset (save measured values in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected (1-9)	-
	• Geometry: Save measured values in the tool geometry • Wear: Save measured values in the tool wear	-

Parameter	Description	Unit
	• Automatic: Automatic selection of the tool length or tool radius • Length L1-L3: Correct tool length L1-L3 • Radius: Correct tool radius	-
Calculation	• Not inverted (tool offset is not calculated inverted) • Inverted (tool offset is calculated inverted)	-
Measuring axis	Measuring axis (for measuring plane G17) • X • Y	-
W	Rib width setpoint	mm
XM, YM	Setpoint value specification for the center point of the rib, corresponding to the measuring axis (only for setpoint center point "Yes")	mm
α0	Angle between measuring axis and workpiece	Degrees
DZ	Infeed distance at measuring height (for measuring plane G17)	mm
Protection zone	Use protection zone • Yes • No	-
WS	Width of the protection zone (only for protection zone "Yes")	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
TDIF	Tolerance range for dimensional difference monitoring	mm
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TZL	Tolerance range for work offset	mm
Data set empirical value	• Without (do not use empirical values) • 1-20 (data set for empirical value)	-
Data set average value	• Without (do not generate average value) • 1-20 (data set for average value generation)	-
TMV	Range for correction with average value generation	-
FW	Weighting factor for averaging	-
Measurements	Number of measurements at the same location	-

[1] The "3D probe with spindle reversal" function is shown if bit 16 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[2] The "Align 3D probe" function is shown if bit 17 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[3] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

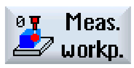
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

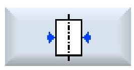
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Edge distance" softkey.



3. Press the "Rib" softkey.
   The input window "Measure: Rib" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Rib" provides the following result parameters:

Table 3-17 "Rib" result parameters

Parameters	Description	Unit
_OVR [0]	Rib width setpoint	mm
_OVR [1]	Rib center setpoint in the 1st axis of the plane	mm
_OVR [2]	Rib center setpoint in the 2nd axis of the plane	mm
_OVR [4]	Rib width actual value	mm
_OVR [5]	Rib center actual value in the 1st axis of the plane	mm
_OVR [6]	Rib center actual value in the 2nd axis of the plane	mm
_OVR [16]	Rib width difference	mm
_OVR [17]	Rib center difference in the 1st axis of the plane	mm
_OVR [18]	Rib center difference in the 2nd axis of the plane	mm
_OVI [0]	D number or WO number	-

Parameters	Description	Unit
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring variant	-
_OVS_TNAME	Tool name	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, see Additional result parameters (Page 342).

3.3.11 Corner - right-angled corner (CYCLE961)

Function

This measuring variant can be used to measure a right-angled inside or outside corner of a workpiece.

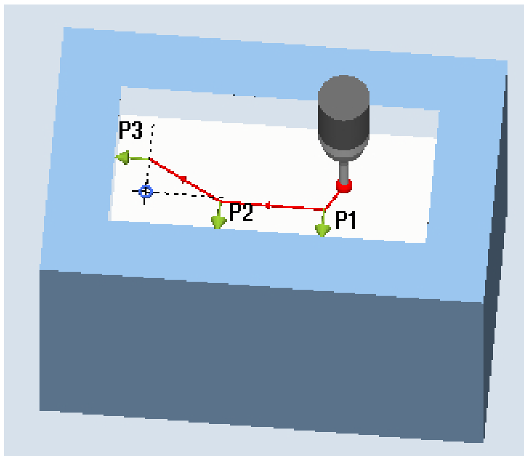
In addition to the measurement, the position of the corner can be used as workpiece zero in a specified work offset (WO).

The measurements are performed paraxially to the machine coordinate system. Rotation of the coordinates about Z is not taken into consideration. To traverse the probe parallel to the edges to the corner to be measured, this must be achieved by means of corresponding angle specifications in mask parameter α0.

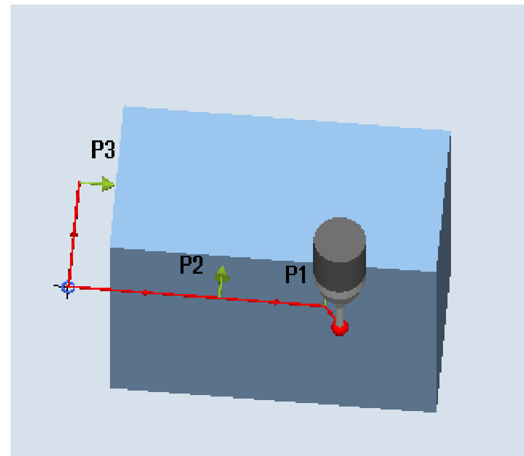
Measuring principle

The measuring cycle moves to 3 measuring points and determines the point of intersection of the resulting straight lines and the angle of rotation to the positive 1st axis of the actual plane. The corner to be calculated can be offset.

The result, the position of the corner is saved as an absolute value in the result parameters _OVR[ ] and optionally in the specified zero offset (offset and rotation). The measured corner is shifted by the values in setpoint parameter (X0, Y0 for G17) in the workpiece coordinate system in the plane.



Measure: Right-angled corner, inner (CYCLE961)



Measure: Right-angled corner, outer (CYCLE961)

Requirements

- The probe must be called as a tool with a tool length compensation.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)

Starting position before the measurement

The probe is at the measuring height or above the corner (see protection zone) opposite to the corner to be measured or in front of the 1st measuring point.

The measuring points must be able to be approached from here collision-free.

The measuring points are derived from the programmed distances L1 to L3 and the pole position (XP, YP). When positioning, α0 (angle between the X axis and 1st edge in MCS) is also taken into account.

The measuring cycle generates the required traversing blocks and performs the measurements at the measuring points P1 to P3, starting with P1.

Positioning measuring points P1 to P3 taking into account a protection zone

- Protection zone = no
  The probe is pre-positioned at the measuring height and remains at this measuring height when measuring the corner. An outer corner is traversed around.
- Protection zone = yes
  The probe is pre-positioned above the corner. When measuring, the 3rd axis of the plane (Z for G17) is moved by the value in parameter DZ to the measuring height and the corresponding measuring point is measured. After the measurement, the probe is raised by the value of parameter DZ and moves to the next measuring point, where it is lowered again.

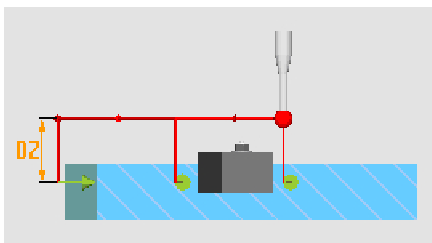


Figure 3-13 Protection zone = yes Traversing around the outer corner with DZ>0 (measuring height + DZ) for G17

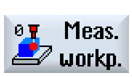
Position after the end of the measuring cycle

The probe is at the starting position again (opposite the measured corner).

Depending on the protection zone parameter yes/no, the probe is at the measuring height or above the corner.

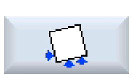
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Corner" softkey.



3. Press the "Right-angled corner" softkey.
   The input window "Measure: Right-angled corner" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		**T**	Name of the probe	-
	Calibration data set (1 - 40)	-		**D**	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description		Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [1)]		-
Position	Type of corner:		-
	Outside corner	Inside corner	-
Position of the corner	• • • •	• • • •	-
X0	Setpoint X of the corner (for measuring plane G17)		mm
Y0	Setpoint Y of the corner (for measuring plane G17)		mm
XP	Pole (for measuring plane G17)		mm
YP	Pole (for measuring plane G17)		mm
α0	Angle specification with regard to the angle reference edge to be measured and the 1st geometry axis of the active plane in the machine coordinate system (MCS). This allows the axes to be traversed to the angle parallel to the edges.		Degrees
L1	Distance between the pole and measuring point P1 in the direction of the 1st axis of the plane (for G17, X)		mm
L2	Distance between the pole and measuring point P2 in the direction of the 1st axis of the plane		mm
L3	Distance between the pole and measuring point P3 in the direction of the 2nd axis of the plane (for G17, Y)		mm
Protection zone	Use protection zone • Yes • No		-
DZ	Infeed distance at measuring height (only for protection zone "Yes")		mm
DFA	Measurement path		mm
TSA	Safe area for the measurement result		mm

[1)] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

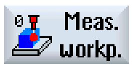
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

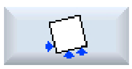
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Corner" softkey.



3. Press the "Right-angled corner" softkey.
   The input window "Measure: Right-angled corner" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 40)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Right-angled corner" provides the following result parameters:

Table 3-18 "Right-angled corner" result parameters

Parameters	Description	Unit
_OVR [4]	The actual angle value of the angle reference edge to be measured, relative to the 1st geo-axis of the active plane in the workpiece coordinate system (WCS).	Degrees
_OVR [5]	Corner point actual value in the 1st axis of the plane in the WCS	mm
_OVR [6]	Corner point actual value in the 2nd axis of the plane in the WCS	mm
_OVR [20]	The actual angle value of the angle reference edge to be measured, relative to the 1st geo-axis of the active plane in the machine coordinate system (WCS). [1)]	Degrees
_OVR [21]	Corner point actual value in the 1st axis of the plane in the MCS [1)]	mm
_OVR [22]	Corner point actual value in the 2nd axis of the plane in the MCS [1)]	mm
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring version	-
_OVI [5]	Probe number	-
_OVI [9]	Alarm number	-

[1)] For deactivated transformation, otherwise basic coordinate system

3.3.12 Corner - any corner (CYCLE961)

Function

This measuring variant can be used to measure the inside or outside corner of an unknown workpiece geometry. The measurements are performed paraxially to the machine coordinate system. Rotation of the coordinates about Z is not taken into consideration. To traverse the probe parallel to the edges to the corner to be measured, this must be achieved by means of corresponding angle specifications in mask parameter α0.

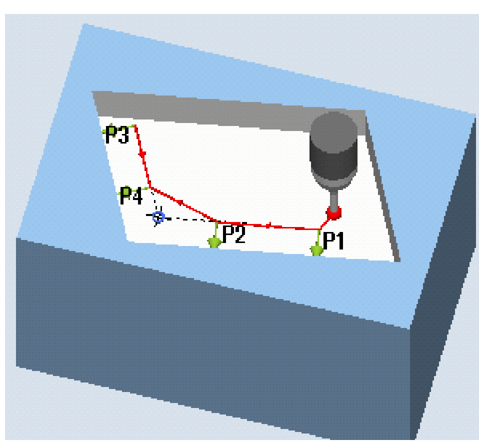
In addition to the measurement, the position of the corner can be used as workpiece zero in a specified work offset (WO).

Measuring principle

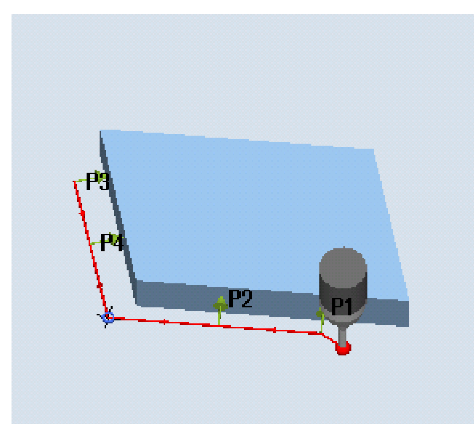
The measuring cycle traverses to the 4 measuring points (P1 to P4) one after the other and establishes the point of intersection of the resulting straight lines and the angle of rotation to the reference edge of measuring points P1 and P2 to the 1st axis of the plane (X for G17) in the positive direction

The result (the position of the corner) is saved as an absolute value in the result parameters _OVR[ ] and optionally in the specified work offset (offset and rotation). The measured corner is shifted by the values in setpoint parameter (X0, Y0 for G17) in the workpiece coordinate system in the plane.

The position of points P1 and P2 in relation to each other determines the direction of the 1st axis of the plane of the new coordinate system.



Measure: Any corner, inside (CYCLE961)



Measure: Any corner, outside (CYCLE961)

Requirements

- The probe must be called as a tool with a tool length compensation.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)

Starting position before the measurement

The probe is at the measuring height or above the corner (see protection zone) opposite to the corner to be measured or in front of the 1st measuring point.

The measuring points must be able to be approached from here collision-free.

The measuring cycle generates the required traversing blocks and performs the measurements at the measuring points P1 to P4, starting with P1.

Positioning measuring points P1 to P4 taking into account a protection zone

- Protection zone = no
  The probe is pre-positioned at the measuring height and remains at this measuring height when measuring the corner. An outer corner is traversed around.
- Protection zone = yes
  The probe is pre-positioned above the corner. When measuring, the 3rd axis of the plane (Z for G17) is moved by the value in parameter DZ to the measuring height, and the corresponding measuring point is measured. After the measurement, the probe is raised by the value of parameter DZ and moves to the next measuring point, where it is lowered again.

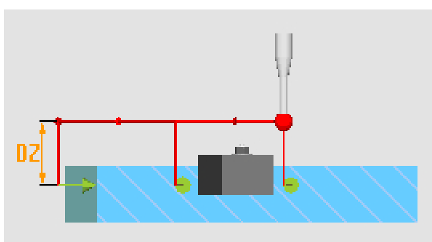


Figure 3-14 Protection zone = yes: Traversing around the outer corner with DZ>0 (measuring height + DZ) for G17

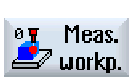
Position after the end of the measuring cycle

After the last measurement, the probe is at measuring point P4.

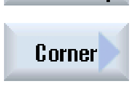
Depending on the protection zone parameter (yes/no), the probe is at the measuring height or above the corner.

Procedure

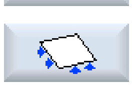
The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.



2. Press the "Corner" softkey.



3. Press the "Any corner" softkey.
   The input window "Measure: Any corner" opens

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		**T**	Name of the probe	-
	Calibration data set (1 - 40)	-		**D**	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description		Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [1]		-
Coordinate system	• Polar • Right-angled		-
Position	Type of corner:		-
	Outside corner	Inside corner	-
Position of the corner	• • • •	• • • •	-
X0	Setpoint X of the measured corner (X for G17)		mm
Y0	Setpoint Y of the measured corner (X for G17)		mm
Only for coordinate system = "Polar":			
XP	Position of the pole in the 1st axis of the plane (X for G17)		mm
YP	Position of the pole in the 2nd axis of the plane (Y for G17)		mm
α0	Angle specification with regard to the angle reference edge to be measured and the 1st geometry axis of the active plane in the machine coordinate system (MCS). This allows the axes to be traversed to the angle parallel to the edges.		Degrees
L1	Distance to the start position of the 1st measurement		mm
L2	Distance to the start position of the 2nd measurement		mm
α1	Opening angle		Degrees
L3	Distance to the start position of the 3rd measurement		mm
L4	Distance to the start position of the 4th measurement		mm
Only for coordinate system = "Right-angled":			
X1	Start position X of the 1st measurement		mm
Y1	Start position Y of the 1st measurement		mm
X2	Start position X of the 2nd measurement		mm
Y2	Start position Y of the 2nd measurement		mm
X3	Start position X of the 3rd measurement		mm
Y3	Start position Y of the 3rd measurement		mm
X4	Start position X of the 4th measurement		mm

Parameter	Description	Unit
Y4	Start position Y of the 4th measurement	mm
Protection zone	Use protection zone • Yes • No	-
DZ	Infeed distance at measuring height (only for protection zone "Yes")	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

[1)] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

Machine manufacturer

Please observe the information provided by the machine manufacturer.

Note

The four measuring points or the measuring path DFA must be selected so that contour within the total path: 2 · DFA [in mm] is reached. Otherwise, no measurement will be able to be made.

Internally in the cycle, a minimum value of 20 mm for the measurement distance DFA is generated.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		**T**	Name of the probe	-
	Calibration data set (1 - 40)	-		**D**	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description		Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [1)]		-
Coordinate system	• Polar • Right-angled		-
Position	Type of corner:		-
	Outside corner	Inside corner	-

Parameter	Description	Unit
Position of the corner	• • • • • • • •	-
X0	Setpoint X of the measured corner (X for G17)	mm
Y0	Setpoint Y of the measured corner (X for G17)	mm
Only for coordinate system = "Polar":		
XP	Position of the pole in the 1st axis of the plane (X for G17)	mm
YP	Position of the pole in the 2nd axis of the plane (Y for G17)	mm
α0	Angle between X axis and the 1st edge (for G17)	Degrees
L1	Distance to the start position of the 1st measurement	mm
L2	Distance to the start position of the 2nd measurement	mm
α1	Opening angle	Degrees
L3	Distance to the start position of the 3rd measurement	mm
L4	Distance to the start position of the 4th measurement	mm
Only for coordinate system = "Right-angled":		
X1	Start position X of the 1st measurement	mm
Y1	Start position Y of the 1st measurement	mm
X2	Start position X of the 2nd measurement	mm
Y2	Start position Y of the 2nd measurement	mm
X3	Start position X of the 3rd measurement	mm
Y3	Start position Y of the 3rd measurement	mm
X4	Start position X of the 4th measurement	mm
Y4	Start position Y of the 4th measurement	mm
Protection zone	Use protection zone • Yes • No	-
DZ	Infeed distance at measuring height (only for protection zone "Yes")	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

[1] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

Machine manufacturer

Please observe the information provided by the machine manufacturer.

Note

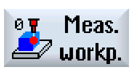
The four measuring points or the measuring path DFA must be selected so that contour within the total path: 2 · DFA [in mm] is reached. Otherwise, no measurement will be able to be made.

Internally in the cycle, a minimum value of 20 mm for the measurement distance DFA is generated.

Measuring variant, turning on a milling machine (only 840D sl)

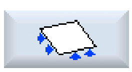
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Corner" softkey.



3. Press the "Any corner" softkey.
   The input window "Measure: Any corner" opens

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 40)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Any corner" provides the following result parameters:

Table 3-19 "Any corner" result parameters

Parameters	Description	Unit
_OVR [4]	The actual angle value of the angle reference edge to be measured, relative to the 1st geo-axis of the active plane in the workpiece coordinate system (WCS).	Degrees
_OVR [5]	Corner point actual value in the 1st axis of the plane in the WCS	mm
_OVR [6]	Corner point actual value in the 2nd axis of the plane in the WCS	mm
_OVR [20]	The actual angle value of the angle reference edge to be measured, relative to the 1st geo-axis of the active plane in the machine coordinate system (WCS). [1)]	Degrees

Parameters	Description	Unit
_OVR [21]	Corner point actual value in the 1st axis of the plane in the MCS [1)]	mm
_OVR [22]	Corner point actual value in the 2nd axis of the plane in the MCS [1)]	mm
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring version	-
_OVI [5]	Probe number	-
_OVI [9]	Alarm number	-

[1)] For deactivated transformation, otherwise basic coordinate system

3.3.13 Hole - rectangular pocket (CYCLE977)

Function

This measuring variant can be used to measure a rectangular pocket in a workpiece. The pocket width and the pocket length are measured and the pocket center point is determined.

The measurements are always performed parallel to the geometry axis of the active plane. Measurements are also possible at a rectangular pocket rotated around the infeed axis. To do this, an angle corresponding to the real pocket position must be entered into the parameterization screen form. Probing at the sides of the pocket is always at right angles to these. A protection zone can be defined in the pocket.

With the "3D probe with spindle reversal" measuring method, measurement is performed in the axes of the plane as differential measurement. Two complete measurements of the rectangular pocket are automatically carried out one after the other, one with a spindle position of 180 degrees, and one with 0 degrees. The special procedure for this measurement permits the use of an uncalibrated multi-directional probe. However, the correct tool radius of the probe must be determined once by calibrating the probe. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

With the "Align 3D probe" measuring method, the switching direction of the probe is always aligned to the current measuring direction. This function is recommended when high demands are placed on the measuring accuracy. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

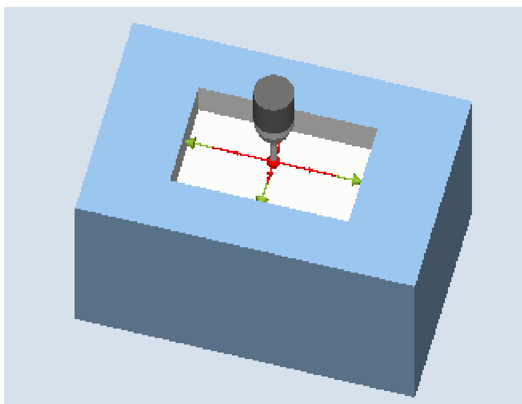
The measurement result (measurement difference) can be used as follows:

- Correction of a WO so that the workpiece zero is in relation to the center point of the rectangle
- Offset of a tool
- Measurement without offset

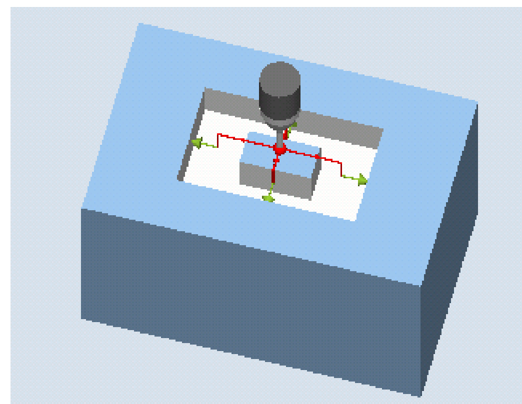
Measuring principle

Two opposite points in each of the two geometry axes of the plane are measured. The measurements start in the positive direction of the 1st geometry axis. From the four measured actual positions of the pocket sides, the pocket width and the pocket length are calculated, taking into account the calibration values. The position of the pocket center as workpiece zero is determined corresponding to the work offset selected to be corrected. The measuring differences of the side lengths are used as the basic quantity for a tool offset, the position of the pocket zero point as basis for the work offset.

With the selection Setpoint center point "YES", the position of the rectangular pocket center can be defined as workpiece zero through setpoint specifications.



Measure: Rectangular pocket (CYCLE977)



Measure: Rectangular pocket with protection zone (CYCLE977)

Requirements

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)
  - Star-type probe (type 714)

Note

The following measuring methods are only possible in the axes of the plane:

- 3D probe with spindle reversal (differential measurement)
- Align 3D probe

The probe types 712, 713 and 714 generally **cannot** be used for these measuring methods.

Starting position before the measurement

The probe must be positioned at the position setpoint of the pocket center point. This position approached in the pocket represents the starting position and at the same time the setpoint for the offsets to be determined. For a protection zone, the position of the probe ball is at a height above the protection zone.

With the infeed path that has been entered, it must be guaranteed that from this height the desired measuring height in the pocket can be reached.

Note

If too large a measurement path DFA has been selected so that the protection zone is violated, then the distance is reduced automatically in the cycle. However, there must be sufficient room for the probe ball.

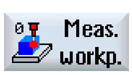
Position after the end of the measuring cycle

Without activated protection zone, at the end of the measuring cycle, the probe ball is at the measuring height in the center of the pocket.

With a protection zone, at the end of the measuring cycle, the probe ball is centered above the pocket at the height of the starting position of the measuring cycles.

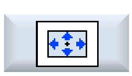
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Hole" softkey.



3. Press the "Rectangular pocket" softkey.
   The input window "Measure: Rectangular pocket" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal 1) • Align 3D probe 2)	-		**T**	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
PL	Measuring plane (G17 - G19)	-		**Measuring method**	• Standard measuring method • 3D probe with spindle reversal 1) • Align 3D probe 2)	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-			Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) 3) • Tool offset (save measured values in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected	-
W	Pocket width setpoint	mm
L	Pocket length setpoint	mm
XM, YM	The setpoint value specification for rectangular pocket center point (only for setpoint center point "Yes")	mm
α0	Angle between measuring axis and workpiece	Degrees
Protection zone	Use protection zone • Yes • No	-
WS	Width of the protection zone (only for protection zone "Yes")	mm
LS	Length of the protection zone (only for protection zone "Yes")	mm
DX / DY / DZ	Infeed distance at measuring height (only for protection zone "Yes")	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

Parameter	Description	Unit
Dimensional tolerance	Use dimensional tolerance for tool offset • Yes • No	-
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm

[1] The "3D probe with spindle reversal" function is shown if bit 16 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[2] The "Align 3D probe" function is shown if bit 17 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[3] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

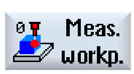
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

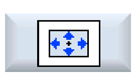
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Hole" softkey.



3. Press the "Rectangular pocket" softkey.
   The input window "Measure: Rectangular pocket" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1] • Align 3D probe[2]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Rectangular pocket" provides the following result parameters:

Table 3-20 "Rectangular pocket" result parameters

Parameters	Description	Unit
_OVR [0]	Rectangle length setpoint in the 1st axis of the plane	mm
_OVR [1]	Rectangle length setpoint in the 2nd axis of the plane	mm
_OVR [2]	Rectangle center point setpoint in the 1st axis of the plane	mm
_OVR [3]	Rectangle center point setpoint in the 2nd axis of the plane	mm
_OVR [4]	Rectangle length actual value in the 1st axis of the plane	mm
_OVR [5]	Rectangle length actual value in the 2nd axis of the plane	mm
_OVR [6]	Rectangle center point actual value in the 1st axis of the plane	mm
_OVR [7]	Rectangle center point actual value in the 2nd axis of the plane	mm
_OVR [16]	Rectangle length difference in the 1st axis of the plane	mm
_OVR [17]	Rectangle length difference in the 2nd axis of the plane	mm
_OVR [18]	Rectangle center point difference in the 1st axis of the plane	mm
_OVR [19]	Rectangle center point difference in the 2nd axis of the plane	mm
_OVI [0]	D number or WO number	-
_OVI [2]	Measuring cycle number	-
_OVS_TNAME	Tool name	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, see Additional result parameters (Page 342).

3.3.14 Hole - 1 hole (CYCLE977)

Function

This measuring variant can be used to measure a hole in a workpiece. The hole diameter is measured as well as the hole center point determined. The measurements are always performed parallel to the geometry axis of the active plane.

With a starting angle, the measuring points can be shifted to the periphery of the hole through rotation around the infeed axis as center point.

A protection zone can be defined in the hole.

With the "3D probe with spindle reversal" measuring method, measurement is performed in the axes of the plane as differential measurement. Two complete measurements of the hole are automatically carried out one after the other, one with a spindle position of 180 degrees, and one with 0 degrees. The special procedure for this measurement permits the use of an uncalibrated multi-directional probe. However, the correct tool radius of the probe must be determined once by calibrating the probe. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

With the "Align 3D probe" measuring method, the switching direction of the probe is always aligned to the current measuring direction. This function is recommended when high demands are placed on the measuring accuracy. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

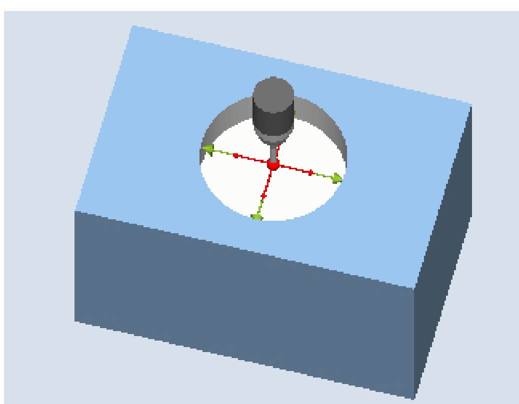
The measurement result (measurement difference) can be used as follows:

- Correction of a WO so that the workpiece zero is in relation to the center of the hole
- Offset of a tool
- Measurement without offset

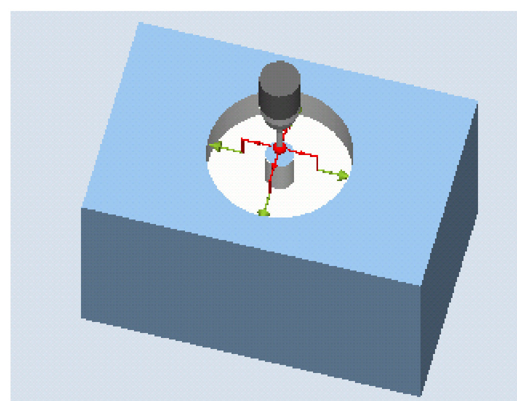
Measuring principle

Two opposite points in each of the two geometry axes of the plane are measured. The hole diameter and the center point are calculated from these four measured actual positions, taking into account the calibration values. From the measuring points of the 1st geometry axis of the plane, the center of this axis is calculated and the probe positioned at this center. Starting from this center point, the two points in the 2nd geometry axis are measured, from which the actual hole diameter is determined. The measurements start in the positive direction of the 1st geometry axis. The measured difference of the hole diameter is used for a tool offset and the position of the hole zero point as basis for a work offset.

With the selection Setpoint center point "YES", the position of the hole center can be defined as workpiece zero through setpoint specifications.



Measure: Hole (CYCLE977)



Measure: Hole with protection zone (CYCLE977)

Requirements

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)
  - Star-type probe (type 714)

Note

The following measuring methods are only possible in the axes of the plane:

- 3D probe with spindle reversal (differential measurement)
- Align 3D probe

The probe types 712, 713 and 714 generally **cannot** be used for these measuring methods.

Note

For measurement of reference rings, the diameter of the reference ring is only reflected exactly in the measurement results if the mechanical complexity of all the axis positions is considered. This can be achieved by performing the calibration in accordance with the following measurement situation. This can be applied to all measurements.

Starting position before the measurement

The probe must be positioned at the position setpoint of the hole center point. This position approached in the hole is the starting position and, at the same time, the setpoint for the offsets to be determined.

For a protection zone, the center of the probe ball is at a height above the protection zone. With the infeed path that has been entered, it must be guaranteed that from this height the desired measuring height in the hole can be reached.

Note

If too large a measurement path DFA has been selected so that the protection zone is violated, then the distance is reduced automatically in the cycle. However, there must be sufficient room for the probe ball.

Position after the end of the measuring cycle

Without activated protection zone, the probe ball is at the measuring height in the center of the hole.

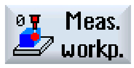
With a protection zone, the measuring cycle end position of the probe ball is centered above the hole at the height of the starting position.

Note

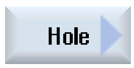
The range of the measuring cycle starting points with regard to the hole center point must be within the value of the measuring path DFA, otherwise, there is danger of collision or the measurement cannot be performed!

Procedure

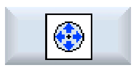
The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.



2. Press the "Hole" softkey.



3. Press the "1 hole" softkey.
   The input window "Measure: 1 hole" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-		**T**	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
PL	Measuring plane (G17 - G19)	-		**Measuring method**	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-			Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [3)] • Tool offset (save measured values in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected	-
∅	Hole diameter setpoint	mm
α0	Contact angle [4)]	Degrees

Parameter	Description	Unit
Protection zone	Use protection zone • Yes • No	-
∅S	Diameter of the protection zone (only for protection zone "Yes")	mm
XM, YM	The setpoint value specification for drill-hole center point (only for setpoint center point "Yes")	mm
DX / DY / DZ	Infeed distance at measuring height (only for protection zone "Yes")	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Dimensional tolerance	Use dimensional tolerance for tool offset • Yes • No	-
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm

[1] The "3D probe with spindle reversal" function is shown if bit 16 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[2] The "Align 3D probe" function is shown if bit 17 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[3] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

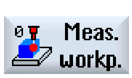
[4] The contact angle always refers to the positive direction of the 1st axis of the active coordinate system, e.g. for G17 to +X, G18/+Z, G19/+Y

Machine manufacturer

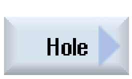
Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

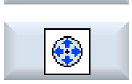
Procedure



1. Press the "Meas. workp." softkey.



2. Press the "Hole" softkey.



3. Press the "1 hole" softkey.
   The input window "Measure: 1 hole" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-

ShopTurn program		
Parameter	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Hole" provides the following result parameters:

Table 3-21 "Hole" result parameters

Parameters	Description	Unit
_OVR [0]	Hole diameter setpoint	mm
_OVR [1]	Hole center point setpoint in the 1st axis of the plane	mm
_OVR [2]	Hole center point setpoint in the 2nd axis of the plane	mm
_OVR [4]	Hole diameter actual value	mm
_OVR [5]	Hole center point actual value in the 1st axis of the plane	mm
_OVR [6]	Hole center point actual value in the 2nd axis of the plane	mm
_OVR [16]	Hole diameter difference	mm
_OVR [17]	Hole center point difference in the 1st axis of the plane	mm
_OVR [18]	Hole center point difference in the 2nd axis of the plane	mm
_OVI [0]	D number or WO number	-
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring variant	-
_OVS_TNAME	Tool name	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, see Additional result parameters (Page 342).

3.3.15 Hole - inner circle segment (CYCLE979)

Function

This measuring variant can be used to measure a circle segment from the inside. The diameter and the center point of the circle segment in the plane are determined. With the selection setpoint value center point "YES", the position of the circle segment center can be defined as the workpiece zero by means of setpoint specifications.

With a starting angle in relation to the 1st geometry axis of the plane, the measuring points can be shifted along the circumference of the circle segment. The distance between the measuring points along the circumference is defined using an incremental angle.

With the "3D probe with spindle reversal" measuring method, measurement is performed in the axes of the plane as differential measurement. The special procedure for this measurement permits the use of an uncalibrated multi-directional probe. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

With the "Align 3D probe" measuring method, the switching direction of the probe is always aligned to the current measuring direction. This function is recommended when high demands are placed on the measuring accuracy. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

The measurement result (measurement difference) can be used as follows:

- Correction of a WO so that the workpiece zero is in relation to the center point of the circle segment
- Offset of a tool
- Measurement without offset

Measuring principle

The circle segment can be measured with 3 or 4 measuring points. The intermediate positions to the measuring points are not approached along a circular path parallel to the geometry axis. The distance between the probe ball circumference and the hole corresponds to the measuring path DFA. The direction of the circular path is obtained from the sign of the incremental angle. The measuring path from the intermediate positions to the measuring points is radial to the hole periphery.

The circle segment obtained from the number of measuring points and the incremental angle must not exceed 360 degrees. The measured difference of the segment diameter is used as tool offset, the segment zero as a basis for a zero offset.

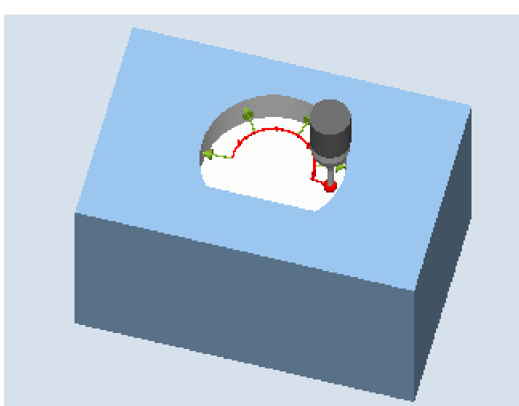


Figure 3-15 Measure: Circle segment inner (CYCLE979), example 4 measuring points

Requirements

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)

Note

The following measuring methods are only possible in the axes of the plane:

- 3D probe with spindle reversal (differential measurement)
- Align 3D probe

The probe types 712, 713 and 714 generally **cannot** be used for these measuring methods.

Note

When measuring circle segments of < 90 degrees, it should be noted that, mathematically speaking, measuring points that deviate from the circular shape exert a particularly great influence on the accuracy of the results (center point, diameter).

For this reason, an especially high degree of care should be taken when measuring small circle segments. Good results can be attained if the following procedures are used:

The circle segment to be measured should be:

- Free from machining residue.
- Have as exact a circular form as possible, guaranteed by the machining technology.
- Have as smooth a surface as possible, guaranteed by the machining technology.
- Measured with high-quality probes, i.e. the shape of the probe ball is as homogeneous as possible.
- Measured with four points (setting via parameters).
- Measured with a recently calibrated probe.

Starting position before the measurement

The probe is in the 3rd axis of the plane (tool axis) at the required measuring height, approx. at a distance of the measuring path DFA in front of the first measuring point. When selecting this preliminary position in the axes of the plane, the start angle setting must be taken into account. This is because the first measuring point and all additional ones are shifted on the circular path through the start angle.

Using a start angle of 180° as example, the first contact point is on the opposite side of the hole to be measured. If this would not be taken into account for the start position, then the collision would occur with possible obstructions in the hole.

Position after the end of the measuring cycle

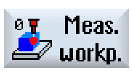
After measuring, the probe ball circumference is a distance of the measuring path DFA radially from the last measuring point at the measuring height.

Note

The range of the measuring cycle starting points with regard to the circle segment center point must be within the value of the measuring path DFA, otherwise, there is danger of collision or the measurement cannot be performed!

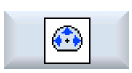
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Hole" softkey.



3. Press the "Inner circle segment" softkey.
   The input window "Measure: Inner circle segment" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-		T	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
PL	Measuring plane (G17 - G19)	-		Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-			Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [3] • Tool offset (save measured values in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected	-
Number of measuring points	Measurement with: • 3 points • 4 points	-
∅	Diameter of hole	mm
XM	Center point X (for measuring plane G17)	mm
YM	Center point Y (for measuring plane G17)	mm
XMS	Setpoint value specification for center point X	mm
YMS	Setpoint value specification for center point Y	mm
α0	Contact angle [4]	Degrees
α1	Incremental angle [5]	Degrees
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Dimensional tolerance	Use dimensional tolerance for tool offset • Yes • No	-
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm

1) The "3D probe with spindle reversal" function is shown if bit 16 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

2) The "Align 3D probe" function is shown if bit 17 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

3) Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

4) The contact angle always refers to the positive direction of the 1st axis of the active coordinate system, e.g. for G17 to +X, G18/+Z, G19/+Y

5) The sign of the incremental angle specifies the positioning direction of this angle.

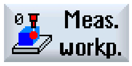
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

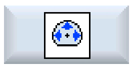
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Hole" softkey.



3. Press the "Inner circle segment" softkey.
   The input window "Measure: Inner circle segment" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Inner circle segment" provides the following result parameters:

Table 3-22 "Inner circle segment" result parameters

Parameters	Description	Unit
_OVR [0]	Hole diameter setpoint	mm
_OVR [1]	Center point setpoint in the 1st axis of the plane	mm
_OVR [2]	Center point setpoint in the 2nd axis of the plane	mm
_OVR [4]	Hole diameter actual value	mm
_OVR [5]	Center point actual value in the 1st axis of the plane	mm
_OVR [6]	Center point actual value in the 2nd axis of the plane	mm
_OVR [16]	Hole diameter difference	mm
_OVR [17]	Center point difference in the 1st axis of the plane	mm
_OVR [18]	Center point difference in the 2nd axis of the plane	mm
_OVI [0]	D number or WO number	-
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring variant	-
_OVS_TNAME	Tool name	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, see Additional result parameters (Page 342).

3.3.16 Spigot - rectangular spigot (CYCLE977)

Function

This measuring variant can be used to measure a rectangular spigot on a workpiece. The spigot width and spigot length are measured as well as the spigot center point determined.

The measurements are always performed parallel to the geometry axis of the active plane. Measurements are also possible at a rectangular spigot rotated around the infeed axis. To do this, an angle corresponding to the real spigot position must be entered in the parameterization axis. Probing at the sides of the spigot is always at right angles to these.

A protective zone can be defined around the spigot.

With the "3D probe with spindle reversal" measuring method, measurement is performed in the axes of the plane as differential measurement. Two complete measurements of the rectangular spigot are automatically carried out one after the other, one with a spindle position of 180 degrees, and one with 0 degrees. The special procedure for this measurement permits the use of an uncalibrated multi-directional probe. However, the correct tool radius of the probe must be determined once by calibrating the probe. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

With the "Align 3D probe" measuring method, the switching direction of the probe is always aligned to the current measuring direction. This function is recommended when high demands are placed on the measuring accuracy. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

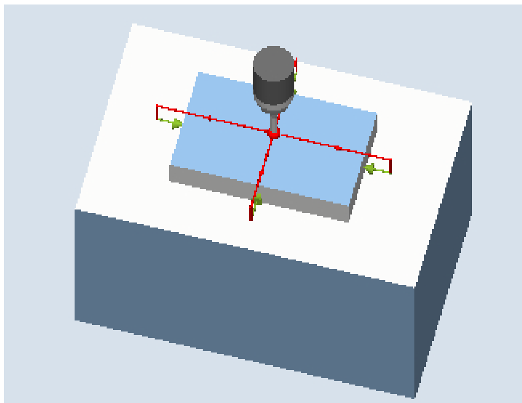
The measurement result (measurement difference) can be used as follows:

- Correction of a WO so that the workpiece zero is in relation to the center point of the rectangular spigot
- Offset of a tool
- Measurement without offset

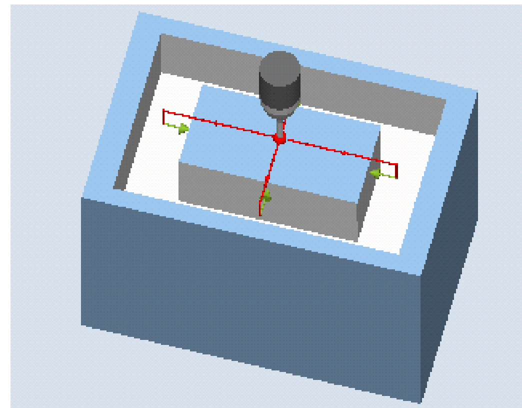
Measuring principle

Two opposite points in each of the two geometry axes of the plane are measured. The measurements start in the positive direction of the 1st geometry axis. The spigot width and the spigot length are calculated from the four measured actual positions of the spigot sides, taking into account the calibration values. Corresponding to the work offset selected to be corrected, the position of the spigot center is determined as the workpiece zero. The measuring differences of the side lengths are used as the basic variable for a tool offset. The position of the spigot zero as basis for the work offset.

With the selection Setpoint center point "YES", the position of the rectangular spigot center can be defined as workpiece zero through setpoint specifications.



Measure: Rectangular spigot (CYCLE977)



Measure: Rectangular spigot with protection zone (CYCLE977)

Requirements

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)
  - Star-type probe (type 714)

Note

The following measuring methods are only possible in the axes of the plane:

- 3D probe with spindle reversal (differential measurement)
- Align 3D probe

The probe types 712, 713 and 714 generally **cannot** be used for these measuring methods.

Starting position before the measurement

The probe must be positioned above the rectangular spigot at the position setpoint of the center point. This position approached above the spigot represents the starting position and at the same time the setpoint for the offsets to be determined.

With the infeed path that has been entered, it must be guaranteed that from the starting position height, the desired measuring height at the rectangular spigot can be reached.

A protection zone has no effect on the starting position.

Note

If too large a measurement path DFA has been selected so that the protection zone is violated, then the distance is reduced automatically in the cycle. However, there must be sufficient room for the probe ball.

Position after the end of the measuring cycle

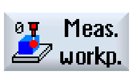
The measuring cycle end position of the probe ball is centered above the spigot at the height of the measuring cycles starting position.

Note

The range of the cycle starting positions with regard to the spigot center point must be within the value of the measuring path DFA, otherwise, there is danger of collision or the measurement cannot be performed!

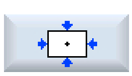
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Spigot" softkey.



3. Press the "Rectangular spigot" softkey.
   The input window "Measure: Rectangular spigot" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1] • Align 3D probe[2]	-		**T**	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
PL	Measuring plane (G17 - G19)	-		**Measuring method**	• Standard measuring method • 3D probe with spindle reversal [1] • Align 3D probe[2]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-			Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [3] • Tool offset (save measured values in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected	-
W	Setpoint, spigot width	mm
L	Setpoint, spigot length	mm
XM, YM	The setpoint value specification for rectangular spigot center point (only for setpoint center point "Yes")	mm
α0	Contact angle [4]	Degrees
DZ	Infeed distance at measuring height (for G17)	mm
Protection zone	Use protection zone • Yes • No	-
WS	Width of the protection zone (only for protection zone "Yes")	mm
LS	Length of the protection zone (only for protection zone "Yes")	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

Parameter	Description	Unit
Dimensional tolerance	Use dimensional tolerance for tool offset • Yes • No	-
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm

1) The "3D probe with spindle reversal" function is shown if bit 16 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

2) The "Align 3D probe" function is shown if bit 17 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

3) Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

4) The contact angle always refers to the positive direction of the 1st axis of the active coordinate system, e.g. for G17 to +X, G18/+Z, G19/+Y

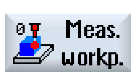
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

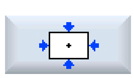
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Spigot" softkey.



3. Press the "Rectangular spigot" softkey.
   The input window "Measure: Rectangular spigot" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1] • Align 3D probe[2]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Rectangular spigot" provides the following result parameters:

Table 3-23 "Rectangular spigot" result parameters

Parameters	Description	Unit
_OVR [0]	Rectangle length setpoint in the 1st axis of the plane	mm
_OVR [1]	Rectangle length setpoint in the 2nd axis of the plane	mm
_OVR [2]	Rectangle center point setpoint in the 1st axis of the plane	mm
_OVR [3]	Rectangle center point setpoint in the 2nd axis of the plane	mm
_OVR [4]	Rectangle length actual value in the 1st axis of the plane	mm
_OVR [5]	Rectangle length actual value in the 2nd axis of the plane	mm
_OVR [6]	Rectangle center point actual value in the 1st axis of the plane	mm
_OVR [7]	Rectangle center point actual value in the 2nd axis of the plane	mm
_OVR [16]	Rectangle length difference in the 1st axis of the plane	mm
_OVR [17]	Rectangle length difference in the 2nd axis of the plane	mm
_OVR [18]	Rectangle center point difference in the 1st axis of the plane	mm
_OVR [19]	Rectangle center point difference in the 2nd axis of the plane	mm
_OVI [0]	D number or WO number	-
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring variant	-
_OVS_TNAME	Tool name	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, see Additional result parameters (Page 342).

3.3.17 Spigot - 1 circular spigot (CYCLE977)

Function

This measuring variant can be used to measure a circular spigot on a workpiece.

The spigot diameter is measured and the spigot center point is determined. The measurements are always performed parallel to the geometry axis of the active plane.

With a starting angle, the measuring points can be shifted along the circumference of the spigot around the infeed axis as center of rotation.

A protective zone can be defined around the spigot.

With the "3D probe with spindle reversal" measuring method, measurement is performed in the axes of the plane as differential measurement. Two complete measurements of the spigot are automatically carried out one after the other, one with a spindle position of 180 degrees, and one with 0 degrees. The special procedure for this measurement permits the use of an uncalibrated multi-directional probe. However, the correct tool radius of the probe must be determined once by calibrating the probe. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

With the "Align 3D probe" measuring method, the switching direction of the probe is always aligned to the current measuring direction. This function is recommended when high demands are placed on the measuring accuracy. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

The measurement result (measurement difference) can be used as follows:

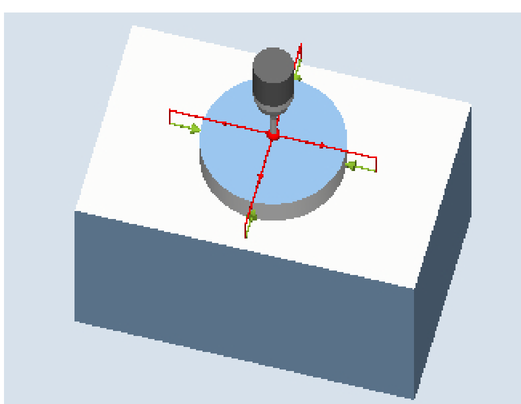
- Correction of a WO so that the zero point is in relation to the center point of the spigot
- Offset of a tool
- Measurement without offset

Measuring principle

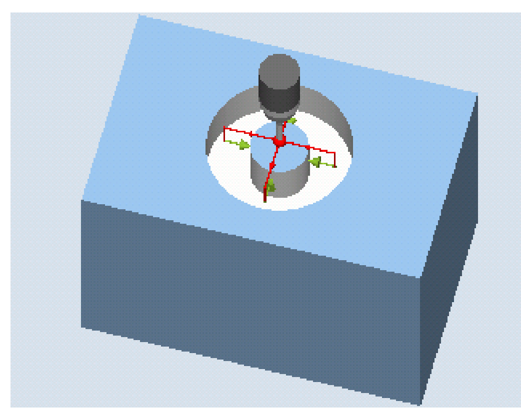
Two opposite points in each of the two geometry axes of the plane are measured. The spigot diameter and the center point are calculated from these four measured actual positions, taking into account the calibration values. From the measuring points of the 1st geometry axis of the plane, the center of this axis is calculated and the probe positioned at this center.

Starting from this center point, the measuring points in the 2nd geometry axis are measured, from which the actual spigot diameter is determined. The measurements start in the positive direction of the 1st geometry axis. The measured difference of the spigot diameter is used as tool offset and the position of the spigot zero point as basis for a work offset.

With the selection Setpoint center point "YES", the position of the spigot center can be defined as workpiece zero through setpoint specifications.



Measure: Circular spigot (CYCLE977)



Measure: Circular spigot with protection zone (CYCLE977)

Requirements

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)
  - Star-type probe (type 714)

Note

The following measuring methods are only possible in the axes of the plane:

- 3D probe with spindle reversal (differential measurement)
- Align 3D probe

The probe types 712, 713 and 714 generally **cannot** be used for these measuring methods.

Starting position before the measurement

The probe must be positioned above the circular spigot at the position setpoint of the center point. This position approached above the spigot represents the starting position and at the same time the setpoint for the offsets to be determined.

With the infeed path that has been entered, it must be guaranteed that from the starting position height, the desired measuring height at the spigot can be reached.

A protection zone has no effect on the starting position.

Note

If too large a measurement path DFA has been selected so that the protection zone is violated, then the distance is reduced automatically in the cycle. However, there must be sufficient room for the probe ball.

Position after the end of the measuring cycle

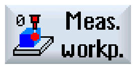
The measuring cycle end position of the probe ball is centered above the spigot at the height of the measuring cycles starting position.

Note

The range of the measuring cycle starting positions with regard to the spigot center point must be within the value of the measuring path DFA, otherwise, there is danger of collision or the measurement cannot be performed!

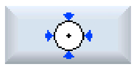
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Spigot" softkey.



3. Press the "1 circular spigot" softkey.
   The input window "Measure: 1 circular spigot" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal 1) • Align 3D probe 2)	-		**T**	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
PL	Measuring plane (G17 - G19)	-		**Measuring method**	• Standard measuring method • 3D probe with spindle reversal 1) • Align 3D probe 2)	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-			Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) 3) • Tool offset (save measured values in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected	-
∅	Spigot diameter setpoint	mm
XM, YM	The setpoint value specification for spigot center point (only for setpoint center point "Yes")	mm
α0	Contact angle 4)	Degrees

Parameter	Description	Unit
DZ	Infeed distance at measuring height (for G17)	mm
Protection zone	Use protection zone • Yes • No	-
∅S	Diameter of the protection zone (only for protection zone "Yes")	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Dimensional tolerance	Use dimensional tolerance for tool offset • Yes • No	-
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm

[1] The "3D probe with spindle reversal" function is shown if bit 16 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[2] The "Align 3D probe" function is shown if bit 17 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[3] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[4] The contact angle always refers to the positive direction of the 1st axis of the active coordinate system, e.g. for G17 to +X, G18/+Z, G19/+Y

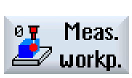
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, milling on a turning machine (only 840D sl)

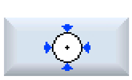
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Spigot" softkey.



3. Press the "1 circular spigot" softkey.
   The input window "Measure: 1 circular spigot" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-

ShopTurn program		
Parameter	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1)] • Align 3D probe[2)]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "1 circular spigot" provides the following result parameters:

Table 3-24 "1 circular spigot" result parameters

Parameters	Description	Unit
_OVR [0]	Circular spigot diameter setpoint	mm
_OVR [1]	Circular spigot center point setpoint in the 1st axis of the plane	mm
_OVR [2]	Circular spigot center point setpoint in the 2nd axis of the plane	mm
_OVR [4]	Circular spigot diameter actual value	mm
_OVR [5]	Circular spigot center point actual value in the 1st axis of the plane	mm
_OVR [6]	Circular spigot center point actual value in the 2nd axis of the plane	mm
_OVR [16]	Circular spigot diameter difference	mm
_OVR [17]	Circular spigot center point difference in the 1st axis of the plane	mm
_OVR [18]	Circular spigot center point difference in the 2nd axis of the plane	mm
_OVI [0]	D number or WO number	-
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring variant	-
_OVS_TNAME	Tool name	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, see Additional result parameters (Page 342).

3.3.18 Spigot - outer circle segment (CYCLE979)

Function

This measuring variant can be used to measure circle segment from the outside. The diameter and the center point of the circle segment in the plane are determined. With the selection setpoint value center point "YES", the position of the circle segment center can be defined as the workpiece zero by means of setpoint specifications. With a starting angle in relation to the 1st geometry axis of the plane, the measuring points can be shifted along the circumference of the circle segment. The distance between the measuring points along the circumference is defined using an incremental angle.

With the "3D probe with spindle reversal" measuring method, measurement is performed in the axes of the plane as differential measurement. The special procedure for this measurement permits the use of an uncalibrated multi-directional probe. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

With the "Align 3D probe" measuring method, the switching direction of the probe is always aligned to the current measuring direction. This function is recommended when high demands are placed on the measuring accuracy. Probe types 712, 713 and 714 are not suitable for this purpose. A positionable spindle is mandatory.

The measurement result (measurement difference) can be used as follows:

- Correction of a WO so that the workpiece zero is in relation to the center point of the circle segment
- Offset of a tool
- Measurement without offset

Measuring principle

The circle segment can be measured with three or four measuring points. The intermediate positions to the measuring points are not approached along a circular path parallel to the geometry axis. The distance between the probe ball circumference and the hole corresponds to the measuring path DFA. The direction of the circular path is obtained from the sign of the incremental angle. The measuring path from the intermediate positions to the measuring points is radial to the hole periphery.

The circle segment obtained from the number of measuring points and the incremental angle must not exceed 360 degrees. The measured difference of the segment diameter is used as tool offset, the segment zero point as a basis for a zero offset.

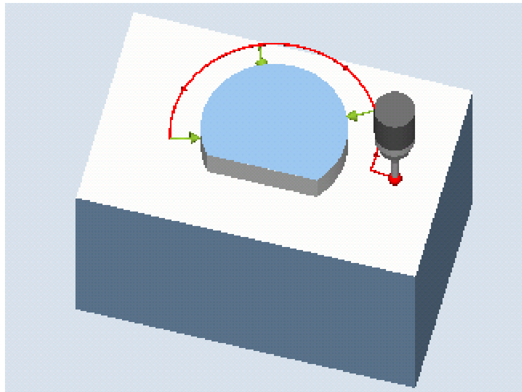


Figure 3-16 Measure: Outer circle segment (CYCLE977)

Requirements

- The probe must be active as tool.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)

Note

The following measuring methods are only possible in the axes of the plane:

- 3D probe with spindle reversal (differential measurement)
- Align 3D probe

The probe types 712, 713 and 714 generally **cannot** be used for these measuring methods.

Note

When measuring circle segments of < 90 degrees, it should be noted that, mathematically speaking, measuring points that deviate from the circular shape exert a particularly great influence on the accuracy of the results (center point, diameter).

For this reason, an especially high degree of care should be taken when measuring small circle segments. Good results can be attained if the following procedures are used:

The circle segment to be measured should be:

- Free from machining residue.
- Have as exact a circular form as possible, guaranteed by the machining technology.
- Have as smooth a surface as possible, guaranteed by the machining technology.
- Measured with high-quality probes, i.e. the shape of the probe ball is as homogeneous as possible.
- Measured with four points (setting via parameters).
- Measured with a recently calibrated probe.

Starting position before the measurement

The probe is in the 3rd axis of the plane (tool axis) at the required measuring height, approx. at a distance of the measuring path DFA in front of the first measuring point. When selecting this preliminary position in the axes of the plane, the start angle setting must be taken into account. This is because the first measuring point and all additional ones are shifted on the circular path through the start angle.

Using a start angle of 180° as example, the first contact point is on the opposite side of the hole to be measured. If this would not be taken into account for the start position, then a collision would occur with possible obstructions in the hole.

Position after the end of the measuring cycle

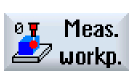
At the end of the measurement, the probe ball circumference is a distance of the measuring path DFA radially from the last measuring point at the measuring height.

Note

The range of the measuring cycle starting points with regard to the circle segment center point must be within the value of the measuring path DFA, otherwise, there is danger of collision or the measurement cannot be performed!

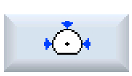
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "Spigot" softkey.



3. Press the "Outer circle segment" softkey.
   The input window "Measure: Outer circle segment" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1] • Align 3D probe[2]	-		**T**	Name of the probe	-
				D	Cutting edge number (1 - 9)	-
PL	Measuring plane (G17 - G19)	-		**Measuring method**	• Standard measuring method • 3D probe with spindle reversal [1] • Align 3D probe[2]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-			Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [3] • Tool offset (save measured values in the tool data)	-
TR	Name of tool to be corrected	-
D	Cutting edge number of tool to be corrected	-
Number of measuring points	Measurement with: • 3 points • 4 points	-
∅	Diameter of spigot	mm
XM	Center point X (for measuring plane G17)	mm
YM	Center point Y (for measuring plane G17)	mm
XMS	Setpoint value specification for center point X	mm
YMS	Setpoint value specification for center point Y	mm
α0	Contact angle [4]	Degrees
α1	Incremental angle [5]	Degrees
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

Parameter	Description	Unit
Dimensional tolerance	Use dimensional tolerance for tool offset • Yes • No	-
TUL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm
TLL	Workpiece upper tolerance limit (incremental to the setpoint, only for dimensional tolerance "Yes")	mm

1) The "3D probe with spindle reversal" function is shown if bit 16 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

2) The "Align 3D probe" function is shown if bit 17 is set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

3) Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

4) The contact angle always refers to the positive direction of the 1st axis of the active coordinate system, e.g. for G17 to +X, G18/+Z, G19/+Y

5) The sign of the incremental angle specifies the positioning direction of this angle.

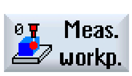
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

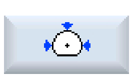
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Spigot" softkey.



3. Press the "Outer circle segment" softkey.
   The input window "Measure: Outer circle segment" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
Measuring method	• Standard measuring method • 3D probe with spindle reversal [1] • Align 3D probe[2]	-
	Calibration data set (1 - 40) (only for measuring without spindle reversal)	-
X	Start point X of the measurement	mm

ShopTurn program		
Parameter	Description	Unit
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Outer circle segment" provides the following result parameters:

Table 3-25 "Outer circle segment" result parameters

Parameters	Description	Unit
_OVR [0]	Circle segment diameter setpoint	mm
_OVR [1]	Center point setpoint in the 1st axis of the plane	mm
_OVR [2]	Center point setpoint in the 2nd axis of the plane	mm
_OVR [4]	Circle segment diameter actual value	mm
_OVR [5]	Center point actual value in the 1st axis of the plane	mm
_OVR [6]	Center point actual value in the 2nd axis of the plane	mm
_OVR [16]	Circle segment diameter difference	mm
_OVR [17]	Center point difference in the 1st axis of the plane	mm
_OVR [18]	Center point difference in the 2nd axis of the plane	mm
_OVI [0]	D number or WO number	-
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring variant	-
_OVS_TNAME	Tool name	-

For workpiece measurement with tool offset or correction in the work offset, additional parameters are displayed, see Additional result parameters (Page 342).

3.3.19 3D - align plane (CYCLE998)

Function

This measuring variant can be used to determine and correct the angular position of a three-dimensional inclined plane on a workpiece by measuring three points. The angles are in relation to the rotation around the axes of the active plane G17 to G19.

The same requirements as for the simple angle measurement apply, see measuring variant Align edge (Page 134).

Additional data is required for the setpoint specification of the 2nd angle. A correction is made in the zero offset in the rotary components (rotation) of the specified work offset (WO).

The translatory components of the WO remain unchanged, and should be corrected in a subsequent measurement (e.g. set edge, corner).

After the measurement, at suitable machines where orientation transformation (swiveling, TRAORI) is set up, the probe can be aligned perpendicular on the measuring plane (machining plane).

- Swiveling: See the Programming Manual *SINUMERIK 840D sl/840D/840Di sl cycles*, Section "Swiveling - CYCLE800".
- TRAORI
  G0 C3=1 ;align to tool axis Z for G17

Measuring principle

The "Align plane" measuring variant is performed according to the 2-angle measurement principle:

The angular offsets are in the rotary part of the geometry axes for a workpiece with a three-dimensional inclined plane.

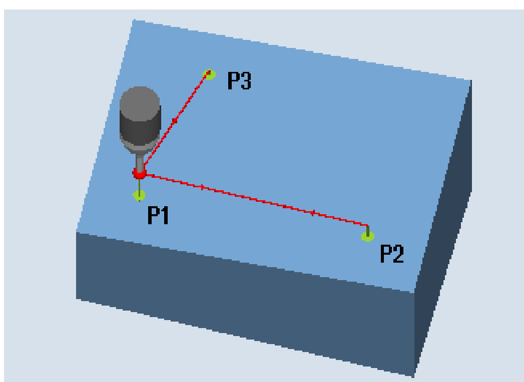


Figure 3-17 Measure: Align plane (CYCLE998)

Note

Maximum measured angle

The `CYCLE998` measuring cycle is capable of measuring a maximum angle of -45 ... +45 degrees.

Requirements

- The probe must be called as a tool with a tool length compensation.
- Tool type of the probe:
  - 3D multi probe (type 710)
  - Mono probe (type 712)

Starting position before the measurement

The probe is pre-positioned over the 1st measuring point P1 in the axes of the plane (for G17: XY).

Positioning taking into account a protection zone

- Protection zone "no"
  The probe is positioned in the measuring axis as a maximum at the distance of measurement path DFA above the surface to be measured above measuring point P1 at the measuring height.
- Protection zone "yes"
  The probe is positioned in the measuring axis as a maximum at the distance of measurement path DFA and the amount in parameter **DZ** (for G17 always measuring axis Z) above the surface to be measured above measuring point P1 at the measuring height.

In both cases, when making the measurement, measuring point P1 must be able to be safely reached.

If the distances from the reference surface are selected too large for the 1st measurement, then a measurement is not made.

Measuring axis is always the 3rd axis of the plane (for G17: Z). Measuring point P1 should be selected in the plane so that the distance to the 2nd measuring point (L2) and to the 3rd measuring point (L3) results in positive values.

Positioning between measuring points P1, P2, P3

Intermediate positioning "parallel to the plane"

The probe traverses parallel to the reference surface at the distance of parameter L2 to measuring point P2, or after the 2nd measurement at the distance of parameter L3 to measuring point P3. In so doing, the angle from parameters **α** and **TSA** is taken into account. TSA contains the value for the maximum permissible angular deviation.

After performing the measurement in P1, the probe is positioned to P2 in the 1st axis of the plane and in the 3rd axis of the plane (for G17 in X and Z) taking into account angle **β** and a maximum deviation in **TSA**. After the measurement in P2 has been performed the probe is repositioned to P1 along the same path. The probe is positioned from P1 to P3 in the 2nd axis of the plane (for G17 in X and Y) and the 3rd axis of the plane taking into account angle **α** and maximum deviation in **TSA** and then a measurement performed.

Intermediate positioning "parallel to the axis"

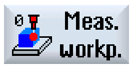
Positioning from P1 to P2 is performed in the 1st axis of the plane, from P1 to P3 in the 2nd axis of the plane. With the starting position P1 in the 3rd axis of the plane (for G17 in Z), P2 and P3 must also be able to be reached without any collision.

Position after the end of the measuring cycle

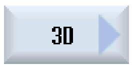
The probe is at a distance of the measurement path above the last measuring point (P3).

Procedure

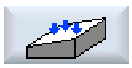
The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.



2. Press the "3D" softkey.



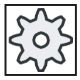
3. Press the "Align plane" softkey.
   The input window "Measure: Align plane" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		**T**	Name of the probe	-
	Calibration data set (1 - 40)	-		**D**	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [1]	-
Positioning	Position probe: • Parallel to the axis • Parallel to the plane	-
α	Inclination of the plane to the X axis (X for G17)	Degrees
L2X	Distance to the 2nd measuring point in the direction of the X axis	mm
β	Inclination of the plane to the Y axis (Y for G17)	Degrees
L3X	Distance to the 3rd measuring point in the direction of the X axis	mm
L3Y	Distance to the 3rd measuring point in the direction of the Y axis	mm
Protection zone	Use protection zone • Yes • No	-
DZ (only for protection zone "Yes")	Infeed path at the measuring height in the Z axis (for G17)	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

[1] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

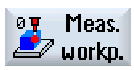


Machine manufacturer
Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

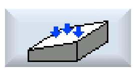
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "3D" softkey.



3. Press the "Align plane" softkey.
   The input window "Measure: Align plane" opens.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 40)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Align plane" provides the following result parameters:

Table 3-26 "Align plane" result parameters

Parameters	Description	Unit
_OVR [0]	Angle setpoint between workpiece surface and 1st axis in the plane of the active WCS	Degrees
_OVR [1]	Angle setpoint between workpiece surface and 2nd axis in the plane of the active WCS	Degrees
_OVR [4]	Angle actual value between workpiece surface and 1st axis in the plane of the active WCS	Degrees
_OVR [5]	Angle actual value between workpiece surface and 2nd axis in the plane of the active WCS	Degrees
_OVR [16]	Angle difference around the 1st axis of the plane	Degrees
_OVR [17]	Angle difference around the 2nd axis of the plane	Degrees
_OVR [20]	Angle offset value	Degrees
_OVR [21]	Angle offset value around the 1st axis of the plane	Degrees

Parameters	Description	Unit
_OVR [22]	Angle offset value around the 2nd axis of the plane	Degrees
_OVR [23]	Angle offset value around the 3rd axis of the plane	Degrees
_OVR [28]	Safe area	Degrees
_OVR [30]	Empirical value	Degrees
_OVI [0]	WO number	-
_OVI [2]	Measuring cycle number	-
_OVI [5]	Probe number	-
_OVI [7]	Empirical value memory number	-
_OVI [9]	Alarm number	-
_OVI [11]	Status offset request	-

3.3.20 3D - sphere (CYCLE997)

Function

This measuring variant can be used to measure a sphere. Measuring can be parallel to the axis or on a circular path in the workpiece coordinate system.

The center point (position of the sphere) for a known diameter is determined from three or four measuring points at the circumference and one measuring point at the "north pole" of the sphere. With the selection "Determine sphere diameter" and "No repeat measurement", using an additional measurement, the sphere diameter is correctly determined.

If "Determine sphere diameter" and "With repeat measurement" are selected, the additional measurement is performed in the 1st pass only.

In the 2nd pass (repeat pass), the diameter is calculated internally without an additional measurement.

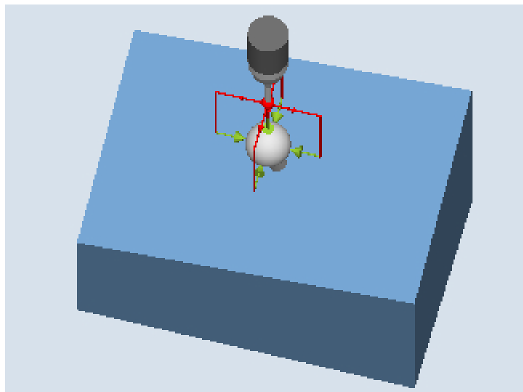
Measuring cycle CYCLE997 can measure the sphere and, in addition, automatically correct a work offset (WO) in the translational offsets of the three axes of the active plane on the basis of the position of the sphere center.

Measuring principle

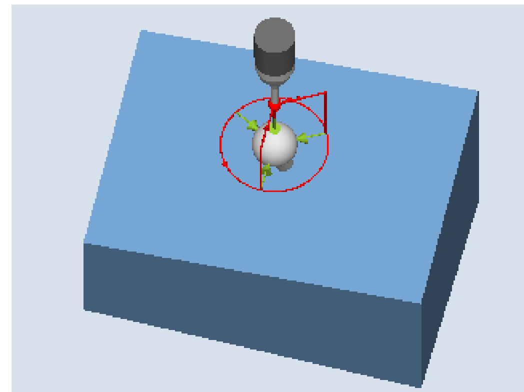
The following description refers to the machining plane G17:

- Axes of the plane: XY
- Tool axis: Z

Beginning at the starting position, the setpoint of the sphere equator is approached initially in -X and then in -Z. Three or four points are measured at this measuring height.



Measure: Sphere (CYCLE997), Example of "paraxial" positioning



Measure: Sphere (CYCLE997), Example of positioning "on a circular path"

- Measuring variant "Paraxial positioning":
  When positioning between measuring points (e.g. P1-> P2, P2->P3), the axis always retracts to the starting position (at the north pole of the sphere).
  The angular position when measuring measuring point P1 is defined using the probe angle **α0** (starting angle)
- Measuring variant "Positioning on a circular path":
  Positioning between measuring points (e.g. P1-> P2, P2->P3) is realized on a circular path at the same height as the equator of the sphere.
  With probe angle **α0** (starting angle), the angular position when the measuring point P1 is defined; with **α1** the incremental angle to P2 and further to P3 – and for the measuring variant with four measuring points, to P4.
  The number of measuring points multiplied with the stepping angle **α1** must not exceed 360 degrees.

Internally, the actual center point of circle XY is determined from these measured values (sphere center in the plane). Then with +Z and in XY, the axis traverses to the calculated "north pole" of the sphere. A measurement is made there in -Z.

The complete center point of the sphere is calculated in the three axes of the plane (XYZ) from the measuring points.

In the case of a repeat measurement, the axis traverses to the precise equator of the sphere (from the 1st measurement); this improves the measurement result.

If the actual sphere diameter is also to be measured in addition to the sphere center point, the cycle performs a supplementary measurement parallel to the axis at the equator in the +X direction in the 1st measuring pass.

If "Repeat measurement" is selected, an additional measurement is not performed in the 2nd pass (repeat pass) and the diameter is calculated internally.

The "Positioning on a circular path" measuring variant should be preferably used, because this permits optimum positioning behavior. In addition, with this measuring variant, when circling around the sphere, the probe can be aligned in the switching direction (see the "align probe" parameter).

Correction in a work offset (WO)

The set-actual differences of the center point coordinates are calculated in the translatory part of the WO. During the correction, the determined sphere center point includes the specified position setpoint (workpiece coordinates, three axes) in the corrected WO.

Requirements

- The probe must be called as a tool with tool length compensation and be active.
- Tool type of the probe: 3D multi probe (type 710)
- The sphere diameter must be significantly greater than the sphere diameter of the probe stylus.

Note

For measurement of reference spheres, the diameter of the reference sphere is only reflected exactly in the measurement results if the mechanical complexity of all the axis positions is considered. This can be achieved by performing the calibration in accordance with the following measurement situation. This can be applied to all sphere measurements.

Starting position before the measurement

The probe must be positioned above the set sphere center point at a safe height.

The measuring cycle generates the traversing motion for approaching the measuring points itself and performs the measurements depending on the measuring variant selected.

Note

The sphere to be measured must be mounted in such a way that when positioning the probe, the probe ball can safely reach the equator of the measuring object in the WCS and no collision with the sphere clamping occurs. By specifying a variable starting and incremental angle, when positioning on a circular path, this is also possible under difficult clamping conditions.

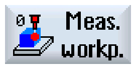
The measurement path in parameter DFA should be selected so large that all measuring points can be reached within total measurement path 2 x DFA. Otherwise no measurement can be performed or the measurements are incomplete.

Position after the end of the measuring cycle

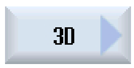
The probe is above the determined sphere center point at a safe height (height at the starting position).

Procedure

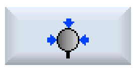
The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.



2. Press the "3D" softkey.



3. Press the "Sphere" softkey.
   The input window "Measure: Sphere" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		**T**	Name of the probe	-
	Calibration data set (1 - 40)	-		**D**	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [1]	-
Positioning	Traverse around sphere: • Parallel to the axis • On circular path	-
Only for positioning "On circular path":		
Align probe	Always align probe in the same contact direction • No • Yes	-
Number of measuring points	Measuring the sphere with three or four measuring points at the sphere equator	-
Repeat measurement	Repeat measurement with determined values • No • Yes	-
Determining the sphere diameter	• No • Yes	-
∅	Sphere diameter setpoint	mm
α0	Contact angle [2]	Degrees
α1	Incremental angle (only for positioning "On circular path") [3]	Degrees

Parameter	Description	Unit
XM	Center point of the sphere on the X axis (for G17)	mm
YM	Center point of the sphere on the Y axis	mm
ZM	Center point of the sphere on the Z axis	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

[1] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[2] The contact angle always refers to the positive direction of the 1st axis of the active coordinate system, e.g. for G17 to +X, G18/+Z, G19/+Y

[3] The sign of the incremental angle specifies the positioning direction of this angle.

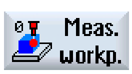
Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring variant, turning on a milling machine (only 840D sl)

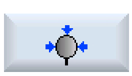
Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "3D" softkey.



3. Press the "Sphere" softkey.
   The input window "Measure: Sphere" opens.

Parameter

ShopTurn program		
Parameter	Description	Unit
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 40)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Sphere" provides the following result parameters:

Table 3-27 "Sphere" result parameters

Parameters	Description	Unit
_OVR[0]	Sphere diameter setpoint	mm
_OVR[1]	Center point coordinate setpoint in the 1st axis of the plane	mm
_OVR[2]	Center point coordinate setpoint in the 2nd axis of the plane	mm
_OVR[3]	Center point coordinate setpoint in the 3rd axis of the plane	mm
_OVR[4]	Sphere diameter actual value	mm
_OVR[5]	Center point coordinate actual value in the 1st axis of the plane	mm
_OVR[6]	Center point coordinate actual value in the 2nd axis of the plane	mm
_OVR[7]	Center point coordinate actual value in the 3rd axis of the plane	mm
_OVR[8]	Sphere diameter difference	mm
_OVR[9]	Center point coordinate difference in the 1st axis of the plane	mm
_OVR[10]	Center point coordinate difference in the 2nd axis of the plane	mm
_OVR[11]	Center point coordinate difference in the 3rd axis of the plane	mm
_OVR[28]	Safe area	mm
_OVI[0]	WO number	-
_OVI[2]	Measuring cycle number	-
_OVI[5]	Probe number	-
_OVI[9]	Alarm number	-
_OVI[11]	Status offset request	-
_OVI[12]	Supplementary error data for alarm, internal measurement evaluation	-

3.3.21 3D - 3 spheres (CYCLE997)

Function

This measuring method can be used to measure three spheres of equal size, fixed to a common base (workpiece).

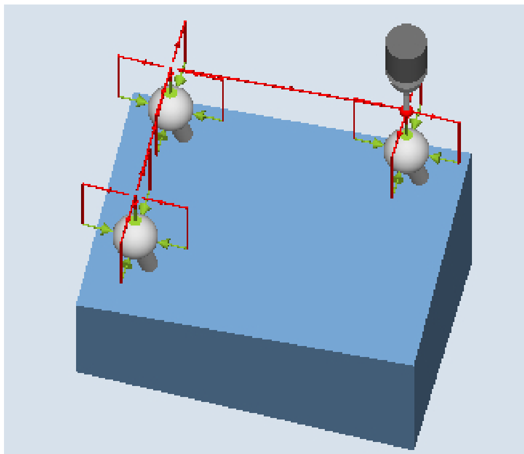
Measuring individual spheres is realized the same as when measuring one sphere, see 3D sphere (CYCLE997) (Page 200).

After measuring the 3rd sphere, for a correction in a work offset (WO), the position of the workpiece on which the spheres are mounted, is corrected as a rotation in the WO.

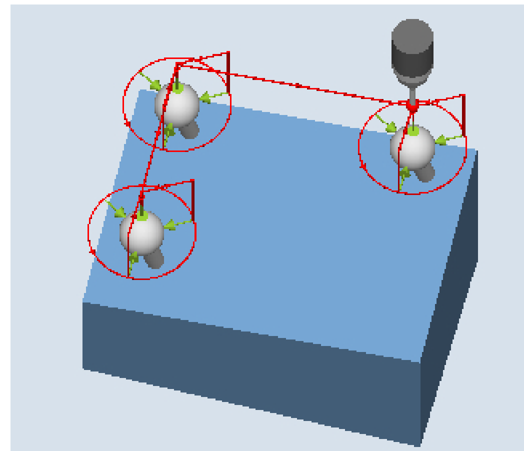
Measuring principle

The position of the center points of the three spheres should be entered as a setpoint in parameters XM1 to ZM3 in the active workpiece coordinate system. The measurement begins with the 1st sphere and ends with the 3rd sphere.

Positioning between the spheres is realized along a straight line at the height of the starting position of the 1st sphere. The parameter settings – such as the number of measuring points, determining the diameter, diameter – apply to all three spheres.



Measure: 3 spheres (CYCLE997),
Example of "paraxial positioning"



Measure: 3 spheres (CYCLE997),
Example of "positioning on a circular path"

Correction of the work offset (WO)

After the measurement of the 3rd sphere, a work offset is calculated from the measured center points of the balls. This consists of translatory components (offset) and rotary components (rotation), and describes the position of the workpiece on which the spheres are mounted.

During the correction, the triangle of the determined sphere center points includes the specified center point setpoint position (workpiece coordinates). The sum of the deviations of the spheres to each other must be within the value of parameter TVL. Otherwise no correction is performed and an alarm is output.

Requirements

- The probe must be called as a tool with tool length compensation and be active.
- Tool type of the probe: 3D multi probe (type 710)
- In the active WO, the approximate values for the position of the spheres regarding offset and rotation are entered and activated. The value in the offset of the WO refers to the 1st sphere.
- Only minor deviations from the actual position of workpiece from the cycle can be expected.
- The sphere diameter must be significantly greater than the ball diameter of the probe stylus.

Starting position before the measurement

The probe must be positioned above the set sphere center point of the 1st sphere at a safe height.

Note

The measuring points must be selected so that there is no danger of a collision with a sphere fixture or another obstacle during measuring or intermediate positioning.

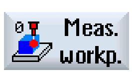
The measurement path in parameter DFA should be selected so large that all measuring points can be reached within total measurement path 2 x DFA. Otherwise no measurement can be performed or the measurements are incomplete.

Position after the end of the measuring cycle

The probe is above the determined sphere center point of the 3rd sphere at a safe height (height at the starting position).

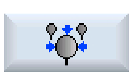
Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "3D" softkey.



3. Press the "3 spheres" softkey.
   The input window "Measure: 3 spheres" opens.

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		T	Name of the probe	-
	Calibration data set (1 - 40)	-		D	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 40)	-
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm
				Z	Start point Z of the measurement	mm

Parameter	Description	Unit
Correction target	• Measuring only (no offset) • Work offset (save measured values in a settable WO) [1]	-
Positioning	Traverse around sphere: • Parallel to the axis • On circular path	-
Only for positioning "On circular path":		
Align probe	Always align probe in the same contact direction • Yes • No	-
Number of measuring points	Measuring the spheres with three or four measuring points at the equator of the spheres	-
Repeat measurement	Repeat measurement with determined values • Yes • No	-
Determining the sphere diameter	• Yes • No	-
Ø	Sphere diameter setpoint	mm
α0	Contact angle [2]	Degrees
α1	Incremental angle (only for positioning "On circular path") [3]	Degrees
XM1	Center point of the 1st sphere X axis	mm
YM1	Center point of the 1st sphere Y axis	mm
ZM1	Center point of the 1st sphere Z axis	mm
XM2	Center point of the 2nd sphere X axis	mm
YM2	Center point of the 2nd sphere Y axis	mm
ZM2	Center point of the 2nd sphere Z axis	mm
XM3	Center point of the 3rd sphere X axis	mm
YM3	Center point of the 3rd sphere Y axis	mm
ZM3	Center point of the 3rd sphere Z axis	mm
TVL	Limit value of the minimum inside angle of the measured triangle of the three measurements of the rotary axes.	-
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

[1] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

[2] The contact angle always refers to the positive direction of the 1st axis of the active coordinate system, e.g. for G17 to +X, G18/+Z, G19/+Y

[3] The sign of the incremental angle specifies the positioning direction of this angle.

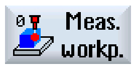
Machine manufacturer

Please observe the information provided by the machine manufacturer.

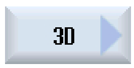
Measuring variant, turning on a milling machine (only 840D sl)

Procedure

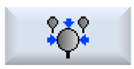
The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.



2. Press the "3D" softkey.



3. Press the "3 spheres" softkey.
   The input window "Measure: 3 spheres" opens.

Parameter

ShopTurn program		
Parameter	Description	Unit
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 40)	-
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "3 spheres" provides the following result parameters:

Table 3-28 "3 spheres" result parameters

Parameters	Description	Unit
_OVR[0]	Sphere diameter setpoint of 1st sphere	mm
_OVR[1]	Center point coordinate setpoint in the 1st axis of the plane of 1st sphere	mm
_OVR[2]	Center point coordinate setpoint in the 2nd axis of the plane of 1st sphere	mm
_OVR[3]	Center point coordinate setpoint in the 3rd axis of the plane of 1st sphere	mm
_OVR[4]	Sphere diameter actual value of 1st sphere	mm
_OVR[5]	Center point coordinate actual value in the 1st axis of the plane of 1st sphere	mm
_OVR[6]	Center point coordinate actual value in the 2nd axis of the plane of 1st sphere	mm
_OVR[7]	Center point coordinate actual value in the 3rd axis of the plane of 1st sphere	mm
_OVR[8]	Sphere diameter difference of 1st sphere	mm
_OVR[9]	Center point coordinate difference in the 1st axis of the plane of 1st sphere	mm
_OVR[10]	Center point coordinate difference in the 2nd axis of the plane of 1st sphere	mm
_OVR[11]	Center point coordinate difference in the 3rd axis of the plane of 1st sphere	mm
_OVR[12]	Sphere diameter actual value of 2nd sphere	mm

Parameters	Description	Unit
_OVR[13]	Center point coordinate actual value in the 1st axis of the plane of 2nd sphere	mm
_OVR[14]	Center point coordinate actual value in the 2nd axis of the plane of 2nd sphere	mm
_OVR[15]	Center point coordinate actual value in the 3rd axis of the plane of 2nd sphere	mm
_OVR[16]	Sphere diameter difference of 2nd sphere	mm
_OVR[17]	Center point coordinate difference in the 1st axis of the plane of 2nd sphere	mm
_OVR[18]	Center point coordinate difference in the 2nd axis of the plane of 2nd sphere	mm
_OVR[19]	Center point coordinate difference in the 3rd axis of the plane of 2nd sphere	mm
_OVR[20]	Sphere diameter actual value of 3rd sphere	mm
_OVR[21]	Center point coordinate actual value in the 1st axis of the plane of 3rd sphere	mm
_OVR[22]	Center point coordinate actual value in the 2nd axis of the plane of 3rd sphere	mm
_OVR[23]	Center point coordinate actual value in the 3rd axis of the plane of 3rd sphere	mm
_OVR[24]	Sphere diameter difference of 3rd sphere	mm
_OVR[25]	Center point coordinate difference in the 1st axis of the plane of 3rd sphere	mm
_OVR[26]	Center point coordinate difference in the 2nd axis of the plane of 3rd sphere	mm
_OVR[27]	Center point coordinate difference in the 3rd axis of the plane of 3rd sphere	mm
_OVR[28]	Safe area	mm
_OVI[0]	WO number	-
_OVI[2]	Measuring cycle number	-
_OVI[5]	Probe number	-
_OVI[9]	Alarm number	-
_OVI[11]	Status offset request	-
_OVI[12]	Supplementary error data for alarm, internal measurement evaluation	-

3.3.22 3D - angular deviation spindle (CYCLE995)

Function

With this measuring method the angularity of a spindle to the machine tool is measured on a calibration ball. The measurement is carried out by combining the measuring methods "sphere" (CYCLE997) and "outer circle segment" (CYCLE979).

Based on the measured values, the angular deviation of the spindle to the axis of the plane is calculated.

With the measured angular deviations, the spindle can be mechanically aligned parallel to the tool axis or the corresponding tables for sag compensation can be updated.

If there are rotary axes, the determined angular data can be used to align the rotary axis. To do this, the result parameter (_OVR) of CYCLE995 must be used.

Measuring principle

The 1st The calibration ball is measured using CYCLE997 and the measurement is repeated. The starting angle can be freely selected. The incremental angle between the measuring points should be set to 90 degrees. From two measuring points along the circumference and one measuring point at the "north pole" of the sphere (highest point), the center point (position of the ball) is determined. In addition, the diameter of the calibration ball can be determined.

The 2nd measurement is performed with CYCLE979 at the shank of the probe at a distance of DZ. The starting angle and the incremental angle are taken from the 1st measurement. The measuring path and the safe area are also from the 1st measurement times a factor of 1.5. measurement. The center point of the probe shaft in the plane is determined.

For both measurements, the switching direction of the probe is corrected for each individual measurement.

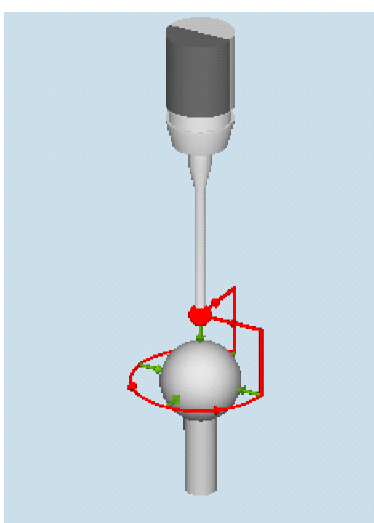
The angular deviation in XY is calculated from the results of the two center points in XY and the distance between the two measurements in Z (for G17).

The tolerance parameter of the angular values is optionally checked (dimensional tolerance "yes").

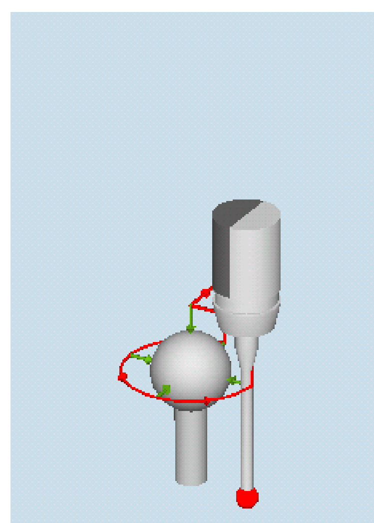
Note:

The cycle *CYCLE995* is based on the Renishaw AxiSet™ method based on the patent application, WO 2007068912 A1.

It is recommended to use the Renishaw probe with maximum accuracy for the application of the `CYCLE995`.



Measure: Angular deviation, spindle (CYCLE995), 1st measurement



Measure: Angular deviation, spindle (CYCLE995), 2nd measurement

Requirements

- The precision of the calibration ball should be better than 0.001 mm.
- An electronic program is loaded into the spindle with the longest possible stylus tip (>100 mm).
- The probe shaft should have a good surface quality (e.g. ground steel shaft).

Starting position before the measurement

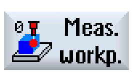
Before the cycle is called, the probe must be positioned at the distance of the measuring path (DFA) above the mounted calibration ball (North Pole) so that this can be approached without any collisions at the circumference (equator).

Position after the end of the measuring cycle

The probe is located after the measuring cycle at the start position. In the probe direction (for G17 Z), the probe is at the distance of the measuring path (DFA) above the north pole.

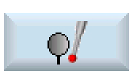
Procedure

The part program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "3D" softkey.



3. Press the "Spindle angular displacement" softkey.
   The input window "Measure: Spindle angular deviation" opens.

Parameter

G code program		
Parameter	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-
	Calibration data set (1 - 40)	-
Det. sphere diam.	Determining the sphere diameter • No • Yes	-
Ø	Sphere diameter	mm
α0	Contact angle	Degrees
DZ	Depth infeed for 2nd measurement	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

G code program		
Parameter	**Description**	**Unit**
Dimensional tolerance	Use dimensional tolerance • Yes • No	-
TUL	Upper tolerance limit of the angular deviation (only for dimensional tolerance "Yes")	Degrees

[1] Other parameters and correction targets can be set in the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE .

Machine manufacturer

Please observe the information provided by the machine manufacturer.

List of the result parameters

The measuring variant "machine geometry" provides the following result parameters:

Table 3-29 Result parameter "Machine geometry" (CYCLE995)

Parameters	Description	Unit
_OVR [2]	Actual angle between X and Z (X = 1st axis of the plane for G17, Z = 3rd axis of the plane for G17)	Degrees
_OVR [3]	Actual angle between Y and Z (Y = 2nd axis of the plane for G17)	Degrees
_OVR [4]	Distance in Z between the probe ball and measuring position at the probe shaft	mm
_OVR [5]	Exceeding the tolerance between X and Z (for dimensional tolerance "Yes")	mm
_OVR [6]	Exceeding the tolerance between Y and Z (for dimensional tolerance "Yes")	mm
_OVR [7]	Spindle camber in XZ (XZ for G17)	mm
_OVR [8]	Spindle camber in YZ (YZ for G17)	mm
_OVR [9]	Upper tolerance limit of the measured angle values (_OVR[2], _OVR[3])	mm
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring version	-
_OVI [5]	Number, probe calibration data field	-
_OVI [9]	Alarm number	-

Table 3-30 Intermediate results 1st measurement (calibration ball)

Parameters	Description	Unit
_OVR [10]	Setpoint calibration ball	mm
_OVR [11]	Setpoint center point coordinate, 1st axis of the plane	mm
_OVR [12]	Setpoint center point coordinate, 2nd axis of the plane	mm
_OVR [13]	Setpoint center point coordinate, 3rd axis of the plane	mm
_OVR [14]	Actual ball diameter	mm

Parameters	Description	Unit
_OVR [15]	Actual value center point coordinate, 1st axis of the plane	mm
_OVR [16]	Actual value center point coordinate, 2nd axis of the plane	mm
_OVR [17]	Actual value center point coordinate, 3rd axis of the plane	mm
_OVR [18]	Ball diameter difference	mm
_OVR [19]	Difference center point coordinate, 1st axis of the plane	mm
_OVR [20]	Difference center point coordinate, 2nd axis of the plane	mm
_OVR [21]	Difference center point coordinate, 3rd axis of the plane	mm

Table 3-31 Intermediate results 2nd measurement (measuring probe shaft or 2nd probe ball at the shaft)

Parameters	Description	Unit
_OVR [22]	Setpoint calibration ball diameter	mm
_OVR [23]	Center point setpoint in the 1st axis of the plane	mm
_OVR [24]	Center point setpoint in the 2nd axis of the plane	mm
_OVR [25]	Center point actual value in the 1st axis of the plane	degrees
_OVR [26]	Center point actual value in the 2nd axis of the plane	degrees
_OVR [27]	Center point difference in the 1st axis of the plane	Degrees
_OVR [28]	Center point difference in the 2nd axis of the plane	degrees

3.3.23 3D - kinematics (CYCLE996)

Function

With the "Measure kinematics" measuring variant (CYCLE996), it is possible to calculate the geometric vectors used to define the kinematic 5-axis transformation (TRAORI and TCARR) by measuring the positions of the sphere in space.

The measurement is essentially carried out by means of workpiece probes which scan three positions of a measuring sphere on each rotary axis. The sphere positions can be defined in accordance with user specifications so that they correspond to the geometric ratios on the machine. The only way of setting the sphere positions is to reposition the rotary axis that is to be measured in each case.

Precise knowledge of the mechanical system of the machine is not required when using CYCLE996. No dimension drawings or structural drawings are necessary to make measurements.

If the vectors of the machine are approximately known, the drawing dimensions must be entered in the vectors of the swivel data set and the machine measured with active orientable tool carrier (TCARR) or active 5-axis transformation (TRAORI). See also the programming example at the end of this section.

Reference: /PGZ/ Programming Manual *SINUMERIK 840D sl/840D/840Di sl Cycles*, CYCLE800.

Possible fields of application

The measuring variant "Measure kinematics" can be used to determine transformation-relevant data for kinematic transformations that contain rotary axes (TRAORI, TCARR).

- Redetermination of swivel data sets
  - Machine start-up
  - Use of swivel-mounted workholders as TCARR
- Check of swivel data sets
  - Service following collisions
  - Checking the kinematics during the machining process

Kinematics with manual axes (manually adjustable rotary tables, swivel-mounted workholders) can be measured in the same way as kinematics with NC-controlled rotary axes.

When starting *CYCLE996* a swivel data set must be parameterized with the basic data (for kinematic type, see the Programming Manual *SINUMERIK 840D sl/840D/840Di sl Cycles*, CYCLE800). The measurement itself must be carried out without an active kinematic transformation.

Requirements

The following requirements must be met in order to use `CYCLE996` (Measure kinematics):

- Calibrated 3D probe (probe type 710).
- Mounted calibration sphere.
- Oriented tool carrier has been set up (general MD 18088: $MN_MM_NUM_TOOL_CARRIER > 0)
- The basic geometry of the machine (X, Y, Z) is rectangular and referenced.
- The right angle refers to the workpiece spindle and should be preferably checked using a test mandrel or with the *CYCLE995* measuring cycle.
- Defined position of the rotary axes involved in the transformation.
- Defined traverse directions in compliance with the standard of all axes involved in the transformation according to ISO 841-2001 and/or DIN 66217 (right-hand rule).
- Linear and rotary axes must have their optimum dynamic settings. This applies especially, when the machine is to perform tool orientations during machining with active TRAORI.
- The probe must be calibrated precisely. The calibrated tool length of the probe is included directly in the calculated vectors of the kinematics.
- When measuring, the measuring variant "Circling around the calibration sphere with tracking of the switching direction" should be used.

Note

The vectors of the measured kinematics are only entered in the swivel data set if the manufacturer's password is active. Kinematics can only be corrected when no persistent transformation is active.

Machine manufacturer

Please observe the information provided by the machine manufacturer.

Measuring principle

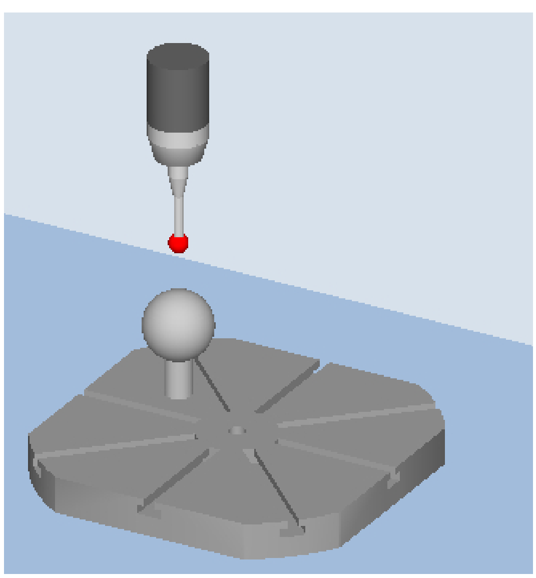
The "Measure kinematics" measuring variant always requires the following procedure:

1. Measure a rotary axis
2. Measure a second rotary axis (if this exists)
3. Calculate the swivel data sets (calculate kinematics)
4. The calculated data is activated automatically or with the aid of the user

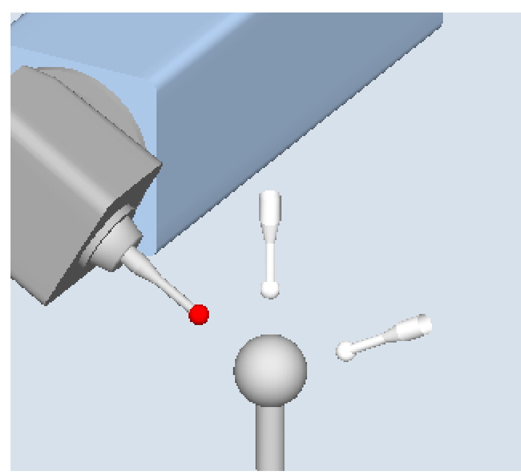
The user (preferably the machine manufacturer) should ensure compliance with the specified sequence.

If the position of the calibration sphere within the machine can be specified as an inherent part of the design, then it will be possible to store the entire kinematic measurement process (carried out using CYCLE996) as a part program, which is extremely advantageous. As a result, the user can carry out measurement of the kinematics under a set of predefined conditions at any given point in time.

The measurement of the rotary axis must be performed in the basic system of the machine. Metric machine with G710 and positions in mm. "INCH" machine with G700 and positions in INCHES.



Measure: Kinematic (CYCLE996),
1. Measurement swivel table



Measure: Kinematic (CYCLE996),
3. Measurement swivel head

Measuring kinematics

Starting from the kinematics initial state, the relevant rotary axes are measured individually.

- Rotary axes 1 or 2 can be measured in any order. If the machine kinematics only have one rotary axis, this is measured as rotary axis 1.
- The basic data for the kinematics is always the data of the tool carrier with orientation capability. If a dynamic 5-axis transformation is to be supported, it is preferable to use transformation type 72 (vectors from TCARR data).
- The linear and rotary axes must be prepositioned at starting positions P1 to P3 before measuring cycle CYCLE996 is called in the NC program. The starting position is automatically accepted in *CYCLE996* as the position setpoint for the "Measure sphere" function.
- In each of the sphere (rotary axis) positions selected, measuring is performed in accordance with the parameters and by calling *CYCLE996*.
- The kinematics are calculated using a separate, parameterized call of *CYCLE996*.
- When the 3rd measurement has been completed, the results of the measurement and the *CYCLE996* setting "Calculate kinematics" are written to the _OVR[ ] result parameters. When the "Enter vectors" function is selected (refer to `S_MVAR`, `S_TC`), then data is output to the swivel data set that has been set-up (TCARR, TRAORI(1)).
- A protocol file with the measurement results in an appropriate data format (machine data or TCARR data) can be optionally output.

Note

Requirements for measuring the kinematics with active TRAORI or active TCARR

- Set SD 55740: $SCS:MEA_FUNCTION_MASK, bit8 = 1
- Data set (swivel data or machine data) of the kinematics must be roughly set up (±1 mm).
- The probe must be positioned perpendicular on the measuring plane at the individual measuring points of the rotary axes. This can be performed with the swivel function (`CYCLE800`) or by positioning the rotary axes with TRAORI and then TOROT (for G17).
- If very small values are entered in the XYZ components of the rotary axis vectors (V1, V2), the kinematics should always be measured with active TCARR or active TRAORI.

Input screen forms "kinematics"

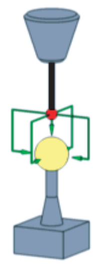
`CYCLE996` has to be called three times in order to complete the entire measuring and vector calculation process for one rotary axis. Between cycle calls, the user must reposition the rotary axis to be measured. Any rotary axis that is not being measured must not be repositioned during the measurement procedure. The linear axes are positioned at the starting positions P1, P2, P3.

The 1st to 3rd measurements are called using the respective softkeys.

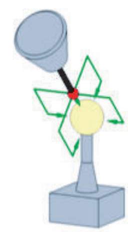
At the end of the 3rd measurement, the vectors of the measured rotary axis are calculated at the call. The requirement for this is that the 1st to 3rd measurements have been performed for the respective rotary axis and that the corresponding measurement results (center points of the calibration the calibration sphere) have been saved. The vectors of the machine kinematics are then calculated in full when both rotary axes have been measured. The measurement counter, parameter _OVR[40], is displayed in the result bit or in the protocol.

Measurement for kinematics with swivel head:

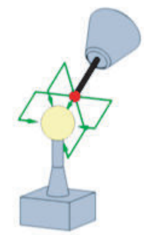
1st measurement P1 (initial state)



2nd measurement P2



3rd measurement P3



For the 2nd and 3rd measurements, the rotary axis to be measured is rotated around the largest possible angle. The calibration sphere position must be stationary during the measurements.

Starting position before the measurement

A rotary axis is measured by calling *CYCLE996* three times (measurements 1 to 3).

The probe ball must be able to reach the equator of the calibration sphere. The 1st measurement must take place in the initial state of the kinematics. If a rotary axis rotates parallel to the spindle without offset in a head kinematics (fork head), the 1st measurement can be made with applied probe. The rotary axis that is not to be measured is not in the initial state of the kinematics.

The starting position of the probe must be approached by the user or from the user program (see example program). The probe must be prepositioned in the direction of the tool orientation (ORI) above the highest point of the calibration sphere (probe aligned with the center of the sphere). After approaching the starting position, the distance (A) from the calibration sphere should be approximately DFA.

Note

Measuring variant "Positioning on a circular path":

For the variant "Positioning on circular path", positioning through 90° is always in the mathematical positive direction.

Position after the end of the measuring cycle

After each measurement (1 to 3) of a rotary axis, the probe is located above the calibration sphere at a maximum distance of the measurement path DFA.

See also

3D - kinematics (CYCLE996) (Page 214)

3D - kinematics (CYCLE996) (Page 214)

Measuring an individual rotary axis

The following steps must be carried out in order to measure a rotary axis:

- Mount the calibration ball on the machine table (user)
- Define and approach the three ball positions with the rotary axis that is to be measured (user)
- Specify and approach the three ball positions with the probe in a linear movement/in linear movements (user)
- Using *CYCLE996*, scan all three ball positions of the calibration ball with the probe.

Mounting the calibration ball

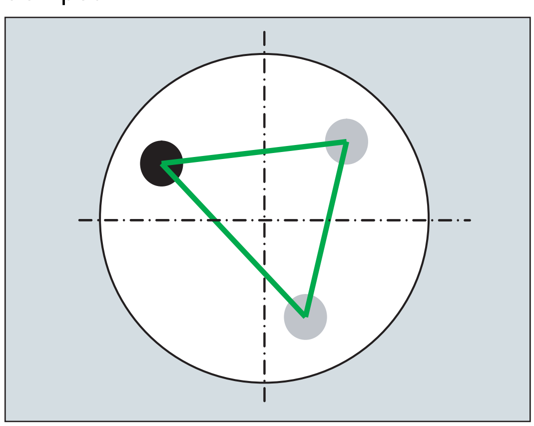
In the case of machinery, the calibration ball is to be installed on the machine table.

In order to measure kinematics for swivel-mounted workholders, the ball must be incorporated into the appropriate workholder. In all cases it must be ensured that the probe can approach and bypass the mounted calibration ball without collision in all the selected rotary axis positions.

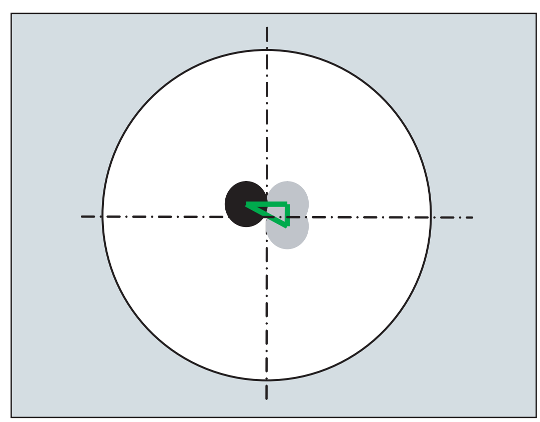
Considering the need to avoid collisions, the calibration ball should be mounted as far as possible from the center of rotation of the rotary axis that is to be measured.

If the three ball positions result in too small a triangle, this will negatively affect the accuracy of the procedure:

Calibration ball mounted sufficiently far from the center of rotation; large triangle can be clamped



Calibration ball mounted too near the center of rotation; clamped triangle is too small



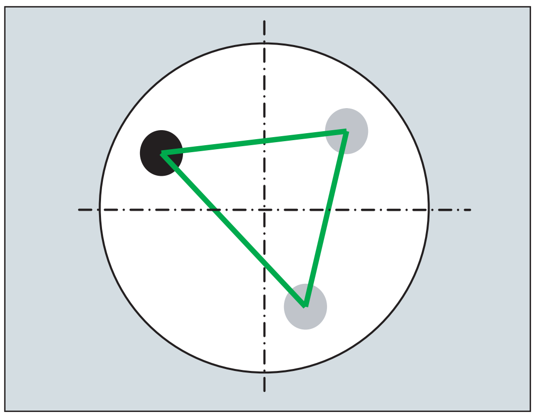
Note

While measuring a rotary axis, the mechanical hold-down of the calibration ball must not be altered. It is only with table and mixed kinematics that different calibration ball mounting positions are permissible for the purpose of measuring the first and subsequent rotary axes.

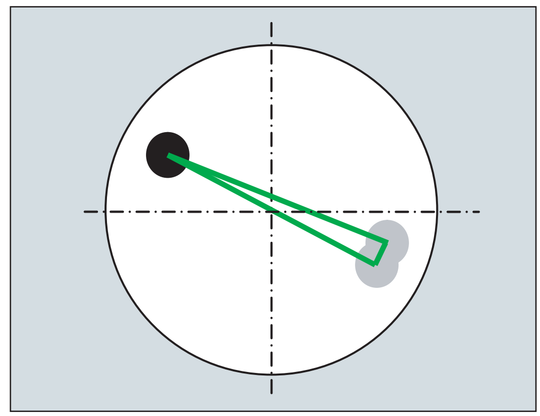
Defining the rotary axis positions

Three measuring points (ball position) must be defined for each rotary axis. Please note that the positions of the ball in space (resulting from the three defined rotary axis positions) should lead to as large a triangle as possible being clamped.

Rotary axis positions sufficiently far away from one another; large triangle clamped



Rotary axis positions poorly selected; clamped triangle is too small



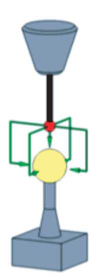
The calculated inside angle of the rotary axis angle segment is monitored in the **TVL** parameter. Angle values of < 20 degrees can cause inaccuracies when calculating the kinematics.

Approaching the ball position

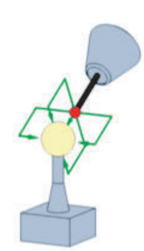
First of all, the probe must be positioned above the calibration ball at each of the three rotary axis positions defined by the user. The position must only be approached by traversing the linear axes (X, Y, Z). The positions themselves must be entered (set up) by the user. They should be determined manually using an active probe.

When selecting approach positions, please bear in mind that, within the context of automatic calibration ball scanning, the probe always moves in its preferred direction. Particularly where head and mixed kinematics are concerned, the starting position should be selected in a way that ensures alignment of the probe with the center point of the calibration ball in the approach position.

Starting position selected directly above the calibration ball



Starting position selected laterally above the calibration ball



Note

If the machine does not proceed as expected when the calibration ball is being scanned, the basic orientation and travel direction of the rotary axes should be checked. (Has DIN conformity been maintained when defining the axes?)

Starting position

The probe must be prepositioned in the direction of the tool orientation (ORI) above the highest point of the calibration ball (probe aligned with ball center point). After approaching the starting position, the distance (A) from the calibration sphere should be approximately DFA.

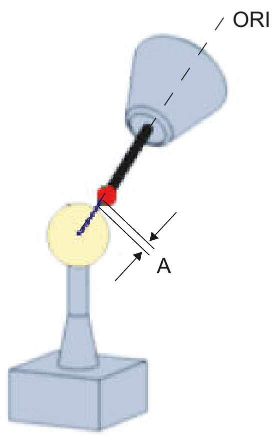


Figure 3-18 Starting position for the tool length in relation to the probe ball circumference

Note

Measuring the kinematics is also possible with active 5-axis transformation (TRAORI).

As a requirement for measuring the kinematics with active TRAORI, the vectors of the 5-axis transformation must be roughly set. The positions for measuring the kinematics are approached in the user program with active transformation. The transformation can be switched on or off during the actual measuring.

SD55740 $SCS_MEA_FUNCTION_MASK
Bit 8 = 0 Measure kinematics without active TRAORI or TCARR
Bit 8 = 1 Measure kinematics with active TRAORI or TCARR

Measuring an individual ball position

Once the probe has been positioned in accordance with user specifications above the ball, either manually or by the part program (starting point of CYCLE996), the calibration ball is scanned by calling CYCLE996 and the current ball position is measured.

To this end, the user should parameterize and call CYCLE996 separately for each ball position.

Calculating and activating the swivel data sets

After measuring the three sphere positions that are required in each case for all the relevant rotary axes, the entire set of swivel data sets can be calculated by means of CYCLE996. CYCLE996 should be parameterized and called for this purpose.

Correction target

In the "Calculate kinematics" screen form, in the "offset target" field, you can set whether vectors will "only" be calculated (measuring only) or whether the calculated vectors will be saved in the swivel data set. Before saving, the user can decide whether the calculated swivel data set will be displayed and changed. If the calculated swivel data set should not be displayed, the user can decide whether the swivel data set should be immediately overwritten. In all other cases, before saving the swivel data set, the operator is prompted to make a selection.

Table 3-32 Display options in the "Calculate kinematics" screen form

Parameter	Measuring only		Swivel data set	
Display data set	Yes	No	No	Yes
Data set can be changed	-	-	-	Yes/no
Confirm the change	-	-	Yes/no	-

- entry field is not displayed

In addition, the swivel data set can be saved as data file ("save data set").

The data file is stored in the current workpiece folder "WKS.DIR", "MPF.DIR", or "SPF.DIR". The storage location of the data file is in the current NC data path (if nested, in the path of the smallest program level). The file name corresponds to the name of the swivel data set, and is generated with a count index "_M1" to "_M99".

The data file contains the syntax of the parameters of the swivel data set of the NC function TCARR, e.g. :

$TC_CARR1[1]=-426.708853 $TC_CARR2[1]=-855.050806 … ;I1xyz.

If a transformation type <> 72 is set in the machine data for the dynamic transformation (TRAORI), the calculated vectors are saved in the protocol file also as machine data.

Saving the log file

When calculating the kinematics, before calling CYCLE996, the log cycle (CYCLE150) can be called. A log file is created with the measured and calculated vectors of the kinematics.

Tolerance limits

Activating tolerance limits when parameterizing CYCLE996 (compare Starting values – calculated values), allows conclusions to be drawn regarding unusual changes in the mechanical kinematic chain. The unintentional automatic overwriting of starting values can be avoided by adjusting the tolerance limits.

Note

The rotary axis vectors V1/V2 (orientation of the rotary axes) are never automatically overwritten.

Primarily, the calculated rotary axis vectors enable an assessment to be made regarding the mechanical desired/actual state of the kinematics. Depending on the kinematics configuration, even the smallest and corrected deviations in the position of the rotary axis vectors can result in large compensating movements.

Normalizing = setting a fixed value

Through normalizing, a new fixed value can be calculated in an axis direction (XYZ) for each rotary axis. This is required particularly for table kinematics because the result of the kinematics calculation refers to the measurement height of the calibration sphere. By normalizing, you can, for example, calculate the Z component to the reference point of the workpiece table.

In head kinematics, when calculating the kinematics, the initial state of the 1st measurement of rotary axis 2 (if available, otherwise rotary axis 1) is calculated. Normalizing is therefore usually not required for head kinematics. With orthogonal machine kinematics, the normalizing of a rotary axis only makes sense for a specific axis direction.

Example:
Table kinematics
Rotary axis 2(C) rotates around Z -> normalizing of rotary axis 2(C) in axis direction Z makes sense.

With normalizing "Yes," the value of the normalizing (fixed value) is written to the following linear vectors:

	Rotary axis 1	Rotary axis 2
Head kinematics	I1	I3
Table kinematics	I2	I4
Mixed kinematics	I2	I4

Example:
Table kinematics, rotary axis 1(A) rotates around X, rotary axis 2(C) rotates around Z.
Normalizing of rotary axis 1(A) X=100 -> I2x=100
Normalizing of rotary axis 2(Z) Z=0 -> I4z=0

Note

Normalizing (setting a fixed value) the vectors when measuring the kinematics

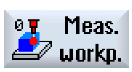
SD55740: $SCS_MEA_FUNCTION_MASK/ bit 7 (corresponded to _CHBIT[29]) activated.

- Bit 7 = 0: Normalizing on the basis of the calculated orientation vectors (V1xyz, V2xyz)
- Bit 7 = 1: Normalizing on the basis of the orientation vectors entered in the swivel data set (TCARR) or with TRAORI, in the machine data.

It is recommended that SD55740 bit 7 = 1 be set, as a machine test has proved that this further improves the accuracy of the calculated offset vectors.

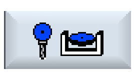
Procedure

The part program to be processed has been created and you are in the editor.



1. Press the "Meas. workpiece" softkey.

2. Press the "3D" softkey.



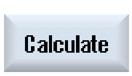
3. Press the "Kinematics" softkey.
   The "Measure: Kinematic" input window opens.

You can then open the following input windows via the following softkeys:

1. Measurement (see Parameters of 1st to 3rd measurement (Page 214))

2. Measurement

3. Measurement



Calculate (see Calculate parameters (Page 214))

Parameters 1st to 3rd measurement

G code program		
Parameter	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-
	Calibration data set (1 - 40)	-
Positioning	Traverse around sphere: • Parallel to the axis • On circular path	-
Align probe (only for positioning "On circular path")	Always align probe [2)] in the same contact direction: • Yes • No [2)]	-

G code program		
Parameter	**Description**	**Unit**
Rotary axis 1	Name of rotary axis 1 of the swivel data set	-
Rotary axis angle 1	Rotary axis angle during the measurement [1)]	Degrees
Rotary axis 2	Name of rotary axis 2 of the swivel data set	-
Rotary axis angle 2	Rotary axis angle during the measurement [1)]	Degrees
∅	Sphere diameter	mm
α0	Contact angle [3)]	Degrees
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

1) Only for manual or semi-automatic rotary axis of the swivel data set

2) Preferably the measuring variants "Positioning on circular path" and "Align probe in contact direction" should be used for the best measurement results.

3) The contact angle always refers to the positive direction of the 1st axis of the active coordinate system, e.g. for G17 to +X, G18/+Z, G19/+Y

Calculate parameters

G code program				
Parameter	**Description**			**Unit**
PL	Measuring plane (G17 - G19)			-
Correction target	Only measuring (only calculate vectors)	Swivel data set (calculate vectors and save to swivel data set)		-
Display data set	Yes/No	No	Yes	-
Data set can be changed	-	-	Yes/No	-
Confirm the change	-	Yes/No	-	-
Save data set	Data set is saved in a protocol file			
Rotary axis 1	Name of rotary axis 1 of the swivel data set			-
Normalizing	• No (without normalizing) • X (normalizing in direction X) • Y (normalizing in direction Y) • Z (normalizing in direction Z)			-
Value input	Position value for normalizing			mm
Rotary axis 2	Name of rotary axis 2 of the swivel data set			-
Normalizing	• No (without normalizing) • X (normalizing in direction X) • Y (normalizing in direction Y) • Z (normalizing in direction Z)			-
Value input	Position value for normalizing			mm
Tolerance	Use dimensional tolerance • Yes • No			-

G code program		
Parameter	**Description**	**Unit**
TLIN	Max. tolerance of the offset vectors (only for tolerance "Yes")	mm
TROT	Max. tolerance of the rotary axis vectors (only for tolerance "Yes")	Degrees
TVL	Limit value of the minimum inside angle of the measured triangle of the three measurements of the rotary axis (see "Mounting the calibration" above).	Degrees
Close vector chain	• Yes for kinematics mounted permanently on the machine • No for changeable kinematics (e.g. interchangeable heads)	-

- entry field is not displayed

Note

TVL

With TVL values < 20 degrees, scattering of the measured values can result in inaccuracies in the calculation of the kinematics.

List of the result parameters

The measuring variant "Calculate kinematics" provides the following result parameters:

Table 3-33 "Calculate kinematics" result parameters

Parameter	Description	Unit
_OVR[1]	Offset vector I1 $TC_CARR1[n] X component	mm
_OVR[2]	Offset vector I1 $TC_CARR2[n] Y component	mm
_OVR[3]	Offset vector I1 $TC_CARR3[n] Z component	mm
_OVR[4]	Offset vector I2 $TC_CARR4[n] X component	mm
_OVR[5]	Offset vector I2 $TC_CARR5[n] Y component	mm
_OVR[6]	Offset vector I2 $TC_CARR6[n] Z component	mm
_OVR[7]	Rotary axis vector V1 $TC_CARR7[n] X component	
_OVR[8]	Rotary axis vector V1 $TC_CARR8[n] Y component	
_OVR[9]	Rotary axis vector V1 $TC_CARR9[n] Z component	
_OVR[10]	Rotary axis vector V2 $TC_CARR10[n] X component	
_OVR[11]	Rotary axis vector V2 $TC_CARR11[n] Y component	
_OVR[12]	Rotary axis vector V2 $TC_CARR12[n] Z component	
_OVR[15]	Offset vector I3 $TC_CARR15[n] X component	mm
_OVR[16]	Offset vector I3 $TC_CARR16[n]Y component	mm
_OVR[17]	Offset vector I3 $TC_CARR17[n] Z component	mm
_OVR[18]	Offset vector I4 $TC_CARR18[n] X component	mm
_OVR[19]	Offset vector I4 $TC_CARR19[n] Y component	mm
_OVR[20]	Offset vector I4 $TC_CARR20[n] Z component	mm
_OVI[2]	Measuring cycle number	-
_OVI[3]	Measuring variant (`S_MVAR`)	-

Parameter	Description	Unit
_OVI[8]	Number of swivel data set (`S_TC`)	-
_OVI[9]	Alarm number	-

The measurement results (calculated vectors) depend on the type of kinematics

Kinematics type		Measuring result
Head kinematics [1]		
I1 $TC_CARR1...3[n]	Corresponds to	_OVR[1]..._OVR[3]
I2 $TC_CARR4...6[n]		_OVR[4]..._OVR[6]
I3 $TC_CARR15...17[n]		_OVR[15]..._OVR[17]
		_OVR[18]..._OVR[20] = 0
Table kinematics [2]		
I2 $TC_CARR4...6[n]	Corresponds to	_OVR[4]..._OVR[6]
I3 $TC_CARR15...17[n]		_OVR[15]..._OVR[17]
I4 $TC_CARR18...20[n]		_OVR[18]..._OVR[20]
		_OVR[1]..._OVR[3] = 0
Mixed kinematics [3]		
I1 $TC_CARR1...3[n]	Corresponds to	_OVR[1]..._OVR[3]
I2 $TC_CARR4...6[n]		_OVR[4]..._OVR[6]
I3 $TC_CARR15...17[n]		_OVR[15]..._OVR[17]
I4 $TC_CARR18...20[n]		_OVR[18]..._OVR[20]

The result parameters that are not calculated = 0

[1] Close vector chain **I1=-(I3+I2)**; for fixed-mounted machine kinematics

[2] Close vector chain **I4=-(I3+I2)**; for fixed-mounted machine kinematics

[3] Close vector chain **I1=-I2 I4=-I3**; for fixed-mounted machine kinematics

Table 3-34 Intermediate results _OVR[32] to _OVR[71]

Parameter	Description	Unit
_OVR[32,33,34] [1]	Linear vector of 1st rotary axis unscaled	mm
_OVR[35,36,37] [1]	Linear vector of 2nd rotary axis unscaled	mm
_OVR[40] [2]	Measurement counter x0 = 1st measurement, 1st rotary axis started x1 = 1st measurement, 1st rotary axis is OK x2 = 2nd measurement, 1st rotary axis is OK x3 = 3rd measurement, 1st rotary axis is OK 0x = 1st measurement, 2nd rotary axis started 1x = 1st measurement, 2nd rotary axis is OK 2x = 2nd measurement, 2nd rotary axis is OK 3x = 3rd measurement, 2nd rotary axis is OK 33 = both rotary axes measured	-
_OVR[41,42,43] [2]	1st measurement, 1st rotary axis	mm
_OVR[44,45,46] [2]	2nd measurement, 1st rotary axis	mm

Parameter	Description	Unit
_OVR[47,48,49] 2)	3rd measurement, 1st rotary axis	mm
_OVR[50]	Tool length of the probe	mm
_OVR[51,52,53] 2)	1st measurement, 2nd rotary axis	mm
_OVR[54,55,56] 2)	2nd measurement, 2nd rotary axis	mm
_OVR[57,58,59] 2)	3rdd measurement, 2nd rotary axis	mm
_OVR[60,61,62]	Measuring positions, rotary axis 1 for 1st, 2nd, 3rd measurement	Degrees
_OVR[63,64,65]	Measuring positions, rotary axis 2 for 1st, 2nd, 3rd measurement	Degrees
_OVR[66,67,68]	Active rotation of the WO for 1st measurement, rotary axis 1 in XYZ	Degrees
_OVR[69,70]	Reserved	-
_OVR[71]	Actual calibration ball diameter from the 1st measurement of rotary axis 1	mm
_OVR[72,73,74]	Actual calibration ball diameter of the 1st, 2nd, 3rd measurement, rotary axes 1	mm
_OVR[75,76,77]	Actual calibration ball diameter of the 1st, 2nd, 3rd Measurement, rotary axes (if rotary axis available) (see note regarding SD55644 $SCS_MEA_KIN_DM_TOL)	mm
_OVR[98]	Vector V1x after calculating as unit vector (without user-specific normalization)	
_OVR[99]	Vector V1y after calculating as unit vector	
_OVR[100]	Vector V1z after calculating as unit vector	
_OVR[101]	Vector V2x after calculating as unit vector (without user-specific normalization)	
_OVR[102]	Vector V2y after calculating as unit vector	
_OVR[103]	Vector V2z after calculating as unit vector	

1) The linear vectors are assigned to the specific vectors of the kinematics (I1, I2, etc.) in accordance with the normalizing process.

2) Result parameters _OVR[41] up to _OVR[59] are saved in groups of 3. The values include the measured actual values of the 3 linear axes (XYZ) in the machine coordinate system MCS.

At the start of the 1st measurement, the intermediate results (sphere center points) of the rotary axis are deleted.
For 1st measurement, 1st rotary axis → Delete _OVR[41] ... _OVR[49]
For 1st measurement, 2nd rotary axis → Delete _OVR[51] ... _OVR[59]

Programming example

Note

The measuring program example can be analogously used for head and table kinematics. The swivel data set must be appropriately adapted between marks SDA and SDE - and the rotary axis names and rotary axis positions.

```
;Measure kinematics
;Mixed kinematics with a B axis around Y and C axis around Z (MIXED_BC).
;Calibration sphere at 2*45 degrees, directly mounted on a table.
;WO in G56. Only the position of the calibration sphere
;has to be specified in the initial state of the kinematics (B=0 C=0).
;Determine G56 with measuring spigot in the JOG mode and approach in XY,
;then set sphere north pole Z=0.
;Swivel data must be entered according to the machine drawing dimensions -> _SDA _SDE.
;Intermediate positions are approached with active TRAORI.
;To do this, using the online tool offset TOFFL, the TCP
;is shifted to the center of the measuring sphere.

;Measuring positions for MIXED_BC
;P1 .. P3 rotary axis 1
;P4 .. P6 rotary axis 2

DEF REAL _P1[2]=SET(0,0) ;Measuring point P1 rotary axis 1(B), rotary axis 2(C)
DEF REAL _P2[2]=SET(45,0)
DEF REAL _P3[2]=SET(-45,0)
DEF REAL _P4[2]=SET(0,0)
DEF REAL _P5[2]=SET(0,90)
DEF REAL _P6[2]=SET(0,180)

DEF REAL _BALL=25 ;Calibration sphere diameter
DEF REAL _SAVB=1 ;Safety clearance above the calibration sphere
DEF REAL _U_FA, _U_TSA
;Pre-assign measuring parameters
_U_FA=_SAVB*3
_U_TSA=_SAVB*4

REPEAT _SDA _SDE  ;Read-in swivel data set
MSG(" load transformation data. OK ?? ")
M0
STOPRE
MSG()
;GOTOF _MCA ;Only calculate kinematics _OVR[40] to _OVR[71] OK

G17
CYCLE800()
ORIAXES ORIMKS
TRAORI
G56
T="3D-TASTER" D1
M6

IF (NOT $P_SEARCH) AND (NOT $P_ISTEST) AND (NOT $P_SIM)

_OVR[40]=0 ;Zero the measuring counter
ENDIF
```

```
; --------------------- 1st measurement, rotary axis 1
N99 G1 G710 G90 Z30 FFWON F2000
TOFFL=_BALL/2+_SAVB

D1 B=_P1[0] C=_P1[1] ;Kinematics initial state
Z = _SAVB
TOFFL=0
X0 Y0

;Circle around the sphere.
TOROT
CYCLE996(10101,1,1,_BALL,0,0,0,0,0,0,0,0,_U_FA,_U_TSA,1,,1,)
M1
STOPRE

M1
Z=IC(-_U_FA+_SAVB)
TOROTOF
M1

; --------------------- 2nd measurement, rotary axis 1
G1 F2000

TOFFL=_BALL/2+_SAVB ;When repositioning, correct the tool online
B=_P2[0] C=_P2[1]

TOFFL=0 ;Disable online correction again
;Circle around the sphere, starting angle 45 degrees
TOROT
CYCLE996(10102,1,1,_BALL,45,0,0,0,0,0,0,0,_U_FA,_U_TSA,1,,1,)

Z=IC(-_U_FA+_SAVB) ;Approach starting position
TOROTOF

;--------------------- 3rd measurement, rotary axis 1
G1 F2000
TOFFL=_BALL/2+_SAVB
D1 B=_P3[0] C=_P3[1]
TOFFL=0
TOROT
CYCLE996(10103,1,1,_BALL,210,0,0,0,0,0,0,0,_U_FA,_U_TSA,1,,1,)
Z=IC(-_U_FA+_SAVB)
TOROTOF

;--------------------- 1st measurement, rotary axis 2
; initial state 1st measurement rotary axis 1 = 1st measurement, rotary axis 2
```

```
_OVR[51]=_OVR[41] _OVR[52]=_OVR[42] _OVR[53]=_OVR[43]
_OVR[75] = _OVR[72] ;accept actual diameter

IF (NOT $P_SEARCH) AND (NOT $P_ISTEST) AND (NOT $P_SIM)


_OVR[40]=_OVR[40]+10

ENDIF


;--------------------- 2nd measurement, rotary axis 2
G1 F2000
TOFFL=_BALL/2+_SAVB
D1 B=_P5[0] C=_P5[1]
TOFFL=0
M1
TOROT
CYCLE996(20102,1,1,_BALL,0,0,0,0,0,0,0,0,_U_FA,_U_TSA,1,,1,)
Z=IC(-_U_FA+_SAVB)
TOROTOF

;--------------------- 3rd measurement, rotary axis 2
TOFFL=_BALL/2+_SAVB
G1 D1 C=_P6[1] F2000
TOFFL=0
TOROT
CYCLE996(20103,1,1,_BALL,_STA1,0,0,0,0,0,0,0,_U_FA,_U_TSA,1,,1,)
Z=IC(-_U_FA+_SAVB)
TOROTOF
ENDIF
G0 Z30
B0 C0

;-------------------- Calculate kinematics
;Display data set. Save data set as protocol file
;Normalizing rotary axis 2(C) on Z=0 -> table upper edge
CYCLE996(13001000,1,1,0,0,0,0,0.02,0.001,22,1,,1,101)
MSG("Kinematics measurement OK")
M1
M30 ;end of program

;----------------------------------------------------
```

```
_SDA:  ;Swivel data set according to machine drawing
TCARR=0

TRAFOOF

$TC_CARR1[1]=-25 $TC_CARR2[1]=0  $TC_CARR3[1]=-121
;I1xyz
$TC_CARR4[1]=25  $TC_CARR5[1]=0  $TC_CARR6[1]=121
;I2xyz
$TC_CARR7[1]=0   $TC_CARR8[1]=1  $TC_CARR9[1]=0 ;V1 axis B around Y
$TC_CARR10[1]=0  $TC_CARR11[1]=0 $TC_CARR12[1]=-1 ;V2 axis C around Z
$TC_CARR13[1]=0  $TC_CARR14[1]=0

$TC_CARR15[1]=0  $TC_CARR16[1]=0 $TC_CARR17[1]=0
;I3xyz
$TC_CARR18[1]=0  $TC_CARR19[1]=0 $TC_CARR20[1]=0
;I4xyz
$TC_CARR23[1]="M"

$TC_CARR24[1]=0   $TC_CARR25[1]=0

$TC_CARR26[1]=0   $TC_CARR27[1]=0

$TC_CARR28[1]=0   $TC_CARR29[1]=0

$TC_CARR30[1]=-92 $TC_CARR31[1]=0

$TC_CARR32[1]=92  $TC_CARR33[1]=360



STOPRE

NEWCONF

_SDE:
```

3.3.24 Expanded functionality CYCLE996

3.3.24.1 Checking the sphere diameter

When measuring the calibration sphere (1.2.3. measurement) the measured diameter (actual diameter) of the calibration sphere is saved to the following result parameters:

_OVR[72] to _OVR[74]	Actual diameter, calibration sphere 1.2.3. Measurement, rotary axis 1
_OVR[75] to _OVR[77]	Actual diameter, calibration sphere 1.2.3. Measurement, rotary axis 2 (if a rotary axis is available)

When setting data 55644 $SCS_MEA_KIN_DM_TOL > 0, after the 1st measurement and when calculating the kinematics, the measured calibration sphere diameter is checked. If the deviation is greater than in setting data $SCS_MEA_KIN_DM_TOL, fault 62321 or 62322 is output.

62321 rotary axis 1: Tolerance, diameter calibration sphere between measurement %4 exceeded.

62322 rotary axis 2: Tolerance, diameter calibration sphere between measurement %4 exceeded.

3.3.24.2 Scaling of rotary axis vectors V1 and V2

When calculating the kinematics, the vectors can be calculated as unit vector or as a user-specific vector. For user-specific rotary axis vectors, a vector component is always 1 or -1. The two remaining vector components are appropriately converted using a factor.

The function is activated using setting data 55740 $SCS_MEA_FUNCTION_MASK, bit 9.

Example: Swivel head with 45 degrees rotary axis

1. Vector V2xyz as unit vector calculating the kinematics (SD55740, bit 9=0):
   $TC_CARR10[1] = **0.7070974092**
   $TC_CARR11[1] = -1.823908EX-06
   $TC_CARR12[1] = **-0.7071161531**
2. Vector V2xyz user-specific after calculating the kinematics (SD55740, bit 9=1)
   $TC_CARR10[1] = **0.9999734924**
   $TC_CARR11[1] = -2.579361244EX-06
   $TC_CARR12[1] = **1**

If SD55740, bit 9=1 is set, for comparison purposes, vectors V1 and V2 are saved in the result parameters _OVR[98] up to _OVR[103] before calculating the user-specific scaling. Result parameters _OVR[98] to _OVR[103] are also written to the measuring data file.

_OVR[98]	Vector V1x after calculating as unit vector (without user-specific normalization)
_OVR[99]	Vector V1y after calculating as unit vector
_OVR[100]	Vector V1z after calculating as unit vector
_OVR[101]	Vector V2x after calculating as unit vector (without user-specific normalization)
_OVR[102]	Vector V2y after calculating as unit vector
_OVR[103]	Vector V2z after calculating as unit vector

3.3.24.3 Compensation of the rotary axes orientation with VCS and CYCLE996

CYCLE996 measures the kinematics. The calculated rotation vectors are determined but not corrected. CYCLE996 writes the VCSROTVEC.SPF transfer file which is read-in by VCS so that the deviation of the rotation vectors from the ideal vectors can be compensated by VCS.

Creating the compensation file for VCS

VCSROTVEC_VERIFICATION=0 (default)

The existing /_N_CMA_DIR/_N_VCSROTVEC_SPF file is deleted at the 1st measuring point and rewritten with the ideal vectors from the tool carrier.

The orientation vectors are calculated and the /_N_CMA_DIR/_N_VCSROTVEC_SPF file is rewritten in accordance with the measurements. The VCS file is reactivated.

Example of /_N_CMA_DIR/_N_VCSROTVEC_SPF:

```
[ROTV1]
-0.9999998863 0.000325562546 0.000348567077
[ROTV2]
0.000605196161 -0.000244774126 -0.9999997869
```

Verifying the compensation file for VCS

VCSROTVEC_VERIFICATION=1

The existing /_N_CMA_DIR/_N_VCSROTVEC_SPF file is retained during measurement. After the measurement, the new /_N_CMA_DIR/_N_VCSROTVEC_VERIFI_SPF file is created.

The file contains the orientation vectors of the compensation and the calculated orientation vectors with active compensation.

Example of /_N_CMA_DIR/_N_VCSROTVEC_VERIFI_SPF:

```
//active compensation for rotary axis orientation
[ROTV1]
-0.9999998863 0.000325562546 0.000348567077
[ROTV2]
0.000605196161 -0.000244774126 -0.9999997869
//measured rotary axis orientation with active compensation
[ROTV1]
-0.999999998 0.000003232074 0.000003458678
[ROTV2]
0.000006049775 -0.000002447851 -0.999999997
```

3.3.25 Measuring kinematics completely (CYCLE9960)

3.3.25.1 Function

With the "Measure kinematics completely" measuring variant (`CYCLE9960`), it is possible to correct the geometric vectors used to define the kinematic 5-axis transformation on the basis of kinematic chains and the tool carrier (in the conventional way via $TC_CARR) by measuring the positions of the ball in space.

The measurement is always carried out by means of workpiece probes which sense up to twelve positions of a measuring sphere on each rotary axis. The sphere positions are defined evenly over an area specified by the user so that they correspond to the geometric ratios on the machine. The sphere positions are set automatically solely through the repositioning of a rotary axis that is to be measured in each case.

For the use of the `CYCLE9960`, the kinematics must be set up precisely in accordance with the drawing dimensions to be able to guarantee automatic repositioning.

With `CYCLE9960`, it is also possible to measure the deviation on the tool tip (TCP) with active transformation for various rotary axis positions, after the measurement and correction of the kinematics. These deviations can be compensated with the "VCS Rotary" compile cycle.

Possible fields of application

- Check and correction of the machine kinematics
  - Service following collisions
  - Checking the kinematics during the machining process
- Measuring the reference (only for kinematics with changeable heads)
  - Using the Z dimension of a reference head
  - Vector of the tool axis remains unchanged as entered by the machine manufacturer
- Adapting to the reference (only for kinematics with changeable heads)
  - Enables the use of several heads for machining a workpiece
- Measuring and correcting interpolation points
  - Compensation with the aid of VCS Rotary of the TCP for rotary axis motion
  - Automatic creation of a compensation file

A transformation based on a kinematic chain must be active during the measurement.

Requirements

The following requirements must be met in order to use `CYCLE9960` (measure kinematics):

- Calibrated 3D probe (probe type 710)
- Mounted calibration sphere
- A transformation on the basis of kinematic chains ($MN_MM_NUM_TRAFOS>0) or a tool carrier must be set up.
- The basic geometry of the machine (X, Y, Z) is rectangular and referenced
- The right angle refers to the workpiece spindle and should be preferably checked with a test mandrel or with the `CYCLE995` measuring cycle
- Defined position of the rotary axes involved in the transformation
- Defined traverse directions in compliance with the standard of all axes involved in the transformation according to ISO 841-2001 and/or DIN 66217 (right-hand rule)
- Linear and rotary axes must have their optimum dynamic settings.
- The probe must be calibrated precisely. The calibrated tool length of the probe is included directly in the calculated vectors of the kinematics.
- When measuring, the measuring variant "Circling around the calibration sphere with tracking of the switching direction" should be used

Note

Kinematics can only be corrected when no persistent transformation is active. In this case, the kinematics can be measured with "Measuring only". The resulting vectors can be read with the _OVR[1] to _OVR[20] parameters.

Machine manufacturer

Please observe the information provided by the machine manufacturer.

3.3.25.2 Mounting the calibration sphere

For machines, the calibration sphere must be mounted on the machine table. In order to measure kinematics for swivel-mounted workholders, the sphere must be incorporated into the appropriate workholder. In all cases it must be ensured that the probe can approach and bypass the mounted calibration sphere without collision in all the selected rotary axis positions.

Considering the need to avoid collisions, the calibration sphere should be mounted as far as possible from the center of rotation of the rotary axis that is to be measured.

Note

While measuring a rotary axis, the mechanical attachment of the calibration sphere must not be changed.

Positioning the rotary axes

The user specifies the range to be measured for each rotary axis as well as the number of measuring points within this range. The measuring range should match the later machining range.

`CYCLE9960` calculates the rotary axis positions to be approached in the specified measuring range. The positioning direction of the rotary axes to be measured is DEFINED IN THE MATHEMATICAL POSITIVE DIRECTION OF ROTATION.

A reference measurement is always performed first in the initial state (usually 0°). If the initial state is included in the specified measuring range, it is not measured again.

To measure the interpolation points, the initial state must be a point included in the measuring range. The measuring range must not exceed 360°. As many measuring points are approached as specified.

With Hirth toothed axes, the measuring positions are rounded off to match the grid.

Example 1

Starting angle = -90°, end angle = 0°, number of measuring points = 3 (kinematics)

Measuring point 1 = 0°, measuring point 2 = -90°, measuring point 3 = -45°

Example 2

Starting angle = 30°, end angle = 180°, number of measuring points = 3 (kinematics)

Measuring point 1 = 0°, measuring point 2 = 30°, measuring point 3 = 180°

Example 3

Starting angle = 30°, end angle = 180°, number of measuring points = 6 (interpolation points)

Reference measurement = 0°, MP 1 = 30°, MP 2 = 60°, MP 3 = 90°, MP 4 = 120°, MP 5 = 150°, MP 6 = 180°

Example 4

Starting angle = -180°, end angle = 180°, number of measuring points = 6

Reference measurement = 0°, MP 1 = -180°, MP 2 = -120°, MP 3 = -60°, MP 4 = 0°, MP 5 = 60°, MP 6 = 120°

MP 4 is skipped and the values used from the reference measurement. +180° is not measured, because this position corresponds to MP 1 -180°.

Example 5: Head kinematics with 2 rotary axes

1st and 2nd rotary axis: Starting angle = -120°, end angle = 120°, number of measuring points = 6

1st rotary axis: Reference measurement not required.

MP 1=-120°, MP 2= -72°, MP 3= -24°, MP 4= 24°, MP 5= 72°, MP 6= 120°

2nd rotary axis:

Reference measurement: MP 1= 0°, MP 2= -120°, MP 3= -60°, MP 4= 0°, MP 5= 60°, MP 6= 120°

MP 4 is skipped because the reference measurement has already been performed.

In order to obtain a measurement result that is as precise as possible, the rotary axis range to be measured should not be too small. With the setting data $SCS_MEA_KIN_MIN_ANG_POS, a minimum angle can be set for the rotary axis range to be measured.

With the setting data $SCS_MEA_KIN_MIN_ANG_TRIANGLE, a minimum inner angle of the measuring triangle can be specified for a measurement of the rotary axes with three measuring points.

Measuring the kinematics

The linear vectors of the orientation axes are calculated from up to twelve measuring points per rotary axis and entered optionally. With several changeable kinematics (e.g. changeable heads for drilling machines), they are measured separately. A Z length reference is not established between the individual kinematics. The active WO is not changed

Measuring the reference

The Reference selection is only displayed when at least to swivel heads are available for selection. The toggler is not displayed for table kinematics. Generally, this only refers to the Z dimension relation between the MCS and the WCS! With the setting data $SCS_MEA_FUNCTION_MASK, the function can be activated via bit 10.

Whereby, the Z dimension of the reference head determines the center point of the measuring sphere in Z. The zero point of the active settable WO is corrected accordingly when measuring. In the correction of the vectors, only the two axes of the plane (X, Y for G17) and not the vector of the tool axis (Z) are corrected. The vector of the tool axis remains unchanged as entered by the machine manufacturer. The data of the active WO is saved for checking later measurements.

Adapting to the reference

All the length vectors of the head are adapted (X, Y, Z). The zero point of the active WO is used as reference, which was adapted accordingly with the "Measure reference head" measuring method. This enables the use of several heads for machining a workpiece. The operator is responsible for complying with the measuring sequence (first "Measure reference head", then all other heads with "Adapt head to reference head"). However, a check is made as to whether the active WO saved for "Measure reference head" is identical for the "Adapt head to reference head" measuring method.

All of the length vectors of the kinematics are corrected (e.g. from drawing dimensions to real values).

With an active orientation transformation based on the kinematic chain, the kinematics are corrected in the correction elements ($NT_CORR_ELEM_T[n,m], $NT_CORR_ELEM_P[n,m]) specified by the machine manufacturer.

Measuring interpolation points

The "VCS Rotary" compile cycle is required for the "Measure interpolation points" function.

The kinematics should always be measured first and then corrected. For machines with very high demands on precision, it may be necessary to use the more precise compensation via the "VCS Rotary" compile cycle. The "Measure interpolation points" selection is only displayed when the "VCS Rotary" compile cycle has also been installed.

Up to twelve measuring points in a uniform measuring grid are recorded for each rotary axis.

A file with a table (one probe length) is generated by `CYCLE9960`.

Measuring sequence

The deviation in the three geometry axes is determined and saved for each measuring point in different orientations. Whereby, the compensation is determined and then automatically saved to a compensation file and activated.

Compensation file

The compensation file is created automatically and save to the manufacturer cycle or user cycle directory.

MD62738 $MC_E996_FILE_LOCATION: Storage location of the compensation file, 1=CMA.DIR, 2=CUS.DIR

CYCLE9960 provides a compensation file with the following name:
E996<TC_NAME>_<ChanNo>.SPF

Whereby, TC_NAME is the name of the active transformation and ChanNo the number of the channel, e.g. E996HEAD_1.spf

If a compensation file is active before the start, it remains active. Before measuring, a check is made as to whether the name of the compensation file matches the active transformation. (As of SW 4.7 SP2)

- **Measuring and correcting interpolation points**
  An already available compensation file is automatically saved with the name E996<TC_NAME>_OLD<n>_<ChanNo>.SPF.
  Whereby, n is a consecutive number less than twelve. The advantage of an automatic backup is that the old file can be activated again when an error occurs during measuring or the result is not satisfactory. After measuring, the operator can write and activate the compensation file through an operator acknowledgment (NC start).
- **Measuring interpolation points only**
  With the remeasurement of the interpolation points, a new file is written which contains the new measured compensation. The file is called E996>TC_NAME>_MEA<n>.SPF and is written automatically after the measurement. The advantage of this file is that when the operator is of the opinion that the new compensation through the remeasurement should be used, the new compensation can be activated by simply changing the file name.

Activating and deactivating a compensation file

CC_E996()	Deactivate compile cycle "VCS Rotary"
CC_E996("TC_NAME")	Activation of the E996<TC_NAME>_<ChanNo>.SPF compensation file. If only measuring was performed and this compensation file (E996TC_NAME_MEA1.MPF) is to be activated, then this file must be renamed as E996TC_NAME_1.MPF so that it can be activated with CC_E996("TC_NAME"). Or the compensation file is renamed as E996TC_NAME_MEA_1.MPF and activated wtih CC_E996("TC_NAME_MEA"). This has the advantage that the old compensation file is still available.

3.3.25.3 Measurement result display

The measurement result display is very similar to the log. The measuring variant, the active transformation, the measured rotary axes and the associated measuring range are displayed in the header. The measuring differences for each measurement are then displayed in the Basic Coordinate System. The current and the new calculated correction element are displayed for an estimation as to whether the measured kinematics should also be corrected.

Example 1: Transformation on the basis of a kinematic chain:

```
---------------------------------------------------------------------------
-
2          :                       Time: 08:59:42
Results measure: Kinematics measure complete / CYCLE9960
Variant    : S_MVAR=11400
Measuring plane: G17
Name/number: HEAD_CA_Y100/2
Rotary axis 1: C1 start: 120.000 final: 240.000 no.: 3
Position of rotary axis 2: 30
Rotary axis 2: A1 start: 30.000 final: 90.000 no.: 3
Position of rotary axis 1: 0
---------------------------------------------------------------------------
-
Difference of measure:      X[mm]   Y[mm]   Z[mm]
max Value            0.03663   0.01208   0.04873
min Value            -0.02591   -0.05250   0.00000
  C1[deg]   A1[deg]    X[mm]    Y[mm]    Z[mm]
  120.0000  30.0000  -0.02591  0.00373  0.01599
  180.0000  30.0000  -0.00379  -0.03623  0.03088
  240.0000  30.0000  0.03663   -0.05250  0.048
   0.0000   0.0000   0.0000   0.0000   0.0000
   0.0000  30.0000   0.00682  -0.00950  0.04377
   0.0000  90.0000   0.00505  0.01208   0.01473
Difference of vector before:  X[mm]  Y[mm]  Z[mm]
MC1_OFFSET_2_CORR               0.00000   0.00000   0.00000
MA1_OFFSET_2_CORR               0.00000   0.00000   0.00000
Results:
Difference of vector:         X[mm]  Y[mm]  Z[mm]
MC1_OFFSET_2_CORR               0.00470   -0.00449   0.15641
MA1_OFFSET_2_CORR              -0.01612   -0.00129   -0.25343

Overwrite kinematics data record, yes -> NC start, no -> reset
```

Example 2: Tool carrier

```
-------------------------------------------------------------
2             :                          Time: 08:59:42
Results measure: Kinematic measure complete /CYCLE9960
Variant       : S_MVAR=11400
Measuring plane: G17
Name / number  : HEAD_CA / 2
Rotary axis 1  :  C1  start:  120.000  final:  240.000  no.:3
Position of rotary axis 2  : 30
Rotary axis 2  :  A1  start:   30.000  final:   90.000  no.:3
Position of rotary axis 1  : 0
--------------------------------------------------------------
Difference of measure:        X [mm]      Y [mm]      Z [mm]
max Value                     0.03663     0.01208     0.04873
min Value                    -0.02591    -0.05250     0.00000
   C1 [deg]    A1  [deg]      X [mm]      Y [mm]      Z [mm]
   120.0000     30.0000      -0.02591     0.00373     0.01599
   180.0000     30.0000      -0.00379    -0.03623     0.03088
   240.0000     30.0000       0.03663    -0.05250     0.04873
     0.0000      0.0000       0.00000     0.00000     0.00000
     0.0000     30.0000       0.00682    -0.00950     0.04377
     0.0000     90.0000       0.00505     0.01208     0.01473
vectors before:               X [mm]      Y [mm]      Z [mm]
I1                           -9.5000      0.00000     -80.000
I2                            9.50000     0.00000     30.0000
I3                            0.00000     0.00000     50.0000
Results:
vector:                       X [mm]      Y [mm]      Z [mm]
I1                           -9.5047      0.00449     -79.902
I2                            9.50470    -0.0044      30.1564
I3                            0.00000     0.00000     49.7465
Overwrite kinematics data record, yes -> NC start, no -> reset
```

3.3.25.4 Calibration on sphere

Before the measurement of the kinematics with prepositioning on the north pole of the calibration sphere, an automatic calibration on the sphere can be selected in `CYCLE9960`. Whereby, a new calibration is only performed in the plane (X, Y for PL=G17). The length of the probe must be determined as precisely as possible first.

3.3.25.5 Travel around the calibration sphere

In order to ensure that there is no collision with the shaft of the calibration sphere during the automatic measurement of the calibration sphere, the orientation of the shaft can be specified in the machine data $SCS_MEA_KIN_BALL_VEC[0..2]. The direction of the vector goes from the calibration sphere to the shaft. If this vector is specified, the starting angles α1 and α2 are calculated automatically when measuring the sphere to ensure that there is no collision with the shaft.

3.3.25.6 Tolerance limits

Tolerance of the offset vectors (TLIN)

Activating the tolerance limits when parameterizing `CYCLE9960` (compare Starting values – calculated values), allows conclusions to be drawn regarding unusual changes in the kinematics. The unintentional automatic overwriting of starting values can be avoided by adjusting the tolerance limits.

Tolerance of the direction vectors of the rotary axes

Primarily, the calculated rotary axis vectors enable an assessment to be made regarding the mechanical set/actual state of the kinematics. Depending on the kinematics configuration, even the smallest and corrected deviations in the position of the rotary axis vectors can result in large compensating movements.

The maximum permissible angular deviation of the calculated rotary axis vectors can be specified with SD $SN_CORR_TRAFO_DIR_MAX.

Note

The rotary axis vectors V1/V2 (orientation of the rotary axes) are never automatically overwritten.

Tolerance monitoring of the sphere diameter

When setting data 55644 $SCS_MEA_KIN_DM_TOL > 0, the measured calibration sphere diameter is checked after each measurement. If the deviation is greater than in setting data $SCS_MEA_KIN_DM_TOL, fault 62321 or 62322 is output.

62321 rotary axis 1: Tolerance, diameter of calibration sphere between measurement %4 exceeded.

62322 rotary axis 2: Tolerance, diameter of calibration sphere between measurement %4 exceeded.

3.3.25.7 Setting a fixed value (scaling)

A fixed value can be set in an axis direction (X, Y, Z) for each rotary axis. This is required particularly for table kinematics because the result of the kinematics calculation refers to the measurement height of the calibration sphere. With the fixed value, you can, for example, calculate the Z component to the reference point of the workpiece table.

Setting a fixed value only makes sense for specific axis directions.

Example

Table kinematics

- Rotary axis C rotates around Z → Set a fixed value for rotary axis C in axis direction Z.

Mixed kinematics

- Rotary axis C rotates around Y and Z (rotary axis vector = (0,1,1))
  → Set a fixed value for rotary axis C in axis direction Y or Z.
- Table rotates around Y
  → Set a fixed value for rotary axis B in axis direction Y.

The setting for which rotary axis which component is set, is performed via the setting data $SCS_MEA_KIN_MODE and $SCS_MEA_KIN_VALUE.

SCS_MEA_KIN_MODE[0]	Free component of the linear vector of the 1st rotary axis
= 0	All components of the linear vector are calculated
= 1	The component for X is taken from $SCS_MEA_KIN_VALUE[0].
= 2	The component for Y is taken from $SCS_MEA_KIN_VALUE[0].
= 3	The component for Z is taken from $SCS_MEA_KIN_VALUE[0].
= 4	The component for X is taken from the active transformation.
= 5	The component for Y is taken from the active transformation.
= 6	The component for Z is taken from the active transformation.
SCS_MEA_KIN_MODE[1]	Free component of the linear vector of the 2nd rotary axis

Note

The fixed value is always set on the basis of the orientation vectors of the rotary axes that are entered in the kinematic chain or in the tool carrier.

Closing a chain

For a transformation on the basis of kinematic chains, the tool or part chain is closed via the system variable $NT_CNTRL Bit7 and 8. For a tool carrier, you can use the setting data $SCS_MEA_KIN_MODE to set whether the closing vector is not to be calculated.

Table 3-35 SCS_MEA_KIN_MODE[0]

Value	Meaning
0x default	Head chain is closed, meaning I1 is calculated as the closing vector.
1x	Head chain is not closed, meaning I1=(0,0,0) SCS_MEA_KIN_MODE[1].
0x default	Table chain is closed, meaning I4 is calculated as the closing vector.
1x	Table chain is not closed, meaning I4=(0,0,0)

3.3.25.8 Parameter

G code program		
Parameter	**Description**	**Unit**
PL	Plane in which measurement is performed	-
	Calibration data set	-

G code program		
Parameter	**Description**	**Unit**
TC	Name of the transformation	-
Measuring method	• Measuring the kinematics • Measuring the reference • Adapting to the reference • Measuring interpolation points	-
Work offset	For Measuring reference only	
Measuring variants for measuring kinematics:	• Correcting • Measuring only	
Calibrate	Calibration of the probe in the plane of the first measurement [1)] • Yes • No	
Positioning	• Paraxial • On circular path	
∅	Sphere diameter	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
Rotary axis 1	Name of the 1st rotary axis to be measured	-
AX1S	Starting angle of measurement series 1	Degrees
AX1E	End angle of measurement series 1	Degrees
AX1N	Number of measuring points for the 1st measurement series (3...12)	-
Ax2P	Position of the 2nd rotary axis during the measurement	Degrees
αAx1	Contact angle on the calibration sphere in the measurement series for rotary axis 1[2]	Degrees
Rotary axis 2	Name of the 2nd rotary axis to be measured	-
AX2S	Starting angle of measurement series 2	Degrees
Ax2E	End angle of measurement series 2	Degrees
Ax2N	Number of measuring points for the 2nd measurement series (3...12)	-
Ax1P	Position of the 1st rotary axis during the measurement	Degrees
αAx2	Contact angle on the calibration sphere in the measurement series for rotary axis 2[2]	Degrees
Tolerance	• Yes • No Value of the tolerance of the linear vectors for tolerance yes: Value in SD $SN_CORR_TRAFO_LIN_MAX	mm

[1)] The workpiece probe can only be calibrated before the measurement when the workpiece probe is used in an SPOS-capable spindle.

[2)] If the direction of the calibration sphere shaft ($SCS_MEA_KIN_BALL_VEC) is described, the contact angle is calculated automatically.

List of the result parameters

The "Measure kinematics completely" measuring variant provides the following result parameters:

Table 3-36 Transformation on the basis of kinematic chains

Parameter	Description	Unit
_OVR[21,22,23]	Correction values of the offset of rotary axis 1	mm
_OVR[24,25,26]	Correction values of the offset of rotary axis 2	mm
_OVR[130,131,132]	Measurement difference of the 1st measurement in the initial state	mm
_OVR[133,134]	Position of rotary axes 1 and 2 for 1st measurement	Degrees
_OVR[135,136,137]	Measurement difference of the 2nd measurement	mm
_OVR[138,139]	Position of rotary axes 1 and 2 for 2nd measurement	Degrees
_OVR[140,141,142]	Measurement difference of the 2nd measurement	mm
_OVR[143,144]	Position of rotary axes 1 and 2 for 3rd measurement	Degrees
...	...	

As of _OVR[130], the measurement differences are stored with the associated rotary axis positions. Depending on the number of points to be measured, the corresponding number of _OVR variables are written.

Table 3-37 Tool carrier

Parameter	Description	Unit
_OVR[1,2,3]	Offset vector l1	mm
_OVR[4,5,6]	Offset vector l2	mm
_OVR[7,8,9]	Calculated rotary axis vector V1 (not corrected)	mm
_OVR[10,11,12]	Calculated rotary axis vector V2 (not corrected)	mm
_OVR[15,16,17]	Offset vector l3	mm
_OVR[18,19,20]	Offset vector l4	mm
_OVR[130,131,132]	Measurement difference of the 1st measurement in the initial state	mm
_OVR[133,134]	Position of the rotary axis 1 and 2 at 1st measurement	Degrees
_OVR[135,136,137]	Measurement difference of the 2nd measurement	mm
_OVR[138,139]	Position of the rotary axis 1 and 2 at 2nd measurement	Degrees
...	...	

3.3.26 3D measuring on machines with orientation transformation

Function

Measuring with active orientation transformation, i.e. with the swivel cycle *CYCLE800* (orientable tool carrier TCARR), or with the kinematic 5-axis transformation (TRAORI) with the measuring cycles is possible.

The probe must be positioned perpendicular to the machining plane or parallel to the tool axis before calling the measuring cycles.

The Align plane (*CYCLE998*) and Measure kinematics (*CYCLE996*) functions are the exception. Here, the probe is always at an angle to the object to be measured.

The workpiece measurement is generally based on the active workpiece coordinate system WCS.

Checking the correct switching direction when measuring the workpiece

If elements (hole, edge, etc.) are measured in the swiveled, rotated WCS, the switching direction of the 3D workpiece probe must be checked as follows during the first commissioning of the machine in the JOG and AUTO modes:

- Bit1 = 1 must be set in SD 55740 $SCS_MEA_FUNCTION_MASK (coupling of the spindle with the coordinate rotation).
- The switching direction in X+ (for G17) in the initial state of the machine kinematics must be marked accordingly on the probe.
- Using the measuring of a hole with *CYCLE977* in the swiveled plane as an example, the marked switching direction must be aligned towards X+ when starting and probing the 1st measuring point.
  With active orientation transformation (TCARR, *CYCLE800*, TRAORI), the spindle position changed by the tool orientation is calculated internally in the measuring cycles and the spindle corrected accordingly.
  The result of the calculation is saved in the GUD variable _MEA_CORR_ANGLE[1].
  The correct spindle position during measuring must be checked on the workpiece for different orientations of the object to be measured.
- After a successful check, SD 55740 $SCS_MEA_FUNCTION_MASK, bit1 = 0 can be set. The measurement results must correspond to those of the measurements with coupling of the spindle.

Note

Additional adaptation of the correction angle

An additional adaptation of the correction angle for the positioning of the spindle may be required for the selected machine kinematics or applications.

With the CUST_MEACYC.SPF manufacturer cycle, you can write the correction angles _MEA_CORR_ANGLE[0] and _MEA_CORR_ANGLE[1].

These angles affect the spindle position / probe orientation when measuring or the internal conversion of the trigger values if the spindle is not to be aligned in the switching direction (SD 55740 bit1 = 0, SPOS = 0 during measuring).

3.3.27 Measuring with probe that cannot be positioned

General

If a probe at the machine cannot be positioned about the infeed axis, all of the measuring functions that require positioning or alignment are not carried out.

Examples of such measuring functions are:

- Calibrating in the reference ring with a start point that is not in the center of the ring
- Calibration at the ball
- Function 3D probe with spindle rotation
- Function align 3D probe
- Function spindle coupling with coordinate rotation

The following explanations refer to the use of the milling measurement cycles.

A distinction is made between two basic use cases:

- The probe is located in a "non-SPOS-capable spindle". These can be, for example, speed-controlled spindles without position control or high-speed spindles.
- The probe is "permanently installed on the machine". This is possible, for example, with laser finishing machines without a spindle or grinding machines.

3.3.27.1 Non-SPOS-capable spindle

Requirement

- Electronic 3D workpiece probe (multi-probe)
- Between the calibration and measurement, the user must guarantee an identical orientation (spindle position) of the probe, for example by clamping or indexing.

Function

It is generally assumed that the spindle contained in the probe is defined as the master spindle with machine data or a program command. The probe and machining spindle center correspond to the programmed axis position.

The behavior of the measuring cycles is set with the following channel-specific machine data:

MD 52207[n] $MCS_AXIS_USAGE_ATTRIB, bit 9

Value bit 9	Meaning
=0	Spindle is SPOS-capable (default)
=1	Independently of the spindle characteristic, only measurement functions without spindle positioning are carried out by the measurement cycles. The programming of the measurement cycles is done exactly as it is done with a positionable probe. All of the functions that require a positionable spindle cannot be selected in the measurement cycle input screens.

In the measuring cycle, no SPOS commands are called or non-executable measuring functions are rejected by means of an alarm message during the cycle runtime.

Note

Calibration

If a probe is not SPOS-capable, or is permanently mounted on the machine, this results in special requirements for the calibration.

The permissible calibration variants are:

- Calibrating in the ring, with "start point in the center of the ring"
  - AUTO mode: SD54760 Bit22 = 1
  - JOG mode: SD55740 bit 15 = 1
- Calibration at an edge/between two edges

3.3.27.2 Measuring probe permanently affixed to the machine

Requirement

- Electronic 3D workpiece probe (multi-probe)

Function

If the measuring probe is permanently affixed to the machine, a mechanical offset may exist in the three geometry axes:

- between the measuring probe ball (tool tip)
- the tool reference point of the machining spindle
- and the machining medium (laser)

This offset should be entered in the adapter dimension (basis dimension) of the tool data of the workpiece probe. As a component of the tool geometry, the adapter dimension is already contained in the CNC.

The explained adaptation of the tool geometry results in the programmed axis position corresponding to the probe ball (tool tip). You must observe whether the probe length refers to the probe ball center or the probe ball circumference.

The behavior of the measuring cycles is set with the following general machine data:

MD 51740 $MNS_MEA_FUNCTION_MASK, bit 4

Value bit 4	Meaning
=0	Workpiece probe is located in a spindle (default)
=1	Probe is permanently affixed on the machine. The programming of the measurement cycles is done exactly as it is done with a positionable probe. All of the functions that require a positionable spindle cannot be selected in the measurement cycle input screens. In the measuring cycle, no SPOS commands are called or non-executable measuring functions are rejected by means of an alarm message during the cycle runtime.

Note

Calibration

If a probe is not SPOS-capable, or is permanently mounted on the machine, this results in special requirements for the calibration.

The permissible calibration variants are:

- Calibrating in the ring, with "start point in the center of the ring"
  - AUTO mode: SD54760 Bit22 = 1
  - JOG mode: SD55740 bit 15 = 1
- Calibration at an edge/between two edges

3.4 Measuring the workpiece on a machine with combined technologies

3.4.1 Measuring a workpiece on a milling/turning machine

General

This chapter refers to measuring a workpiece on milling/turning machines. Milling is set up as the 1st technology and turning as the 2nd technology.

Preconditions:

1. Milling: MD52200 $MCS_TECHNOLOGY = 2
2. Turning: MD52201 $MCS_TECHNOLOGY_EXTENSION = 1

Further, the following setting data must be set:

- SD 42950 $SC_TOOL_LENGTH_TYPE = 3
- SD 42940 $SC_TOOL_LENGTH_CONST = 17
- SD 42942 $SC_TOOL_LENGTH_CONST_T = 19

Measuring workpieces using turning technology on a milling machine is realized using milling technology. For example, if the outer diameter of a contour is to be measured, then this can be realized using CYCLE977 "Measure spigot" at the G17 plane. If the measured values are to be corrected in a turning tool, then the programmer must specify the tool lengths L3x or L1z to be corrected, and possibly the sign of the correction. The selection of the correction depends on the turning tool orientation (align turning tool function beta and gamma) for turning. Please take into account SD55760 $SNS_MEA_FUNCTION_MASK_PIECE bit12 and bit13. It only makes sense to correct the measured values of the turned tool in a work offset for the Z axis. The machine manufacturer makes the correct setting of the turning center in XY when commissioning the machine.

Note the machine manufacturer's instructions

If the tool probe is to be reorientated for making the measurement, then this is realized using the swivel plane function (CYCLE800).

Additional settings/notes relating to milling/turning technology should be taken from IM9 – Chapter "Turning on milling machines".

The descriptions for the appropriate cycles in this manual should be used to parameterize the individual measuring versions.

3.4.2 Measuring a workpiece on a turning/milling machine

The following section refers to the workpiece measuring on turning/milling machines. Whereby turning is set up as the 1st technology and milling as the 2nd technology.

- Turning measurement (measure diameter, outside, inside, etc.)

If measuring is to be performed in different tool orientations (B axis for turning technology), the probe can be prepositioned with the "Tool alignment" function (*CYCLE800*).

- Milling measurement (measure hole, set edge, align edge, etc.)

If measuring is to be performed in different tool orientations, the probe can be prepositioned with the "Swivel plane" function (*CYCLE800*).

Value specifications of the transverse axis (X) of the measuring cycles under milling are performed in the radius (DIAMOF). The measuring cycles under milling also work internally with radius programming in relation to a transverse axis.

With hole and spigot measurement (*CYCLE977, CYCLE979*), the object to be measured is specified in the diameter.

The workpiece probe cannot be calibrated under the active G18 machining plane (turning) for turning/milling machines for geometric reasons. The workpiece measurements should be performed in G18 during turning. The probe is therefore calibrated under G17 or G19 and the trigger values allocated internally accordingly.

3.4.2.1 Allocating the trigger values

Function

As of SW 4.5 SP2, the following application is enabled with the "Calibrating and measuring in different machining planes" function:

- Calibrating (with *CYCLE976*) in the G17 or G19 working plane
- Workpiece measuring in G18 as for turning (with *CYCLE974*, *CYCLE994*)

Requirement

- 1st turning technology: MD 52200$MCS_TECHNOLOGY = 1
- 2nd milling technology: MD 52201$MCS_TECHNOLOGY_EXTENSION = 2
- Active tool is a 3D multi probe, type 710

3.4.2.2 Uniformity when using a 3D probe of type 710

Function

In accordance with the "Calibrating and measuring in different machining planes" function on a turning/milling machine, the 3D probe type (710) can be used for all workpiece measuring variants (turning and milling) on the basis of a calibration data set.

Requirement

- Setting data SD 42940 $SC_TOOL_LENGTH_CONST = 18 (or -18)
- Setting data SD 42950 $SC_TOOL_LENGTH_TYPE = 2
- Active tool is a 3D multi probe, type 710

Note

If the above requirements are not satisfied for measuring under turning, alarm 61309 "Check tool type of the workpiece probe" is output.

3.5 Measure tool (turning)

3.5.1 General information

The measuring cycles below are intended for use on turning machines.

Note

Spindle

Spindle commands in the measuring cycles always refer to the active master spindle of the control.

When using the measuring cycles at machines with several spindles, then the spindle involved must be defined as master spindle before the cycle call.

References: /PG/ Programming Manual *SINUMERIK 840D sl / 828D Fundamentals*

Plane definition

The measuring cycles work internally with the 1st and 2nd axes of the actual plane G17 to G19.

The default setting for lathes is G18.

Note

The measuring cycle for tool measurement, turning (CYCLE982) does not position in the 3rd axis (Y for G18). The user must position in the 3rd axis.

Machine/workpiece-related measuring/calibrating

- Machine-related measuring/calibrating:
  Measuring is performed in the basic coordinate system (machine coordinate system with kinematics transformation disabled).
  The switching positions of the tool probe refer to the machine zero. Data from the following general setting data are used (PLUS and MINUS define the traversing direction of the tool):
  - ① SD 54625 $SNS_MEA_TP_TRIG_MINUS_DIR_AX1
  - ② SD 54626 $SNS_MEA_TP_TRIG_PLUS_DIR_AX1
  - ③ SD 54627 $SNS_MEA_TP_TRIG_MINUS_DIR_AX2
  - ④ SD 54628 $SNS_MEA_TP_TRIG_PLUS_DIR_AX2

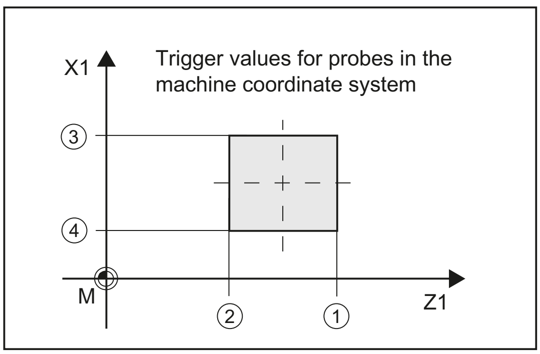


Figure 3-19 Tool probe, machine-related (G18)

- Workpiece-related measuring/calibrating:
  The switching positions of the tool probe refer to the workpiece zero.
  Data from the following general setting data are used (PLUS and MINUS define the traversing direction of the tool):
  - ① SD 54640 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX1
  - ② SD 54641 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX1
  - ③ SD 54642 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX2

– ④ SD 54643 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX2

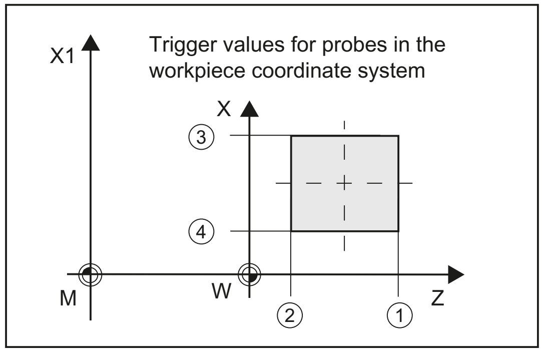


Figure 3-20 Tool probe, workpiece-related (G18)

Note

Workpiece-related or machine-related measurement requires an appropriately calibrated tool probe, see ChapterCalibrate probe (CYCLE982) (Page 255).

Compensation strategy

The tool measuring cycle is intended for various applications:

- First measurement of a tool (general setting data SD 54762 $SNS_MEA_FUNCTION_MASK_TOOL Bit9):
  The tool offset values in geometry and wear are replaced.
  The offset is applied in the geometry component of the particular length.
  The wear component is deleted.
- Post measurement of a tool (general setting data SD 54762 $SNS_MEA_FUNCTION_MASK_TOOL Bit9):
  The resulting difference is calculated into the wear component (length) of the tool.

Empirical values may optionally be included. A mean value is not calculated.

See also

Changes from cycle version SW4.4 and higher (Page 345)

3.5.2 Calibrate probe (CYCLE982)

Function

This measuring version can be used to calibrate a tool probe. Using the calibration tool, the actual distances between machine or workpiece zero and the probe trigger points are determined.

Values are corrected without empirical and mean values.

Note

If a special calibration tool is not available, a turning tool can be used instead with cutting edge positions 1 to 4 for the calibration of two sides of the probe.

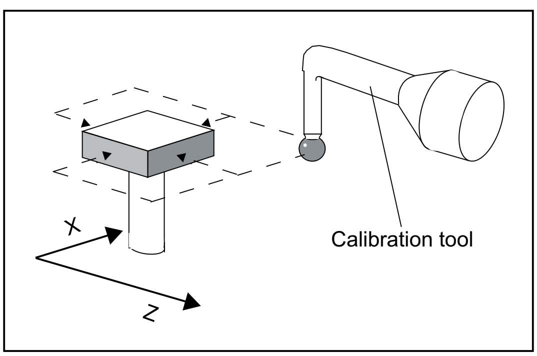
Measuring principle

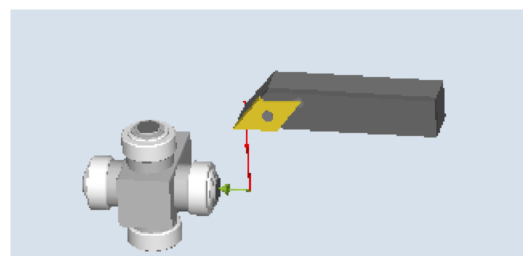
Calibrating with tool type calibration tool (type 585)

The calibration tool is shaped (angled) in such a way that the probe can be calibrated on all four sides with it.

Calibrating with tool type calibration tool (type 725) or turning tool (type 5xy)

When a turning tool or a calibration tool, type 725, is used, the probe can only be calibrated from 2 sides.





Calibrating the tool probe with a calibration toolCalibrating a tool probe with a turning tool

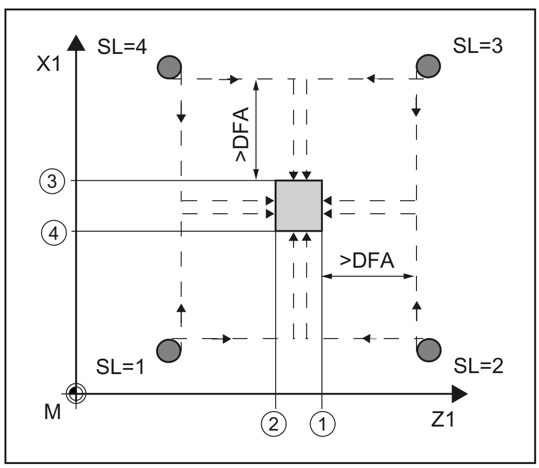
The cycle positions the calibration or turning tool to the probe. With a cycle call, the switching position in the specified measuring axis and measuring direction is calibrated.

Preconditions

- Lengths 1 and 2 and the radius of the calibration or turning tool must be known exactly and stored in a tool offset data record.
  This tool offset must be active when the measuring cycle is called.
- For calibration, a reference turning tool, type 5xy, with precisely known geometry or a type 585 or type 725 calibration tool can be used (type 580 3D probe turning cannot be used)
- Calibration with a calibration or turning tool with cutting edge positions 1 to 4 is possible.

- The lateral surfaces of the probe cube must be aligned parallel to the machine axes Z1, X1 (axes of the plane).
- The approximate positions of the switching surface of the probe regarding the machine or workpiece zero must be entered before calibration starts in the general setting data (see Commissioning Manual *SINUMERIK Operate (IM9) / SINUMERIK 840D sl* , Chapter "Tool measurement in turning").
  These values are used for automatic approach to the probe with the calibration tool and their absolute value must not deviate from the actual value by more than the value in parameter TSA.
  The probe must be reached within the total path 2 · DFA.

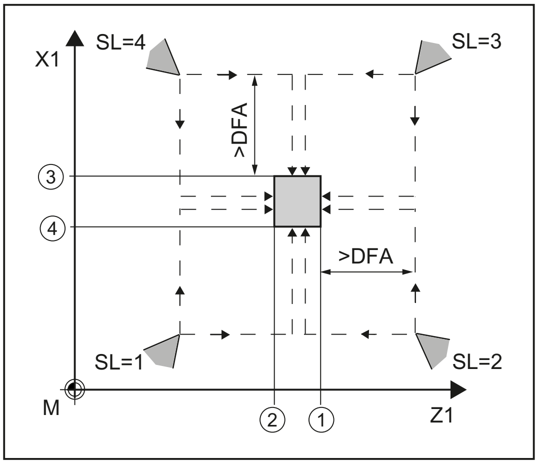
Starting position before the measurement



Cutting edge positions 1 to 4 and suitable approach positions for both axes (machine-related)

① Trigger point of the 1st measuring axis in the negative direction (general SD 54625)
② Trigger point of the 1st measuring axis in the positive direction (general SD 54626)
④ Trigger point of the 2nd measuring axis in the negative direction (general SD 54627)
Trigger point of the 2nd measuring axis in the positive direction (general SD 54628)

Figure 3-21 Calibrating the tool probe with a calibration tool



Cutting edge positions 1 to 4 and suitable approach positions for both axes (machine-related)

① Trigger point of the 1st measuring axis in the negative direction (general SD 54625)

② Trigger point of the 1st measuring axis in the positive direction (general SD 54626)

③ Trigger point of the 2nd measuring axis in the negative direction (general SD 54627)

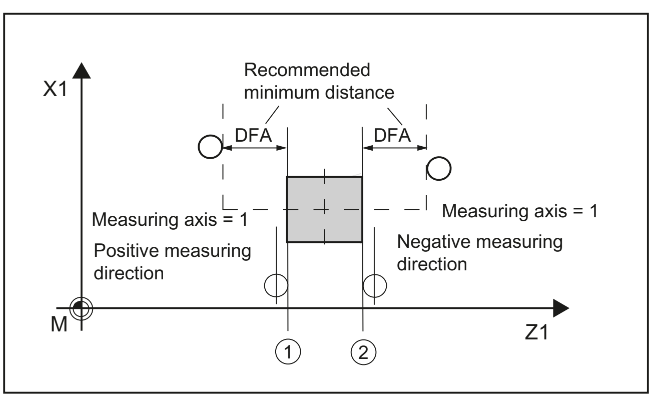
④ Trigger point of the 2nd measuring axis in the positive direction (general SD 54628)

Figure 3-22 Calibrating a tool probe with a turning tool

The cycle handles the approach to the probe.

Position after the end of the measuring cycle

The calibration or turning tool is located by the measurement path away from the measuring surface.



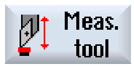
① Trigger point of the 1st measuring axis in the positive direction (general SD 54626)

② Trigger point of the 1st measuring axis in the negative direction (general SD 54625)

Figure 3-23 Position after the end of the measuring cycle, example 1st axis of the plane (for G18: Z)

Procedure

The part program or ShopTurn program to be processed has been created and you are in the editor.



1. Press the "Meas. tool" softkey.

2. Press the "Calibrate probe" softkey.
   The input window "Calibrate: Probe" opens.

Parameter

G code program				ShopTurn program		
Parameters	**Description**	**Unit**		**Parameters**	**Description**	**Unit**
	Calibration data set (1 - 6)	-		T	Name of the calibration tool	-
F	Calibration and measuring feedrate	Distance/ min		D	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 6)	-
				F	Calibration and measuring feedrate	mm/min
				β	Tool alignment with swivel axis • ← (0 degrees) • ↓ (90 degrees) • Value entry	Degrees
				V	Tool orientation with a tool spindle	Degrees
				Z	Start point Z of the measurement	mm
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm

Parameters	Description	Unit
Measuring axis	Measuring axis (for measuring plane G18) • X • Z	-
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

Measuring variant, milling on the turning machine

Procedure

The part program or ShopMill program to be edited has been created and you are in the editor.

Meas. tool

1. Press the "Meas. tool" softkey.

Calibrate probe

2. Press the "Calibrate probe" softkey.

Parameter

ShopMill program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 6)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Calibrate probe" provides the following result parameters:

Table 3-38 "Calibrate probe" result parameters

Parameters	Description	Unit
_OVR[8]	Trigger point in minus direction, actual value of 1st axis of the plane	mm
_OVR[10]	Trigger point in plus direction, actual value of 1st axis of the plane	mm
_OVR[12]	Trigger point in minus direction, actual value of 2nd axis of the plane	mm
_OVR[14]	Trigger point in plus direction, actual value of 2nd axis of the plane	mm
_OVR[9]	Trigger point in minus direction, difference of 1st axis of the plane	mm
_OVR[11]	Trigger point in plus direction, difference of 1st axis of the plane	mm
_OVR[13]	Trigger point in minus direction, difference of 2nd axis of the plane	mm
_OVR[15]	Trigger point in plus direction, difference of 2nd axis of the plane	mm
_OVR[27]	Zero offset area	mm
_OVR[28]	Safe area	mm
_OVI[2]	Measuring cycle number	-
_OVI[3]	Measuring variant	-
_OVI[5]	Probe number	-
_OVI[9]	Alarm number	-

3.5.3 Turning tool (CYCLE982)

Function

With this measuring version, the tool length (L1 and/or L2) of a turning tool with cutting edge positions 1 to 8 can be determined. The measuring version checks whether the difference to be corrected with respect to the old tool length lies within a defined tolerance range:

- Upper limits: Safe area TSA and dimensional difference control DIF
- Lower limit: Work offset range TZL

If this range is not violated, the new tool length is accepted in the tool offset, otherwise an alarm is output. Violation of the lower limit is not corrected.

Measuring principle

For "complete" measuring, all lengths of a turning tool are measured:

- Turning tool with cutting edge positions 1 to 4: L1 and L2
- Turning tool with cutting edge position 5 or 7: L2
- Turning tool with cutting edge position 6 or 8: L1

If the turning tool has a cutting edge position 1 to 4, contact is made with the probe in both axes of the plane (for G18 Z and X), whereby the measurement starts with the 1st axis of the plane (for G18, Z). For cutting edge positions 5 to 8, a measurement is only performed in one axis:

- Cutting edge position 5 or 7: 1. measuring axis for G18 Z
- Cutting edge position 6 or 8: 2. measuring axis for G18 X.

When measuring "axis by axis", the length of the turning tool in the parameterized measuring axis is measured.

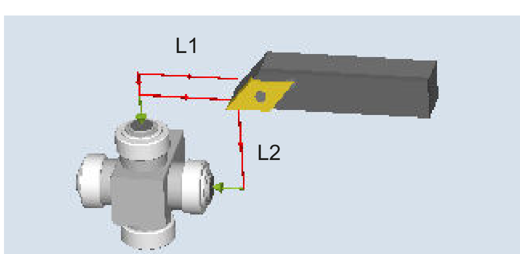


Figure 3-24 Measure: Turning tool (CYCLE982), example: Complete measuring

Preconditions

The tool probe must be calibrated, see Calibrate probe (CYCLE982) (Page 255).

The approximate tool dimensions must be entered in the tool offset data:

- Tool type 5xx
- Cutting edge position, cutting edge radius
- Lengths in X and Z

The tool to be measured must be active with its tool offset values when the cycle is called.

Starting position before the measurement

Before the cycle is called, the tool must be moved to the tool tip starting position, as shown in the following diagram.

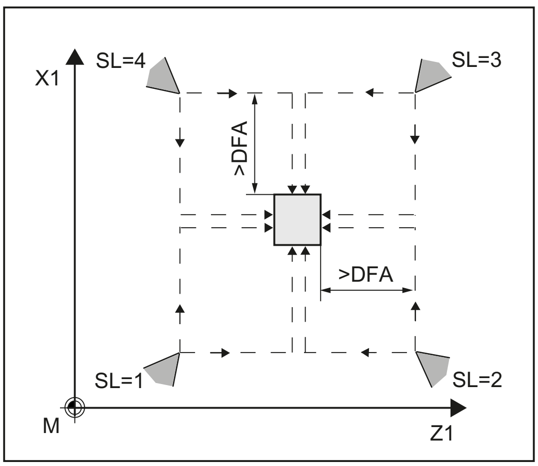


Figure 3-25 Cutting edge positions 1 to 4 and suitable starting positions for both axes

The center of the tool probe and the approach distance are calculated automatically and the required traversing blocks generated. The center of the cutting edge radius is positioned at the center of the probe.

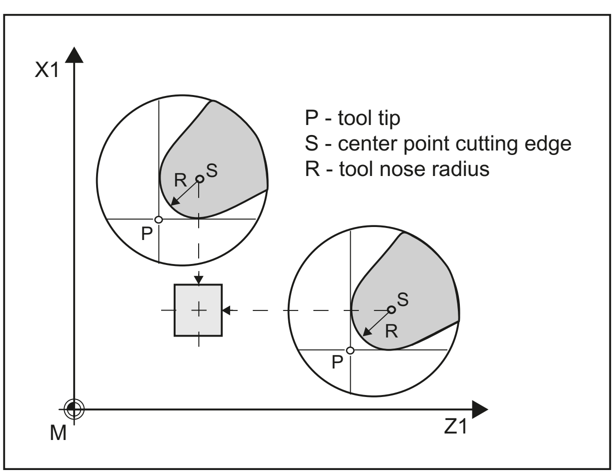


Figure 3-26 Measuring the length of a turning tool: Offset by the cutting edge radius, example SL=3

Position after the end of the measuring cycle

For an "axis by axis" measurement, the tool tip is the measurement path distance away from the probed measuring surface of the probe.

For a "complete" measurement, after the measurement, the tool is positioned at the starting point before the cycle was called.

Procedure

The part program or ShopTurn program to be processed has been created and you are in the editor.

Meas. tool	1. Press the "Meas. tool" softkey.
Turning tool	2. Press the "Turning tool" softkey. The input window "Measure: Turning tool" opens.

Parameter

G code program				ShopTurn program		
Parameters	**Description**	**Unit**		**Parameters**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		T	Name of the tool to be measured	-
	Calibration data set (1 - 6)	-		D	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 6)	-
				β	Tool alignment with swivel axis: • ← (0 degrees) • ↓ (90 degrees) • Value entry	Degrees
				V	Tool orientation with a tool spindle	Degrees
				Z	Start point Z of the measurement	mm
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm

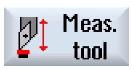
Parameters	Description	Unit
Measure	Measure tool lengths (for measuring plane G18) • Complete (measure length Z and length X • Only measure tool length Z • Only measure tool length X	-
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

Parameters	Description	Unit
TZL	Tolerance range for work offset	mm
TDIF	Tolerance range for dimensional difference monitoring	mm

Measuring variant, milling on a turning machine

Procedure

The part program or ShopMill program to be edited has been created and you are in the editor.



1. Press the "Meas. tool" softkey.

2. Press the "Turning tool" softkey.

Parameters

ShopMill program		
Parameter	Description	Unit
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 6)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Turning tool" provides the following result parameters:

Table 3-39 "Turning tool" result parameters

Parameter	Description	Unit
_OVR[8]	Length actual value L1	mm
_OVR[9]	Length difference L1	mm
_OVR[10]	Length actual value L2	mm
_OVR[11]	Length difference L2	mm
_OVR[12]	Length actual value L3	mm
_OVR[13]	Length difference L3	mm
_OVR[27]	Work offset range	mm
_OVR[28]	Safe area	mm
_OVR[29]	Permissible dimensional difference	mm

Parameter	Description	Unit
_OVR[30]	Empirical value	mm
_OVI[0]	D number	-
_OVI[2]	Measuring cycle number	-
_OVI[3]	Measuring version	-
_OVI[5]	Probe number	-
_OVI[7]	Empirical value memory number	-
_OVI[8]	Tool number	-
_OVI[9]	Alarm number	-

3.5.4 Milling tool (CYCLE982)

Function

This measuring version can be used to measure a milling tool on a turning machine (lathe).

The following measurements can be performed:

- Length
- Radius
- Length and radius

The measuring cycle checks whether the difference to be corrected with respect to the old tool length or to the old tool radius lies within a defined tolerance range:

- Upper limits: Safe area TSA and dimensional difference control DIF.
- Lower limit: Zero offset range TZL.

If this range is not violated, the new tool length is accepted in the tool offset, otherwise an alarm is output. Violation of the lower limit is not corrected.

The tool length correction is is realized depending on the particular turning machine (lathe). The length assignment (L1 in X, L2 in Y) to the geometry axes is realized just the same as for a turning tool.

Measuring principle

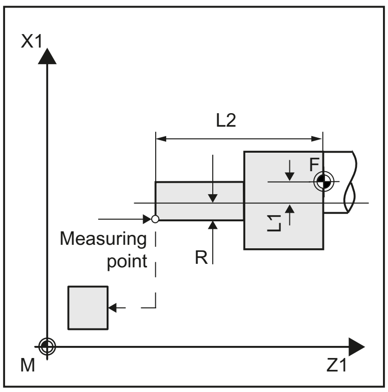
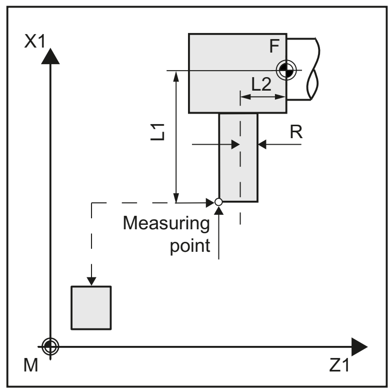
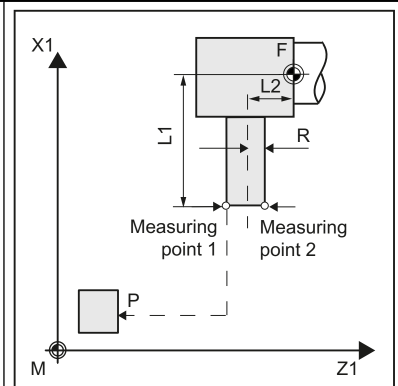
For a "complete" measurement, all measured variables that can be determined (lengths L1 and L2 and radius) are determined. In both axes (for G18: Z and X) of the plane, probing action is performed with respect to the probe, whereby the measurement starts with the first axis of the plane (for G18: Z).

For an "axis-by-axis" measurement, the measured variables are measured corresponding to the selection "only length (L1 or L2)", "only radius" or "length (L1 or L2) and radius" only in the parameterized measuring axis of the active plane.

Measuring "axis-by-axis" - only length (L1 or L2)

Length L1 or L2 is measured in the parameterized measuring axis.

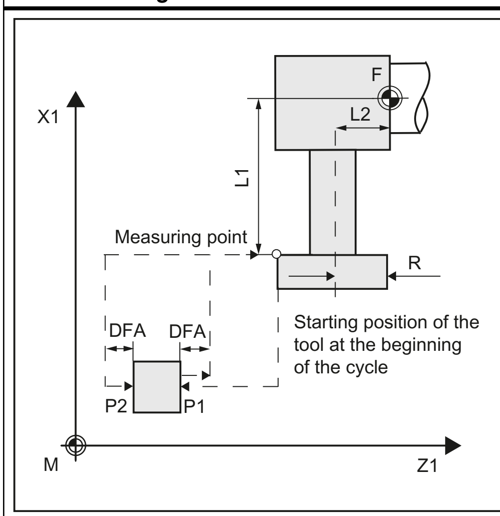
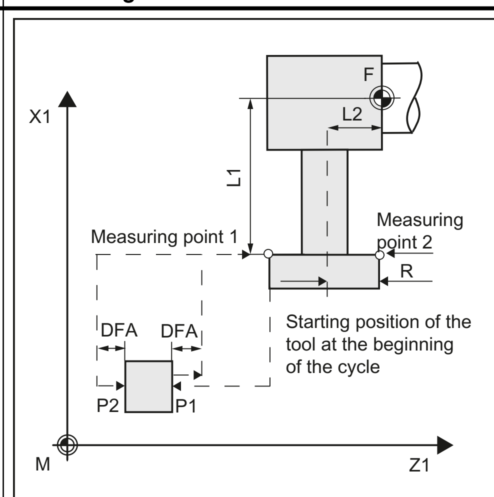
Table 3-40 Measuring "axis-by-axis" - only length (L1 or L2)

Without milling tool reversal		With milling tool reversal
		
Measuring length L2	Measuring length L1	Measuring length L2 Requirement: Radius R must be known.

Measuring "axis-by-axis" - only radius

The radius in the parameterized measuring axis is measured by probing twice at the probe.

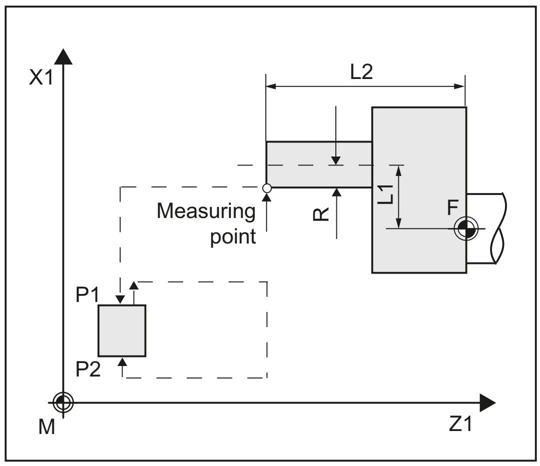
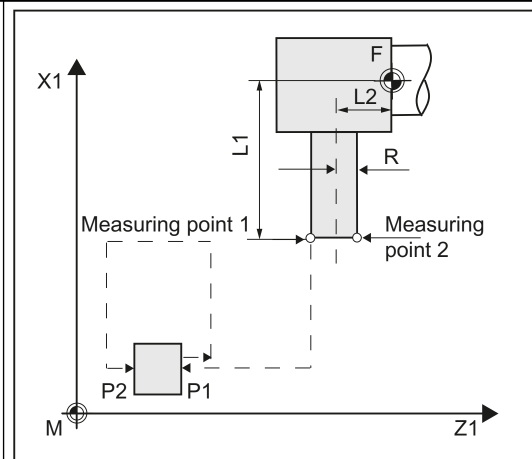
Table 3-41 Measuring "axis-by-axis" - only radius

Without milling tool reversal	With milling tool reversal
	

Measuring "axis-by-axis" - only length (L1 or L2) and radius

Length L1 or L2 and radius are measured in the parameterized measuring axis by probing twice to two different sides of the measuring probe.

Table 3-42 Measuring "axis-by-axis" - only length (L1 or L2) and radius

Length L1 and radius measurement without milling tool reversal	Length L2 and radius measurement with milling tool reversal
	

Measuring "complete" - lengths (L1 and L2) and radius

For complete measurements, all offsets are determined:

- Both lengths and radius (four measurements).
- If the radius is specified to be 0, then both lengths are determined (two measurements).

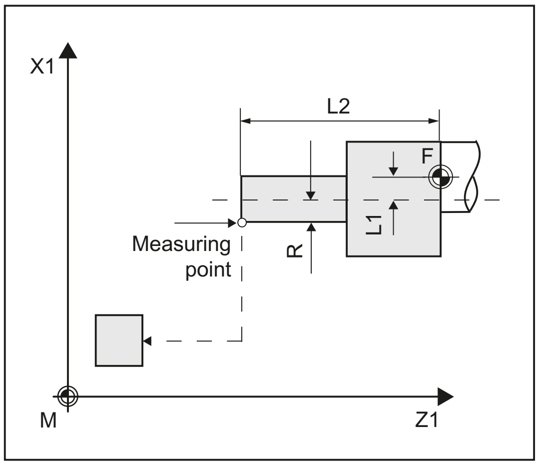
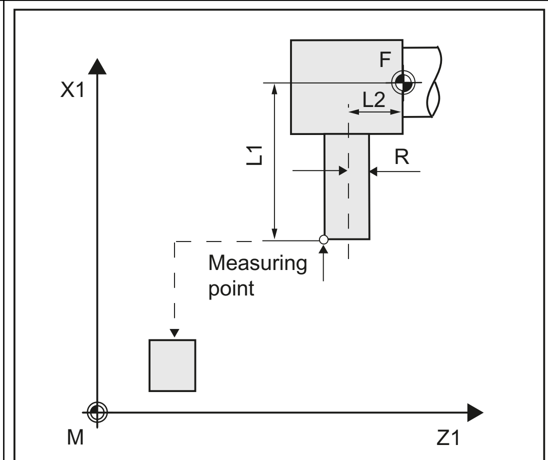
The measuring cycle generates the approach blocks to the probe and the transverse motions to measure length 1, length 2 and the radius. A correctly selected start position is required.

Milling tool reversal

When measuring with reversal, to start, the measuring point in the selected axis and a milling spindle position according to starting angle SPOS is measured. Then the tool (spindle) is turned through 180 degrees and measured again.

The average value is the measured value. Measurement with reversal, results in a second measurement at each measuring point with a spindle rotation through 180 degrees with respect to the starting angle. The offset angle entered in SCOR is summed to these 180 degrees. This enables selection of a specific 2nd milling cutting edge that is offset from the 1st cutting edge by precisely 180 degrees. Measurement with reversal permits measurement of two cutting edges of one tool. The mean value is the offset value.

Tool position

<table>
<tr><th>Axial position</th><th>Radial position</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Milling cutter radius in the 2nd measuring axis (for G18: X)</td><td>Milling cutter radius in the 1st measuring axis (for G18: Z)</td></tr>
</table>

Measurement with rotating/stationary spindle

Measurement is possible with a rotating (M3, M4) or with a stationary milling spindle (M5).

If the milling spindle is stationary, at the beginning it is positioned at the specified starting angle SPOS.

Note

Measurement with rotating spindle

If selection of a specific milling tool cutting edge is not possible, it is possible to measure with a rotating spindle. The user must then program the direction of rotation, speed, and feedrate very carefully before calling up CYCLE982 to prevent damage to the probe. A low speed and feedrate must be selected.

Empirical values may optionally be included. A mean value is not calculated.

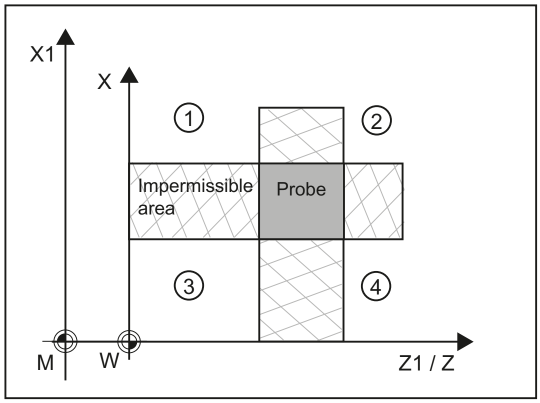
Requirements

- The tool probe must be calibrated, see Calibrate probe (CYCLE982) (Page 255).
- The approximate tool dimensions must be entered in the tool offset data:
  - Tool type: 1xy (milling tool)
  - Radius, length 1, length 2.
- The tool to be measured must be active with its tool offset values when the cycle is called.
- For a milling cutter, the channel-specific SD 42950: $SC_TOOL_LENGTH_TYPE = 2 must be set (length is taken into account just the same as for a turning tool).
- The tool spindle must be declared as the master spindle.

Starting position before the measurement

From the starting position, collision-free approach to the probe must be possible.

The initial positions are located outside the unauthorized area (see the diagram below).



① to ④ permissible area

Figure 3-27 Measure milling cutter: Possible starting positions in the 2nd axis of the plane (for G18: X)

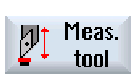
Position after the end of the measuring cycle

For an "axis-by-axis" measurement, the tool tip is positioned at the measurement path distance away from the last probed measuring surface of the probe.

For a "complete" measurement, after the measurement, the tool is positioned at the starting point before the cycle was called.

Procedure

The part program or ShopTurn program to be processed has been created and you are in the editor.



1. Press the "Meas. tool" softkey.

2. Press the "Milling tool" softkey.
   The input window "Measure: Milling tool" opens.

Parameter

G code program				ShopTurn program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		**T**	Name of the tool to be measured	-
	Calibration data set (1 - 6)	-		**D**	Cutting edge number (1 - 9)	-
					Calibration data set (1 - 6)	-
				β	Tool alignment with swivel axis • ← (0 degrees) • ↓ (90 degrees) • Value entry	Degrees
				Z	Start point Z of the measurement	mm
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm

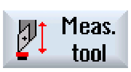
Parameters	Description	Unit
Measurement type	• Axis-by-axis • Complete (measure length and radius)	-
Tool position	• Axial (←) • Radial (↓)	-
For measurement type "Complete":		
Measure	Lengths X, Z and radius (in accordance with the tool position)	-
Cutting edge	• End face • Rear face	-
Approach	Approach probe from the following direction (for measuring plane G18): • In the case of tool position "axial": +/- X • In the case of tool position "radial": +/- Z	-
For measurement type "Axis-by-axis":		
Measure	For measuring plane G18: • Length X/Z and radius (in accordance with the tool position) • Only length Z • Only length X • Only radius	-
Milling tool reversal	• Yes (measurement with reversal of the milling tool (180°)) • No (measurement without reversal)	-
Position spindle	Set position of the tool spindle (only for milling tool reversal "No") • No (any tool spindle position) • Yes (position tool spindle at starting angle)	-

Parameters	Description	Unit
SPOS	Angle for positioning on a tool tip (only for milling cutter reversal "Yes" or position spindle "Yes" or for "complete" measurement type)	Degrees
SCOR	Offset angle for reversal (only for milling tool reversal "Yes")	Degrees
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
TZL	Tolerance range for work offset	mm
TDIF	Tolerance range for dimensional difference monitoring	mm

Measuring variant, milling on the turning machine

Procedure

The part program or ShopMill program to be edited has been created and you are in the editor.



1. Press the "Meas. tool" softkey.

2. Press the "Milling tool" softkey.

Parameter

ShopMill program		
Parameter	Description	Unit
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 6)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Milling tool" provides the following result parameters:

Table 3-43 "Milling tool" result parameters

Parameters	Description	Unit
_OVR[8]	Length actual value L1	mm
_OVR[9]	Length difference L1	mm
_OVR[10]	Length actual value L2	mm
_OVR[11]	Length difference L2	mm
_OVR[12]	Radius actual value	mm
_OVR[13]	Radius difference	mm

Parameters	Description	Unit
_OVR[27]	Work offset range	mm
_OVR[28]	Safe area	mm
_OVR[29]	Permissible dimensional difference	mm
_OVR[30]	Empirical value	mm
_OVI[0]	D number	-
_OVI[2]	Measuring cycle number	-
_OVI[5]	Probe number	-
_OVI[7]	Empirical value memory	-
_OVI[8]	Tool number	-
_OVI[9]	Alarm number	-

3.5.5 Drill (CYCLE982)

Function

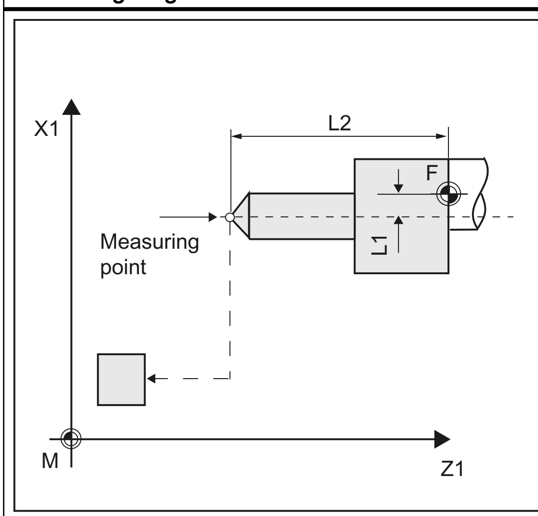
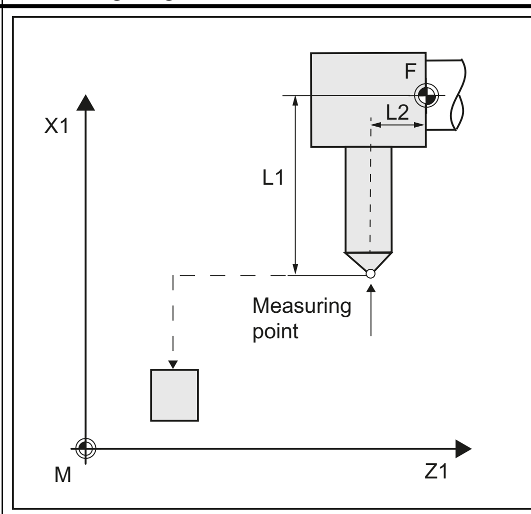
With this measuring variant, the tool length (L1 or L2) of a drill can be measured. The measuring variant checks whether the difference to be corrected with respect to the old tool length lies within a defined tolerance range:

- Upper limits: Safe area TSA and dimensional difference control DIF
- Lower limit: Zero offset range TZL

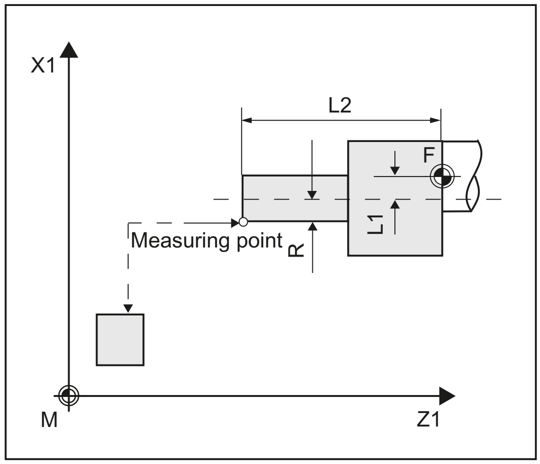
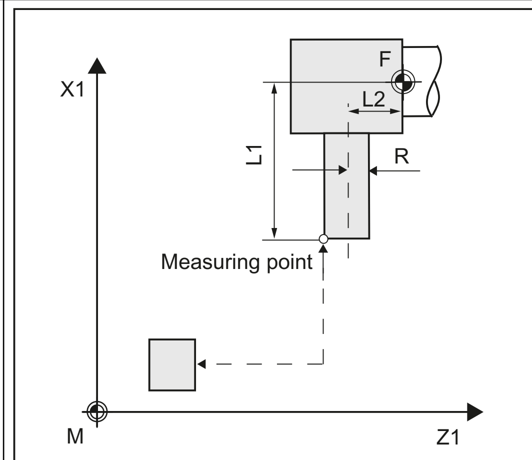
If this range is not violated, the new tool length is accepted in the tool offset, otherwise an alarm is output. Violation of the lower limit is not corrected.

Measuring principle

The length (L1 or L2) of the drill is measured in the parameterized measuring axis.

Measuring length L2	Measuring length L1
	

Tool position:

<table>
<tr><th>Axial position</th><th>Radial position</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Drill radius in the 2nd measuring axis (for G18: X)</td><td>Drill radius in the 1st measuring axis (for G18: Z)</td></tr>
</table>

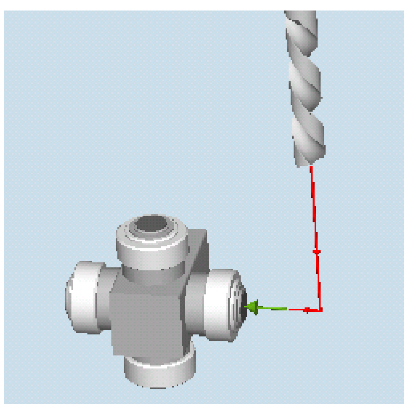


Figure 3-28 Measure: Drill (CYCLE982), example, tool position: ↓ radial position

Note

If the length of the drill is measured by approaching the probe from the side, then it must be ensured that the drill to be measured does not deflect the probe in the area of the twist groove or in the area of its drill tip.

The requirement is that the drill radius was entered in the tool offset, otherwise, an alarm will be output.

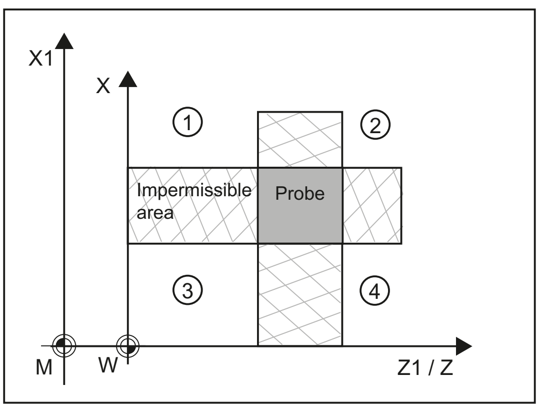
Requirements

- The tool probe must be calibrated.
- The approximate tool dimensions must be entered in the tool offset data:
  - Tool type: 2xy (drill)
  - Length 1, length 2
- The tool to be measured must be active with its tool offset values when the cycle is called.
- The channel-specific SD 42950: $SC_TOOL_LENGTH_TYPE should be assigned 2 as standard (length assignment the same as for turning tools). For special applications, a value 0 can be used (Page 272).

Starting position before the measurement

From the starting position, collision-free approach to the probe must be possible.

The initial positions are located outside the unauthorized area (see the diagram below).



① to ④ permissible area

Figure 3-29 Measure drill: Possible starting positions in the 2nd axis of the plane (for G18: X)

Position after the end of the measuring cycle

The tool tip is positioned at the measurement path from the measuring surface.

Measure drill - special applications

The tool probe has been calibrated with **G18** active as is usual for turning tools.

Function

If **drills** are used on lathes with a length compensation as for milling machines (SD 42950: $SC_TOOL_LENGTH_TYPE=0), then a drill can also be measured (gauged) in this application.

Length L1 is always calculated in the 3rd axis (tool offset axis) of the actual plane G17 to G19. This also characterizes the position of the tool.

G17: L1 in Z axis (corresponds to axial position)

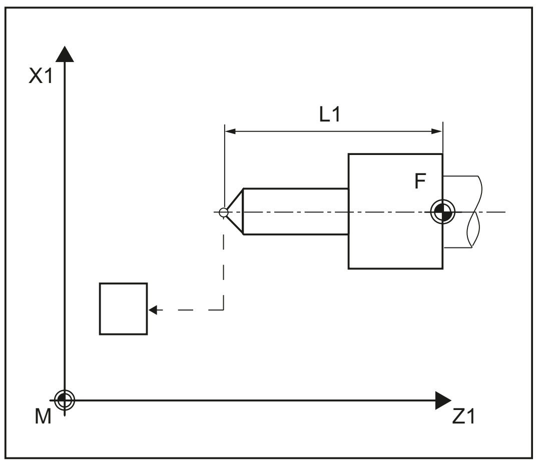
G18: L1 in Y axis (no turning machine application)

G19: L1 in X axis (corresponds to radial position)

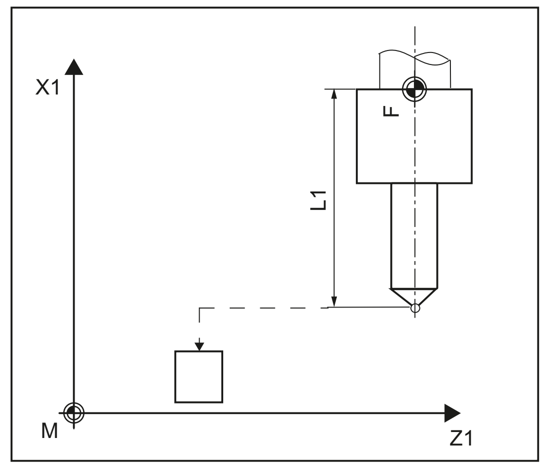
Conditions

Length L1 is determined if the following conditions are satisfied:

- the active tool is of type 2xy (drill)
- Channel-specific SD 42950: $SC_TOOL_LENGTH_TYPE=0
- G17 or G19 are active and



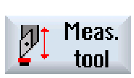
Measure drill length L1 for G17



Measure drill length L1 for G19

Procedure

The part program or ShopTurn program to be processed has been created and you are in the editor.



1. Press the "Meas. tool" softkey.

2. Press the "Drill" softkey.
   The input window "Measure: Drill" opens.

Parameter

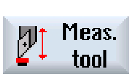
G code program				ShopTurn program		
Parameters	**Description**	**Unit**		**Parameters**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		**T**	Name of the tool to be measured	-
	Calibration data set (1 - 6)	-		**D**	Cutting edge number (1 - 9)	-
Tool position	• Axial (←) • Radial (↓)	-			Calibration data set (1 - 6)	-
				β	Tool alignment with swivel axis • ← (0 degrees) • ↓ (90 degrees) • Value entry	Degrees
				Z	Start point Z of the measurement	mm
				X	Start point X of the measurement	mm
				Y	Start point Y of the measurement	mm

Parameters	Description	Unit
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm
TZL	Tolerance range for work offset	mm
TDIF	Tolerance range for dimensional difference monitoring	mm

Measuring variant, milling on the turning machine

Procedure

The part program or ShopMill program to be edited has been created and you are in the editor.



1. Press the "Meas. tool" softkey.

2. Press the "Drill" softkey.

Parameter

ShopMill program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 6)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm

ShopMill program		
Parameter	**Description**	**Unit**
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Drill" provides the following result parameters:

Table 3-44 "Drill" result parameters

Parameters	Description	Unit
_OVR[8]	Length actual value L1	mm
_OVR[9]	Length difference L1	mm
_OVR[10]	Length actual value L2	mm
_OVR[11]	Length difference L2	mm
_OVR[27]	Work offset range	mm
_OVR[28]	Safe area	mm
_OVR[29]	Permissible dimensional difference	mm
_OVR[30]	Empirical value	mm
_OVI[0]	D number	-
_OVI[2]	Measuring cycle number	-
_OVI[3]	Measuring version	-
_OVI[5]	Probe number	-
_OVI[7]	Empirical value memory	-
_OVI[8]	Tool number	-
_OVI[9]	Alarm number	-

3.5.6 Measure tool with toolholder that can be orientated

Overview

The functionality is designed for a specific configuration on turning machines (turning/milling machines). As well as the linear axes (Z and X) and main spindle, the turning machines must have swivel axis about Y with accompanying tool spindle. The swivel axis can be used to align the tool on the X/Z level.

Preconditions

- The lateral surfaces of the tool probe should be aligned parallel to the relevant axes (machine or workpiece coordinate system in the 1st and 2nd axis of the plane). The tool probe must be calibrated in the measuring axis and direction in which measuring will be performed.
- The tool to be measured must be active with its tool offset values when the cycle is called.

- When measuring turning tools, the cutting edge position of the tool must be entered in the tool offset in accordance with the **basic position of the tool carrier**.
- When measuring drilling and milling tools, the setting data must be
  SD 42950: TOOL_LENGTH_TYPE = 2
  i.e., lengths are assigned to the axes in the same way as for turning tools.
- The active level must be G18.

Function

To take into account the tool carrier that can be orientated in measuring cycle CYCLE982, the following machine data must be set:

MD 51740 $MNS_MEA_FUNCTION_MASK, bit 16 = 1

The tool components are corrected corresponding to the orientation of the tool carrier in the initial state.

When measuring turning tools, especially roughers, finishers and mushroom-shaped tools, the swivel axis can assume any position around Y. Multiples of 90° are permitted for milling and drilling tools. Multiples of 180° are possible when positioning the tool spindle.

This is monitored within the cycle.

If turning tools are measured around Y using any positions (not multiples of 90°) of the swivel axis, then it should be taken into consideration that the turning tool is measured with the same tool position in both axes X/Z, assuming that this is possible.

Sequence

Before CYCLE 982 is called, the tool must be aligned in the same way as it will eventually be measured.

The tool should be preferably aligned with CYCLE800, refer to the Operating Manual *Turning*, Chapter "Swivel plane/align tool (CYCLE800)".

Please note that the measuring cycle assumes that the tool has been aligned in advance.

From the position adopted by the tool, it must be possible to approach the probe in X, Z via the measuring cycle.

The measuring procedure that follows is the same as for the measuring variants when the tool carrier is in its basic position.

Note

Measuring milling tools

The following measuring version is not supported when using a tool carrier that can be orientated:

Measuring type: "complete" and cutting edge: measure "rear side".

When this measuring version is used, alarm 61037: "Incorrect measuring version" is output.

3.6 Measure tool (milling)

3.6.1 General information

The measuring cycles described in this chapter are intended for use on milling machines and machining centers.

Note

Spindle

Spindle commands in the measuring cycles always refer to the active master spindle of the control.

When using the measuring cycles at machines with several spindles, then the spindle involved must be defined as master spindle before the cycle call.

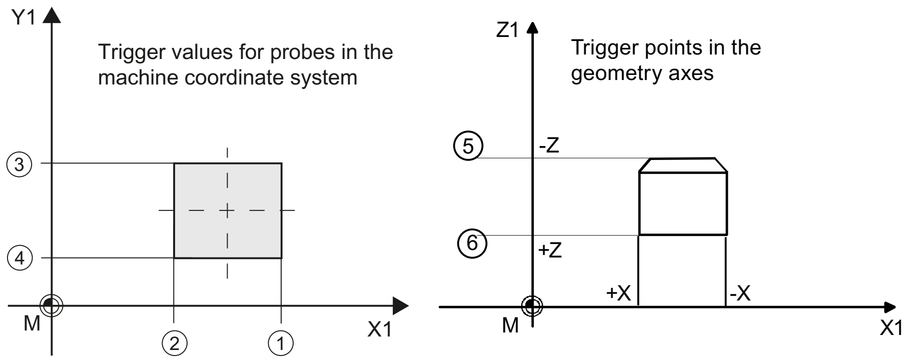
Reference:/PG/"Programming Guide Fundamentals"

Plane definition

For milling machines and machining centers, the default setting is the actual machining plane G17.

Machine/workpiece-related measuring/calibrating

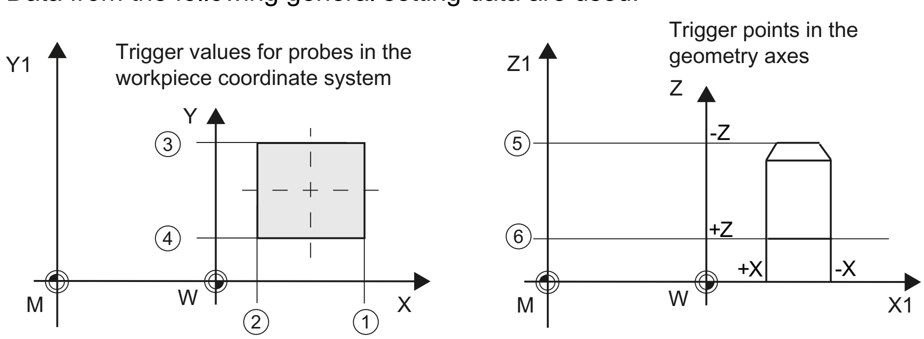
- Machine-related measuring/calibrating:
  Measuring is performed in the basic coordinate system (machine coordinate system with kinematics transformation disabled).
  The switching positions of the tool probe refer to the machine zero. Data from the following general setting data are used:



①	SD54625 $SNS_MEA_TP_TRIG_MINUS_DIR_AX1
②	SD54626 $SNS_MEA_TP_TRIG_PLUS_DIR_AX1
③	SD54627 $SNS_MEA_TP_TRIG_MINUS_DIR_AX2
④	SD54628 $SNS_MEA_TP_TRIG_PLUS_DIR_AX2
⑤	SD54629 $SNS_MEA_TP_TRIG_MINUS_DIR_AX3
⑥	SD54630 $SNS_MEA_TP_TRIG_PLUS_DIR_AX3

Figure 3-30 Tool probe, machine-related (G17)

- Workpiece-related measuring/calibrating:
  The switching positions of the tool probe refer to the workpiece zero.
  Data from the following general setting data are used:



①	SD54640 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX1
②	SD54641 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX1
③	SD54642 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX2
④	SD54643 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX2
⑤	SD54644 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX3
⑥	SD54645 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX3

Figure 3-31 Tool probe, workpiece-related (G17)

Note

Workpiece-related or machine-related measurement requires an appropriately calibrated tool probe, see Chapter Calibrate probe (CYCLE971) (Page 281).

Compensation strategy

The tool measuring cycle is intended for various applications:

- First measurement of a tool (general setting data SD54762 $SNS_MEA_FUNCTION_MASK_TOOL[Bit9]):
  The tool offset values in geometry and wear are replaced.
  The offset is applied in the geometry component of the length or the radius.
  The wear component is deleted.
- Post measuring a tool (general setting data SD 54762 $SNS_MEA_FUNCTION_MASK_TOOL[Bit9]):
  The resulting difference is calculated into the wear component (links or radius) of the tool.

Empirical values may optionally be included. A mean value is not calculated.

3.6.2 Calibrate probe (CYCLE971)

Function

This measuring version calibrates a tool probe machine-related or workpiece-related.

Values are corrected without empirical and mean values.

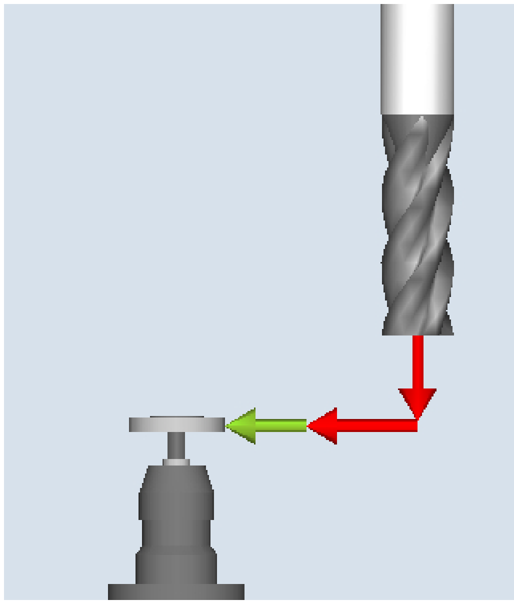
Measuring principle

The current clearances between machine zero (machine-related calibration) or workpiece zero (workpiece-related calibration) and the tool probe trigger point are determined with the aid of the calibration tool. The cycle positions the calibration tool to the probe.

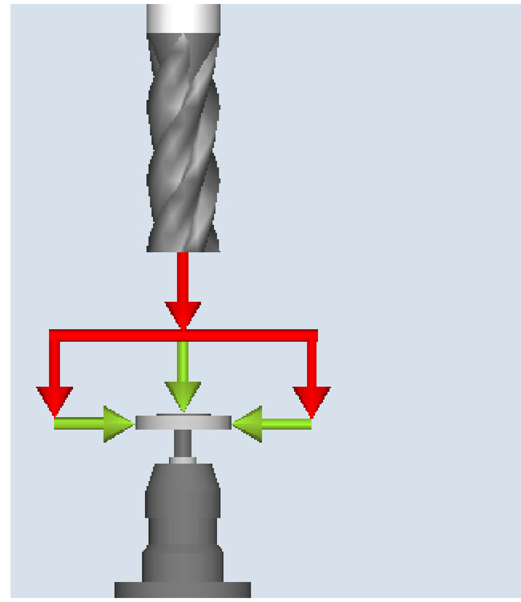
Note

When using a disk as the probe type and the calibration method "axis-by-axis" or "complete – with restricted directions of approach on the plane", the positions of the probe on the plane must be precisely pre-entered into the setting data to ensure accurate measurement.

You can find additional information in the Commissioning Manual SINUMERIK Operate (IM9) / SINUMERIK 840D sl, Chapter "Tool measurement in milling"



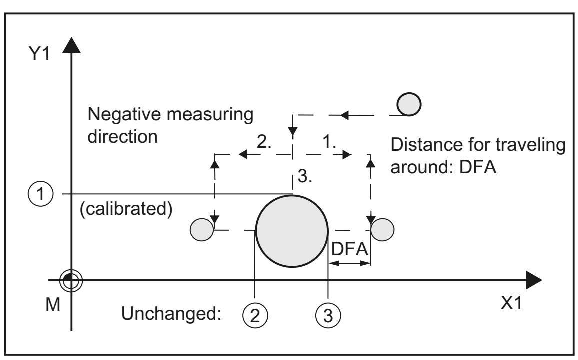
Calibrate: Probe (CYCLE971), axis-by-axis



Calibrate: Probe (CYCLE971), complete

Axis-by-axis calibration

For "axis-by-axis" calibration, the probe is calibrated in the parameterized measuring axis and measuring direction. The probing point can be centered in the offset axis. The actual center of the tool probe is determined first in the offset axis before the calibration is performed in the measuring axis.



① General SD 54627 $SNS_MEA_TP_TRIG_MINUS_DIR_AX2

② General SD 54626 $SNS_MEA_TP_TRIG_PLUS_DIR_AX1

③ General SD 54625 $SNS_MEA_TP_TRIG_MINUS_DIR_AX1

Figure 3-32 Calibrate probe (CYCLE971) with offset axis, example G17: Determine center in X, calibrate in Y

Complete calibration

The tool probes are automatically calibrated for the "complete" calibration. Using the calibration tool, the measuring cycle determines the tool probe trigger points in all axes or axis directions in which the probe can be approached.
See, Commissioning Manual *SINUMERIK Operate (IM9) / SINUMERIK 840D sl*, Chapter "Tool

measurement in milling": General setting data SD 54632 $SNS_MEA_TP_AX_DIR_AUTO_CAL or SD 54647 $SNS_MEA_TPW_AX_DIR_AUTO_CAL.

The tool axis (for G17: Z) must always be able to be approached in the minus direction. Otherwise no "complete" calibration is possible. Calibration is started in the 3rd axis, followed by the axes of the plane. "Complete" calibration is shown in the following figures (example: G17).

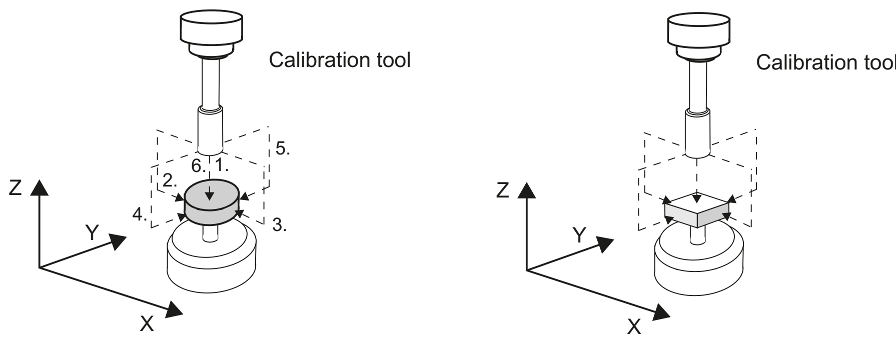
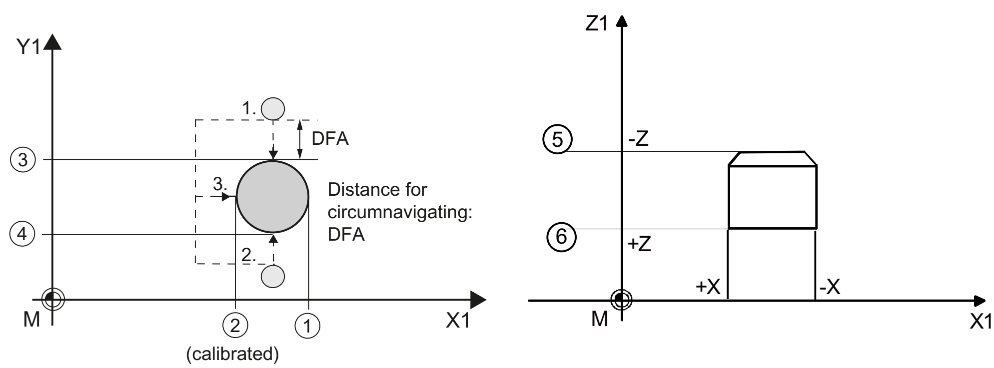


Figure 3-33 Tool probe, disk and cube version

Before the first calibration operation in the plane, e.g. plus direction of the 1st axis, the precise center of the probe is determined in the other axis (2nd axis), as long as the probe can be approached in this axis. Additional movements are performed in the plane for this purpose.



① General SD 54625 $SNS_MEA_TP_TRIG_MINUS_DIR_AX1
② General SD 54626 $SNS_MEA_TP_TRIG_PLUS_DIR_AX1
③ General SD 54627 $SNS_MEA_TP_TRIG_MINUS_DIR_AX2
④ General SD 54628 $SNS_MEA_TP_TRIG_PLUS_DIR_AX2
⑤ General SD 54629 $SNS_MEA_TP_TRIG_MINUS_DIR_AX3
⑥ General SD 54630 $SNS_MEA_TP_TRIG_PLUS_DIR_AX3

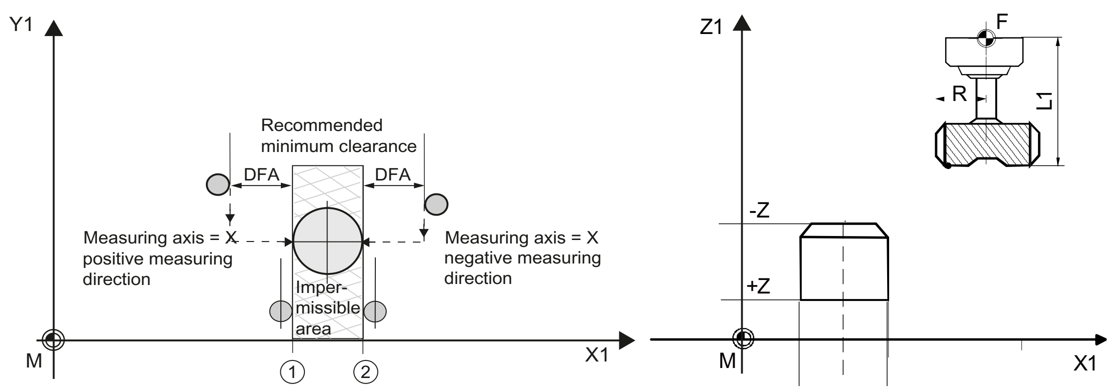
Figure 3-34 Determining the probe center in the 2nd axis of the plane, calibration +X

Requirements

- The exact length and radius of the calibration tool must be stored in a tool offset data record. This tool offset must be active when the measuring cycle is called.
- Tool type:
  - Calibration tool (type 725)
  - Milling tool (type 1xy)
- The machining plane G17 or G18 or G19 must be defined prior to the cycle call.
- The approximate coordinates of the tool probe must be entered in the general setting data before calibration starts (see Commissioning Manual *SINUMERIK Operate (IM9) / SINUMERIK 840D sl*, Chapter "Tool measurement in milling").
  These values are used to automatically approach the probe with the calibration tool and their absolute value must not deviate from the actual value by more than the value in parameter TSA.
- The probe must be reached within the total path 2 x DFA.

Starting position before the measurement

For **"axis-by-axis" calibration**, from the starting position, the cycle calculates the approach distance to the probe and generates the appropriate traversing blocks. It must be ensured that a collision-free approach is possible.



① General SD 54626 $SNS_MEA_TP_TRIG_PLUS_DIR_AX1

② General SD 54625 $SNS_MEA_TP_TRIG_MINUS_DIR_AX1

Figure 3-35 Starting positions for calibration in the plane, example: G17

Note

Calibrating in the 3rd axis of the measuring plane

If the tool diameter is larger, the calibration tool is positioned, offset by the tool radius, to the center of the probe. The value of the offset is subtracted.

For **"complete" calibration**, the position before the cycle call should be selected so that a collision-free, centered approach is possible above the probe center by measuring path DFA.

The axis sequence for the approach is first the tool axis (3rd axis) followed by the axes of the plane.

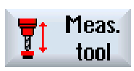
Position after the end of the measuring cycle

For "axis-by-axis" calibration, the calibration tool is positioned above the measuring surface by measuring path DFA.

For "complete" calibration, the calibration tool is positioned about the center of the probe by measuring path DFA.

Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Meas. tool" softkey.

2. Press the "Calibrate probe" softkey.
   The input window "Calibrate: Probe" opens.

Parameters

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		**T**	Name of the calibration tool	-
	Calibration data record (1 - 6)	-		**D**	Cutting edge number (1 - 9)	-
F	Calibration and measuring feedrate	Distance/ min			Calibration data record (1 - 6)	-
				F	Calibration and measuring feedrate	mm/min

Parameter	Description			Unit
Measurement type	• Axis-by-axis calibration • Complete calibration			-
Only for measuring mode "axis-by-axis" (for G17):				
Measuring axis	X	Y	Z	-
Center probing point	• No • In Y	• No • In X	See tool offset	-

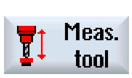
Parameter	Description	Unit
Tool offset	Direction of the tool offset axis for large tools • No – Calibration in the 3rd axis: Calibration is performed, centered about the probe. – Calibration in the plane: The precise probe center is not defined in the other axis to the measuring axis. • In X – Calibration in the plane: Prior to the calibration in Y, the precise probe center in X is determined. – Calibration in the 3rd axis: See offset • In Y – Calibration in the plane: Prior to the calibration in X, the precise probe center in Y is determined. – Calibration in the 3rd axis: See offset	-
Spindle reversal	Compensation of eccentricity through spindle reversal [1)] • Yes • No	-
V	Lateral offset (only for measuring axis "Z", for G17) The offset is active when calibrating the 3rd measuring axis, if the calibration tool diameter is larger than the upper diameter of the probe. Here, the tool is offset from the center of the probe by the tool radius, minus the value of V. An offset axis must be specified.	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

[1)] The "Spindle reversal" function is shown if bit 11 is set in the general SD 54762 $SNS_MEA_FUNCTION_MASK_TOOL .

Measuring variant, turning on a milling machine (only 840D sl)

Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Calibrate probe" softkey.

Parameter

ShopTurn program		
Parameter	**Description**	**Unit**
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 6)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm

ShopTurn program		
Parameter	Description	Unit
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

List of the result parameters

The measuring variant "Calibrate probe" provides the following result parameters:

Table 3-45 "Calibrate probe" result parameters

Parameters	Description	Unit
_OVR [8]	Trigger point in minus direction, actual value of 1st geometry axis	mm
_OVR [10]	Trigger point in plus direction, actual value of 1st geometry axis	mm
_OVR [12]	Trigger point in minus direction, actual value of 2nd geometry axis	mm
_OVR [14]	Trigger point in plus direction, actual value of 2nd geometry axis	mm
_OVR [16]	Trigger point in minus direction, actual value of 3rd geometry axis	mm
_OVR [18]	Trigger point in plus direction, actual value of 3rd geometry axis	mm
_OVR [9]	Trigger point in minus direction, difference of 1st geometry axis	mm
_OVR [11]	Trigger point in plus direction, difference of 1st geometry axis	mm
_OVR [13]	Trigger point in minus direction, difference of 2nd geometry axis	mm
_OVR [15]	Trigger point in plus direction, difference of 2nd geometry axis	mm
_OVR [17]	Trigger point in minus direction, difference of 3rd geometry axis	mm
_OVR [19]	Trigger point in plus direction, difference of 3rd geometry axis	mm
_OVR [27]	Work offset range	mm
_OVR [28]	Safe area	mm
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring version	
_OVI [5]	Probe number	-
_OVI [9]	Alarm number	-

3.6.3 Milling tool or drill (CYCLE971)

Function

With this measuring version, the tool length or the tool radius of milling and drilling tools can be measured. With milling tools, optionally the cutting edge length or the cutting edge radius can be measured (e.g. to check whether individual cutting edges of the milling tool have been broken out), see Section, "individually check teeth".

A check is made whether the difference to be corrected in the entered tool length or to the entered tool radius in the tool management lies within a defined tolerance range:

- Upper limit: Safe area TSA and dimensional difference control DIF
- Lower limit: Work offset range TZL

When this area is maintained, the measured tool length or the tool radius is entered in the tool management, otherwise a message is output. Violation of the lower limit is not corrected.

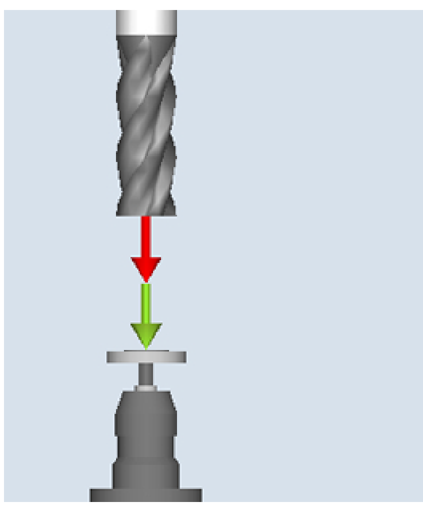
Measuring is possible either with:

- Stationary spindle (see Section Tool measurement with stationary spindle (Page 293))
- Rotating spindle (see Section Tool measurement with rotating spindle (Page 293))

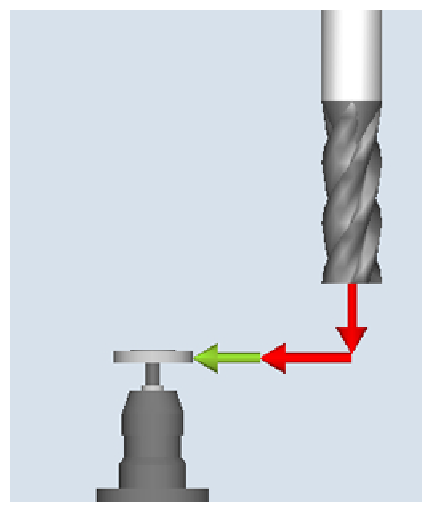
Note

The "individually check teeth" function is only possible in conjunction with the "Tool measurement with rotating spindle" function!

Measuring principle



Measure: Milling tool (CYCLE971), example, length



Measure: Milling tool (CYCLE971), example, radius

The milling tool or drill must always be aligned perpendicular to the probe before the measuring cycle is called. This means that the tool axis is parallel to the center line of the probe.

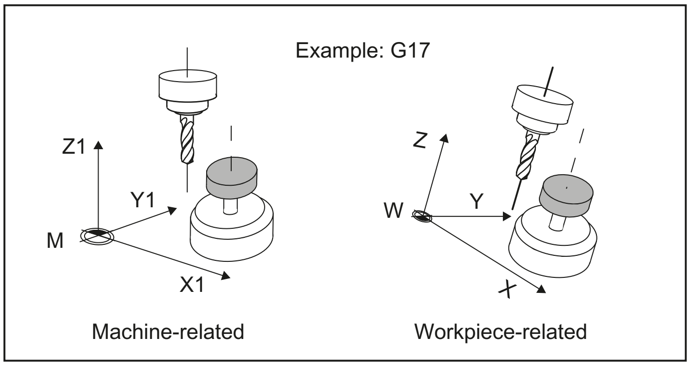


Figure 3-36 Parallel alignment of tool axis, probe axis and axis of the coordinate system

Length measurement

When measuring the tool length, the probe is applied in the direction of the tool.

The measurement can be performed with and without tool offset. Tool offset means a lateral shift of the tool from the center of the probe in an offset axis around the tool radius and corrected by an offset vector.

There are two options when measuring the length with tool offset:

1. "automatic" tool offset:
   An offset is only performed in the selected offset axis, if the tool diameter is greater than the diameter for the length measurement of the tool probe ($SNS_MEA_TP_EDGE_DISK_SIZE or $SNS_MEA_TPW_EDGE_DISK_SIZE).
   The direction of the offset in the selected offset axis is obtained from the starting position of the tool before measurement. If the starting position in the offset axis is closer to the center of the probe, then the offset is performed in the “+" direction of the offset axis, otherwise in the "-" direction. The absolute tool offset amount is obtained from the tool radius minus the offset correction.
2. Tool offset "yes"
   The offset is traversed through in the selected offset axis independent of the size of the tool diameter to the diameter of the probe, and from the approach behavior, is identical with the "auto" tool offset.

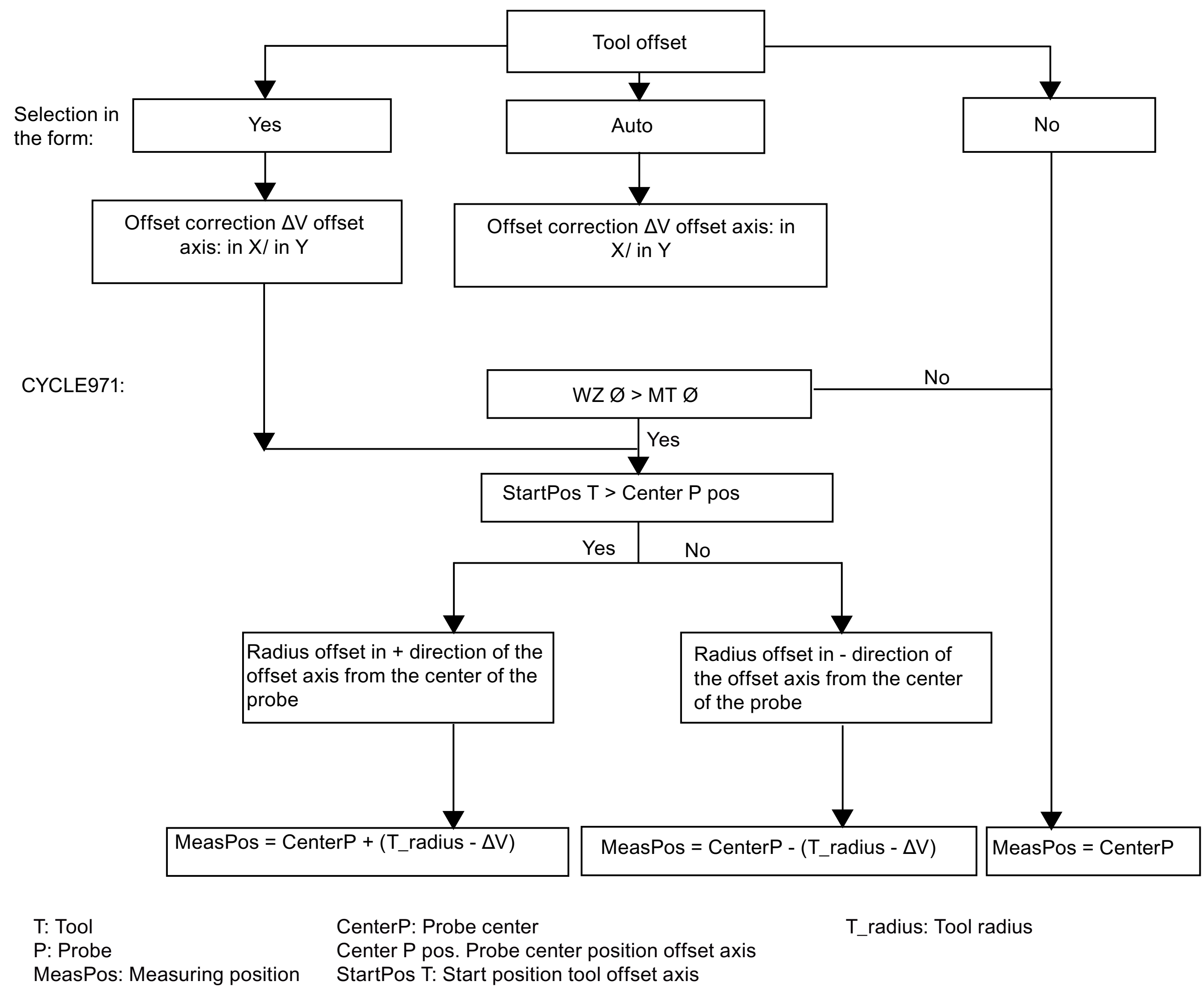


Figure 3-37 Effect tool offset (radius) and offset correction for measuring tool length or calibration in the 3rd axis with CYCLE971 in the G17 plane

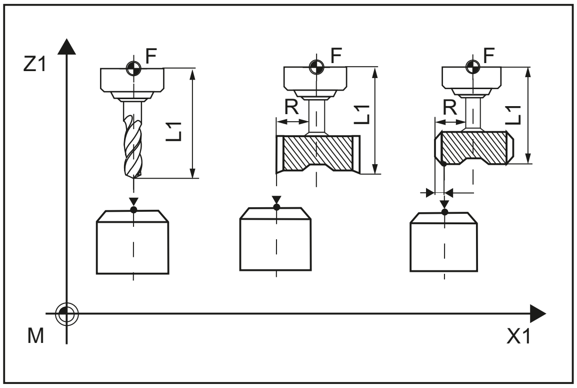


Figure 3-38 Length measurement with and without offset

Radius measurement

The tool radius is measured using lateral probing at the probe in the parameterized measuring axis and measuring direction (see the following diagram).

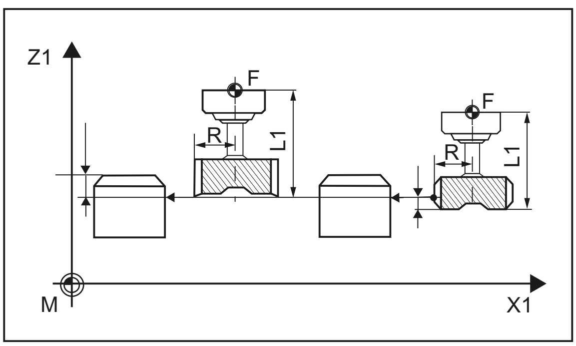


Figure 3-39 Radius measurement with and without offset

Requirements

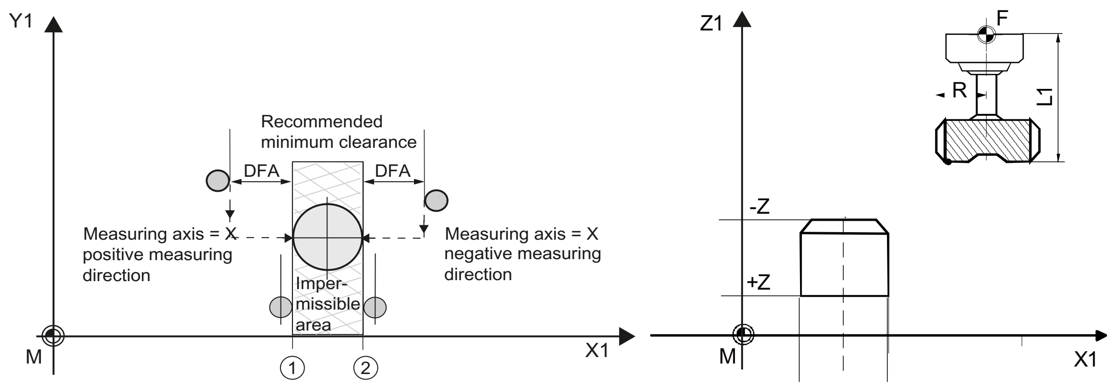
Note

The tool probe must be calibrated before the tool measurement (see Calibrate probe (CYCLE971) (Page 281)).

- The tool geometry data (approximate values) must be entered in a tool offset data record.
- The tool must be active.
- The machining plane must be programmed in which the probe was calibrated.
- The tool must be prepositioned in such a way that collision-free approach with the probe is possible in the measuring cycle.

Starting position before the measurement

Before the cycle call, a starting position must be assumed from which the probe can be approached collision-free. The measuring cycle calculates the direction of approach and generates the appropriate traversing blocks.



① General SD 54626 $SNS_MEA_TP_TRIG_PLUS_DIR_AX1

② General SD 54625 $SNS_MEA_TP_TRIG_MINUS_DIR_AX1

Figure 3-40 Measure tool (CYCLE971), starting positions for measuring in the plane

Position after the end of the measuring cycle

The tool is positioned at the measurement path distance away from the measuring surface.

3.6.3.1 Measurement with stationary spindle

Tool measurement with stationary spindle

When measuring milling tools, before the measuring cycle is called, the tool with the spindle must be rotated so that the selected cutting edge can be measured (length or radius).

3.6.3.2 Measurement with rotating spindle

Tool measurement with rotating spindle

Typically, measurements of the radius of milling tools are executed with rotating spindle, which means that the largest cutting edge determines the measuring result.

Likewise, it can make sense to measure the length of milling tools with the spindle rotating.

The following must be taken into account:

- Is it permissible to use the tool probe to perform measurements with rotating spindle with length and/or radius calculation? (manufacturer data)
- Permissible peripheral (circumferential) speed for the tool to be measured
- Maximum permissible speed

- Maximum permissible feedrate when probing
- Minimum feedrate when probing
- Selecting the direction of rotation depending on the cutting edge geometry to avoid a hard impact when probing at the probe
- Specified measuring accuracy

When performing a measurement with rotating tool, the ratio between the measuring feedrate and speed must be taken into account. In this case, a cutting edge is considered. For multiple cutting edges, the longest cutting edge is responsible for the measuring result.

The following interrelationships have to be taken into account:

$n = S / (2\pi \cdot r \cdot 0.001)$

$F = n \cdot \Delta$

Where:		Basic system	
		Metric	*Inch*
n	Speed	rev/min	rev/min
S	Max. permissible peripheral speed	m/min	Feet/min
r	Tool radius	mm	Inch
F	Measuring feedrate	mm/min	inch/min
Δ	Measuring accuracy	mm	Inch

Special issues when performing measurements with rotating spindle

- As standard, the feedrate and speed with the limit values defined in the general setting data SD 54670 - SD 54677 for peripheral speed, speed, minimum feedrate maximum feedrate and measuring accuracy, as well as the intended direction of spindle rotation for measurement are calculated in a cycle (see Commissioning Manual *SINUMERIK Operate (IM9) / SINUMERIK 840D sl*, Chapter "Tool measurement in milling - monitoring for measuring with rotating spindle")
  Measuring is conducted by probing twice; the 1st probing action causes a higher feedrate. A maximum of three probing operations are possible for measuring. If probing is performed several times the speed is additionally reduced on the last probing operation.
  By setting the general SD 54740 $SNS_MEA_FUNCTION_MASK[Bit19], this speed reduction can be suppressed.
- Using the general SD 54762 $SNS_MEA_FUNCTION_MASK_TOOL[Bit5], the user can hide the cycle-internal calculation and enter the values for feedrate and speed via the input screen form of the cycle.
  To specify the values with bit 5 set in the general SD 54762 $SNS_MEA_FUNCTION_MASK_TOOL, the input fields in the screen form F1 (feedrate 1) and S1 (speed 1), F2 (feedrate 2) and S2 (speed 2) or F3 (feed 3) and S3 (Speed 3) are used. For the first probing, the values of F1 and S1 are effective, and for the second probing the values F2 and S2. If S2=0, only one probing action is performed. If S3>0 and S2>0, triple probing is performed, whereby for the 3rd probing, the values from F3 and S3 are effective.
  The monitoring functions for the general setting data SD 54670 - SD 54677 are not active!
- If, when calling the measuring cycle, the spindle is stationary, then the direction of rotation is determined from the general SD 54674 $SNS_MEA_CM_SPIND_ROT_DIR.

Note

If, when calling a measuring cycle, the spindle is already rotating, then this direction of rotation is kept independent of the general SD 54674 $SNS_MEA_CM_SPIND_ROT_DIR!

3.6.3.3 Individually check teeth

Individually check teeth

The "Individually check teeth" function can be used for remeasuring (offset in the wear) and initial measuring (offset in the geometry). Milling tools with up to 100 cutting edges can be measured.

A check is made as to whether the measured values of all cutting edges are within a defined tolerance range:

- Upper limit: Safe area TSA and dimensional difference control DIF
- Lower limit: Work offset range TZL

If the measured values are outside the tolerance range, an alarm is output.

If the measured value of the longest cutting edge is within the tolerance range, this is entered in the tool management. Violation of the lower limit is not corrected.

Note

The "individually check teeth" function is only possible in conjunction with the Tool measurement with rotating spindle (Page 293) function.

Length measurement

The tool is positioned to the side of the probe and below the upper edge of the probe in the offset axis. To determine the spindle position of a cutting edge, the probe makes contact twice with the rotating tool.

This is followed by the length measurement with stationary spindle. For this purpose, the tool is positioned above the probe and offset by the tool radius to the center of the probe.

First, the cutting edge whose spindle position has been determined through lateral contact is measured. The other cutting edges are measured through spindle orientation.

After the measurements, the measured value of the longest cutting edge is entered in the tool offset, when this is within the tolerance range.

Radius measurement

For radius measurement, the distance between the cutting edges must be identical (example: A tool with three cutting edges has a cutting edge every 120 degrees).

The tool is positioned to the side of the probe and below the upper edge of the probe in the offset axis. To determine the spindle position of the longest cutting edge, the probe makes contact twice with the rotating tool.

The exact spindle position and the cutting edge radius at the highest point of the cutting edge are then measured through multiple contacts when the spindle is stationary.

The other cutting edges are measured by changing the spindle orientation. The measured radius of the longest cutting edge is entered in the tool offset, when the value is within the tolerance range.

Special features of the "Individually check teeth" function

The following additional requirements apply:

- The number of cutting edges of the milling tool must be entered in the tool offset.
- Tool spindle with position measuring system.
- The tool probe must be calibrated, see Calibrate probe (CYCLE971) (Page 281)

Before the cycle call, the tool must be positioned next to the probe and above the probe edge.

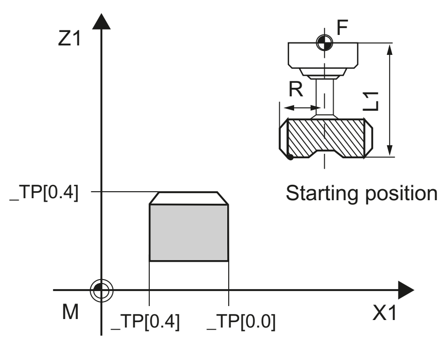
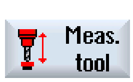


Figure 3-41 "Individually check teeth" (CYCLE971), starting position before measuring cycle call

3.6.3.4 Calling the measuring version milling tool

Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



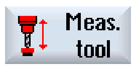
1. Press the "Measure tool" softkey in the vertical softkey bar.

2. Press the "Milling tool" softkey in the horizontal softkey bar.
   The input window "Measure: Tool" opens.

3.6.3.5 Calling the measuring version drill

Procedure

The part program or ShopMill program to be processed has been created and you are in the editor.



1. Press the "Measure tool" softkey in the vertical softkey bar.

2. Press the "Drilling tool" softkey in the horizontal softkey bar.
   The input window "Measure: Tool" opens.

3.6.3.6 Parameters

Parameter

G code program				ShopMill program		
Parameter	**Description**	**Unit**		**Parameter**	**Description**	**Unit**
PL	Measuring plane (G17 - G19)	-		**T**	Name of the tool to be measured	-
	Calibration data record (1 - 6)	-		**D**	Cutting edge number (1 - 9)	-
					Calibration data record (1 - 6)	-

Parameter	Description	Unit
Measure	• Length (measure tool length) • Radius (measure tool radius)	-
Spindle	Behavior of spindle during measurement: • Spindle stationary • Spindle rotates	-
Individually check teeth	Cutting tooth breakage monitoring (only with "rotating spindle") 1) • Yes • No	-
Only for measure "Radius":		-
Measuring axis	Corresponding to the set measuring plane: • X (for G17) • Y (for G17)	-
DZ	Length offset (for G17)	mm
Only for measure "Length":		-
Tool offset	Offset axis • Yes: with specification of the offset axis • No: the tool is measured centered. • Automatic: with specification of the offset axis (only effective for large tools)	-

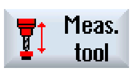
Parameter	Description	Unit
ΔV	Offset correction (only for tool offset "Yes" or "Automatic")	mm
DFA	Measurement path	mm
TSA	Safe area for the measurement result	mm

1) The "Individually check teeth" function is displayed if bit 10 is set in the general SD 54762 $SNS_MEA_FUNCTIONS_MASK_TOOL .

Measuring variant, turning on a milling machine (only 840D sl)

Procedure

The part program or ShopTurn program to be edited has been created and you are in the editor.



1. Press the "Meas. workp." softkey.

2. Press the "Milling tool" softkey.

Parameter

ShopTurn program		
Parameter	Description	Unit
T	Name of the probe	-
D	Cutting edge number (1 - 9)	-
	Calibration data set (1 - 6)	-
F	Calibration and measuring feedrate	mm/min
X	Start point X of the measurement	mm
Y	Start point Y of the measurement	mm
Z	Start point Z of the measurement	mm

3.6.3.7 Result parameters

List of the result parameters

The measuring version "Measure milling tool" or "Measure drill" provides the following result parameters:

Table 3-46 "Measure tool" result parameters

Parameter	Description	Unit
_OVR [8]	Actual value of length L1 1) / length of the longest cutting edge 3)	mm
_OVR [9]	Difference of length L1 1) / difference of length of the longest cutting edge 3)	mm
_OVR [10]	Actual value of radius R 2), / actual value of radius of the longest cutting edge 4)	mm

Parameter	Description	Unit
_OVR [11]	Difference of radius R 2) / difference of radius of the longest cutting edge 4)	mm
_OVR [12]	Actual value of length of the shortest cutting edge 3)	mm
_OVR [13]	Difference of length of the shortest cutting edge 3)	mm
_OVR [14]	Actual value of radius of the shortest cutting edge 4)	mm
_OVR [15]	Difference of radius of the shortest cutting edge 4)	mm
_OVR [27]	Work offset range	mm
_OVR [28]	Safe area	mm
_OVR [29]	Permissible dimensional difference	mm
_OVR [30]	Empirical value	mm
_OVR [100] - _OVR [199]	Actual values of the individual radii 4),	mm
_OVR [200] - _OVR [299]	Difference of the individual radii 4),	mm
_OVR [300] - _OVR [399]	Actual value of the individual lengths 3)	mm
_OVR [400] - _OVR [499]	Difference of the individual lengths 3)	mm
_OVI [0]	D number	-
_OVI [2]	Measuring cycle number	-
_OVI [3]	Measuring version	-
_OVI [5]	Probe number	-
_OVI [7]	Number of the empirical value memory	-
_OVI [8]	T name	-
_OVI [9]	Alarm number	-

1) Only for measure "Length"

2) Only for measure "Radius"

3) Only for the "Individually check teeth" function, measure cutting edge length

4) Only for the "Individually check teeth" function, measure cutting edge radius

3.6.3.8 Measuring the tool on machines with combined technologies

General information

This chapter refers to measuring a tool on milling/turning machines. Turning is set up as the 1st technology and milling as the 2nd technology.

Preconditions:

1. Milling: MD 52200 $MCS_TECHNOLOGY = 2
2. Turning: MD 52201 $MCS_TECHNOLOGY_EXTENSION = 1

Further, the following setting data must be set:

- SD 42950 $SC_TOOL_LENGTH_TYPE = 3
- SD 42940 $SC_TOOL_LENGTH_CONST = 17
- SD 42942 $SC_TOOL_LENGTH_CONST_T = 19

Additional settings/notes relating to milling/turning technology should be taken from IM9, Chapter "Turning on milling machines".

Function

Using measuring cycles, the probe can be calibrated on milling/turning machines and milling, drilling and turning tools can be measured.

- A probe is calibrated using the CYCLE971 cycle
- Cycle CYCLE971 is used to measure milling and drilling tools
- Cycle CYCLE982 is used to measure turning tools

The descriptions for the appropriate cycles in this manual should be used to parameterize the individual measuring versions.

4 Parameter lists

4.1 Overview of measuring cycle parameters

4.1.1 CYCLE973 measuring cycle parameters

```
PROC CYCLE973(INT S_MVAR,INT S_PRNUM,INT S_CALNUM,REAL S_SETV,INT S_MA,INT S_MD,REAL
S_FA,REAL S_TSA,REAL S_VMS,INT S_NMSP,INT S_MCBIT,INT _DMODE,INT _AMODE)
```

Table 4-1 CYCLE973 call parameters [1]

No.	Screen form parameters	Cycle parameters	Meaning	
1		S_MVAR	Measuring variant (default=0012103)	
			Values:	UNITS: Calibration on a surface, edge or in a groove 0 = Length on surface/edge (in the WCS) with known setpoint 1 = Radius on surface (in the WCS) with known setpoint 2 = Length in groove (in the WCS), see S_CALNUM 3 = Radius in groove (in the WCS), see S_CALNUM
				TENS: Reserved 0 = 0
				HUNDREDS: Reserved 0 = 0
				THOUSANDS: Selection of measuring axis and measuring direction for calibration [2] 0 = No specification (for surface calibration on the groove base, no selection of the measuring axis and measuring direction) [4] 1 = Specify selection of measuring axis and measuring direction, see S_MA, S_MD (one measuring direction in a measuring axis) 2 = Specify selection of measuring axis, see S_MA (two measuring directions in a measuring axis)
				TEN THOUSANDS: Determination of the positional deviation (probe skew) [2,3] 0 = Determine positional deviation 1 = Do not determine positional deviation
				HUNDRED THOUSANDS: Reserved 0 = 0
				ONE MILLION:adapt tool length [7] 0 = Do not adapt tool length (only trigger points) 1 = Adapt tool length

No.	Screen form parameters	Cycle parameters	Meaning
2	Icon+ number	`S_PRNUM`	Number of the field of the probe parameters (not probe number) (default=1)
3		`S_CALNUM`	Number of the calibration groove for calibration on a groove (default=1) [5]
4		`S_SETV`	Setpoint for calibration on a surface
5	X0	`S_MA`	Measuring axis (number of the axis) [6] (default=1) Values: 1 = 1st axis of the plane (for G18 Z) 2 = 2nd axis of the plane (for G18 X) 3 = 3rd axis of the plane (for G18 Y) [6]
6	+-	`S_MD`	Measuring direction (default=1) Values: 0 = Positive measuring direction 1 = Negative measuring direction
7	DFA	`S_FA`	Measurement path
8	TSA	`S_TSA`	Safe area
9	VMS	`S_VMS`	Variable measuring velocity for calibration [2]
10	Measure- ments	`S_NMSP`	Number of measurements at the same location [2] (default=1)
11		`S_MCBIT`	Reserved
12		`_DMODE`	Display mode Values: UNITS: Machining plane G17/G18/G19 0 = compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
13		`_AMODE`	Alternative mode

1) All default values = 0 or marked as default=x

2) Display depends on the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE

3) Only relevant for calibration in two axis directions

4) Only measuring axis and measuring direction are determined automatically from the cutting edge position (SL) of the probe. SL=8 → -X , SL=7 → -Z

5) The number of the calibration groove (n) refers to the following general setting data (all positions in machine coordinate system):
For cutting edge SL=7:
SD54615 $SNS_MEA_CAL_EDGE_BASE_AX1[n] Position base of the groove in the 1st axis of the plane (for G18 Z)
SD54621 $SNS_MEA_CAL_EDGE_PLUS_DIR_AX2[n] Position of the groove wall in the positive direction of the 2nd axis of the plane (for G18 X)
SD54622 $SNS_MEA_CAL_EDGE_MINUS_DIR_AX2[n] Position of the groove wall in the negative direction of the 2nd axis of the plane
for cutting edge position SL=8:
SD54619 $SNS_MEA_CAL_EDGE_BASE_AX2[n] Position of the groove base in the 2nd axis of the plane
SD54620 $SNS_MEA_CAL_EDGE_UPPER_AX2[n] Position of the upper edge of the groove in the 2nd axis of the plane (only to preposition the probe)
SD54617 $SNS_MEA_CAL_EDGE_PLUS_DIR_AX1[n] Position of the groove wall in the positive direction of the 1st axis of the plane
SD54618 $SNS_MEA_CAL_EDGE_MINUS_DIR_AX1[n] Position of the groove wall in the negative direction of the 1st axis of the plane
Note:
The positions values for the groove wall +- can be determined roughly.

The groove width from the difference of the position values of the groove wall must be determined precisely (precision dial gauge).
For calibration in the groove, it is assumed that the tool length of the probe of the calibrated axis = 0.
The positions values for the groove base must also be determined precisely on the machine (no drawing dimensions).

6) Measuring axis `S_MA=3` for calibration on a surface and on a turning machine with real 3rd axis of the plane (for G18 Y).

7) Adapt tool length when calibrating length in the groove, or for lengths at the surface.
Workpiece probe in lathes can be defined using 2 lengths (X Z).
Turning probe, type 580
cutting-edge position 7: For length calibration, optionally, the Z length is corrected.
Turning probe, type 580
cutting edge position 8: For length calibration, optionally, the X length is corrected
The tool length is not adapted for the measurement version, radius at groove or radius at the surface.
Only the corresponding trigger points are saved.

4.1.2 CYCLE974 measuring cycle parameters

```
PROC CYCLE974(INT S_MVAR,INT S_KNUM,INT S_KNUM1,INT S_PRNUM,REAL S_SETV,INT S_MA,REAL
S_FA,REAL S_TSA,REAL S_STA1,INT S_NMSP,STRING[32] S_TNAME,INT S_DLNUM,REAL S_TZL,REAL
S_TDIF,REAL S_TUL,REAL S_TLL,REAL S_TMV,INT S_K,INT S_EVNUM,INT S_MCBIT,INT _DMODE,INT
_AMODE)
```

Table 4-2 CYCLE974 call parameters [1]

<table>
<tr><th>No.</th><th>Screen form parameters</th><th>Cycle parameters</th><th colspan="2">Meaning</th></tr>
<tr><td rowspan="6">1</td><td rowspan="6"></td><td rowspan="6">S_MVAR</td><td colspan="2">Measuring variant</td></tr>
<tr><td rowspan="5">Values:</td><td>UNITS:
0 = Measure front face
1 = Inside measurement
2 = Outside measurement</td></tr>
<tr><td>TENS: Reserved</td></tr>
<tr><td>HUNDREDS: Correction target
0 = Only measurement (no correction of the WO or no tool offset)
1 = Measurement, determination and correction of the WO (see S_KNUM) [3]
2 = Measurement and tool offset (see S_KNUM1)</td></tr>
<tr><td>THOUSANDS: Reserved</td></tr>
<tr><td>TEN THOUSANDS: Measurement with or without reversal of the main spindle (workspindle)
0 = Measurement without reversal
1 = Measurement with reversal</td></tr>
</table>

No.	Screen form parameters	Cycle parameters	Meaning	
2	Selection	`S_KNUM`	Correction in work offset (WO) or basic WO or basic reference [2)]	
			Values:	UNITS:
				TENS: 0 = No correction 1 to max. 99 numbers of the work offset or 1 to max. 16 numbers of the basic offset
				HUNDREDS: Reserved
				THOUSANDS: Correction in WO or basic WO or basic reference 0 = Correction of the adjustable WO 1 = Correction of the channel-specific basic WO 2 = Correction of the basic reference 3 = Correction of the global basic WO 9 = Correction of the active WO or for G500, last active channel-specific basic WO
				TEN THOUSANDS: Coarse or fine correction in the WO, basic WO or basic reference 0 = Fine correction [6)] 1 = Coarse correction
3	Selection	`S_KNUM1`	Correction in tool offset [2), 4)]	
			Values:	UNITS:
				TENS:
				HUNDREDS: 0 = No correction 1 to max. 999 D numbers (cutting edge numbers) for tool offset; for additive and setup offset, see also `S_DLNUM`
				THOUSANDS: 0 or unique D number
				TEN THOUSANDS: 0 or unique D number 1 to max. 32000 if unique D numbers in MD have been set up
				HUNDRED THOUSANDS: Tool offset[2)] 0 = No specification (offset in tool geometry) 1 = Offset of length L1 2 = Offset of length L2 3 = Offset of length L3 4 = Radius offset
				ONE MILLION: Tool offset[2)] 0 = No specification (offset of the tool length wear) 1 = Tool offset, additive offset (AO) [5)] Tool offset value is added to the existing AO 2 = Tool offset, setup offset (SO) [5)] SO (new) = SO (old) + AO (old) offset value, AO (new) = 0 3 = Tool offset, setup offset (SO) [5)] Tool offset value is added to the existing SO 4 = Tool offset, geometry
				TEN MILLION: Tool offset[2)] 0 = No specification (offset in tool geometry normal (not inverted)) 1 = Offset inverted
4	Icon+ number	`S_PRNUM`	Number of the field of the probe parameters (not probe number) (default=1)	

No.	Screen form parameters	Cycle parameters	Meaning
5	X0	`S_SETV`	Setpoint
6	X	`S_MA`	Measuring axis (number of the axis) (default=1) Values: 1 = 1st axis of the plane (for G18 Z) 2 = 2nd axis of the plane (for G18 X) 3 = 3rd axis of the plane (for G18 Y) [5]
7	DFA	`S_FA`	Measurement path
8	TSA	`S_TSA`	Safe area
9	α	`S_STA1`	Starting angle for measurement with reversal
10	Measurements	`S_NMSP`	Number of measurements at the same location [2] (default=1)
11	T	`S_TNAME`	Tool name [2]
12	DL	`S_DLNUM`	Setup additive offset DL number [5]
13	TZL	`S_TZL`	Work offset [2, 4]
14	DIF	`S_TDIF`	Dimensional difference check [2, 4]
15	TUL	`S_TUL`	Upper tolerance limit (incremental to the setpoint) [4]
16	TLL	`S_TLL`	Lower tolerance limit (incremental to the setpoint) [4]
17	TMV	`S_TMV`	Offset range for averaging [2]
18	FW	`S_K`	Weighting factor for averaging [2]
19	EVN	`S_EVNUM`	Number of the empirical mean value memory [2, 7]
20		`S_MCBIT`	Reserved
21		`_DMODE`	Display mode Values: UNITS: Machining plane G17/G18/G19 0 = Compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
22		`_AMODE`	Alternative mode Values: UNITS: Dimensional tolerance yes/no 0 = No 1 = Yes

1) All default values = 0 or marked as default=x

2) Display depends on the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE

3) Correction in WO only possible for measurement without reversal

4) For tool offset in the channel-specific MD 20360 TOOL_PARAMETER_DEF_MASK , observe bit0 and bit1

5) Only if the "Setup additive offset" function has been set-up in the general MD 18108 $MN_MM_NUM_SUMCORR . In addition, in the general MD 18080 $MN_MM_TOOL_MANAGEMENT_MASK , bit8 must be set to 1.

6) If WO "fine" has not been set up in MDs, correction is according to WO "coarse"

7) Empirical averaging only possible for tool offset
Value range for empirical mean value memory:
1 to 20 numbers (n) of the empirical value memory, see channel-specific SD 55623 $SCS_MEA_EMPIRIC_VALUE[n-1]
10000 to 200000 numbers (n) of the mean value memory, see channel-specific SD 55625 $SCS_MEA_AVERAGE_VALUE[n-1]

4.1.3 CYCLE994 measuring cycle parameters

```
PROC CYCLE994(INT S_MVAR,INT S_KNUM,INT S_KNUM1,INT S_PRNUM,REAL S_SETV,INT S_MA,REAL
S_SZA,REAL S_SZO,REAL S_FA,REAL S_TSA,INT S_NMSP,STRING[32] S_TNAME,INT S_DLNUM,REAL
S_TZL,REAL S_TDIF,REAL S_TUL,REAL S_TLL,REAL S_TMV,INT S_K,INT S_EVNUM,INT S_MCBIT,INT
_DMODE,INT _AMODE)
```

Table 4-3 CYCLE994 call parameters [1]

No.	Screen form parameters	Cycle parameters	Meaning	
1		S_MVAR	Measuring variant	
			Values:	UNITS: Inside or outside measurement (default = 1) 1 = Inside measurement 2 = Outside measurement
				TENS: Reserved
				HUNDREDS: Correction target 0 = Only measurement (no correction of the WO or no tool offset) 1 = Measurement and determination and correction of the WO (see S_KNUM) [3] 2 = Measurement and tool offset (see S_KNUM1)
				THOUSANDS: Bypass area 0 = no bypass area 1 = bypass axis 1st axis of the plane (for G18 Z) Measuring axis, see S_MA. 2 = bypass axis 2nd axis of the plane (for G18 X) Measuring axis, see S_MA. 3 = bypass axis 3rd axis of the plane (for G18 Y). Measuring axis, see S_MA. [8]
2	Selection	S_KNUM	Correction of work offset (WO) or basic WO or basic reference [2]	
			Values:	UNITS:
				TENS: 0 = No correction 1 to max. 99 numbers of the work offset or 1 to max. 16 numbers of the basic offset
				HUNDREDS: Reserved
				THOUSANDS: Correction of WO or basic or basic reference 0 = Correction of the adjustable WO 1 = Correction of the channel-specific basic WO 2 = Correction of the basic reference 3 = Correction of the global basic WO 9 = Correction of the active WO or for G500 in last active channel-specific basic WO
				TEN THOUSANDS: Coarse or fine correction in the WO, basic WO or basic reference 0 = Fine correction [6] 1 = Coarse correction

No.	Screen form parameters	Cycle parameters	Meaning	
3	Selection	`S_KNUM1`	Correction in tool offset [2), 4)]	
			Values:	UNITS:
				TENS:
				HUNDREDS: 0 = No correction 1 to max. 999 D numbers (cutting edge numbers) for tool offset; for additive and setup offset, see also `S_DLNUM`
				THOUSANDS: 0 or unique D numbers
				TEN THOUSANDS: 0 or unique D numbers 1 to max. 32000, if unique D numbers in MD have been set up
				HUNDRED THOUSANDS: Tool offset[2)] 0 = No specification (offset tool geometry) 1 = Offset of length L1 2 = Offset of length L2 3 = Offset of length L3 4 = Radius offset
				ONE MILLION: Tool offset[2)] 0 = No specification (offset of the tool length wear) 1 = Tool offset, additive offset (AO) [5)] Tool offset value is added to the existing AO 2 = Tool offset, setup offset (SO) [5)] SO (new) = SO (old) + AO (old) offset value, AO (new) = 0 3 = Tool offset, setup offset (SO) [5)] Tool offset value is added to the existing SO 4 = Tool offset, geometry
				TEN MILLION: Tool offset[2)] 0 = No specification (offset in tool geometry normal, not inverted) 1 = Offset inverted
4	Icon+ number	`S_PRNUM`	Number of the field of the probe parameters (not probe number) (default=1)	
5	X0	`S_SETV`	Setpoint	
6	X	`S_MA`	Number of the measuring axis (default=1)	
			Values:	1 = 1st axis of the plane (for G18 Z) 2 = 2nd axis of the plane (for G18 X) 3 = 3rd axis of the plane (for G18 Y) [8)]
7	X1	`S_SZA`	Bypass distance in the measured axis	
8	Y1	`S_SZO`	Bypass distance in the bypass axis	
9	DFA	`S_FA`	Measurement path	
10	TSA	`S_TSA`	Safe area	
11	Measure- ments	`S_NMSP`	Number of measurements at the same location [2)] (default=1)	
12	T	`S_TNAME`	Tool name [2)]	
13	DL	`S_DLNUM`	Setup additive offset DL number [5)]	
14	TZL	`S_TZL`	Work offset [2), 4)]	
15	DIF	`S_TDIF`	Dimensional difference check [2), 4)]	

No.	Screen form parameters	Cycle parameters	Meaning
16	TUL	`S_TUL`	Upper tolerance limit (incremental to the setpoint) [4]
17	TLL	`S_TLL`	Lower tolerance limit (incremental to the setpoint) [4]
18	TMV	`S_TMV`	Offset range for averaging [2]
19	FW	`S_K`	Weighting factor for averaging [2]
20	EVN	`S_EVNUM`	Number of the empirical value memory [2), 7)]
21		`S_MCBIT`	Reserved
22		`_DMODE`	Display mode Values: UNITS: Machining plane G17/G18/G19 0 = Compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
23		`_AMODE`	Alternative mode Values: UNITS: Dimensional tolerance yes/no 0 = No 1 = Yes

1) All default values = 0 or marked as default=x

2) Display depends on the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE

3) Correction in WO only possible for measurement without reversal

4) For tool offset, observe the channel MD 20360 TOOL_PARAMETER_DEF_MASK

5) Only if the "Setup additive offset" function has been set-up in the general MD 18108 $MN_MM_NUM_SUMCORR . In addition, the general MD 18080 $MN_MM_TOOL_MANAGEMENT_MASK , bit8 must be set to 1.

6) If WO "fine" has not been set up in MDs, correction is according to WO "coarse"

7) Empirical averaging only possible for tool offset
Value range for empirical mean value memory:
1 to 20 numbers (n) of the empirical value memory, see channel-specific SD 55623 $SCS_MEA_EMPIRIC_VALUE[n-1]
10000 to 200000 numbers (n) of the mean value memory, see channel-specific SD 55625 $SCS_MEA_AVERAGE_VALUE[n-1]

8) If Y axis is available on the machine

4.1.4 CYCLE976 measuring cycle parameters

```
PROC CYCLE976(INT S_MVAR,INT S_PRNUM,REAL S_SETV,REAL S_SETV0,INT S_MA,INT S_MD,REAL
S_FA,REAL S_TSA,REAL S_VMS,REAL S_STA1,INT S_NMSP,INT S_SETV1,INT _DMODE,INT _AMODE)
```

Table 4-4 CYCLE976 call parameters [1]

No.	Screen form parameters	Cycle parameters	Meaning	
1		S_MVAR	Measuring version (default=1000)	
			Values:	UNITS: Calibration on surface, calibration sphere or calibration ring [2] 0 = Length on surface with known setpoint 1 = Radius in calibration ring with known diameter (setpoint) and known center point. 2 = Radius in calibration ring with known diameter (setpoint) and an unknown center point 3 = Radius and length at the calibration sphere 4 = Radius at the edge with known setpoint. Note selection of measuring axis and measuring direction. [3] 5 = Radius between two edges with known setpoint and edge clearance. Measuring axis should be selected.
				TENS: Reserved 0 = 0
				HUNDREDS: Reserved 0 = 0
				THOUSANDS: Selection of measuring axis and measuring direction during calibration. 0 = No specification (no selection of the measuring axis and measuring direction required) [8] 1 = Specify selection of measuring axis and measuring direction, see S_MA, S_MD (one measuring direction in a measuring axis) 2 = Specify selection of measuring axis, see S_MA (two measuring directions in a measuring axis)
				TEN THOUSANDS: Determination of the positional deviation (probe skew) [2] 0 = Determine positional deviation of the probe [6] 1 = Do not determine positional deviation
				HUNDRED THOUSANDS: Paraxial calibration or at an angle 0 = Paraxial calibration in the active WCS 1 = Calibration at an angle [7]
				ONE MILLION: Determination of tool length during calibration on surface or on sphere 0 = tool length is not determined 1 = tool length is determined[4] 2 = infeed axis is calibrated at the sphere, the tool length is determined, the tool length measured difference is entered in the calibration data
2	Icon+ number	S_PRNUM	Number of the field of the probe parameters (not probe number) (default=1)	
3		S_SETV	Setpoint	
4	Z0	S_SETV0	Setpoint of the length for sphere calibration	
5	X / Y / Z	S_MA	Measuring axis (number of the axis) [2), 6)] (default=1)	
			Values:	1 = 1st axis of the plane (for G17 X) 2 = 2nd axis of the plane (for G17 Y) 3 = 3rd axis of the plane (for G17 Z)

No.	Screen form parameters	Cycle parameters	Meaning	
6	+-	S_MD	Measuring direction [2), 6)]	
			Values:	0 = Positive 1 = Negative
7	DFA	S_FA	Measurement path	
8	TSA	S_TSA	Safe area	
9	VMS	S_VMS	Variable measuring velocity for calibration [2)]	
10	α	S_STA1	Starting angle [2), 5)]	
11	Measurements	S_NMSP	Number of measurements at the same location [2)] (default=1)	
12	X0	S_SETV1	Edge reference point when calibrating between 2 edges [3)]	
13		_DMODE	Display mode	
			Values:	UNITS: Machining plane G17/G18/G19 0 = Compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
14		_AMODE	Alternative mode	

1) All default values = 0 or marked as default=x

2) Display depends on the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE

3) For "Radius in the calibration ring" calibration, the diameter and the center point of the ring must be known (four measuring directions).
For "Radius on two edges" calibration, the distance to the edges in the direction of the measuring axis must be known (two measuring directions).
For "Radius on one edge" calibration, the setpoint of the surface must be known.

4) Measuring variant only calibration on a surface (length on surface), corrected tool length results from S_MD and S_MA.

5) Only for measuring variant "Calibration ring, ... and known center point" (S_MVAR=1xxx02).

6) Measuring axis only for measuring variant S_MVAR=0 or =xx1x01 or =xx2x01 or =20000
Measuring variant: "Calibration on a surface" → selection of measuring axis and measuring direction
or on the "Calibration ring, ... and known center point" → selection of an axis direction and selection of measuring axis and measuring direction
or on the "Calibration ring, ... and known center point" → selection of two axis directions and selection of measuring axis
or "Determination of the probe length" → S_MA=3 → 3rd axis of the plane (for G17 Z)

7) Measuring version, only calibration in calibration ring or on calibration sphere
For "Calibration on calibration sphere", for measuring at an angle, the axis circles around the sphere at the equator.

8) For "Radius in calibration ring" calibration with unknown center point, four measuring directions in the plane (for G17 +-X +-Y).
For "Length on surface" calibration in minus direction of the tool axis (for G17 -Z).

4.1.5 CYCLE978 measuring cycle parameters

```
PROC CYCLE978(INT S_MVAR,INT S_KNUM,INT S_KNUM1,INT S_PRNUM,REAL S_SETV,REAL S_FA,REAL
S_TSA,INT S_MA,INT S_MD,INT S_NMSP,STRING[32] S_TNAME,INT S_DLNUM,REAL S_TZL,REAL
S_TDIF,REAL S_TUL,REAL S_TLL,REAL S_TMV,INT S_K,INT S_EVNUM,INT S_MCBIT,INT _DMODE,INT
_AMODE)
```

Table 4-5 CYCLE978 call parameters [1)]

No.	Screen form parameters	Cycle parameters	Meaning	
1		S_MVAR	Measuring variant	
			Values:	UNITS: Contour element 0 = Measure surface
				TENS: Reserved
				HUNDREDS: Correction target 0 = Only measurement (no correction of the WO or no tool offset) 1 = Measurement, determination and correction of the WO (see S_KNUM) 2 = Measurement and tool offset (see S_KNUM1)
				THOUSANDS: Reserved
				TEN THOUSANDS: Measurement with/without spindle reversal or align probe in the switching direction [9)] 0 = Measurement without spindle reversal, without probe alignment 1 = Measurement with spindle reversal 2 = Align probe in switching direction
2	Selection	S_KNUM	Correction of work offset (WO) or basic WO or basic reference [2)]	
			Values:	UNITS:
				TENS: 0 = No correction 1 to max. 99 numbers of the work offset or 1 to max. 16 numbers of the basic offset
				HUNDREDS: Reserved
				THOUSANDS: Correction of WO or basic or basic reference 0 = Correction of the adjustable WO 1 = Correction of the channel-specific basic WO 2 = Correction of the basic reference 3 = Correction of the global basic WO 9 = Correction of the active WO or for G500 in last active channel-specific basic WO
				TEN THOUSANDS: Coarse or fine correction in the WO, basic WO or basic reference 0 = Fine correction [6)] 1 = Coarse correction

No.	Screen form parameters	Cycle parameters	Meaning	
3	Selection	`S_KNUM1`	Correction in tool offset [2)]	
			Values:	UNITS:
				TENS:
				HUNDREDS: 0 = No correction 1 to max. 999 D numbers (cutting edge numbers) for tool offset, for additive and setup offset, see also `S_DLNUM`
				THOUSANDS: 0 or unique D numbers
				TEN THOUSANDS: 0 or unique D numbers 1 to max. 32000 if unique D numbers in MDs have been set up
				HUNDRED THOUSANDS: Tool offset[2)] 0 = No specification (offset in tool geometry) 1 = Offset of length L1 2 = Offset of length L2 3 = Offset of length L3 4 = Radius offset
				ONE MILLION: Tool offset[2)] 0 = No specification (offset of the tool radius wear) 1 = Tool offset, additive offset (AO) [5)] Tool offset value is added to the existing AO 2 = Tool offset, setup offset (SO) [5)] SO (new) = SO (old) + AO (old) offset value, AO (new) = 0 3 = Tool offset, setup offset (SO) [5)] Tool offset value is added to the existing SO 4 = Tool offset, geometry
				TEN MILLION: Tool offset[2)] 0 = No specification (offset in tool geometry normal, not inverted) 1 = Offset inverted
4	Icon+number	`S_PRNUM`	Number of the field of the probe parameters (not probe number) (value range 1 to 40)	
5	X0	`S_SETV`	Setpoint	
6	DFA	`S_FA`	Measurement path	
7	TSA	`S_TSA`	Safe area	
8	X	`S_MA`	Number of the measuring axis [7)] (value range 1 to 3)	
			Values:	1 = 1st axis of the plane (for G17 X) 2 = 2nd axis of the plane (for G17 Y) 3 = 3rd axis of the plane (for G17 Z) measurement in tool direction
9		`S_MD`	Measuring direction of the measuring axis	
			Values:	1 = Positive measuring direction 2 = Negative measuring direction
10	Measurements	`S_NMSP`	Number of measurements at the same location [2)] (value range 1 to 9)	
11	TR	`S_TNAME`	Tool name [3)]	
12	DL	`S_DLNUM`	Setup additive offset DL number [5)]	
13	TZL	`S_TZL`	Work offset [2), 3)]	
14	DIF	`S_TDIF`	Dimensional difference check [2), 3)]	

<table>
<tr><th>No.</th><th>Screen form parameters</th><th>Cycle parameters</th><th colspan="2">Meaning</th></tr>
<tr><td>15</td><td>TUL</td><td>S_TUL</td><td colspan="2">Upper tolerance limit (incremental to the setpoint) 3)</td></tr>
<tr><td>16</td><td>TLL</td><td>S_TLL</td><td colspan="2">Lower tolerance limit (incremental to the setpoint) 3)</td></tr>
<tr><td>17</td><td>TMV</td><td>S_TMV</td><td colspan="2">Offset range for averaging 2)</td></tr>
<tr><td>18</td><td>FW</td><td>S_K</td><td colspan="2">Weighting factor for averaging 2)</td></tr>
<tr><td>19</td><td>EVN</td><td>S_EVNUM</td><td colspan="2">Date set, empirical value memory 2), 8)</td></tr>
<tr><td>20</td><td></td><td>S_MCBIT</td><td colspan="2">Reserved</td></tr>
<tr><td rowspan="2">21</td><td rowspan="2"></td><td rowspan="2">_DMODE</td><td colspan="2">Display mode</td></tr>
<tr><td>Values:</td><td>UNITS: Machining plane G17/G18/G19
0 = Compatibility, the plane active before the cycle call remains active
1 = G17 (only active in the cycle)
2 = G18 (only active in the cycle)
3 = G19 (only active in the cycle)</td></tr>
<tr><td rowspan="2">22</td><td rowspan="2"></td><td rowspan="2">_AMODE</td><td colspan="2">Alternative mode</td></tr>
<tr><td>Values:</td><td>UNITS: Dimensional tolerance yes/no
0 = No
1 = Yes</td></tr>
</table>

1) All default values = 0 or marked as the range of values a to b

2) Display depends on the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE

3) Only for offset in tool, otherwise parameter = ""

4) Only for offset in tool and dimensional tolerance "Yes", otherwise parameter = 0

5) Only if the "Setup additive offset" function has been set-up in the general MD 18108 $MN_MM_NUM_SUMCORR . In addition, in the general MD 18080 $MN_MM_TOOL_MANAGEMENT_MASK , bit8 must be set to 1.

6) If WO "fine" has not been set up in MDs, correction is according to WO "coarse"

7) Offset in tool geometry:
For measurement in the plane (`S_MA=1` or `S_MA=2`) Offset in tool radius
For measurement in tool direction (`S_MA=3`) Offset in tool length L1

8) Empirical averaging for tool offset and correction in WO possible
Value range for empirical mean value memory:
1 to 20 numbers (n) of the empirical value memory, see channel-specific SD 55623 $SCS_MEA_EMPIRIC_VALUE[n-1]
10000 to 200000 numbers (n) of the mean value memory, see channel-specific SD 55625 $SCS_MEA_AVERAGE_VALUE[n-1]

9) When measuring with spindle reversal, the radius/diameter of the probe must be precisely determined. This should be realized with a calibration variant of the CYCLE976 radius at the ring or at the edge or at the sphere. Otherwise, the measurement result will be falsified.

4.1.6 CYCLE998 measuring cycle parameters

```
PROC CYCLE998(INT S_MVAR,INT S_KNUM,INT S_RA,INT S_PRNUM,REAL S_SETV,REAL S_STA1,REAL
S_INCA,REAL S_FA,REAL S_TSA,INT S_MA,INT S_MD,REAL S_ID,REAL S_SETV0,REAL S_SETV1,REAL
S_SETV2,REAL S_SETV3,INT S_NMSP,INT S_EVNUM,INT _DMODE,INT _AMODE)
```

Table 4-6 CYCLE998 call parameters [1)]

No.	Screen form parameters	Cycle parameters	Meaning	
1		`S_MVAR`	Measuring variant (default=5)	
			Values:	UNITS: Contour element 5 = Measure edge (one angle) 6 = Measure plane (two angles)
				TENS: Reserved
				HUNDREDS: Correction target 0 = Only measurement and no correction of WO 1 = Measurement and determination and correction of the WO (see `S_KNUM`)
				THOUSANDS: Protection zone 0 = No consideration of a protection zone 1 = Consideration of a protection zone
				TEN THOUSANDS: Measurement with spindle reversal (difference measurement) 0 = Measurement without spindle reversal 1 = Measurement with spindle reversal
				HUNDRED THOUSANDS: Measurement at an angle or paraxial 0 = Measurement at an angle 1 = Measurement paraxial
2	Selection	`S_KNUM`	Correction of work offset (WO) or basic WO or basic reference [2)]	
			Values:	UNITS:
				TENS: 0 = No correction 1 to max. 99 numbers of the work offset or 1 to max. 16 numbers of the basic offset
				HUNDREDS: Reserved
				THOUSANDS: Correction of WO or basic or basic reference 0 = Correction of the adjustable WO 1 = Correction of the channel-specific basic WO 2 = Correction of the basic reference 9 = Correction of the active WO or for G500 in last active channel-specific basic WO
				TEN THOUSANDS: Coarse or fine correction in the WO or basic WO or basic reference [3)] 0 = Fine correction 1 = Coarse correction
3		`S_RA`	Correction target coordinate rotation or rotary axis	
	A, B, C		Values:	0 = Correction target coordinate rotation around the axis that results from parameter `S_MA` [4)] >0 = Correction target rotary axis. Number of the channel axis number of the rotary axis (preferably rotary table). The angular offset is made in the translatory part of the WO of the rotary axis.
4	Icon+ number	`S_PRNUM`	Number of the field of the probe parameter (default=1)	

No.	Screen form parameters	Cycle parameters	Meaning
5	DX / DY / DZ	`S_SETV`	Distance (incremental) from the starting position to measuring point P1 of the measuring axis (`S_MA`) [5)]
6	α	`S_STA1`	Angle setpoint for "Align edge" or for "Align plane" around the 1st axis of the plane (for G17 X) [9)]
7	β	`S_INCA`	Angle setpoint for "Align plane" around the 2nd axis of the plane (for G17 Y) [9)]
8	DFA	`S_FA`	Measurement path
9	TSA	`S_TSA`	Safe area Monitoring of the angle difference to the angle setpoint [degrees] [6)]
10	X / Y / Z	`S_MA`	Measuring axis, offset axis [7)] (default=201) Values: UNITS: Number of the measuring axis 1 = 1st axis of the plane (for G17 X) 2 = 2nd axis of the plane (for G17 Y) 3 = 3rd axis of the plane (for G17 Z) TENS: Reserved HUNDREDS: Number of the offset axis 1 = 1st axis of the plane (for G17 X) 2 = 2nd axis of the plane (for G17 Y) 3 = 3rd axis of the plane (for G17 Z)
11	+-	`S_MD`	Measuring direction of the measuring axis [8)] Values: 0 = Measuring direction is determined from the setpoint and the actual position of the measuring axis (compatibility) 1 = Positive measuring direction 2 = Negative measuring direction
12	L2	`S_ID`	For measuring variant "Align edge": Distance (incremental) between the measuring points P1 and P2 in the offset axis (value >0) For measuring variant "Align plane", the parameters listed below apply.
13	L2	`S_SETV0`	Distance between the measuring points P1 and P2 in the 1st axis of the plane [10)]
14		`S_SETV1`	Distance between the measuring points P1 and P2 in the 2nd axis of the plane [11), 12)]
15	L3x	`S_SETV2`	Distance between the measuring points P1 and P3 in the 1st axis of the plane [11)]
16	L3y	`S_SETV3`	Distance between the measuring points P1 and P3 in the 2nd axis of the plane [10)]
17	Measurements	`S_NMSP`	Number of measurements at the same location [2)] (default=1)
18		`S_EVNUM`	Date set, empirical value memory [2), 13)]
19		`_DMODE`	Display mode Values: UNITS: Machining plane G17/G18/G19 0 = compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
20		`_AMODE`	Reserved (alternative mode)

1) All default values = 0 or marked as default=x

2) Display depends on the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE

3) WO "fine" only if correction target is rotary axis and MD 52207 $MCS_AXIS_USAGE_ATTRIB[n] Bit6=1.
If WO has not been set up in MDs, correction is according to WO "coarse".

[4)] Example for offset in coordinate rotation: `S_MA=102` Measuring axis Y, offset axis X results in coordinate rotation around Z (for G17)

[5)] Value only relevant for protection zone "Yes" (`S_MVAR` THOUSANDS position = 1)

[6)] When positioning from measuring point P1 to measuring point P2 in the offset axis, the angles in parameters `S_STA1` and `S_TSA` are added.

[7)] Number of the measuring axis must not be the same as the number of the offset axis (e.g. 101 not permitted)

[8)] Measuring direction only for "Align edge" and "Measurement paraxial" (`S_MVAR=10x105`)

[9)] Angular range `S_STA1` ±45 degrees for "Align edge"
Angular range `S_STA1` 0 to +60 degrees and `S_INCA` ±30 degrees for "Align plane"

[10)] For measuring variants "Align plane" and "Align edge"

[11)] For measuring variants "Measure plane" and "Measurement paraxial"

[12)] Not for measuring cycle version SW04.04.

[13)] Empirical value generation for correction in WO; value range of the empirical mean value memory:
1 to 20 numbers of the empirical value memory, see channel-specific SD 55623 $SCS_MEA_EMPIRIC_VALUE[n-1]

4.1.7 CYCLE977 measuring cycle parameters

```
PROC CYCLE977(INT S_MVAR,INT S_KNUM,INT S_KNUM1,INT S_PRNUM,REAL S_SETV,REAL S_SETV0,REAL
S_SETV1,REAL S_FA,REAL S_TSA,REAL S_STA1,REAL S_ID,REAL S_SZA,REAL S_SZO,INT S_MA,INT
S_NMSP,STRING[32] S_TNAME,INT S_DLNUM,REAL S_TZL,REAL S_TDIF,REAL S_TUL,REAL S_TLL,REAL
S_TMV,INT S_K,INT S_EVNUM,INT S_MCBIT,INT _DMODE,INT _AMODE)
```

Table 4-7 CYCLE977 call parameters [1)]

No.	Screen form parameters	Cycle parameters	Meaning	
1		`S_MVAR`	Measuring variant	
			Values:	UNITS: Contour element (value range 1 to 6) 1 = Measure hole 2 = Measure spigot (shaft) 3 = Measure groove 4 = Measure rib 5 = Measure rectangle, inside 6 = Measure rectangle, outside
				TENS: Reserved
				HUNDREDS: Correction target 0 = Only measurement (no correction of the WO or no tool offset) 1 = Measurement and determination and correction of the WO (see `S_KNUM`) 2 = Measurement and tool offset (see `S_KNUM1`)
				THOUSANDS: Protection zone 0 = No consideration of a protection zone 1 = Consideration of a protection zone
				TEN THOUSANDS: Measurement with/without spindle reversal (differential measurement) or align probe in the switching direction 0 = Measurement without spindle reversal, do not align probe 1 = Measurement with spindle reversal 2 = Align probe in switching direction
2	Selection	`S_KNUM`	Correction of work offset (WO) or basic WO or basic reference [2)]	
			Values:	UNITS:
				TENS: 0 = No correction 1 to max. 99 numbers of the work offset or 1 to max. 16 numbers of the basic offset
				HUNDREDS: Reserved
				THOUSANDS: Correction of WO or basic or basic reference 0 = Correction of the adjustable WO 1 = Correction of the channel-specific basic WO 2 = Correction of the basic reference 3 = Correction of the global basic WO 9 = Correction of the active WO or for G500 in last active channel-specific basic WO
				TEN THOUSANDS: Coarse or fine correction in the WO, basic WO or basic reference 0 = Fine correction [6)] 1 = Coarse correction

No.	Screen form parameters	Cycle parameters	Meaning
3	Selection	`S_KNUM1`	Correction in tool offset [2]
			Values: UNITS:
			TENS:
			HUNDREDS: 0 = No correction 1 to max. 999 D numbers (cutting edge numbers) for tool offset; for additive and setup offset, see also `S_DLNUM`
			THOUSANDS: 0 or unique D numbers
			TEN THOUSANDS: 0 or unique D numbers 1 to max. 32000 if unique D numbers in MDs have been set up
			HUNDRED THOUSANDS: Tool offset[2] 0 = No specification (offset tool radius) 1 = Offset of length L1 2 = Offset of length L2 3 = Offset of length L3 4 = Radius offset
			ONE MILLION: Tool offset[2] 0 = No specification (offset of the tool radius wear) 1 = Tool offset, additive offset (AO) [5] Tool offset value is added to the existing AO 2 = Tool offset, setup offset (SO) [5] SO (new) = SO (old) + AO (old) offset value, AO (new) = 0 3 = Tool offset, setup offset (SO) [5] Tool offset value is added to the existing SO 4 = Tool offset, geometry
			TEN MILLION: Tool offset[2] 0 = No specification (offset in tool geometry normal, not inverted) 1 = Offset inverted
4	Icon+ number	`S_PRNUM`	Number of the field of the probe parameters (not probe number) (value range 1 to 40)
5	X0	`S_SETV`	Setpoint
6	X0	`S_SETV0`	Setpoint for rectangle in 1st axis of the plane (X for G17)
7	Y0	`S_SETV1`	Setpoint for rectangle in 2nd axis of the plane (Y for G17)
8	DFA	`S_FA`	Measurement path
9	TSA	`S_TSA`	Safe area
10	α 0	`S_STA1`	Starting angle
11	DZ	`S_ID`	Absolute incremental value 1. Incremental infeed of the 3rd axis of the plane (Z for G17) Infeed direction via sign of `S_ID`. For measurement of spigot, rib and rectangle outside, `S_ID` is used to define the lowering to measuring height. 2. Consideration of a protection zone For measurement of hole, groove and rectangle inside and a protection zone, `S_ID` is used to define the overtravel height.
12	X1	`S_SZA`	Diameter or length (width) of the protection zone [7]
13	Y1	`S_SZO`	For "Measure rectangle": Width of the protection zone of the 2nd axis of the plane

No.	Screen form parameters	Cycle parameters	Meaning
14	X	S_MA	Number of the measuring axis [7] (only for measurement of groove or rib) Values: 1 = 1st axis of the plane (for G17 X) 2 = 2nd axis of the plane (for G17 Y)
15	Measurements	S_NMSP	Number of measurements at the same location [2] (value range 1 to 9)
16	TR	S_TNAME	Tool name [2]
17	DL	S_DLNUM	Setup additive offset DL number [5]
18	TZL	S_TZL	Work offset [2, 4]
19	DIF	S_TDIF	Dimensional difference check [2, 4]
20	TUL	S_TUL	Upper tolerance limit (incremental to the setpoint) [4]
21	TLL	S_TLL	Lower tolerance limit (incremental to the setpoint) [4]
22	TMV	S_TMV	Offset range for averaging [2]
23	FW	S_K	Weighting factor for averaging [2]
24		S_EVNUM	Data set, empirical mean value memory [2, 8]
25		S_MCBIT	Reserved
26		_DMODE	Display mode Values: UNITS: Machining plane G17/G18/G19 0 = Compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
27		_AMODE	Alternative mode Values: UNITS: Dimensional tolerance yes/no 0 = No 1 = Yes

1) All default values = 0 or marked as the range of values a to b

2) Display depends on the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE

3) Only for offset in tool, otherwise parameter = ""

4) Only for offset in tool and dimensional tolerance "Yes", otherwise parameter = 0

5) Only if the "Setup additive offset" function has been set-up in the general MD 18108 $MN_MM_NUM_SUMCORR . In addition, in the general MD 18080 $MN_MM_TOOL_MANAGEMENT_MASK , bit8 must be set to 1.

6) If WO "fine" has not been set up in MDs, correction is according to WO "coarse"

7) Diameter or width of the protection zone within a hole or groove
Diameter or width of the protection zone outside of a spigot or rib

8) Empirical averaging possible for tool offset
Value range for empirical mean value memory:
1 to 20 numbers (n) of the empirical value memory, see channel-specific SD 55623 $SCS_MEA_EMPIRIC_VALUE[n-1]
10000 to 200000 numbers (n) of the mean value memory, see channel-specific SD 55625 $SCS_MEA_AVERAGE_VALUE[n-1]

4.1.8 CYCLE961 measuring cycle parameters

```
PROC CYCLE961(INT S_MVAR,INT S_KNUM,INT S_PRNUM,REAL S_SETV0,REAL S_SETV1,REAL
S_SETV2,REAL S_SETV3,REAL S_SETV4,REAL S_SETV5,REAL S_SETV6,REAL S_SETV7,REAL S_SETV8,REAL
S_SETV9,REAL S_STA1,REAL S_INCA,REAL S_ID,REAL S_FA,REAL S_TSA,INT S_NMSP,INT S_MCBIT,INT
_DMODE,INT _AMODE)
```

Table 4-8 CYCLE961 call parameters [1]

No.	Screen form parameters	Cycle parameters	Meaning	
1		S_MVAR	Measuring variant (default ≥ 6)	
			Values:	UNITS: Contour element 5 = Setup of right-angled inside corner, setpoint specification of angle and distances A1 to A3 6 = Setup of right-angled outside corner, setpoint specification of angle and distances A1 to A3 7 = Setup of inside corner, specification of angle and distances A1 to A4 8 = Setup of outside corner, specification of angle and distances A1 to A4
				TENS: Setpoint specification as distance or via four points 0 = Setpoint specification as distance (polar) 1 = Setpoint specification using four points (measuring points P1 to P4)
				HUNDREDS: Correction target 0 = Only measurement (no correction of the WO or no tool offset) 1 = Measurement and determination and correction of the WO, see S_KNUM
				THOUSANDS: Protection zone 0 = No consideration of a protection zone (obstacle) 1 = Consideration of a protection zone (obstacle), see S_ID
				TEN THOUSANDS: Position of the corner in the WCS 0 = Position of the corner is determined via parameter S_STA1 (compatibility) 1 = Position 1 of the corner in the positioned starting point of the measurement [6] 2 = Position 2 of the corner, distances in the 1st axis of the plane (for G17 X) are negative (see S_SETV0, S_SETV1) 3 = Position 3 of the corner, distances in the 1st and 2nd axis of the plane (for G17 XY) are negative (see S_SETV0 to S_SETV3) 4 = Position 4 of the corner, distances in the 2nd axis of the plane (for G17 Y) are negative (see S_SETV2, S_SETV3)

No.	Screen form parameters	Cycle parameters	Meaning
2	Selection	`S_KNUM`	Correction of work offset (WO) or basic WO or basic reference [2] Values: UNITS: TENS: 0 = No correction 1 to max. 99 numbers of the work offset or 1 to max. 16 numbers of the basic offset HUNDREDS: Reserved THOUSANDS: Correction of WO or basic or basic reference 0 = Correction of the adjustable WO 1 = Correction of the channel-specific basic WO 2 = Correction of the basic reference 9 = Correction of the active WO or for G500 in last active channel-specific basic WO TEN THOUSANDS: Coarse or fine correction in the WO, basic WO or basic reference 0 = Fine correction [5] 1 = Coarse correction
3	Icon+ number	`S_PRNUM`	Number of the field of the probe parameters (not probe number) (value range 1 to 40)
4	L1/X1	`S_SETV0`	Distance L1 between the pole and measuring point P1 in the direction of the 1st axis of the plane (for G17 X) [3] (if the actual distance L1=0, then L1 = M_SETV1 / 2 is automatically calculated) or starting point P1x of the 1st axis of the plane (for G17 X) [4]
5	L2/Y1	`S_SETV1`	Distance L2 between the pole and measuring point P2 in the direction of the 1st axis of the plane [3] or starting point P1y of the 2nd axis of the plane (for G17 Y) [4]
6	L3/X2	`S_SETV2`	Distance L3 between the pole and measuring point P3 in the direction of the 2nd axis of the plane [3] (if the distance L3=0, then for a corner that is not right angled, L3 = M_SETV3 / 2 is automatically calculated) or starting point P2x of the 1st axis of the plane[4]
7	L4/Y2	`S_SETV3`	Distance L4 between the pole and measuring point P3 in the direction of the 2nd axis of the plane with a corner that is not right angled [3] or starting point P2y of the 2nd axis of the plane[4]
8	XP/X3	`S_SETV4`	Position of the pole in the 1st axis of the plane [3] or starting point P3x of the 1st axis of the plane[4]
9	XP/Y3	`S_SETV5`	Position of the pole in the 2nd axis of the plane [3] or starting point P3y of the 2nd axis of the plane[4]
10	X4	`S_SETV6`	Starting point P4x of the 1st axis of the plane [4]
11	Y4	`S_SETV7`	Starting point P4y of the 2nd axis of the plane [4]
12	X0	`S_SETV8`	Setpoint of the measured corner in the 1st axis of the plane for correcting in WO
13	Y0	`S_SETV9`	Setpoint of the measured corner in the 2nd axis of the plane for correcting in WO
14	α0	`S_STA1`	Starting angle from the positive direction of the 1st axis of the plane to the reference edge of the workpiece in the MCS (+-270 degrees)
15	α1	`S_INCA`	Angle between workpiece reference edges when measuring a non-right-angled corner [7]
16	DZ	`S_ID`	Infeed amount at the measuring height for each measuring point for active protection zone (see `S_MVAR`).

No.	Screen form parameters	Cycle parameters	Meaning
17	DFA	S_FA	Measurement path
18	TSA	S_TSA	Safe area Monitoring the angular difference to the angle setpoint [degrees]
19	Measurements	S_NMSP	Number of measurements at the same location [2] (value range 1 to 9) [2]
20		S_MCBIT	Reserved
21		_DMODE	Display mode
			Values: UNITS: Machining plane G17/G18/G19 0 = compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
22		_AMODE	Alternative mode

[1] All default values = 0 or marked as the range of values a to b

[2] Display depends on the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE

[3]) Input of the measuring points in polar coordinates, taking into account the starting angle S_STA1 for measuring point 3 or 4 of the incremental angle S_INCA .

[4] Input of the measuring points in the right-angled coordinate system (input using 4 points),

[5] If WO "fine" has not been set up in MDs, correction is according to WO "coarse".

[6] Value range of angle S_INCA: -180 to +180 degrees

[7] Starting angle S_STA1, value range: right-angled corner: +- 90 degrees, any corner: +- 45 degrees

4.1.9 CYCLE979 measuring cycle parameters

```
PROC CYCLE979(INT S_MVAR,INT S_KNUM,INT S_KNUM1,INT S_PRNUM,REAL S_SETV,REAL S_FA,REAL
S_TSA,REAL S_CPA,REAL S_CPO,REAL S_STA1,REAL S_INCA,INT S_NMSP,STRING[32] S_TNAME,REAL
S_DLNUM,REAL S_TZL,REAL S_TDIF,REAL S_TUL,REAL S_TLL,REAL S_TMV,INT S_K,INT S_EVNUM,INT
S_MCBIT,INT _DMODE,INT _AMODE)
```

Table 4-9 CYCLE979 call parameters [0)]

No.	Screen form parameters	Cycle parameters	Meaning	
1		`S_MVAR`	Measuring variant	
			Values:	UNITS: Contour element 1 = Measure hole 2 = Measure spigot (shaft)
				TENS: Reserved
				HUNDREDS: Correction target 0 = Only measurement (no correction of the WO or no tool offset) 1 = Measurement and determination and correction of the WO (see `S_KNUM`) 2 = Measurement and tool offset (see `S_KNUM1`)
				THOUSANDS: Number of measurement points 0 = 3 measuring points 1 = 4 measuring points
				TEN THOUSANDS: Measurement with/without spindle reversal (differential measurement) or align probe in the switching direction 0 = Measurement without spindle reversal, without probe alignment 1 = Measurement with spindle reversal 2 = Align probe in switching direction
2	Selection	`S_KNUM`	Correction of work offset (WO) or basic WO or basic reference [2)]	
			Values:	UNITS:
				TENS: 0 = No correction 1 to max. 99 numbers of the work offset or 1 to max. 16 numbers of the basic offset
				HUNDREDS: Reserved
				THOUSANDS: Correction of WO or basic or basic reference 0 = Correction of the adjustable WO 1 = Correction of the channel-specific basic WO 2 = Correction of the basic reference 3 = Correction of the global basic WO 9 = Correction of the active WO or for G500 in last active channel-specific basic WO
				TEN THOUSANDS: Coarse or fine correction in the WO, basic WO or basic reference 0 = Fine correction [6)] 1 = Coarse correction

No.	Screen form parameters	Cycle parameters	Meaning
3	Selection	`S_KNUM1`	Correction in tool offset [2)] Values: UNITS: TENS: HUNDREDS: 0 = No correction 1 to max. 999 D numbers (cutting edge numbers) for tool offset; for additive and setup offset, see also `S_DLNUM` THOUSANDS: 0 or unique D numbers TEN THOUSANDS: 0 or unique D numbers 1 to max. 32000 if unique D numbers in MDs have been set up HUNDRED THOUSANDS: Tool offset[2)] 0 = No specification (offset in tool radius) 1 = Offset of length L1 2 = Offset of length L2 3 = Offset of length L3 4 = Radius offset ONE MILLION: Tool offset[2)] 0 = No specification (offset of the tool radius wear) 1 = Tool offset, additive offset (AO) [5)] Tool offset value is added to the existing AO 2 = Tool offset, setup offset (SO) [5)] SO (new) = SO (old) + AO (old) offset value, AO (new) = 0 3 = Tool offset, setup offset (SO) [5)] Tool offset value is added to the existing SO 4 = Tool offset, geometry TEN MILLION: Tool offset[2)] 0 = No specification (offset in tool geometry normal, not inverted) 1 = Offset inverted
4	Icon+ number	`S_PRNUM`	Number of the field of the probe parameters (not probe number) (value range 1 to 40)
5	X0	`S_SETV`	Setpoint
6	DFA	`S_FA`	Measurement path
7	TSA	`S_TSA`	Safe area
8	X0	`S_CPA`	Center point of the 1st axis of the plane (for G17 X)
9	Y0	`S_CPO`	Center point of the 2nd axis of the plane (for G17 Y)
10	alpha 0	`S_STA1`	Starting angle [7)]
11	Alpha 1	`S_INCA`	Incremental angle [8)]
12	Measure-ments	`S_NMSP`	Number of measurements at the same location [1)] (value range 1 to 9)
13	T	`S_TNAME`	Tool name [2)]
14	DL	`S_DLNUM`	Setup additive offset DL number [1), 4)]
15	TZL	`S_TZL`	Work offset [1), 2)]
16	DIF	`S_TDIF`	Dimensional difference check [1), 2)]
17	TUL	`S_TUL`	Upper tolerance limit (incremental to the setpoint) [2)]
18	TLL	`S_TLL`	Lower tolerance limit (incremental to the setpoint) [2)]

No.	Screen form parameters	Cycle parameters	Meaning	
19	TMV	`S_TMV`	Offset range for averaging [1]	
20	FW	`S_K`	Weighting factor for averaging [1]	
21		`S_EVNUM`	Date set, empirical value memory [1), 6)]	
22		`S_MCBIT`	Reserved	
23		`_DMODE`	Display mode	
			Values:	UNITS: Machining plane G17/G18/G19 0 = Compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
24		`_AMODE`	Alternative mode	
			Values:	UNITS: Dimensional tolerance yes/no 0 = No 1 = Yes

[0] All default values = 0 or marked as the range of values a to b

[1] Display depends on the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE

[2] Only for offset in tool, otherwise parameter = ""

[3] Only for offset in tool and dimensional tolerance "Yes", otherwise parameter = 0

[4] Only if the "Setup additive offset" function has been set-up in the general MD 18108 $MN_MM_NUM_SUMCORR .

[5] If WO "fine" has not been set up in MDs, correction is according to WO "coarse".

[6] Empirical averaging only possible for tool offset
Value range for empirical mean value memory:
1 to 20 numbers (n) of the empirical value memory, see channel-specific SD 55623 $SCS_MEA_EMPIRIC_VALUE[n-1]
10000 to 200000 numbers (n) of the mean value memory, see channel-specific SD 55625 $SCS_MEA_AVERAGE_VALUE[n-1]

[7] Value range of starting angle -360 to +360 degrees

[8] Value range of incremental angle >0 to ≤90 degrees for four measuring points or >0 to ≤120 degrees for three measuring points.

4.1.10 CYCLE997 measuring cycle parameters

```
PROC CYCLE997 (INT S_MVAR,INT S_KNUM,INT S_PRNUM,REAL S_SETV,REAL S_FA,REAL S_TSA,REAL
S_STA1,REAL S_INCA,REAL S_SETV0,REAL S_SETV1,REAL S_SETV2,REAL S_SETV3,REAL S_SETV4,REAL
S_SETV5,REAL S_SETV6,REAL S_SETV7,REAL S_SETV8,REAL S_TNVL,INT S_NMSP,INT S_MCBIT,INT
_DMODE,INT _AMODE)
```

Table 4-10 CYCLE997 call parameters [1), 2)]

No.	Screen form parameters	Cycle parameters	Meaning	
1		S_MVAR	Measuring variant (default =9)	
			Values:	UNITS: Contour element 9 = Measure sphere
				TENS: Repeat measurement 0 = Without measurement repetition 1 = With measurement repetition
				HUNDREDS: Correction target 0 = Only measurement (no correction of WO) 1 = Measurement and determination and correction of the WO (see S_KNUM)
				THOUSANDS: Measuring strategy 0 = Paraxial measurement, without starting angle, probe alignment corresponding to SD55740, bit 1 1 = Circling measurement, with starting angle, probe alignment corresponding to SD55740, Bit 1 2 = Circling measurement, with starting angle, align probe in the switching direction 3 = Paraxial measurement, with starting angle, probe alignment corresponding to SD55740, bit 1 4 = Paraxial measurement, with starting angle, align probe in the switching direction
				TEN THOUSANDS: Number of spheres to be measured 0 = Measure one sphere 1 = Measure three spheres
				HUNDRED THOUSANDS: Number of measuring points, only for measurement at an angle (note measuring strategy: THOUSANDS position > 0) 0 = Three measuring points for measurement at an angle (traversing around the sphere) 1 = Four measuring points for measurement at an angle (traversing around the sphere)
				ONE MILLION: Determination of the diameter setpoint of the sphere 0 = No determination of the diameter setpoint of the sphere 1 = Determination of the diameter setpoint of the sphere

No.	Screen form parameters	Cycle parameters	Meaning
2	Selection	`S_KNUM`	Correction in work offset (WO) or basic or basic reference [3] Values: UNITS: TENS: 0 = No correction 1 to max. 99 numbers of the work offset or 1 to max. 16 numbers of the basic offset HUNDREDS: Reserved THOUSANDS: Correction in WO or basic WO or basic reference 0 = Correction in adjustable WO 1 = Correction in channel-specific basic WO 2 = Correction in basic reference 3 = Correction in global basic WO [7] 9 = Correction in active WO or for G500 in last active channel-specific basic WO TEN THOUSANDS: Correction in WO or basic WO or basic reference coarse or fine 0 = Fine correction [6] 1 = Coarse correction
3	Icon+ number	`S_PRNUM`	Number of the field of the probe parameters (not probe number) (value range 1 to 40)
4		`S_SETV`	Diameter of the sphere(s) [4]
5	DFA	`S_FA`	Measurement path
6	TSA	`S_TSA`	Safe area
7	Alpha 0	`S_STA1`	Starting angle for measurement at an angle
8	Alpha 1	`S_INCA`	Incremental angle for measurement at an angle
9	X1	`S_SETV0`	Position setpoint of the 1st sphere of the 1st axis of the plane (for G17 X) for 3 sphere measurement
10	Y1	`S_SETV1`	Position setpoint of the 1st sphere of the 2nd axis of the plane (for G17 Y) for 3 sphere measurement
11	Z1	`S_SETV2`	Position setpoint of the 1st sphere of the 3rd axis of the plane (for G17 Z) for 3 sphere measurement
12	X2	`S_SETV3`	Position setpoint of the 2nd sphere of the 1st axis of the plane for 3 sphere measurement
13	Y2	`S_SETV4`	Position setpoint of the 2nd sphere of the 2nd axis of the plane for 3 sphere measurement
14	Z2	`S_SETV5`	Position setpoint of the 2nd sphere of the 3rd axis of the plane for 3 sphere measurement
15	X3	`S_SETV6`	Position setpoint of the 3rd sphere of the 1st axis of the plane for 3 sphere measurement
16	Y3	`S_SETV7`	Position setpoint of the 3rd sphere of the 2nd axis of the plane for 3 sphere measurement
17	Z3	`S_SETV8`	Position setpoint of the 3rd sphere of the 3rd axis of the plane for 3 sphere measurement
18	TVL	`S_TNVL`	Limit value for distortion of the triangle (sum of the deviations) for 3 sphere measurement [5]
19	Measure-ments	`S_NMSP`	Number of measurements at the same location [2] (value range 1 to 9)
20		`S_MCBIT`	Reserved

<table>
<tr><th>No.</th><th>Screen form parameters</th><th>Cycle parameters</th><th colspan="2">Meaning</th></tr>
<tr><td rowspan="2">21</td><td rowspan="2"></td><td rowspan="2">_DMODE</td><td colspan="2">Display mode</td></tr>
<tr><td>Values:</td><td>UNITS: Machining plane G17/G18/G19
0 = compatibility, the plane active before the cycle call remains active
1 = G17 (only active in the cycle)
2 = G18 (only active in the cycle)
3 = G19 (only active in the cycle)</td></tr>
<tr><td>22</td><td></td><td>_AMODE</td><td colspan="2">Alternative mode</td></tr>
</table>

1) All default values = 0 or marked as the range of values a to b

2) Display depends on the general SD 54760 $SNS_MEA_FUNCTION_MASK_PIECE

3) Intermediate positioning, circling around the sphere at the equator

4) 3 sphere measurement: The same diameter setpoint applies for all three spheres (_SETV)

5) Default value for `S_TNVL=1.2`
Correction in WO: Correction is only performed in the WO when the determined distortion is below the `S_TNVL` limit value.

6) If WO "fine" has not been set up in MDs, correction is according to WO "coarse"

7) For measuring variant "Measure three spheres", correction in a global basic frame is not possible (`S_KNUM` = 3001 to 3016), as the frame does not have a rotation component.

4.1.11 CYCLE995 measuring cycle parameters

```
PROC CYCLE995 (INT S_MVAR,INT S_KNUM,INT S_PRNUM,REAL S_SETV,REAL S_FA,REAL S_TSA,REAL
S_STA1,REAL S_INCA,REAL S_DZ,REAL S_SETV0,REAL S_SETV1,REAL S_SETV2,REAL S_TUL,REAL
S_TZL,INT S_NMSP,INT S_MCBIT,INT _DMODE,INT _AMODE)
```

Table 4-11 CYCLE995 call parameters [1)]

No.	Screen form parameters	Cycle parameters	Meaning	
1		S_MVAR	Measuring variant (default=5)	
			Values:	UNITS: Contour element 5 = Spindle geometry (parallel to the tool axis)
				TENS: Repeat measurement 1 = with repeat measurement
				HUNDREDS: No offset target 0 = measurement only
				THOUSANDS: Measuring strategy 2 = measurement at an angle, align probe in direction of switching
				TEN THOUSANDS: Number of spheres to be measured 0 = measure a sphere
				HUNDRED THOUSANDS: Number of measurement points 1 = 4 measurement points when measuring at an angle (circle the sphere)
				ONE MILLION: Determination of the diameter setpoint of the sphere 0 = No determination of the diameter setpoint of the sphere 1 = Determination of the diameter setpoint of the sphere
2	Selection	S_KNUM	Correction target 0 = 0	
3	Icon+ number	S_PRNUM	Number of the field of the probe parameters (not probe number) (value range 1 to 40)	
4	DM	S_SETV	Diameter of the calibration sphere [4)]	
5	DFA	S_FA	Measurement path	
6	TSA	S_TSA	Safe area [5)]	
7	alpha 0	S_STA1	Starting angle for measurement at an angle [3)]	
8		S_INCA	Incremental angle for measurement at an angle [2)]	
9	DZ	S_DZ	Clearance 1st measurement P1 to the 2nd measurement P2 at the shaft of the probe	
10		S_SETV0	Setpoint position of the sphere of the 1st axis of the plane (for G17 X) [2)]	
11		S_SETV1	Setpoint position of the sphere of the 2nd axis of the plane (for G17 Y) [2)]	
12		S_SETV2	Setpoint position of the sphere of the 3rd axis of the plane (for G17 Z) [2)]	
13	TUL	S_TUL	Upper tolerance value of the angular deviation	
14	TZL	S_TZL	Zero offset range [1), 4)]	
15	Number	S_NMSP	Number of measurements at the same location [2)] (value range 1 to 9)	
16		S_MCBIT	Reserved[2)]	
17		_DMODE	Display mode	
			Values:	UNITS: Machining plane G17/G18/G19 0 = compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)

No.	Screen form parameters	Cycle parameters	Meaning	
18		_AMODE	Alternative mode	
			Values:	UNITS: Dimensional tolerance yes/no 0 = No 1 = Yes

All default values = 0 or marked as the range of values a to b

1) Display depends on the general SD54760 $SNS_MEA_FUNCTION_MASK_PIECE

2) Parameters are currently not used and also not displayed in the input screen.
The parameter incremental angle S_INCAis permanently set to 90 degrees.

3) Value range of starting angle -360 to +360 degrees

4) for dimensional tolerance yes:
If the measured angle is less than the value of the work offset range TZL, then the result parameters for the angle (_OVR[2], _OVR[3]) and deviations (_OVR[7], _OVR[8]) are set to zero.
DisplayTZL is realized using the general SD54760 $SNS_MEA_FUNCTION_MASK_PIECE bit25=1.
(enable selected zero offset when measuring angularity, spindle)

5) Parameter TSA refers to the 1st measurement of the calibration sphere.

4.1.12 CYCLE996 measuring cycle parameters

```
PROC CYCLE996(INT S_MVAR,INT S_TC,INT S_PRNUM,REAL S_SETV,REAL S_STA1,REAL S_SETV0,REAL
S_SETV1,REAL S_SETV2,REAL S_SETV3,REAL S_SETV4,REAL S_SETV5,REAL S_TNVL,REAL S_FA,REAL
S_TSA,INT S_NMSP,INT S_MCBIT,INT _DMODE,INT _AMODE)
```

Table 4-12 CYCLE996 call parameters [1)]

No.	Screen form parameters	Cycle parameters	Meaning	
1		S_MVAR	Measurement version (default=1)	
			Values:	UNITS: Measuring sequence 0 = Calculate kinematics (selection with: Result display, protocol, change of the swivel data sets, where relevant with operator acknowledgment), see _AMODE 1 = 1st measurement 2 = 2nd measurement 3 = 3rd measurement
				TENS: Reserved 0 = 0
				HUNDREDS: Measurement version for 1st to 3rd measurement 0 = Measurement of the calibration ball paraxial 1 = Measurement of the calibration sphere at an angle and no spindle correction [3)] 2 = Measurement of the calibration sphere and correction of the spindle in the switching direction of the probe [3)] 3 = Paraxial measurement, with starting angle [8)] 4 = Paraxial measurement, with starting angle, tracking spindle in the switching direction of the probe [8)]
				THOUSANDS: Calculate correction target for kinematics [4)] 0 = measuring only. Swivel data sets are calculated, but remain unchanged 1 = calculate swivel data set. Swivel data sets are, if necessary, changed after acknowledgment by the operator [4)]
				TEN THOUSANDS: Measuring axis (rotary axis 1 or 2) or vector chain open or closed for calculate kinematics 0 = Vector chain closed (only for calculate kinematics) 1 = Rotary axis 1 (only for 1st to 3rd measurement) 2 = rotary axis 2 (only for the 1st to 3rd measurement) [5)] 3 = vector chain open (only for calculate kinematics)
				HUNDRED THOUSANDS: Normalizing of rotary axis 1 for calculate kinematics 0 = no scaling rotary axis 1 1 = scaling in the direction of the 1st axis of the plane (for G17 X) 2 = scaling in the direction of the 2nd axis of the plane (for G17 Y) 3 = scaling in the direction of the 3rd axis of the plane (for G17 Z)
				ONE MILLION: Normalizing of rotary axis 2 for calculate kinematics [5)] 0 = no scaling rotary axis 2 1 = scaling in the direction of the 1st axis of the plane (for G17 X) 2 = scaling in the direction of the 2nd axis of the plane (for G17 Y) 3 = scaling in the direction of the 3rd axis of the plane (for G17 Z)
				TEN MILLION: Log file 0 = no protocol file 1 = protocol file with the calculated vectors (tool carrier) and the 1st dynamic 5-axis transformation (TRAORI(1)), if set-up in MDs.
2		S_TC	Number of the swivel data record (tool carrier)	
3	Icon+ number	S_PRNUM	Number of the field of the probe parameters (not probe number) (default=1)	

No.	Screen form parameters	Cycle parameters	Meaning
4		`S_SETV`	Diameter of the calibration ball
5	alpha 0	`S_STA1`	Starting angle for measurement at an angle
6	alpha 0	`S_SETV0`	Position value of rotary axis 1 (if rotary axis is manual or semi-automatic)
7	alpha 1	`S_SETV1`	Position value of rotary axis 2 (if rotary axis is manual or semi-automatic) [6]
8	XN	`S_SETV2`	Position value for normalizing rotary axis 1
9	XN	`S_SETV3`	Position value for normalizing of rotary axis 2 [6]
10	Delta	`S_SETV4`	Tolerance value of the offset vectors I1 to I4
11	Delta	`S_SETV5`	Tolerance value of rotary axis vectors V1 and V2
12	TVL	`S_TNVL`	Limit value of angular segment of the rotary axis (value range 1 to 60 degrees) (default=20) [7]
13	DFA	`S_FA`	Measurement path
14	TSA	`S_TSA`	Safe area
15	Measurements	`S_NMSP`	Number of measurements at the same location [2] (default=1)
16		`S_MCBIT`	Reserved
17		`_DMODE`	Display mode
			Values: UNITS: Machining plane G17/G18/G19 0 = compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
18		`_AMODE`	Alternative mode
			Values: UNITS: Tolerance check yes/no 0 = No 1 = Yes: Evaluation of the tolerance values of the vectors `S_SETV4`, `S_SETV5`
			TENS: Acknowledgment by the operator when entering the calculated vectors in the swivel data set [4] 0 = yes: Operator must acknowledge the change 1 = no: calculated vectors are entered immediately (only effective if HUNDREDS and THOUSANDS position = 0)
			HUNDREDS: Measurement result display [5] 0 = no 1 = yes
			THOUSANDS: Measurement result display can be edited 0 = no 1 = yes, and can be edited (only effective, if the HUNDREDS position = 1)

1) All default values = 0 or marked as default=x

2) Display depends on the general SD54760 $SNS_MEA_FUNCTION_MASK_PIECE

3) Using this version, for example, for 90 degree positions, the kinematics can be measured at the calibration ball, without colliding with the retaining shaft of the calibration ball. A starting angle `S_STA1` (0 to 360 degrees) can be entered. The incremental angle when circling the sphere is equal to 90 degrees.
As feedrate along the circular path, the channel-specific SD55634 $SCS_MEA_FEED_PLANE_VALUE is used

4) There is an operator prompt with M0 before entering. The vectors are only entered with NC start.
If the measuring program is aborted with RESET no calculated vectors are entered.
Vectors are only entered when the tolerance of the offset vectors has not been exceeded during the calculation.

5) Measurement result display only for the calculated kinematics measuring version.
If the measurement result should also be displayed after the 1st to the 3rd measurement, then this is realized by setting the channel-specific SD 55613 $SCS_MEA_RESULT_DISPLAY.

6) Rotary axis 2 only for kinematics with two rotary axes

7) Limit value angular segment of the rotary axis. Value range of `S_TNVL` between 20 and 60 degrees. For values of `S_TNVL` < 20 degrees, inaccuracies can be expected as a result of the measuring inaccuracies in the micrometer range of the probe. If the limit value is violated, then error message 61430 is output – with a display of the minimum limit value.

8) Spindle is tracked in the probe switching direction if SD54760 bit 17 = 1

4.1.13 CYCLE982 measuring cycle parameters

```
PROC CYCLE982(INT S_MVAR,INT S_KNUM,INT S_PRNUM,INT S_MA,INT S_MD,REAL S_ID,REAL S_FA,REAL
S_TSA,REAL S_VMS,REAL S_STA1,REAL S_CORA,REAL S_TZL,REAL S_TDIF,INT S_NMSP,INT S_EVNUM,INT
S_MCBIT,INT _DMODE,INT _AMODE)
```

Table 4-13 CYCLE982 call parameters [1)]

No.	Screen form parameters	Cycle parameters	Meaning	
1		`S_MVAR`	Measuring version	
			Values:	UNITS: Calibration/measurement 0 = Calibrate tool probe 1 = Single tool measurement [3)] 2 = Multiple tool measurement, determine lengths and tool radius (for milling tools)
				TENS: Calibration or measurement in the MCS or WCS 0 = Machine-related [4)] 1 = Workpiece-related
				HUNDREDS: Measurement with or without reversal for milling tools 0 = Measurement without reversal 1 = Measurement with reversal
				THOUSANDS: Correction target for milling tools 0 = determine length or length and radius (see `S_MVAR` 1st position) 1 = determine radius, if `S_MVAR` 1st position = 1 2 = determine length and radius (face side), if `S_MVAR` 1st position = 1 or 2 3 = side milling tool, upper cutting edge (rear side) and determine length and radius [5)]
				TEN THOUSANDS: Position of the milling tool or the drill 0 = Axial position of the milling tool or the drill, radius in 2nd axis of the plane (for G18 X) [7)] 1 = Radial position of the milling tool or the drill, radius in 1st axis of the plane (for G18 Z) [7)]
				HUNDRED THOUSANDS: Incremental calibration or measurement 0 = No specification 1 = Incremental calibration or measurement
				ONE MILLION: Position spindle at starting angle `S_STA1` (only for measurement of milling tools) 0 = spindle is not positioned 1 = spindle is positioned at the starting angle `S_STA1`
2	Selection	`S_KNUM`	Offset variant [2)]	
			Values:	UNITS: Tool offset 0 = No specification (tool offset in geometry) 1 = Tool offset in wear
3	Icon+ number	`S_PRNUM`	Number of the field of the probe parameters (not probe number) (default=1)	
4	X0	`S_MA`	Measuring axis	
			Values:	1 = 1. Axis of the plane (for G18 Z) 2 = 2nd axis of the plane (for G18 X)
5	+-	`S_MD`	Measuring direction	
			Values:	0 = No selection (measuring direction is determined from actual value) 1 = Positive 2 = Negative

No.	Screen form parameters	Cycle parameters	Meaning	
6	Z2	S_ID	Offset	
7	DFA	S_FA	Measurement path	
8	TSA	S_TSA	Safe area	
9	VMS	S_VMS	Variable measuring velocity for calibration [2)]	
10	Alpha1	S_STA1	Starting angle when measuring milling tools	
11	Alpha2	S_CORA	Offset angle when measuring milling tools with reversal [8)]	
12	TZL	S_TZL	Work offset when measuring milling tools When calibrating S_TZL = 0	
13	DIF	S_TDIF	Dimension difference check	
14	Measurements	S_NMSP	Number of measurements at the same location [2)] (default=1)	
15	EVN	S_EVNUM	Number of the empirical mean value memory [2), 9)]	
16		S_MCBIT	Reserved	
17		_DMODE	Display mode	
			Values:	UNITS: Machining plane G17/G18/G19 0 = Compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
				TENS: Cutting edge position for turning and milling tools (only for display in the input screens 1 to 9)
				HUNDREDS: Tool type 0 = Turning tool 1 = Milling tool 2 = Drill
				THOUSANDS: The approach strategy with reference to the tool probe 0 = PLUS [X/Z]; X if tool position axial, Z if tool position radial 1 = MINUS [X/Z]; X if tool position axial, Z if tool position radial
18		_AMODE	Alternative mode	
			Values:	UNITS: Reserved
				TENS: Reserved
				HUNDREDS: Reserved
				THOUSANDS: approach starting position after measurement for calibration and single measurement (see S_MVAR - UNITS) 0 = tool is located, offset by DFA with respect to the probe edge 1 = approach starting position

1) All default values = 0 or marked as default=x

2) Display depends on the general SD 54762 _MEA_FUNCTION_MASK_TOOL

3) Measure turning or milling tool or drill. Measuring axis in parameter S_MA
Specification for turning tools via cutting edge position 1...8, for milling tools via HUNDREDS to THOUSANDS position in parameter S_MVAR.

4) Measurement and calibration are performed in the basic coordinate system (MCS for kinematic transformation switched off).

5) Not for incremental measuring

6) Only for multiple measurements `S_MVAR=x2x02` or `x3x02` (example, disk-type or groove milling tools)

7) If the channel-specific SD 42950 $SC_TOOL_LENGTH_TYPE = 2, then the tool length components are assigned just the same as for turning tools

8) Only for measurement with reversal `S_MVAR=xx1x1`

9) Empirical value generation
Value range of the empirical value memory: 1 to 20 numbers(n) of the empirical value memory, see channel-specific SD 55623 $SCS_MEA_EMPIRIC_VALUE[n-1].

4.1.14 CYCLE971 measuring cycle parameters

```
PROC CYCLE971(INT S_MVAR,INT S_KNUM,INT S_PRNUM,INT S_MA,INT S_MD,REAL S_ID,REAL S_FA,REAL
S_TSA,REAL S_VMS,REAL S_TZL,REAL S_TDIF,INT S_NMSP,REAL S_F1,REAL S_S1,REAL S_F2,REAL
S_S2,REAL S_F3,REAL S_S3,INT S_EVNUM,INT S_MCBIT,INT _DMODE,INT _AMODE)
```

Table 4-14 CYCLE971 call parameters 1)

No.	Screen form parameters	Cycle parameters	Meaning	
1		`S_MVAR`	Measuring version	
			Values:	UNITS: 0 = Calibrate tool probe 1 = Measure tool with stationary spindle (length or radius) 2 = Measure tool with rotating spindle (length or radius), see parameters `S_F1` to `S_S4`
				TENS: Measurement in the machine coordinate system or workpiece coordinate system 0 = Measurement in MCS (machine-related), measure tool or calibrate tool probe 1 = Measurement in WCS (workpiece-related), measure tool or calibrate tool probe
				HUNDREDS: Individually check teeth 0 = no 1 = yes
				THOUSANDS: 0 = 0
				TEN THOUSANDS: Incremental calibration or measurement 0 = No specification 1 = Incremental calibration or measurement
				HUNDRED THOUSANDS: Calibrate tool probe automatically 0 = Do not calibrate tool probe automatically 1 = Calibrate tool probe automatically
				ONE MILLION: Calibrating in the plane with spindle reversal 0 = Calibrating in the plane without spindle reversal 1 = Calibrating in the plane with spindle reversal

<table>
<tr><th>No.</th><th>Screen form parameters</th><th>Cycle parameters</th><th colspan="2">Meaning</th></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Selection</td><td rowspan="2"><code>S_KNUM</code></td><td colspan="2">Offset variant [2)]</td></tr>
<tr><td>Values:</td><td>UNITS: Tool offset
0 = No specification (tool offset in geometry)
1 = Tool offset in wear</td></tr>
<tr><td>3</td><td>Icon+ number</td><td><code>S_PRNUM</code></td><td colspan="2">Number of the field of the probe parameters (not probe number)</td></tr>
<tr><td rowspan="4">4</td><td rowspan="4">X0</td><td rowspan="4"><code>S_MA</code></td><td colspan="2">Measuring axis, offset axis [4)]</td></tr>
<tr><td rowspan="3">Values:</td><td>UNITS: Number of the measuring axis
1 = 1st axis of the plane (for G17 X)
2 = 2nd axis of the plane (for G17 Y)
3 = 3rd axis of the plane (for G17 Z)</td></tr>
<tr><td>TENS:
0 = 0</td></tr>
<tr><td>HUNDREDS: Number of the offset axis
0 = not an offset axis
1 = 1. axis of the plane (for G17 X)
2 = 2nd axis of the plane (for G17 Y)</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">+-</td><td rowspan="2"><code>S_MD</code></td><td colspan="2">Measuring direction</td></tr>
<tr><td>Values:</td><td>0 = No selection (measuring direction is determined from actual value)
1 = Positive
2 = Negative</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">V</td><td rowspan="2"><code>S_ID</code></td><td colspan="2">Offset</td></tr>
<tr><td>Values:</td><td>0 = For tools without offset
>0 =
• Calibration: The offset acts on the 3rd axis of the plane (for G17 Z) if the diameter of the calibration tool is greater than the upper diameter of the probe. The tool is offset by the tool radius from the center of the probe, minus the value of <code>S_ID</code>. The offset axis is also specified in <code>S_MA</code> .
• Measure: With multiple cutting edges, the offset of tool length and the highest point of the cutting edge must be specified for radius measurement or the offset of tool radius to the highest point of the cutting edge must be specified when measuring the length.</td></tr>
<tr><td>7</td><td>DFA</td><td><code>S_FA</code></td><td colspan="2">Measurement path</td></tr>
<tr><td>8</td><td>TSA</td><td><code>S_TSA</code></td><td colspan="2">Safe area</td></tr>
<tr><td>9</td><td>VMS</td><td><code>S_VMS</code></td><td colspan="2">Variable measuring velocity for calibration [2)]</td></tr>
<tr><td>10</td><td>TZL</td><td><code>S_TZL</code></td><td colspan="2">Work offset (only for tool measurement)</td></tr>
<tr><td>11</td><td>DIF</td><td><code>S_TDIF</code></td><td colspan="2">Dimensional difference check for tool measurement (<code>S_MVAR=xx1</code> or <code>S_MVAR=xx2</code>)</td></tr>
<tr><td>12</td><td>Measurements</td><td><code>S_NMSP</code></td><td colspan="2">Number of measurements at the same location [2)]</td></tr>
<tr><td>13</td><td>F1</td><td><code>S_F1</code></td><td colspan="2">1st feedrate for contact with rotating spindle [2)]</td></tr>
<tr><td>14</td><td>S1</td><td><code>S_S1</code></td><td colspan="2">1st speed for contact with rotating spindle [2)]</td></tr>
<tr><td>15</td><td>F2</td><td><code>S_F2</code></td><td colspan="2">2nd feedrate for contact with rotating spindle [2)]</td></tr>
<tr><td>16</td><td>S2</td><td><code>S_S2</code></td><td colspan="2">2nd speed for contact with rotating spindle [2)]</td></tr>
<tr><td>17</td><td>F3</td><td><code>S_F3</code></td><td colspan="2">2nd feedrate for contact with rotating spindle [3)]</td></tr>
</table>

No.	Screen form parameters	Cycle parameters	Meaning	
18	S3	`S_S3`	2nd speed for contact with rotating spindle [3)]	
19	EVN	`S_EVNUM`	Number of the empirical value memory [2)]	
20		`S_MCBIT`	Screen form of the _CBITs or _CHBITs	
21		`_DMODE`	Display mode	
			Values:	UNITS: Machining plane G17/G18/G19 0 = Compatibility, the plane active before the cycle call remains active 1 = G17 (only active in the cycle) 2 = G18 (only active in the cycle) 3 = G19 (only active in the cycle)
22		`_AMODE`	Alternative mode	
			Values:	UNITS: Measuring the tool offset for radius 1 = no 2 = yes
				TENS: Direction of the tool offset when measuring the radius in the 3rd axis of the plane (for G17 Z) 1 = Positive 2 = Negative
				HUNDREDS: Tool offset when measuring the length or when calibrating the probe in the 3rd axis 0 = Compatibility, auto 1 = No 2 = Yes
				THOUSANDS: Direction of the tool offset when measuring the length in the offset axis (see S_MA HUNDREDS) 1 = Positive 2 = Negative

1) All default values = 0 or marked as default=x

2) Display depends on the general SD 54762 MEA_FUNCTION_MASK_TOOL

3) Only for offset in tool and dimensional tolerance "Yes", otherwise parameter = 0

4) For automatic measurement (`S_MVAR=1x00xx`), no display of measuring axis, offset axis ⇒ `S_MA=0`.

4.1.15 CYCLE150 measuring cycle parameters

```
PROC CYCLE150(INT S_PICT,INT S_PROT,STRING[160] S_PATH) SAVE
ACTBLOCNO DISPLOF
```

Table 4-15 CYCLE150 call parameters

No.	Screen parameters	Cycle parameters	Meaning	
1	Measuring result screen	`S_PICT`	Select result display (default = 0)	
			Values:	UNITS: 0 = Measuring result screen OFF 1 = Measuring result screen ON
				Tens: Select display mode (values as for SD 55613) 1 = Display measuring result screen - automatically deselect after 8 s 3 = Display measuring result screen - acknowledge using NC Start 4 = Display measuring result screen - only for alarms (61303 ... 61306)
2		`S_PROT`	Select logging (default = 0)	
	Log		Values:	UNITS: Select protocol off / on / last measurement 0 = Log OFF 1 = Log ON 2 = Log last measurement
	Log type			TENS: Select log type 0 = Standard log 1 = User log (can be freely defined)
	Log format			HUNDREDS: Select log format 0 = Text format 1 = Table format (for import to Excel)
	Log data			THOUSANDS: Rewrite or attach selection 0 = New 1 = Attach
	Log archive			TEN THOUSANDS: Select log archive 0 = As part program 1 = Directory
3		`S_PATH`	Path for the log file corresponding to the log archive selection (complete path name or only file name, e.g.: "//NC:/WKS.DIR/NAME.WPD or "MESSPROTOKOLL.TXT"	

4.2 Additional parameters

The following supplementary parameters can be hidden or unhidden using setting data in the input screen forms. For more information about setting data SD54760 to SD54764, see the List Manual *SINUMERIK 840D sl, detailed description of the machine data*.

Machine manufacturer

Please observe the information provided by the machine manufacturer.

The supplementary parameter are not available for all measuring cycles. See also the interface description.

Table 4-16 Supplementary parameters for workpiece measurement

Screen form parameters	Transfer parameters	Description	Unit
Calibration data set	`S_PRNUM`	Number of the data set with the calibrated values of the probe	-
F	`S_VMS`	Measuring feedrate when calibrating the probe	mm/min
Selection	`S_MVAR`	Calibrate probe: selection at the known or unknown center point of the calibration ring	-
Selection	`S_MVAR`	Calibrate probe: selection, calibration with or without position deviation (probe skew)	-
Number	`S_NMSP`	Number of measurements at the same location	-
TZL	`S_TZL`	Work offset for correction in a tool	mm
DIF	`S_TDIF`	Dimension difference monitoring for correction in a tool	-
Data set, mean value generation	`S_EVNUM`	Generating mean values for correction in a tool	-
Data set, empirical values	`S_EVNUM`	Generating empirical values for correction in a tool	-
FW	`S_K`	Weighting factor for averaging	-
TMV	`S_TMV`	Offset range for averaging	
Selection	`S_MVAR`	Measuring when turning, diameter inside outside: • With reversal • Travel under center of rotation	-

Additional correction options when measuring workpiece:

1. Work offsets
   - Offset in the basic reference
   - Offset in the channel-specific basic WO
   - Offset in the global basic WO
   - Offset, coarse or fine
2. Tool offsets
   - Tool offset in geometry or wear
   - Tool offset, inverted or not inverted
   - Tool offset in radius or length L1 or L2 or L3

Table 4-17 Supplementary parameter when measuring tool

Screen form parameters	Transfer parameters	Description	Unit
Calibration data set	`S_PRNUM`	Number of the data set with the calibrated values of the probe	-
F	`S_VMS`	Measuring feedrate when calibrating the probe	mm/min
Selection, measuring steps	`S_MVAR`	Input of max. 3 feedrates and 3 spindle speeds when measuring with rotating spindle	-
Selection	`S_MVAR`	Tool offset in geometry or wear	-
Selection	`S_MVAR`	Measurement in the machine coordinate system or workpiece coordinate system	-
Number	`S_NMSP`	Number of measurements at the same location	-
Data set, empirical values	`S_EVNUM`	Generating empirical values for correction in a tool	-

4.3 Additional result parameters

The following table below contains the additional result parameters for the measuring variants of the tool offset.

Parameters	Description	Unit
_OVR [8] [1]	Upper tolerance limit for: • Diameter of hole / circular spigot / circle segment • Measuring axis • Width of groove/rib • Rectangle length in the 1st axis of the plane	mm
_OVR [9] [1), 3]	Upper tolerance limit for rectangle length in the 2nd axis of the plane	mm
_OVR [12] [1]	Lower tolerance limit for: • Diameter of hole / circular spigot / circle segment • Measuring axis • Width of groove/rib • Rectangle length in the 1st axis of the plane	mm
_OVR [13] [1), 3]	Lower tolerance limit for rectangle length in the 2nd axis of the plane	mm
_OVR [20] [1]	Offset value	mm
_OVR [27] [1]	Work offset range	mm
_OVR [28] [1]	Safe area	mm
_OVR [29] [1]	Dimensional difference	mm
_OVR [30] [1]	Empirical value	mm
_OVR [31] [1]	Mean value	mm
_OVI [4] [1]	Weighting factor	-
_OVI [5]	Probe number	-
_OVI [6] [1]	Mean value memory number	-
_OVI [7] [1]	Empirical value memory number	-
_OVI [8] [1]	Tool number	-
_OVI [9] [1]	Alarm number	-
_OVI [11] [2]	Status offset request	-
_OVI [13] [1]	DL number	-

1) Only for workpiece measurement with tool offset

2) only for correction in the WO

3) Only applies for the measuring variants "Rectangular pocket" and "Rectangular spigot"

4.4 Parameter

Table 4-18 List of input/output variables for cycles

Screen form parameters	Cycle parameters	Meaning in English	Meaning in German
	S_CALNUM	**Cal**ibration groove **num**ber	Number of the gauging block
	S_MCBIT	**C**entral **Bit**s	Screen form of the _CBITs or _CHBITs
α2	S_CORA	**Cor**rection **a**ngle position	Offset angle
X0	S_CPA	**C**enter **p**oint **a**bscissa	Center point of the 1st axis of the plane
Y0	S_CPO	**C**enter **p**oint **o**rdinate	Center point of the 2nd axis of the plane
DL	S_DLNUM		DL number for setup or additive offset
EVN	S_EVNUM		Number, mean empirical value memory
DFA	S_FA	Factor for multipl. of measurem. path	Measurement path
	S_ID	Infeed in applicate	Incremental infeed absolute value / offset
α1	S_INCA	**Inc**exing **a**ngle	Incremental angle / angle setpoint
FW	S_K	Weighting factor for averaging	Weighting factor for averaging
Selection	S_KNUM		Correction of WO, basic WO or basic reference
Selection	S_KNUM1		Correction in tool offset
X / Y / Z	S_MA	Number of **m**easuring **a**xis	Measuring axis (number of the axis)
+ / -	S_MD	**M**easuring **d**irection	Measuring direction
	S_MFS		Feedrate and speed for measurement with rotating spindle
	S_MVAR	**M**easuring **var**iant	Measuring variant
Number	S_NMSP	**N**umber of **m**easurements at same **sp**ot	Number of measurements at the same location
	_OVI [20]		Field: Output values INT
	_OVR [32]		Field: Output values REAL
Icon + number	S_PRNUM	**Pr**obe type and probe **num**ber	Number of the field of the probe parameters
X0 / Y0 / Z0	S_SETV	**Set**point **v**alue	Setpoint
α1	S_STA1	**St**arting **a**ngle	Starting angle
X	S_SZA	**S**afety **z**one on workpiece **a**bscissa	Protection zone in the 1st axis of the plane
Y	S_SZO	**S**afety **z**one on workpiece **o**rdinate	Protection zone in the 2nd axis of the plane
DIF	S_TDIF	**T**olerance dimensional **dif**ference check	Dimension difference check
TLL	S_TLL	**T**olerance **l**ower **l**imit	Tolerance lower limit
TMV	S_TMV		Mean value generation with compensation
T	S_TNAME	Tool **name**	Tool name when using tool manager
	S_TNVL		Limit value for distortion of the triangle
TSA	S_TSA	**T**olerance **s**afe **a**rea	Safe area
TUL	S_TUL	**T**olerance **u**pper **l**imit	Tolerance upper limit
TZL	S_TZL	**T**olerance **z**ero offset range	Work offset
VMS	S_VMS	**V**ariable **m**easuring **s**peed	Variable measuring speed

Changes from cycle version SW4.4 and higher A

A.1 Assignment of the measuring cycle parameters to MEA_FUNCTION_MASK parameters

All setting data that were saved up to measuring cycle version 2.6 in GUD variables, from software release SW 4.4 are located in the configurable machine and setting data (e.g. data fields of the calibration values). The GUD modules GUD5, GUD6 and GUD7_MC are no longer required for measuring cycle data.

The following tables include the assignment of function-determining measuring cycle parameters to the MEA_FUNCTION_MASK parameters.

Bit 1)	Function	MD identifier SW 2.6	GUD name up to SW 2.6
General cycle machine data: MD51740 $MNS_MEA_FUNCTION_MASK (32 bits)			
Workpiece measurement			
0	Calibration monitoring (default = 1)	51616 $MNS_MEA_CAL_MONITORING	_CBIT[16]
1	Length reference of the probe in the infeed axis (default = 1) 0 = Reference point is the center of the probe sphere 1 = Reference point is the circumference of the probe sphere	51614 $MNS_MEA_PROBE_LENGTH_RE-LATE	_CBIT[14]
2	Taking into account tool carriers that can be orientated for offset in a tool (default = 0)	51610 $MNS_MEA_TOOLCARR_ENABLE	_CBIT[7]
3	Offset angle for mono-workpiece probe (default = 1)	51612 $MNS_MEA_MONO_COR_POS_AC-TIVE	_CBIT[8]
Tool measurement			
16	Taking into account tool carriers that can be orientated for offset in a tool (default = 0)	MD 51610 $MNS_MEA_TOOLCARR_ENA-BLE	_CBIT[7]
Channel-specific cycle machine data: MD52740 $MCS_MEA_FUNCTION_MASK (32 bits)			
Workpiece measurement			
0	Measuring input, workpiece probe (default = 0) 0 = CNC measuring input 1 1 = CNC measuring input 2	51606 $MNS_MEA_IN-PUT_PIECE_PROBE[0]	_CHBIT[0]
1	Rotating measuring cycles use Y axis as measuring axis (default = 0)	52605 $MCS_MEA_TURN_CYC_SPE-CIAL_MODE	_CHBIT[19]
Tool measurement			
16	Measuring input, tool probe (default = 1) 0 = CNC measuring input 1 1 = CNC measuring input 2	51607 $MNS_MEA_INPUT_TOOL_PROBE[0]	_CHBIT[1]
General cycle setting data: SD 54740 $SNS_MEA_FUNCTION_MASK (32 bits)			
Workpiece measurement			

Bit 1)	Function	MD identifier SW 2.6	GUD name up to SW 2.6
0	Repeat measurement in the event of violation of _TDIF and _TSA (default = 0)	54655 $SNS_MEA_REPEATE_ACTIVE	_CBIT[0]
1	Repeat measurement with alarm output and cycle stop at M0 (default = 0)	54656 $SNS_MEA_REPEATE_WITH_M0	_CBIT[1]
2	Violation of _TUL, _TLL, _TDI, cycle stop at M0 (default = 0)	54657 $SNS_MEA_TOL_ALARM_SET_M0	_CBIT[2]
3	Accept calibrated probe sphere radius in tool data (default = 1)	54660 $SNS_MEA_PROBE_BALL_RAD_IN_TOA	_CBIT[15]
Tool measurement			
16	Repeat measurement in the event of violation of _TDIF and _TSA (default = 0)	54655 $SNS_MEA_REPEATE_ACTIVE	_CBIT[0]
17	Repeat measurement with alarm output and cycle stop at M0 (default = 0)	54656 $SNS_MEA_REPEATE_WITH_M0	_CBIT[1]
18	Violation of _TDIF, cycle stop at M0 (default = 0)	54657 $SNS_MEA_TOL_ALARM_SET_M0	_CBIT[2]
19	Milling cutter, spindle speed reduction at the last contact		_CHBIT[22]
Channel-specific setting data: SD 55740 $SCS_MEA_FUNCTION_MASK (32 bits)			
Workpiece measurement			
0	Collision monitoring (default = 1)	55600 $SCS_MEA_COLLISION_MONITORING	_CHBIT[2]
1	Coupling of the spindle position, with a coordinate rotation around the infeed axis in AUTOMATIC (default = 0)	55602 $SCS_MEA_COUPL_SPIND_COORD	_CHBIT[13]
2	Direction of rotation of the spindle positioning, with active coupling of the spindle and coordinate rotation (default = 0) 0 = In the GUZ 1 = In the UZ	55604 $SCS_MEA_SPIND_MOVE_DIR	_CHBIT[14]
3	Measurement attempts when the probe does not switch (default = 0) 0 = 5 attempts 1 = 1 attempt	55606 $SCS_MEA_NUM_OF_MEASURE	_CHBIT[15]
4	Approach velocity to the measuring position (default = 0) 0 = With measuring feedrate _VMS 1 = With $SCS_MEA_FEED_FAST_MEASURE	55610 $SCS_MEA_FEED_TYP	_CHBIT[17]
5	Retraction velocity from the measuring point (default = 0) 0 = With $SCS_MEA_FEED_PLANE_VALUE 1 = With $SCS_MEA_FEED_RAPID_IN_PERCENT	55608 $SCS_MEA_RETRACTION_FEED	_CHBIT[16]

Bit [1)]	Function	MD identifier SW 2.6	GUD name up to SW 2.6
6	Activate/deactivate workpiece probe before and after the NC command SPOS. See also CUST_MEA_CYC.SPF (default = 0) 0 = No call CUST_MEA_CYC.SPF 1 = Call CUST_MEA_CYC.SPF	-	-
...			
14	Coupling of the spindle position, with a coordinate rotation around the infeed axis when a measuring in AUTOMATIC (default = 1)	55770 $SCS_J_MEA_SET_COUPL_SP_COORD	E_MESS_SETT[0]
15	Calibration in the calibration ring when measuring in JOG (default = 0) 0 = Calibrate with automatic reference center point 1 = Calibrate with known reference center point	55771 $SCS_J_MEA_SET_CAL_MODE	E_MESS_SETT[1]
Tool measurement			
16	Collision monitoring (default = 1)	55600 $SCS_MEA_COLLISION_MONITORING	_CHBIT[2]
17	Measurement attempts when the probe does not switch (default = 0) 0 = 5 attempts 1 = 1 attempt	55606 $SCS_MEA_NUM_OF_MEASURE	_CHBIT[15]
18	Approach velocity to the measuring position (default = 0) 0 = With measuring feedrate _VMS 1 = With $SCS_MEA_FEED_FAST_MEASURE	55610 $SCS_MEA_FEED_TYP	_CHBIT[17]
19	Retraction velocity from the measuring point (default = 0) 0 = With $SCS_MEA_FEED_PLANE_VALUE 1 = With $SCS_MEA_FEED_RAPID_IN_PERCENT	55608 $SCS_MEA_RETRACTION_FEED	_CHBIT[16]

[1)] Bit x=0 means that the function is disabled
Bit x=1 means that the function is enabled
All non-documented bits are not assigned.

A.2 Changes in the machine and setting data from SW 4.4

MD replaced with SD

The following cycle machine data (measuring in JOG) no longer apply from cycle release SW 04.04.01 (compared to SW 02.06.00) and are replaced by the following cycle setting data **that mean the same** .

MDs are no longer required	Replaced by SD
51609 $MNS_MEA_INPUT_TOOL_PROBE_SUB[0 .. 5]	54652 $SNS_MEA_INPUT_TOOL_PROBE_SUB[0 .. 5]
51755 $MNS_J_MEA_MEASURING_FEED	55630 $SCS_MEA_FEED_MEASURE
51774 $MNS_J_MEA_T_PROBE_TYPE[n]	54633 $SNS_MEA_TP_TYPE[n]
51776 $MNS_J_MEA_T_PROBE_ALLOW_AX_DIR[n]	54632 $SNS_MEA_TP_AX_DIR_AUTO_CAL[n]
51778 $MNS_J_MEA_T_PROBE_DIAM_LENGTH[n]	54631 $SNS_MEA_TP_EDGE_DISK_SIZE[n]
51782 $MNS_J_MEA_T_PROBE_T_EDGE_DIST[n]	54634 $SNS_MEA_TP_CAL_MEASURE_DEPTH[n]
51787 $MNS_J_MEA_T_PROBE_MEASURE_FEED	55628 $SCS_MEA_TP_FEED_MEASURE

Change, number of the setting data

For the following cycle setting data, from SW 04.04.01, the number of the setting data changes (with respect to cycle release SW 02.06.00). Identifier and function have not changed.

Number SD		Identifier
Release SW 02.06.00	From SW 04.04.01	
54798	54780	$SNS_J_MEA_FUNCTION_MASK_PIECE
54799	54782	$SNS_J_MEA_FUNCTION_MASK_TOOL
55630	55632	$SCS_MEA_FEED_RAPID_IN_PERCENT
55631	55634	$SCS_MEA_FEED_PLANE_VALUE
55632	55636	$SCS_MEA_FEED_FEEDAX_VALUE
55633	55638	$SCS_MEA_FEED_FAST_MEASURE

A.3 Complete overview of the changed cycle machine and cycle setting data

Table A-1 Complete overview of the changed cycle machine data - from cycle SW 04.04.05.00

SW 02.06.01.03 HF3 CYCLE SW 02.06.56.00	CYCLE SW 04.04.05.00
	N51071 $MNS_ACCESS_ACTIVATE_CTRL_E
	N51072 $MNS_ACCESS_EDIT_CTRL_E
	N51073 $MNS_ACCESS_SET_SOFTKEY_ACCESS
	N51199 $MNS_ACCESS_WRITE_TM_GRIND
N51606 $MNS_MEA_INPUT_PIECE_PROBE[0]	N52740 $MCS_MEA_FUNCTION_MASK Bit 0
N51606 $MNS_MEA_INPUT_PIECE_PROBE[1]	Not applicable
N51607 $MNS_MEA_INPUT_TOOL_PROBE[0]	N52740 $MCS_MEA_FUNCTION_MASK Bit 16
N51607 $MNS_MEA_INPUT_TOOL_PROBE[1]	Not applicable
N51609 $MNS_MEA_INPUT_TOOL_PROBE_SUB[0 .. 5]	Not applicable
N51610 $MNS_MEA_TOOLCARR_ENABLE	Not applicable
N51612 $MNS_MEA_MONO_COR_POS_ACTIVE	Not applicable, function always active
N51614 $MNS_MEA_PROBE_LENGTH_RELATE	N51740 $MCS_MEA_FUNCTION_MASK Bit 1
N51616 $MNS_MEA_CAL_MONITORING	N51740 $MCS_MEA_FUNCTION_MASK Bit 0
N51755 $MNS_J_MEA_MEASURING_FEED	Not applicable
N51774 $MNS_J_MEA_T_PROBE_TYPE[0 .. 5]	N54633 $SNS_MEA_TP_TYPE[n]
N51776 $MNS_J_MEA_T_PROBE_ALLOW_AX_DIR[0 .. 5]	N54632 $SNS_MEA_TP_AX_DIR_AUTO_CAL[n]
N51778 $MNS_J_MEA_T_PROBE_DIAM_LENGTH[0 .. 5]	N54631 $SNS_MEA_TP_EDGE_DISK_SIZE[n]
N51782 $MNS_J_MEA_T_PROBE_T_EDGE_DIST[0 .. 5]	N54634 $SNS_MEA_TP_CAL_MEASURE_DEPTH[n]
N51787 $MNS_J_MEA_T_PROBE_MEASURE_FEED	N54636 $SNS_MEA_TP_FEED[n]
N52605 $MCS_MEA_TURN_CYC_SPECIAL_MODE	N52740 $MCS_MEA_FUNCTION_MASK Bit 1
	N52248 $MCS_REV_2_BORDER_TOOL_LENGTH
	N52290 $MCS_SIM_DISPLAY_CONFIG
	N52740 $MCS_MEA_FUNCTION_MASK
	N52751 $MCS_J_MEA_MAGN_GLAS_POS[0]
	N52751 $MCS_J_MEA_MAGN_GLAS_POS[1]

Table A-2 Complete overview of the changed cycle setting data - from cycle SW 04.04.05.00

SW 02.06.01.03 HF3 CYCLE SW 02.06.56.00	CYCLE SW 04.04.05.00
	N54611 $SNS_MEA_WP_FEED[0 .. 11]
	N54636 $SNS_MEA_TP_FEED[0 .. 5]
	N54651 $SNS_MEA_TPW_FEED[0 .. 5]
	N54652 $SNS_MEA_INPUT_TOOL_PROBE_SUB[0 .. 5]
	N54740 $SNS_MEA_FUNCTION_MASK
	N54760 $SNS_MEA_FUNCTION_MASK_PIECE

SW 02.06.01.03 HF3 CYCLE SW 02.06.56.00	CYCLE SW 04.04.05.00
	N54762 $SNS_MEA_FUNCTION_MASK_TOOL
	N54764 $SNS_MEA_FUNCTION_MASK_TURN
N54798 $SNS_J_MEA_FUNCTION_MASK_PIECE	**N54780** $SNS_J_MEA_FUNCTION_MASK_PIECE
N54799 $SNS_J_MEA_FUNCTION_MASK_TOOL	**N54782** $SNS_J_MEA_FUNCTION_MASK_TOOL
N54655 $SNS_MEA_REPEAT_ACTIVE	N54740 $SNS_MEA_FUNCTION_MASK Bit 0
N54656 $SNS_MEA_REPEAT_WITH_M0	N54740 $SNS_MEA_FUNCTION_MASK Bit 1
N54657 $SNS_MEA_TOL_ALARM_SET_M0	N54740 $SNS_MEA_FUNCTION_MASK Bit 2
N54659 $SNS_MEA_TOOL_MEASURE_RELATE	Not applicable
N54660 $SNS_MEA_PROBE_BALL_RAD_IN_TOA	N54740 $SNS_MEA_FUNCTION_MASK Bit 3
N55600 $SCS_MEA_COLLISION_MONITORING	N55740 $SCS_MEA_FUNCTION_MASK Bit 0
N55602 $SCS_MEA_COUPL_SPIND_COORD	N55740 $SCS_MEA_FUNCTION_MASK Bit 1
N55604 $SCS_MEA_SPIND_MOVE_DIR	N55740 $SCS_MEA_FUNCTION_MASK Bit 2
N55606 $SCS_MEA_NUM_OF_MEASURE	N55740 $SCS_MEA_FUNCTION_MASK Bit 17
N55608 $SCS_MEA_RETRACTION_FEED	N55740 $SCS_MEA_FUNCTION_MASK Bit 5
N55610 $SCS_MEA_FEED_TYP	N55740 $SCS_MEA_FUNCTION_MASK Bit 4
	N55628 $SCS_MEA_TP_FEED_MEASURE
	N55630 $SCS_MEA_FEED_MEASURE
N55630 $SCS_MEA_FEED_RAPID_IN_PERCENT	**N55632** $SCS_MEA_FEED_RAPID_IN_PERCENT
N55631 $SCS_MEA_FEED_PLANE_VALUE	**N55634** $SCS_MEA_FEED_PLANE_VALUE
N55632 $SCS_MEA_FEED_FEEDAX_VALUE	**N55636** $SCS_MEA_FEED_FEEDAX_VALUE
N55633 $SCS_MEA_FEED_FAST_MEASURE	**N55638** $SCS_MEA_FEED_FAST_MEASURE
	N55642 $SCS_MEA_EDGE_SAVE_ANG
N55761 $SCS_J_MEA_SET_NUM_OF_ATTEMPTS	N55740 $SCS_MEA_FUNCTION_MASK Bit 17
N55762 $SCS_J_MEA_SET_RETRAC_MODE	N55740 $SCS_MEA_FUNCTION_MASK Bit 5
N55763 $SCS_J_MEA_SET_FEED_MODE	N55740 $SCS_MEA_FUNCTION_MASK Bit 4
N55770 $SCS_J_MEA_SET_COUPL_SP_COORD	Not applicable, function always active
N55771 $SCS_J_MEA_SET_CAL_MODE	N55740 $SCS_MEA_FUNCTION_MASK Bit 15
N55772 $SCS_J_MEA_SET_PROBE_MONO	Not applicable, function corresponds to tool type

A.4 Comparing GUD parameters (regarding measuring functions)

You can make specific basic settings per cycle machine, setting data (MD, SD).

The following prefixes are defined:

- §SNS_... Generally applicable setting data
- §SCS_... Channel-specific setting data
- §MNS_... Generally applicable machine data
- $MCS_... Channel-specific machine data

The GUD parameters listed in the following table represent the contents of the GUD blocks GUD5, GUD6 and GUD7_MC up to version V7.5 where equivalent MD/SD is available as from version V2.7 / V4.4.

The GUD are backwards compatible with existing measuring programs regarding their use.

The GUD5, GUD6 and GUD7_MC modules are replaced by the PGUD (SGUD in the parameter display).

GUD up to Version 7.5	From MD/SD version V2.7/V4.4
_WP[x,0]	SD54600 $SNS_MEA_WP_BALL_DIAM[0...11]
_WP[x,1]	SD54601 $SNS_MEA_WP_TRIG_MINUS_DIR_AX1[0...11]
_WP[x,2]	SD54602 $SNS_MEA_WP_TRIG_PLUS_DIR_AX1[0...11]
_WP[x,3]	SD54603 $SNS_MEA_WP_TRIG_MINUS_DIR_AX2[0...11]
_WP[x,4]	SD54604 $SNS_MEA_WP_TRIG_PLUS_DIR_AX2[0...11]
_WP[x,5]	SD54605 $SNS_MEA_WP_TRIG_MINUS_DIR_AX3[0...11]
_WP[x,6]	SD54606 $SNS_MEA_WP_TRIG_PLUS_DIR_AX3[0...11]
_WP[x,7]	SD54607 $SNS_MEA_WP_POS_DEV_AX1[0...11]
_WP[x,8]	SD54608 $SNS_MEA_WP_POS_DEV_AX2[0...11]
_WP[x,9]	SD54609 $SNS_MEA_WP_STATUS_RT[0...11]
_WP[x,10]	SD54610 $SNS_MEA_WP_STATUS_GEN[0...11]
_KB[x,0]	SD54621 $SNS_MEA_CAL_EDGE_PLUS_DIR_AX2[0...2]
_KB[x,1]	SD54622 $SNS_MEA_CAL_EDGE_MINUS_DIR_AX2[0...2]
_KB[x,2]	SD54615 $SNS_MEA_CAL_EDGE_BASE_AX1[0...2]
_KB[x,3]	SD54617 $SNS_MEA_CAL_EDGE_PLUS_DIR_AX1[0...2]
_KB[x,4]	SD54618 $SNS_MEA_CAL_EDGE_MINUS_DIR_AX1[0...2]
_KB[x,5]	SD54620 $SNS_MEA_CAL_EDGE_UPPER_AX2[0...2]
_KB[x,6]	SD54619 $SNS_MEA_CAL_EDGE_BASE_AX2[0...2]
_TP[x,0]	SD54625 $SNS_MEA_TP_TRIG_MINUS_DIR_AX1[0...5]
_TP[x,1]	SD54626 $SNS_MEA_TP_TRIG_PLUS_DIR_AX1[0...5]
_TP[x,2]	SD54627 $SNS_MEA_TP_TRIG_MINUS_DIR_AX2[0...5]
_TP[x,3]	SD54628 $SNS_MEA_TP_TRIG_PLUS_DIR_AX2[0...5]
_TP[x,4]	SD54629 $SNS_MEA_TP_TRIG_MINUS_DIR_AX3[0...5]
_TP[x,5]	SD54630 $SNS_MEA_TP_TRIG_PLUS_DIR_AX3[0...5]

GUD up to Version 7.5	From MD/SD version V2.7/V4.4
_TP[x,6] and E_MESS_MT_DL[3]	SD54631 $SNS_MEA_TP_EDGE_DISK_SIZE[0...5]
_TP[x,7] and E_MESS_MT_AX[3]	SD54632 $SNS_MEA_TP_AX_DIR_AUTO_CAL[0...5]
_TP[x,8] and E_MESS_MT_TYP[3]	SD54633 $SNS_MEA_TP_TYPE[0...5]
_TP[x,9] and E_MESS_MT_DZ[3]	SD54634 $SNS_MEA_TP_CAL_MEASURE_DEPTH[0...5]
_TPW[x,1]	SD54641 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX1[0...5]
_TPW[x,2]	SD54642 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX2[0...5]
_TPW[x,3]	SD54643 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX2[0...5]
_TPW[x,4]	SD54644 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX3[0...5]
_TPW[x,5]	SD54645 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX3[0...5]
_TPW[x,6]	SD54646 $SNS_MEA_TPW_EDGE_DISK_SIZE[0...5]
_TPW[x,7]	SD54647 $SNS_MEA_TPW_AX_DIR_AUTO_CAL[0...5]
_TPW[x,8]	SD54648 $SNS_MEA_TPW_TYPE[0...5]
_TWP[x,9]	SD54649 $SNS_MEA_TPW_CAL_MEASURE_DEPTH[0...5]
_CM[0]	SD54670 $SNS_MEA_CM_MAX_PERI_SPEED[0] 1)
_CM[1]	SD54671 $SNS_MEA_CM_MAX_REVOLUTIONS[0] 1)
_CM[4]	SD54672 $SNS_MEA_CM_MAX_FEEDRATE[0] 1)
_CM[2]	SD54673 $SNS_MEA_CM_MIN_FEEDRATE[0] 1)
_CM[5]	SD54674 $SNS_MEA_CM_SPIND_ROT_DIR[0] 1)
_CM[6]	SD54675 $SNS_MEA_CM_FEEDFACTOR_1[0] 1)
_CM[7]	SD54676 $SNS_MEA_CM_FEEDFACTOR_2[0] 1)
_CM[3]	SD54677 $SNS_MEA_CM_MEASURING_ACCURACY[0] 1)
_CM[8]	MD51618 $MNS_MEA_CM_ROT_AX_POS_TOL
_CBIT[0]	SD54740 $SNS_MEA_FUNCTION_MASK, bit 0 (measure workpiece) SD54740 $SNS_MEA_FUNCTION_MASK, bit 16 (measure tool)
_CBIT[1]	SD54740 $SNS_MEA_FUNCTION_MASK bit 1 (measure workpiece) SD54740 $SNS_MEA_FUNCTION_MASK, bit 17 (measure tool)
_CBIT[2]	SD54740 $SNS_MEA_FUNCTION_MASK bit 2 (measure workpiece) SD54740 $SNS_MEA_FUNCTION_MASK bit 18 (measure tool)
_CBIT[7]	MD51740 $MNS_MEA_FUNCTION_MASK bit 2 (measure workpiece) MD51740 $MNS_MEA_FUNCTION_MASK, bit 16 (measure tool)
_CBIT[8]	MD51740 $MNS_MEA_FUNCTION_MASK, bit 3
_CBIT[14]	MD51740 $MNS_MEA_FUNCTION_MASK bit 1
_CBIT[15]	SD54740 $SNS_MEA_FUNCTION_MASK, bit 3
_CBIT[16]	MD51740 $MNS_MEA_FUNCTION_MASK bit 0
_CHBIT[0]	MD52740 $MCS_MEA_FUNCTION_MASK bit 0
_CHBIT[1]	MD52740 $MCS_MEA_FUNCTION_MASK bit 16

GUD up to Version 7.5	From MD/SD version V2.7/V4.4
_CHBIT[2]	SD55740 $SCS_MEA_FUNCTION_MASK bit 0 (measure workplace) SD55740 $SCS_MEA_FUNCTION_MASK bit 16 (measure tool)
_CHBIT[10]	SD55613 $SCS_MEA_RESULT_DISPLAY
_CHBIT[13]	SD55740 $SCS_MEA_FUNCTION_MASK bit 1
_CHBIT[14]	SD55740 $SCS_MEA_FUNCTION_MASK bit 2
_CHBIT[15]	SD55740 $SCS_MEA_FUNCTION_MASK bit 3 (measure workplace) SD55740 $SCS_MEA_FUNCTION_MASK bit 17 (measure tool)
_CHBIT[16]	SD55740 $SCS_MEA_FUNCTION_MASK bit 5 (measure workplace) SD55740 $SCS_MEA_FUNCTION_MASK bit 19 (measure tool)
_CHBIT[17]	SD55740 $SCS_MEA_FUNCTION_MASK bit 4 (measure workplace) SD55740 $SCS_MEA_FUNCTION_MASK bit 18 (measure tool)
_CHBIT[19]	MD52740 $MCS_MEA_FUNCTION_MASK bit 1
_CHBIT[22]	SD54740 $SNS_MEA_FUNCTION_MASK, bit 19
_EVMVNUM[0]	SD55622 $SCS_MEA_EMPIRIC_VALUE
_EVMVNUM[1]	SD55624 $SCS_MEA_AVERAGE_VALUE
_EV[20]	SD55623 $SCS_MEA_EMPIRIC_VALUE[0...19]
_MV[20]	SD55625 $SCS_MEA_AVERAGE_VALUE[0...19]
_SPEED[0]	SD55632 $SCS_MEA_FEED_RAPID_IN_PERCENT
_SPEED[1]	SD55634 $SCS_MEA_FEED_PLANE_VALUE
_SPEED[2]	SD55636 $SCS_MEA_FEED_FEEDAX_VALUE
_SPEED[3]	SD55638 $SCS_MEA_FEED_FAST_MEASURE
_TP_CF	SD54690 $SNS_MEA_T_PROBE_MANUFACTURER
_MT_COMP	SD54691 $SNS_MEA_T_PROBE_OFFSET
_MT_EC_R[1.5]	SD54695 $SNS_MEA_RESULT_OFFSET_TAB_RAD1[0...4]
_MT_EC_R[2.5]	SD54696 $SNS_MEA_RESULT_OFFSET_TAB_RAD2[0...4]
_MT_EC_R[3.5]	SD54697 $SNS_MEA_RESULT_OFFSET_TAB_RAD3[0...4]
_MT_EC_R[4.5]	SD54698 $SNS_MEA_RESULT_OFFSET_TAB_RAD4[0...4]
_MT_EC_R[5.5]	SD54699 $SNS_MEA_RESULT_OFFSET_TAB_RAD5[0...4]
_MT_EC_R[6.5]	SD54700 $SNS_MEA_RESULT_OFFSET_TAB_RAD6[0...4]
_MT_EC_L[1.5]	SD54705 $SNS_MEA_RESULT_OFFSET_TAB_LEN1[0...4]
_MT_EC_L[2.5]	SD54706 $SNS_MEA_RESULT_OFFSET_TAB_LEN2[0...4]
_MT_EC_L[3.5]	SD54707 $SNS_MEA_RESULT_OFFSET_TAB_LEN3[0...4]
_MT_EC_L[4.5]	SD54708 $SNS_MEA_RESULT_OFFSET_TAB_LEN4[0...4]
_MT_EC_L[5.5]	SD54709 $SNS_MEA_RESULT_OFFSET_TAB_LEN5[0...4]
_MT_EC_L[6.5]	SD54710 $SNS_MEA_RESULT_OFFSET_TAB_LEN6[0...4]
E_MESS_D	MD51750 $MNS_J_MEA_M_DIST
E_MESS_D_M	MD51751 $MNS_J_MEA_M_DIST_MANUELL
E_MESS_D_L	MD51752 $MNS_J_MEA_M_DIST_TOOL_LENGTH

GUD up to Version 7.5	From MD/SD version V2.7/V4.4
E_MESS_D_R	MD51753 $MNS_J_MEA_M_DIST_TOOL_RADIUS
E_MESS_FM	SD55630 $SCS_MEA_FEED_MEASURE
E_MESS_F	MD51757 $MNS_J_MEA_COLL_MONIT_FEED
E_MESS_FZ	MD51758 $MNS_J_MEA_COLL_MONIT_POS_FEED
E_MESS_CAL_D[2]	MD51770 $MNS_J_MEA_CAL_RING_DIAM[0...11]
E_MESS_CAL_L[0]	MD51772 $MNS_J_MEA_CAL_HEIGHT_FEEDAX[0...11]
E_MESS_MT_DR[3]	MD51780 $MNS_J_MEA_T_PROBE_DIAM_RAD[0...5]
E_MESS_MT_DIR[3]	MD51784 $MNS_J_MEA_T_PROBE_APPR_AX_DIR[0...5]
E_MESS_SETT[0]	SD55740 $SCS_MEA_FUNCTION_MASK bit 14
E_MESS_SETT[1]	SD55740 $SCS_MEA_FUNCTION_MASK bit 15
1) For parameters SD54670 to 54677, there are two data sets, indices 0 and 1. Note: Data set with index 1 should always be used for GIV 2.7/4.4. Data set with index 0 should always be used from GIV 4.5 and higher.	

GUD up to cycle SW 04.04.00	From cycle SW 04.04.05.00
_RF	N55640 $SCS_MEA_FEED_CIRCLE

A.5 Changes to names of cycle programs and GUD modules

The following measuring programs have been renamed or deleted from measuring cycle version 2.6:

Cycle Name of GUD up to Version 7.5	Cycle Name as of Version 2.6
CYC_JMC	Cycle131
CYC_JMA	Cycle132
Cycle198	CUST_MEACYC
Cycle199	CUST_MEACYC
Cycle100	Program is no longer available.
Cycle101	Program is no longer available.
Cycle105	Program is no longer available.
Cycle106	Program is no longer available.
Cycle107	Program is no longer available.
Cycle108	Program is no longer available.
Cycle113	Program is no longer available.
Cycle118	Program is no longer available.
Cycle972	Program is no longer available.
E_SP_NPV	Program is no longer available.
CYC_JM	Program is no longer available.
GUD5	Module no longer available.
GUD6	Module no longer available.
GUD7	Module no longer available.
GUD7_MC	Module no longer available.

Appendix B

B.1 Abbreviations

Abbreviation	Meaning
CNC	Computerized Numerical Control Computerized numerical control
DIN	Deutsche Industrie Norm (German Industry Standard)
I/O	Input/Output
GUD	Global User Data Global user data
JOG	JOGging: Setup mode
MD	Machine data
MCS	Machine coordinate system
NC	Numerical Control: Numerical Control
NCK	Numerical Control Kernel: NC kernel with block preparation, traversing range, etc.
NCU	Numerical Control Unit: NCK hardware unit
WO	Work offset
PLC	Programmable Logic Control Controller
SL	Cutting edge position
Software	Software
WCS	Workpiece coordinate system

B.2 Documentation overview

Glossary

Actual/set difference

Difference between measured and expected value.

Asynchronous subroutine

Part program that can be started asynchronously to (independently of) the current program status using an interrupt signal (e.g. "Rapid NC input" signal).

Calibration

When calibrating, the trigger points of the probe are identified and saved in the cycle setting data from SD 54600.

Calibration tool

Is a special tool (usually a cylindrical stylus), whose dimensions are known and that is used for precisely determining the distances between the machine zero and the probe trigger point (of the workpiece probe).

Collision monitoring

In the context of measuring cycles, this is a function that monitors all intermediate positions generated within the measuring cycle for the switching signal of the probe. When the probe switches, motion is stopped immediately and an alarm message is output.

Delete distance-to-go

If a measuring point is to be approached, a traverse command is transmitted to the position control loop and the probe is moved towards the measuring point. A point behind the expected measuring point is defined as setpoint position. As soon as the probe makes contact, the actual axis value at the time the switching position is reached is measured and the drive is stopped. The remaining "distance-to-go" is deleted.

Differential measurement

Differential measurement means that the 1st measuring point is measured twice, once with a 180 degree spindle reversal (rotation of the probe), i.e. opposite the cycle start position and once with the spindle position that was available at the start of the cycle. This procedure allows uncalibrated probes to be used without imposing less stringent precision requirements!

Dimension difference check

Is a tolerance parameter, and when a limit (`S_DIF`) is reached the tool is probably worn and must be replaced. The dimension difference check has no effect on generation of the compensation value.

Empirical value

The empirical values are used to suppress constant dimensional deviations that are not subject to a trend.

Flying measurement

This method processes the probe signal directly in the NC.

Kinematic chain

The kinematic chain is the description of the kinematic structure of a machine. It consists of an arbitrary number of interconnected elements. Parallel subchains can branch off from a kinematic chain. Only one active kinematic chain is available in the control. The active kinematic chain starts with the root element. A kinematic chain is defined in the spatially-fixed coordinates of the world coordinate system.

Lower tolerance limit

When measuring a dimensional deviation as the lower tolerance limit (`S_TLL`) ranging between "2/3 tolerance of workpiece" and "Dimensional difference control", this is regarded 100 % as tool offset. The previous average value is deleted.

Mean value

The mean value calculation takes account of the trend of the dimensional deviations of a machining series. The → weighting factor k – used as basis for forming the mean value – is selectable.

Mean value calculation alone is not enough to ensure constant machining quality. The measured dimensional deviation can be corrected for constant deviations without a trend by using an
→ empirical value.

Measure tool

To measure the tool, the new tool is moved up to the probe which is either permanently fixed or swiveled into the working range. The automatically derived tool geometry is entered in the relevant tool offset data set.

Measure workpiece

For workpiece measurement, a probe is moved up to the clamped workpiece in the same way as a tool. The flexibility of measuring cycles makes it possible to perform nearly all measurements required on a milling or turning machine.

Measurement path

Measurement path DFA defines the distance between the starting position and the expected switching position (setpoint) of the probe.

Measuring accuracy

The measurement accuracy that can be obtained is dependent on the following factors:

- Repeat accuracy of the machine
- Repeat accuracy of the probe
- Resolution of the measuring system

The repeat accuracy of the controls for "on-the-fly measurement" is ±1 μm.

Measuring at an angle

A measuring variant used to measure a hole, spigot (shaft), groove, or a web at any angle. The measurement path is traveled at a certain set angle defined in the WCS.

Measuring blanks

The blank measurement determines the position, deviation, and work offset of the workpiece in the result of a → workpiece measurement.

Measuring in JOG

It contains the following functions:

- Semi-automatic calculation of tool geometry and storage in the tool offset memory
- Semi-automatic calculation and setting of reference points and storage in work offset memory

The function is operated with softkeys and input displays.

Measuring variant

The measuring variant of each measuring cycle is defined in parameter `S_MVAR`. The parameter can have certain integer values for each measuring cycle, which are checked for validity within the cycle.

Mono probe

A mono(directional) probe is a probe that can only deflect in one direction. It can only be used for workpiece measurement on milling machines and machining centers with slight limitations.

Multi probe

A multi(directional) probe is one that can deflect in three dimensions.

Multiple measurement at the same location

Parameter `S_NMSP` can be used to determine the number of measurements at the same point. The actual/set difference is determined arithmetically.

Offset angle position

When using a → mono probe, for machine-specific reasons it may be necessary to correct the position of the probe using the tool data in mono probe type 712.

Offset axis

With some measuring variants, for example, measuring an angle in CYCLE998, positioning in another axis that must be defined, (also called offset axis) can be performed between measurements in the measuring axis. This must be defined in parameter `S_MA` with offset axis/ measuring axis.

Paraxial measurement

A measuring variant used for paraxial measurement of a workpiece, such as a hole, spigot (shaft), rectangle, etc. The measuring path is traversed paraxially in the WCS.

Part chain

The part chain is a part chain of the kinematic chain and runs parallel to the tool chain. The part chain begins in the root element and ends at the workpiece clamping.

Positional deviation

The positional deviation (skew) describes the difference between the spindle center and the probe tip center ascertained by calibration. It is compensated for by the measuring cycles.

Probe ball diameter

The active diameter of the probe ball. It is ascertained during calibration and stored in the measuring cycle data.

Probe type

To measure tool and workpiece dimensions, an electronic touch-trigger probe is required that provides a signal change (edge) when deflected.

Probes are distinguished according to the number of measuring directions.

- Multi-directional (3D, multi probe)
- Mono-directional (mono probe)

Reference groove

A groove located in the working area (permanent feature of the machine) whose precise position is known and that can be used to calibrate workpiece probes.

Safe area

The safe area `S_TSA` does not affect the offset value; it is used for diagnostics. If this limit is reached, there is a defect in the probe or the set position is incorrect.

Setpoint

In the "on-the-fly measurement" procedure, a position is specified as the setpoint value for the cycle at which the signal of the touch-trigger probe is expected.

Tool carrier

The tool carrier is used for machines on which the orientation between the tool and the workpiece can be changed. The tool carrier is a static transformation, i.e. the orientation that is set once during operation is permanent and cannot be changed during the procedure. Among other things, changes in the tool length components occur due to the change of orientation. The tool carrier imports the necessary calculations for the change of orientation and offset.

Tool chain

The tool chain is a part chain of the kinematic chain and runs parallel to the part chain. The tool chain begins in the root element and ends at the tool holder.

Tool name

Name of the tool in the tool list.

Trigger point

When calibrating, the trigger points of the probe are determined and saved in the channel-specific setting data from SD 54600 and higher for the corresponding axis direction.

Upper tolerance limit

When measuring a dimensional deviation as the upper tolerance limit (S_TU) ranging between "2/3 tolerance of workpiece" and "Dimensional difference control", this is regarded 100% as tool offset. The previous average value is deleted.

Weighting factor for averaging

The weighting factor k can be applied to allow different weighting to be given to an individual measurement. A new measurement result thus has only a limited effect on the new tool offset as a function of k.

Work offset (WO)

In the result of a measurement, the actual-setpoint value difference is stored in the data set of any settable work offset.

Work offset range

This tolerance range (lower limit S_TZL) corresponds to the absolute value of maximum random dimensional deviations. If the absolute value of the actual/set difference is less than the work offset range, the offset is not applied.

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