HEIDENHAIN

TNC 620

User's Manual
ISO Programming

NC Software
817600-08
817601-08
817605-08

English (en)
01/2021

Controls and displays

Keys

If you are using a TNC 620 with touch control, you can replace some keystrokes with gestures.

Further information: "Operating the touchscreen", Page 459

Keys on the screen

Key	Function
	Select screen layout
	Toggle the display between machine operating mode, programming mode, and a third desktop
	Soft keys for selecting functions on screen
◁ ▷ △	Switch the soft-key rows

Machine operating modes

Key	Function
	Manual operation
	Electronic handwheel
	Positioning with Manual Data Input
	Program Run, Single Block
	Program Run, Full Sequence

Programming modes

Key	Function
	Programming
	Test Run

Entering and editing coordinate axes and numbers

Key	Function
X . . . V	Select the coordinate axes or enter them in the NC program
0 . . . 9	Numbers
. −/+	Decimal separator / Reverse algebraic sign
P I	Polar coordinate entry / Incremental values
Q	Q parameter programming / Q parameter status
	Capture actual position
NO ENT	Skip dialog questions, delete words
ENT	Confirm entry and resume dialog
END	Conclude the NC block, end your input
CE	Clear entries or error message
DEL	Abort dialog, delete program section

Tool functions

Key	Function
TOOL DEF	Define tool data in the NC program
TOOL CALL	Call tool data

Managing NC programs and files, control functions

Key	Function
PGM MGT	Select or delete NC programs or files, external data transfer
PGM CALL	Define program call, select datum and point tables
MOD	Select MOD functions
HELP	Display help text for NC error messages, call TNCguide
ERR	Display all current error messages
CALC	Show calculator
SPEC FCT	Show special functions
	Currently not assigned

Navigation keys

Key	Function
	Position the cursor
GOTO	Go directly to NC blocks, cycles, and parameter functions
HOME	Navigate to the beginning of a program or table
END	Navigate to the end of the program or table row
PG UP	Navigate up one page
PG DN	Navigate down one page
	Select the next tab in forms
	Up/down one dialog box or button

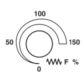
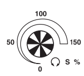
Cycles, subprograms and program section repeats

Key	Function
TOUCH PROBE	Define touch probe cycles
CYCL DEF, CYCL CALL	Define and call cycles
LBL SET, LBL CALL	Enter and call subprograms and program section repeats
STOP	Enter program stop in an NC program

Programming path contours

Key	Function
APPR DEP	Contour approach and departure
FK	FK free contour programming
L	Straight line
CC	Circle center/pole for polar coordinates
C	Circular arc with center
CR	Circular arc with radius
CT	Circular arc with tangential transition
CHF, RND	Chamfer/rounding arc

Potentiometer for feed rate and spindle speed

Feed rate	Spindle speed
	

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Basic information

1.1 About this manual

Safety precautions

Comply with all safety precautions indicated in this document and in your machine tool builder's documentation!

Precautionary statements warn of hazards in handling software and devices and provide information on their prevention. They are classified by hazard severity and divided into the following groups:

DANGER

Danger indicates hazards for persons. If you do not follow the avoidance instructions, the hazard **will result in death or severe injury.**

WARNING

Warning indicates hazards for persons. If you do not follow the avoidance instructions, the hazard **could result in death or serious injury**.

CAUTION

Caution indicates hazards for persons. If you do not follow the avoidance instructions, the hazard **could result in minor or moderate injury.**

NOTICE

Notice indicates danger to material or data. If you do not follow the avoidance instructions, the hazard **could result in property damage**.

Sequence of information in precautionary statements

All precautionary statements comprise the following four sections:

- Signal word indicating the hazard severity
- Type and source of hazard
- Consequences of ignoring the hazard, e.g.: "There is danger of collision during subsequent machining operations"
- Escape – Hazard prevention measures

Informational notes

Observe the informational notes provided in these instructions to ensure reliable and efficient operation of the software.
In these instructions, you will find the following informational notes:

ℹ	The information symbol indicates a **tip**. A tip provides additional or supplementary information.

⚙	This symbol prompts you to follow the safety precautions of your machine tool builder. This symbol also indicates machine-dependent functions. Possible hazards for the operator and the machine are described in the machine manual.

📖	The book symbol represents a **cross reference** to external documentation, e.g. the documentation of your machine tool builder or other supplier.

Have you found any errors or would you like to suggest changes?

We continuously strive to improve our documentation for you. Please help us by sending your suggestions to the following e-mail address:

tnc-userdoc@heidenhain.de

1.2 Control model, software and features

This manual describes programming functions provided by controls as of the following NC software numbers.

Control model	NC software number
TNC 620	817600-08
TNC 620 E	817601-08
TNC 620 Programming Station	817605-08

The suffix E indicates the export version of the control. The following software option is unavailable or only available to a limited extent in the export version:

- Advanced Function Set 2 (option 9) limited to four-axis interpolation

The machine manufacturer adapts the usable features of the control to his machine by setting appropriate machine parameters. Some of the functions described in this manual may therefore not be among the features provided by the control on your machine tool.

Control functions that may not be available on your machine include:

- Tool measurement with the TT

In order to find out about the actual features of your machine, please contact the machine manufacturer.

Many machine manufacturers, as well as HEIDENHAIN, offer programming courses for the HEIDENHAIN controls. Participation in one of these courses is recommended to familiarize yourself thoroughly with the control's functions.

User's Manual for Programming of Machining Cycles:

All functions provided by the machining cycles are described in the User's Manual for **Programming of Machining Cycles**. Please contact HEIDENHAIN if you need this User's Manual.
ID: 1303427-xx

User's Manual for Programming of Measuring Cycles for Workpieces and Tools:

All functions provided by the touch-probe cycles are described in the User's Manual for **Programming of Measuring Cycles for Workpieces and Tools**. Please contact HEIDENHAIN if you need this User's Manual.
ID: 1303431-xx

User's Manual for Setup, Testing and Running NC Programs:

All information for setting up the machine as well as for testing and running your NC programs is provided in the User's Manual for **Setup, Testing and Running NC Programs**. Please contact HEIDENHAIN if you need this User's Manual.
ID: 1263172-xx

Software options

The TNC 620 features various software options, each of which can be enabled separately by your machine tool builder. The respective options provide the functions listed below:

Additional Axis (option 0 and option 1)	
Additional axis	Additional control loops 1 and 2

Advanced Function Set 1 (option 8)	
Advanced functions (set 1)	**Machining with rotary tables** ■ Cylindrical contours as if in two axes ■ Feed rate in distance per minute **Coordinate conversions:** Tilting the working plane

Advanced Function Set 2 (option 9)	
Advanced functions (set 2) Export license required	**3-D machining:** ■ 3-D tool compensation through surface-normal vectors ■ Using the electronic handwheel to change the angle of the swivel head during program run; the position of the tool point remains unchanged (TCPM = **T**ool **C**enter **P**oint **M**anagement) ■ Keeping the tool normal to the contour ■ Tool radius compensation normal to the tool direction ■ Manual traverse in the active tool-axis system **Interpolation:** Linear in > 4 axes (export license required)

Touch Probe Functions (option 17)	
Touch probe functions	**Touch probe cycles:** ■ Compensation of tool misalignment in automatic mode ■ Set the preset in the **Manual operation** mode of operation ■ Presetting in automatic mode ■ Automatically measuring workpieces ■ Tools can be measured automatically

HEIDENHAIN DNC (option 18)	
	Communication with external PC applications over COM component

Advanced Programming Features (option 19)	
Expanded programming functions	**FK free contour programming:** Programming in HEIDENHAIN conversational format with graphic support for workpiece drawings not dimensioned for NC

Advanced Programming Features (option 19)	
	Fixed cycles: ■ Peck drilling, reaming, boring, counterboring, centering ■ Milling internal and external threads ■ Milling of rectangular and circular pockets and studs ■ Clearing level and oblique surfaces ■ Milling of straight and circular slots ■ Circular and linear point patterns ■ Contour train, contour pocket, trochoidal contour slot ■ Engraving ■ OEM cycles (special cycles developed by the machine tool builder) can be integrated

Advanced Graphic Features (option 20)	
Expanded graphic functions	**Program-verification graphics, program-run graphics** ■ Plan view ■ Projection in three planes ■ 3-D view

Advanced Function Set 3 (option 21)	
Expanded functions Group 3	**Tool compensation:** M120: Radius-compensated contour look ahead for up to 99 NC blocks (LOOK AHEAD) **3-D machining:** M118: Superimpose handwheel positioning during program run

Pallet Management (option 22)	
Pallet management	Processing workpieces in any sequence

CAD Import (option 42)	
CAD import	■ Support for DXF, STEP and IGES ■ Adoption of contours and point patterns ■ Simple and convenient specification of presets ■ Selecting graphical features of contour sections from conversational programs

KinematicsOpt (option 48)	
Optimizing the machine kinematics	■ Backup/restore active kinematics ■ Test active kinematics ■ Optimize active kinematics

OPC UA NC Server (1 to 6) (options 56 to 61)	
Standardized interface	The OPC UA NC Server provides a standardized interface (OPC UA) for external access to the control's data and functions These software options allow you to create up to six parallel client connections

Extended Tool Management (option 93)	
Extended tool management	Python-based
Remote Desktop Manager (option 133)	
Remote operation of external computer units	■ Windows on a separate computer unit ■ Incorporated in the control's interface
State Reporting Interface – SRI (option 137)	
HTTP accesses to the control status	■ Reading out the times of status changes ■ Reading out the active NC programs
Cross Talk Compensation – CTC (option 141)	
Compensation of axis couplings	■ Determination of dynamically caused position deviation through axis acceleration ■ Compensation of the TCP (**T**ool **C**enter **P**oint)
Position Adaptive Control – PAC (option 142)	
Adaptive position control	■ Adaptation of the control parameters depending on the position of the axes in the working space ■ Adaptation of the control parameters depending on the speed or acceleration of an axis
Load Adaptive Control – LAC (option 143)	
Adaptive load control	■ Automatic determination of workpiece weight and frictional forces ■ Adaptation of the control parameters depending on the current mass of the workpiece
Active Chatter Control – ACC (option 145)	
Active chatter control	Fully automatic function for chatter control during machining
Machine Vibration Control – MVC (option 146)	
Vibration damping for machines	Damping of machine oscillations for improving the workpiece surface quality through the following functions: ■ Active Vibration Damping (**AVD**) ■ Frequency Shaping Control (**FSC**)
Batch Process Manager (option 154)	
Batch process manager	Planning of production orders
Component Monitoring (option 155)	
Component monitoring without external sensors	Monitoring configured machine components for overload
Opt. contour milling (option 167)	
Optimized contour cycles	Cycles for machining any pockets and islands using trochoidal milling

Further options available

HEIDENHAIN offers further hardware enhancements and software options that can be configured and implemented only by your machine tool builder.This includes functional safety (FS), for example.

For more information, please refer to your machine tool builder's documentation or the HEIDENHAIN brochure titled **Options and Accessories**.

ID: 827222-xx

Feature Content Level (upgrade functions)

Along with software options, significant further improvements of the control software are managed via the **F**eature **C**ontent **L**evel upgrade functions. If you install a software update on your control you do not automatically have the functions available as covered by the FCL.

All upgrade functions are available to you without surcharge when you receive a new machine.

Upgrade functions are identified in the manual as **FCL n**. The **n** signifies the serial number of the development status.

You can purchase a code number in order to permanently enable the FCL functions. For more information, contact your machine tool builder or HEIDENHAIN.

Intended place of operation

The control complies with the limits for a Class A device in accordance with the specifications in EN 55022, and is intended for use primarily in industrially-zoned areas.

Legal information

The control software contains open-source software that is subject to special terms of use. These special terms of use have priority.

Further information is available on the control as follows:

- Press the **MOD** key
- Select the **General information** group in the MOD menu
- Select the **License information** MOD function

Furthermore, the control software contains binary libraries of the OPC UA software from Softing Industrial Automation GmbH. For these libraries, additionally and preferentially the terms of use agreed between HEIDENHAIN and Softing Industrial Automation GmbH shall apply.

When using the OPC UA NC server or DNC server, you can influence the behavior of the control. Therefore, before using these interfaces for productive purposes, verify that the control can still be operated without malfunctions or drops in performance. The manufacturer of the software that uses these communication interfaces is responsible for performing system tests.

New functions 81760x-08

> **Overview of new and modified software functions**
> Further information about the previous software versions is presented in the **Overview of New and Modified Software Functions** documentation. Please contact HEIDENHAIN if you need this documentation.
> ID: 1322094-xx

- The **BLK FORM FILE** function allows you to use STL files to define the workpiece blank, and optionally the finished part, by specifying the path of the files. This enables you to use, e.g., 3-D models from the CAD system in your NC program

  Further information: "Defining the workpiece blank: G30/G31", Page 88
- **FUNCTION MODE SET** allows you to activate settings defined by the machine tool builder (e.g., changes to the range of traverse) from within the NC program

  Further information: "Function Mode Set", Page 327
- The function **PRESET SELECT** allows you to activate a preset from the preset table. You can choose to retain active transformations and select the preset to which the function should apply.

  Further information: "Activating a preset", Page 336
- The function **PRESET COPY** allows you to copy a preset defined in the preset table to another row. You can optionally activate the copied preset and retain the active transformations.

  Further information: "Copying a preset", Page 337
- The function **PRESET CORR** allows you to correct the active preset.

  Further information: "Correcting a preset", Page 337
- The function **POLARKIN** allows you to activate a polar kinematic model. In a polar kinematic model, the control performs movements using a rotary axis and two linear axes. You define the positioning behavior of the rotary axis, as well as whether machining is allowed at the center of rotation of the rotary axis.

  Further information: "Machining with polar kinematics", Page 328
- The function **TABDATA** allows you to access the tool table and the compensation tables (*.tco and *.wco) during program run. In order to access the compensation tables, you need to activate them.
  - The function **TABDATA READ** allows you to read a value from a table and save it to a Q, QL, QR, or QS parameter.

    Further information: "Reading a table value", Page 342
  - The function **TABDATA WRITE** allows you to write a value from a Q, QL, QR, or QS parameter into a table.

    Further information: "Writing a table value", Page 343
  - The function **TABDATA ADD** allows you to add a value from a Q, QL, or QR parameter to a value contained in a table.

    Further information: "Adding a table value", Page 344
- The function **MONITORING** allows you to visualize the monitoring of a defined machine component.

Further information: "Monitoring of configured machine components (option 155)", Page 346

- The **APPLY FILE NAME** soft key has been added to the selection window provided by the **SELECT FILE** soft key. If the called file is located in the same directory as the file you are calling it from, pressing this soft key loads the name of the file without its path.

  Further information: "Calling an external NC program", Page 243
- In the mask file of the **FN 16: F-PRINT** (ISO: **D16**) function, you can define whether the control shows or hides blank lines for undefined QS parameters.

  Further information: "Creating a text file", Page 283
- The **FN 18: SYSREAD** functions (ISO:D18) have been enhanced:
  - **FN 18: SYSREAD (D18) ID50**: values in the tool table
    - **NR45**: value in the **RCUTS** column
    - **NR46**: value in the **LU** column
    - **NR47**: value in the**RN** column
  - **FN 18: SYSREAD (D18) ID950**: values in the tool table of the current tool
    - **NR45**: value in the **RCUTS** column
    - **NR46**: value in the **LU** column
    - **NR47**: value in the**RN** column
  - **FN 18: SYSREAD (D18) ID1070 NR1**: active feed-rate limit through the **F MAX** soft key

  Further information: "System data", Page 474
- The function **SYSSTR(ID10321 NR20)** allows you to determine the number of the current week in accordance with ISO 8601

  Further information: "Reading system data", Page 301
- When you double-click a layer in the **CAD-Viewer**, the control marks the first contour element of this layer.

  Further information: "Setting layers", Page 427
- You can transfer the data from the CAD Import clipboard to an NC program as well as to other applications (e.g., **Leafpad**).

  Further information: "Application", Page 423

Further information: User's Manual for **Setup, Testing and Running NC Programs**

- HEIDENHAIN OPC UA NC Server (options 56 to 61)

  OPC UA provides a standardized interface for secure data exchange between products independent of the manufacturer. HEIDENHAIN provides the **HEIDENHAIN OPC UA NC Server** for data exchange with the control. These software options allow you to create up to six parallel client connections.

  The **Connection Assistant** function has been added to the HEROS menu for setting up the connection. If user administration is active, you link the connections to specific users.
- As part of the **HEIDENHAIN OPC UA NC Server** (options 56 to 61), the machine parameter **CfgMachineInfo** (no. 131700), which allows you to define information about the machine, has been added.

- If you use **TARGET** in the **BLK FORM FILE** function to define a finished part, you can show or hide it by soft key in the **Test Run** operating mode (option 20)
- In **Test Run** operating mode, you can use the **EXPORT WORKPIECE** soft key to export the current status of the motion simulation as a 3-D model in STL format.
- In **Test Run** operating mode, the control provides an extended collision monitoring function that checks for collisions between the workpiece and the tool or tool holder. You can activate extended collision monitoring by soft key.
- You can use M3D and STL files (e.g., from the CAD system) as tool carrier files.
- The control supports USB data media with the NTFS file system.
- The control includes the additional tool **Parole**, which allows you to open video files.
- If a feed-rate limit has been activated with the **F MAX** soft key, the control displays an exclamation mark after the feed-rate value in the general status display.
- When the **PARAXCOMP DISPLAY** function is active, the control displays a corresponding icon in the general status display.
- When the **PARAXCOMP MOVE** function is active, the control displays a corresponding icon in the general status display.
- When the functions **PARAXMODE** oder **POLARKIN** are active, the control displays a corresponding icon in the general status display.
- In the **RCUTS** column of the tool table, you define the front-face cutting width of a tool (e.g., for indexable inserts).
- You define the usable length of a tool in the **LU** column of the tool table. The usable length limits the plunging depth of the tool in cycles.
- You define the neck radius of the tool in the **RN** column of the tool table. This allows the control to display the tool neck correctly in the simulation (e.g., for side milling cutters).
- A link to the **Firewall settings** HEROS function has been added to the **External access** MOD function.
- A link to the **OPC UA NC Server - License Settings** HEROS function (options 56 to 61) has been added within the **External access** MOD function.
- If the machine tool builder has defined the parameter **CfgOemInfo** (no. 131700), then the control displays the **Info about machine manufacturer** area in the **General information** MOD group.
- If the machine operator has defined the **CfgMachineInfo** parameter (no. 131600), the control shows the **Machine information** area within the **General information** MOD group.
- **Remote Desktop Manager** (option 133) allows you to create private connections if user administration is active. Private connections are visible to and usable by the creator only.
- When user administration is active, the control automatically disables the LSV2 connections of the serial interfaces (COM1 and COM2) for security purposes.

- When user administration is active, you can create user-specific private network drive connections. **Single Sign On** allows you to connect to an encrypted network drive while logging on to the control.
- When configuring the user administration, you can use the **Autologin** function to define a user who will automatically be logged on by the control during booting.
- The machine parameter **CfgTTRectStylus** (no. 114300) has been added. This parameter allows you to define settings for a tool touch probe with a cuboid probe contact.

Changed functions 81760x-08

- You can use the **RND** element (ISO: **G24**) to connect circles that are perpendicular to the machining plane instead of lying in the machining plane.
- The **M109** function allows the control to keep the feed rate constant at the cutting edge, including during approach and departure.

  Further information: "Feed rate for circular arcs: M109/M110/ M111", Page 224
- The function **M120** (option 21) for look-ahead calculation of a radius-compensated contour is no longer reset by milling cycles (option 19)

  Further information: "Pre-calculating radius-compensated contours (LOOK AHEAD): M120 (option 21)", Page 226
- You can use UTF-8 character encoding in the mask file of **FN 16: F-PRINT** (ISO: **D16**)
- The priority of arithmetic operations has been changed in the Q parameter formula

  Further information: "Rules for formulas", Page 269
- Scrolling in the structure window works in the same way as scrolling in the NC program You can define the position of the active structure block by soft key.
- The control uses the active unit of measure (mm or inches) for calculations in the cutting data calculator.
- Path finding between individual drilling positions has been optimized in the **CAD-Viewer**
- If, after a hardware change or an update, an error occurs when the control is booting, the control will automatically open the error window and display a question-type error. The control displays soft keys providing different response options.

  Further information: "Detailed error messages", Page 204
- The **FILTER** soft key in the error window allows the control to classify both error messages and warnings. As a result, the list of pending messages becomes shorter and easier to read.

  Further information: "FILTER soft key", Page 205
- In pallet tables (option 22), the control can also open NC programs containing blank spaces.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

- Option 146 has been renamed as **Machine Vibration Control MVC**

  The Frequency Shaping Control (**FSC**) function has been added; it allows the control to suppress low-frequency machine vibrations.
- The control uses hatch marking to depict threads in the simulation.
- In the operating modes **Program run, single block** and **Program run, full sequence**, the **Batch Process Manager** (option 154) shows up to two statuses next to each other in the first column.
- In **Program run, single block** operating mode, the control interprets the workpiece blank definition as a single NC block only.

- The control displays the tool index in the block scan pop-up window if needed.
- The control takes into account manual axes when returning to the contour.
- When the **PARAXCOMP DISPLAY** function or the **PARAXCOMP MOVE** function is active, the control displays **(D)** or **(M)** after the respective axis designations on the **Overview** tab and the **POS** tab of the additional status display.
- On the **FS** tab of the additional status display, the control displays the active limits defined by the specific safety-related operating modes for every axis.
- On the **TT** tab of the additional status display, the control displays the tilt angle of the tool touch probe as well as information about the cuboid probe contacts.
- In **Test Run** operating mode, the control displays the **M** tab of the additional status display when the screen layout **PROGRAM + STATUS** is active.
- When you activate a handwheel with display, the control automatically activates the override potentiometer of the handwheel.
- In the operating modes **Manual Operation** and **Positioning w/ Manual Data Input**, you can activate a handwheel with display while a macro or a manual tool change is being executed.
- You can activate or deactivate the **F MAX** soft key for reducing the feed rate. The defined value is retained.
- By default, the control calculates the basic rotation in the input coordinate system (I-CS). If the axis angles and tilt angles don't coincide, the control calculates the basic rotation in the workpiece coordinate system (W-CS).
- In the compensation tables (*.tco and *.wco), the input range for all columns containing numerical values has been changed from +/– 999.999 to +/– 999.9999
- From within the **Diagnostic functions** MOD group, you can access **TNCdiag** and **Hardware configuration** without a code number.
- The name of a connection in the **Remote Desktop Manager** (option 133) must not contain characters other than letters, numbers, and underscores.
- The **HEIDENHAIN OPC UA NC Server** enables you to access the directories **TNC:** and **PLC:**, including while the NC software is switched off. The contents displayed vary depending on the assigned user's permissions.
- If, when configuring the user administration, you use the **Connection to Windows domain** function, the **Use LDAPs** check box allows you to set up a secure connection.
- If a remote log-in takes place while user administration is inactive, for example via SSH, the control automatically assigns the **HEROS.LegacyUserNoCtrlfct** role.
- When user administration is active, the NC.SetupProgramRun permission is required for the **ACC** (option 145) functions.
- If you deactivate the user administration and select the **Delete existing user databases** check box, the control also deletes the .home folder in the **TNC:** directory.

- If you enter a password or code number with Caps Lock active, then the control issues a message.
- The machine parameter **spindleDisplay** (no. 100807) has been enhanced. The control can also display the spindle position on the **Overview** tab of the additional status display when the spindle is in jog mode.

New cycle functions 81760x-08

Further information: User's Manual for **Programming of Machining Cycles**

- Cycle **277 OCM CHAMFERING** (ISO: **G277**, option 167)

  This cycle allows the control to deburr contours that were last defined, roughed, or finish-machined with other OCM cycles.
- Cycle **1271 OCM RECTANGLE** (ISO: **G1271**, option 167)

  This cycle allows you to define a rectangle that is then used as a pocket, island, or boundary for face milling in conjunction with other OCM cycles.
- Cycle **1272 OCM CIRCLE** (ISO: **G1272**, option 167)

  This cycle allows you to define a circle that is then used as a pocket, island, or boundary for face milling in conjunction with other OCM cycles.
- Cycle **1273 OCM SLOT / RIDGE** (ISO: **G1273**, option 167)

  This cycle allows you to define a slot that is then used as a pocket, island, or boundary for face milling in conjunction with other OCM cycles.
- Cycle **1278 OCM POLYGON** (ISO: **G1278**, option 167)

  This cycle allows you to define a polygon that is then used as a pocket, island, or boundary for face milling in conjunction with other OCM cycles.
- Cycle **1281 OCM RECTANGLE BOUNDARY** (ISO: **G1281**, option 167)

  This cycle allows you to define a rectangular boundary for islands or open pockets that you previously programmed with the standard OCM forms.
- Cycle **1282 OCM CIRCLE BOUNDARY** (ISO: **G1282**, option 167)

  This cycle allows you to define a circular boundary for islands or open pockets that you previously programmed with the standard OCM forms.
- The control offers an **OCM cutting data calculator** with which you can determine the optimum cutting data for the **272 OCM ROUGHING** cycle (ISO: **G272**, option 167). Press the **OCM CUTTING DATA** soft key to open the cutting data calculator during cycle definition. You can load the results directly into the cycle parameters.

Changed cycle functions 81760x-08

Further information: User's Manual for **Programming of Machining Cycles**

- Cycle **225 ENGRAVING** (ISO: **G225**) allows you to use system variables to engrave the number of the current week.
- Cycles **202 BORING** (ISO: **G202**) and **204 BACK BORING** (ISO: **G204**, option 19) restore the spindle status after machining to that which was active before the cycle.
- If the defined usable length in column **LU** of the tool table is less than the depth, the control displays an error message.

  The following cycles monitor the usable length **LU**:
  - All cycles for drilling and boring
  - All cycles for tapping
  - All cycles for the machining of pockets and studs
  - Cycle 22 **ROUGH-OUT** (ISO: **G122**, option 19)
  - Cycle 23 **FLOOR FINISHING** (ISO: **G123**, option 19)
  - Cycle 24 **SIDE FINISHING** (ISO: **G124**, option 19)
  - Cycle 233 **FACE MILLING** (ISO: **G233**, option 19)
  - Cycle 272 **OCM ROUGHING** (ISO: **G272**, option 167)
  - Cycle 273 **OCM FINISHING FLOOR** (ISO: **G273**, option 167)
  - Cycle 274 **OCM FINISHING SIDE** (ISO: **G274**, option 167)
- Cycles **251 RECTANGULAR POCKET** (ISO: **G251**), **252 CIRCULAR POCKET** (ISO: **G252**, option 19), and **272 OCM ROUGHING** (ISO: **G272**, option 167) take into consideration a cutting width defined in the column **RCUTS** when calculating the plunging path.
- Cycles **208 BORE MILLING** (ISO: **G208**), **253 SLOT MILLING** (ISO: **G208**), and **254 CIRCULAR SLOT** (ISO: **G254**, option 19) monitor a cutting width defined in the column **RCUTS** of the tool table. If the center of a tool that is not a center-cut tool would contact the workpiece surface, the control issues an error message.
- The machine manufacturer can hide Cycle **238 MEASURE MACHINE STATUS** (ISO: **G238**, option 155).
- An input value of 2 has been added to parameter **Q569 OPEN BOUNDARY** in Cycle **271 OCM CONTOUR DATA** (ISO: **G271**, option 167). The control uses this value to interpret the first contour within the **CONTOUR DEF** function as a boundary block of a pocket.

- Cycle **272 OCM ROUGHING** (ISO: **G272**, option 167) was expanded:
  - The parameter **Q576 SPINDLE SPEED** allows you to define a spindle speed for the roughing tool.
  - The parameter **Q579 PLUNGING FACTOR S** allows you to define a factor for the spindle speed during plunging.
  - Use the parameter **Q575 INFEED STRATEGY** to define whether the control machines the contour from top to bottom or vice versa.
  - The maximum input range of parameter **Q370 TOOL PATH OVERLAP** has been changed. Old: from 0.01 to 1. New: from 0.04 to 1.99.
  - If helical plunging is not possible, the control attempts a reciprocating plunging motion with the tool.
- Cycle **273 OCM FINISHING FLOOR** (ISO: **G273**, option 167) was expanded.

  The following parameters have been added:
  - **Q595 STRATEGY**: machining with equal path distances or constant tool angle
  - **Q577 APPROACH RADIUS FACTOR**: factor for the tool radius in order to adapt the approach radius

Further information: User's Manual for **Programming of Measuring Cycles for Workpieces and Tools**

- Cycles **480 CALIBRATE TT** (ISO: **G480**) and **484 CALIBRATE IR TT** (ISO: **G484**, option 17) can be used to calibrate a tool touch probe with cuboid probe contacts.
- For rotating tools, Cycle **483 MEASURE TOOL** (ISO: **G483**, option 17) first measures the tool length and then the tool radius.
- By default, Cycles **1410 PROBING ON EDGE** (ISO: **G1410**) and **1411 PROBING TWO CIRCLES** (ISO: **G1411**, option 17) calculate the basic rotation in the input coordinate system (I-CS). If the axis angles and tilt angles don't coincide, the cycles calculate the basic rotation in the workpiece coordinate system (W-CS).

2

First steps

2.1 Overview

This chapter is intended to help you quickly learn to handle the most important procedures on the control. For more information on the respective topic, see the section referred to in the text.

The following topics are covered in this chapter:

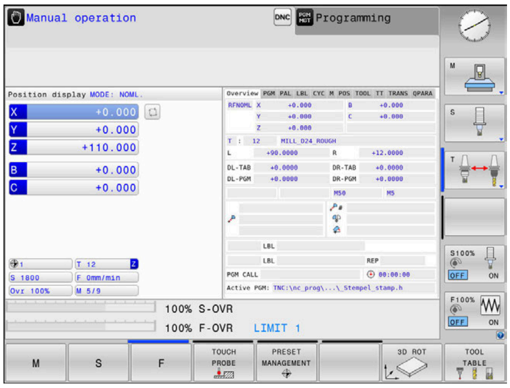
- Switching on the machine
- Programming the workpiece

The following topics are covered in the User's Manual for Setup, Testing and Running NC Programs:

- Switching on the machine
- Graphically testing the workpiece
- Setting up tools
- Setting up the workpiece
- Machining the workpiece

2.2 Switching on the machine

Acknowledging the power interruption



DANGER

Caution: hazard to the user!

Machines and machine components always pose mechanical hazards. Electric, magnetic, or electromagnetic fields are particularly hazardous for persons with cardiac pacemakers or implants. The hazard starts when the machine is powered up!

- Read and follow the machine manual
- Read and follow the safety precautions and safety symbols
- Use the safety devices

Refer to your machine manual!
Switching on the machine and traversing the reference points can vary depending on the machine tool.

To switch on the machine, proceed as follows:

- Switch on the power supply for the control and the machine
- > The control starts the operating system. This process may take several minutes.
- > The control will then display the "Power interrupted" message in the screen header.

CE

- Press the **CE** key
- > The control compiles the PLC program.

I

- Switch on the machine control voltage
- > The control is in the **Manual operation** mode.

Depending on your machine, you may need to carry out further steps in order to run NC programs.

Further information on this topic

- Switching on the machine
  Further information: User's Manual for **Setup, Testing and Running NC Programs**

2.3 Programming the first part

Selecting the operating mode

You can write NC programs only in the **Programming** operating mode:

- ▶ Press the operating mode key
- > The control switches to the **Programming** operating mode.

Further information on this topic

- Operating modes
  Further information: "Programming", Page 71

Important controls and displays

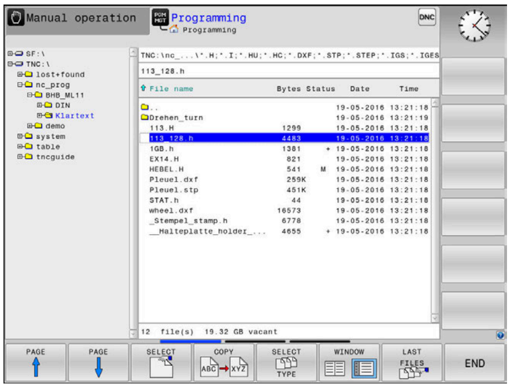
Key	Functions for conversational guidance
ENT	Confirm entry and activate the next dialog prompt
NO ENT	Ignore the dialog question
END	End the dialog immediately
DEL	Abort dialog, discard entries
	Soft keys on the screen with which you select functions appropriate to the active operating state

Further information on this topic

- Writing and editing NC programs
  Further information: "Editing an NC program", Page 95
- Overview of keys
  Further information: "Controls and displays", Page 2

Creating a new NC program / file management

To create a new NC program, proceed as follows:



PGM MGT

- ▶ Press the **PGM MGT** key
- > The control opens the file manager.

The file management of the control is arranged much like the file management on a PC with Windows Explorer. The file management enables you to manage data in the control's internal memory.

- ▶ Select a folder
- ▶ Enter the desired file name with the extension **.I**

ENT

- ▶ Press the **ENT** key
- > The control asks for the unit of measure of the new NC program.

MM

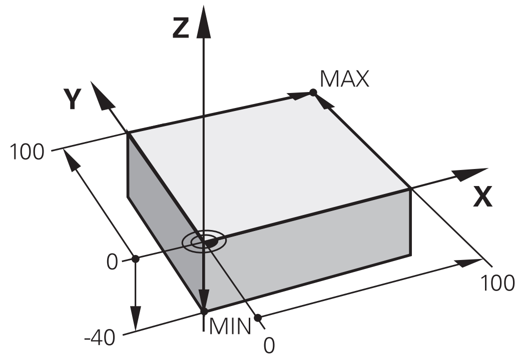
- ▶ Press the soft key of the desired unit of measure: **MM** or **INCH**

The control automatically generates the first and last NC blocks of the NC program. You will not be able to change these NC blocks at a later time.

Further information on this topic

- File management
  Further information: "File management", Page 101
- Creating a new NC program
  Further information: "Creating and entering NC programs", Page 87

Defining a workpiece blank



Once you have opened a new NC program, you can define a workpiece blank. You can define a cuboid by entering the MIN and MAX points relative to the selected preset.

After you have selected the desired shape for the blank with the appropriate soft key, the control automatically initiates the workpiece blank definition process and prompts you to enter the required data.

To define a cuboid-shaped blank, proceed as follows:

- Press the soft key for the desired shape of the workpiece blank
- **Spindle axis Z - Plane XY**: Enter the active spindle axis. G17 is saved as default setting. Accept with the **ENT** key
- **Workpiece blank def.: minimum X**: Enter the smallest X coordinate of the blank relative to the preset, e.g. 0, and confirm with the **ENT** key
- **Workpiece blank def.: minimum Y**: Enter the smallest Y coordinate of the blank relative to the preset, e.g. 0, and confirm with the **ENT** key
- **Workpiece blank def.: minimum Z**: Enter the smallest Z coordinate of the blank relative to the preset, e.g. -40, and confirm with the **ENT** key
- **Workpiece blank def.: maximum X**: Enter the largest X coordinate of the blank relative to the preset, e.g. 100, and confirm with the **ENT** key
- **Workpiece blank def.: maximum Y**: Enter the largest Y coordinate of the blank relative to the preset, e.g. 100, and confirm with the **ENT** key
- **Workpiece blank def.: maximum Z**: Enter the largest Z coordinate of the blank relative to the preset, e.g. 0, and confirm with the **ENT** key

> The control ends the dialog.

Example

```
%NEW G71 *
N10 G30  G17 X+0  Y+0 Z-40*
N20 G31  X+100 Y+100  Z+0*
N99999999 %NEW  G71 *
```

Further information on this topic

- Define workpiece blank
  Further information: "Creating a new NC program", Page 91

Program layout

NC programs should be arranged consistently in a similar manner. This makes it easier to find your place, accelerates programming and reduces errors.

Recommended program layout for simple, conventional contour machining

Example

```
%BSPCONT G71 *
N10 G30  G71 X...  Y... Z...*
N20 G31  X... Y...  Z...*
N30 T5  G17 S5000*
N40 G00  G40 G90  Z+250 M3*
N50 X...  Y...*
N60 G01  Z+10 F3000  M8*
N70 X...  Y... RL  F500*
...
N160 G40  ... X...  Y... F3000  M9*
N170 G00  Z+250 M2*
N99999999 BSPCONT  G71 *
```

1 Call tool, define tool axis
2 Retract the tool; turn on spindle
3 Pre-position the tool in the working plane near the contour starting point
4 Pre-position the tool along the tool axis above the workpiece, or pre-position the tool directly to the cutting depth, and turn on coolant as needed
5 Contour approach
6 Contour machining
7 Contour departure
8 Retract the tool, end the NC program

Further information on this topic

- Contour programming
  Further information: "Programming tool movements for machining", Page 136

Recommended program layout for simple cycle programs

Example

```
%BSBCYC G71 *
N10 G30  G71 X...  Y... Z...*
N20 G31  X... Y...  Z..*
N30 T5  G17 S5000*
N40 G00  G40 G90  Z+250 M3*
N50 G200...*
N60 X...  Y...*
N70 G79  M8*
N80 G00  Z+250 M2*
N99999999 BSBCYC  G71 *
```

1 Call tool, define tool axis
2 Retract the tool; turn on spindle
3 Define the fixed cycle
4 Move to the machining position
5 Call the cycle, and switch on the coolant
6 Retract the tool, end the NC program

Further information on this topic

- Cycle programming
  Further information: User's Manual for **Programming of Machining Cycles**

Programming a simple contour

Suppose you want to mill a single time around the contour shown on the right at a depth of 5 mm. You have already defined the workpiece blank.

After you have opened an NC block with a function key, the control will prompt you to enter all of the data in the header using dialog texts.

To program the contour, proceed as follows:

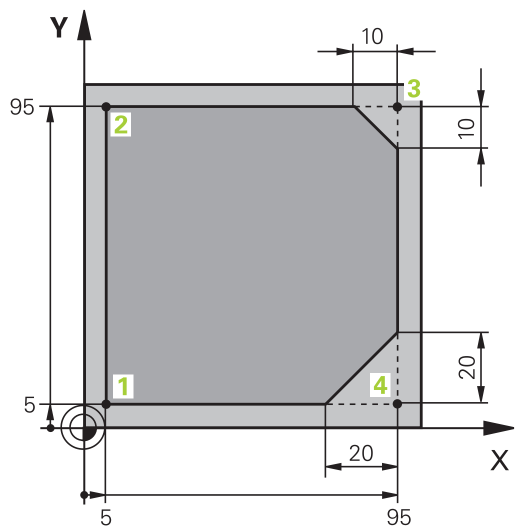
Call the tool

TOOL CALL
- Press the **TOOL CALL** key
- Enter the tool data, e.g., tool number 16

ENT
- Press the **ENT** key

ENT
- Confirm the tool axis **G17** with the **ENT** key
- Enter the spindle speed (e.g., 6500)

END
- Press the **END** key
- > The control completes the NC block.



Retract the tool

L

- Press the **L** key

←

- Press the left arrow key
- > The control opens the input range for G functions.

G00

- Press the **G00** soft key
- > The control executes the NC block in rapid traverse.

Alternative:

G

- Press the **G** key on the alphanumeric keyboard
- Enter **0**

ENT

- Press the **ENT** key
- > The control executes the NC block in rapid traverse.

G90

- Press the **G90** soft key
- > The control processes the entered dimensions as absolute dimensions.

Z

- Press the **Z** axis key
- Enter the retraction value (e.g., 250 mm)

ENT

- Press the **ENT** key

G40

- Press the **G40** soft key
- > The control does not activate radius compensation.
- If needed, enter a miscellaneous function **M**, such as **M3**, turn on spindle

END

- Press the **END** key
- > The control saves the positioning block.

Pre-position the tool in the working plane

G
- ▶ Press the **G** key on the alphanumeric keyboard
- ▶ Enter **0**

ENT
- ▶ Press the **ENT** key
- > The control executes the NC block in rapid traverse.

X
- ▶ Press the **X** axis key
- ▶ Enter the value for the position to be approached (e.g., –20 mm)

Y
- ▶ Press the **Y** axis key
- ▶ Enter the value for the position to be approached (e.g., –20 mm)

ENT
- ▶ Press the **ENT** key

G40
- ▶ Press the **G40** soft key
- > The control does not activate radius compensation.
- ▶ If needed, enter a miscellaneous function M

END
- ▶ Press the **END** key
- > The control saves the positioning block.

Position the tool to the cutting depth

G
- ▶ Press the **G** key on the alphanumeric keyboard
- ▶ Enter **0**

ENT
- ▶ Press the **ENT** key
- > The control executes the NC block in rapid traverse.

Z
- ▶ Press the **Z** axis key
- ▶ Enter the value for the position to be approached (e.g., -5 mm)

ENT
- ▶ Press the **ENT** key

G40
- ▶ Press the **G40** soft key
- > The control does not activate radius compensation.
- ▶ Enter a miscellaneous function **M**, such as **M8** to turn coolant on

END
- ▶ Press the **END** key
- > The control saves the positioning block.

Approach the contour smoothly

L

- ▶ Press the **L** key
- ▶ Enter the coordinates of the contour starting point **1**

ENT

- ▶ Press the **ENT** key

G41

- ▶ Press the **G41** soft key
- > The control activates radius compensation to the left.
- ▶ Enter the value for the machining feed rate (e.g., 700 mm/min)

END

- ▶ Press the **END** key

G

- ▶ Press the **G** key on the alphanumeric keyboard
- ▶ Enter **26**

ENT

- ▶ Press the **ENT** key
- > The control opens the **G26** command, smooth contour approach.
- ▶ Enter the rounding radius of the approach circle (e.g., 8 mm)

END

- ▶ Press the **END** key
- > The control saves the approach movement.

Machine the contour

- Press the L key
- Enter the changing coordinates of contour point **2** (e.g., **Y 95**)
- Press the **END** key
- > The control applies the changed value and retains all of the other information from the previous NC block.
- Press the **L** key
- Approach the changing coordinates of contour point **3** (e.g., **X 95**)
- Press the **END** key
- Press the **CHF** key
- Enter the chamfer width **G24** at contour point **3** (10 mm)
- Press the **END** key
- > The control saves the chamfer at the end of the linear block.
- Press the **L** key
- Enter the changing coordinates of contour point **4**
- Press the **END** key
- Press the **CHF** key
- Enter the chamfer width **G24** at contour point **4** (20 mm)
- Press the **END** key

Complete the contour with a smooth departure

- Press the **L** key
- Enter the changing coordinates of contour point **1**
- Press the **END** key
- Press the **G** key on the alphanumeric keyboard
- Enter **27**
- Press the **ENT** key
- > The control opens the **G27** command, smooth contour approach.
- Enter the rounding radius of the departure circle (e.g., 8 mm)
- Press the **END** key
- > The control saves the departure movement.
- Press the **L** key
- Specify coordinates outside of the workpiece in X and Y (e.g. **, X -20 Y -20**
- Press the **ENT** key
- Press the **G40** soft key
- > The control does not activate radius compensation.
- Enter the value for the positioning feed rate (e.g., 3000 mm/min)
- Press the **ENT** key
- If needed, enter a miscellaneous function **M**, such as M9, turn off coolant
- Press the **END** key
- > The control saves the entered positioning block.

Retract the tool

G

- Press the **G** key on the alphanumeric keyboard
- Enter **0**

ENT

- Press the **ENT** key
- > The control executes the NC block in rapid traverse.

Z

- Press the **Z** axis key
- Enter the retraction value (e.g., 250 mm)

ENT

- Press the **ENT** key

G40

- Press the **G40** soft key
- > The control does not activate radius compensation.
- Enter a miscellaneous function **M**, such as **M30** for program end

END

- Press the **END** key
- > The control saves the positioning block and ends the NC program.

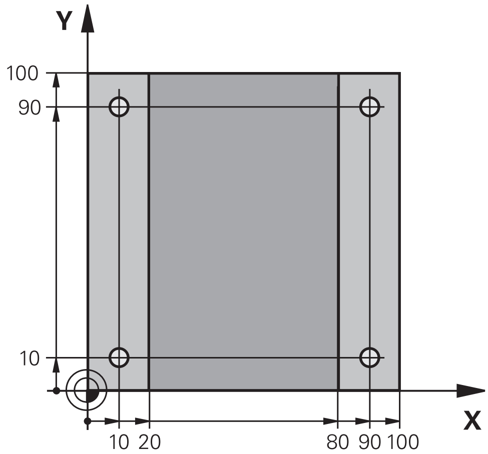
Further information on this topic

- Complete example with NC blocks
  Further information: "Example: Linear movements and chamfers with Cartesian coordinates", Page 159
- Creating a new NC program
  Further information: "Creating and entering NC programs", Page 87
- Approaching/departing contours
  Further information: "Approaching and departing a contour", Page 139
- Programming contours
  Further information: "Overview of path functions", Page 150
- Tool radius compensation
  Further information: "Tool radius compensation", Page 129
- Miscellaneous functions M
  Further information: "Miscellaneous functions for program run inspection, spindle and coolant ", Page 217

Creating a cycle program

Suppose that you are tasked with drilling the holes shown to the right with a standard drilling cycle (depth: 20 mm). You have already defined the workpiece blank.

Call the tool



TOOL CALL

- ▶ Press the **TOOL CALL** key
- ▶ Enter the tool data, e.g., tool number 5

ENT

- ▶ Press the **ENT** key

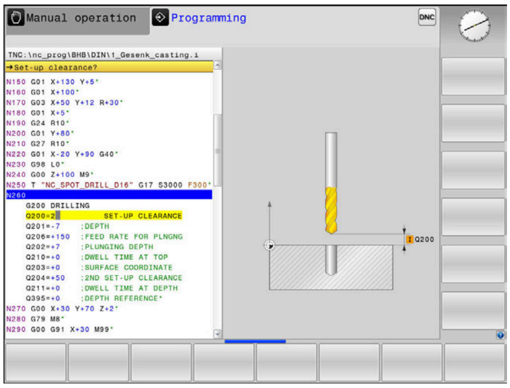
ENT

- ▶ Confirm the tool axis **G17** with the **ENT** key
- ▶ Enter the spindle speed (e.g., 4500)

END

- ▶ Press the **END** key
- > The control completes the NC block.

Retract the tool



L

- ▶ Press the **L** key

←

- ▶ Press the left arrow key
- > The control opens the input range for G functions.

G00

- ▶ Press the **G00** soft key
- > The control executes the NC block in rapid traverse.

Alternative:

G

- ▶ Press the **G** key on the alphanumeric keyboard
- ▶ Enter **0**

ENT

- ▶ Press the **ENT** key
- > The control executes the NC block in rapid traverse.

G90

- ▶ Press the **G90** soft key
- > The control processes the entered dimensions as absolute dimensions.

Z

- ▶ Press the **Z** axis key
- ▶ Enter the retraction value (e.g., 250 mm)

ENT

- ▶ Press the **ENT** key

G40

- ▶ Press the **G40** soft key
- > The control does not activate radius compensation.
- ▶ If needed, enter a miscellaneous function **M**, such as **M3**, turn on spindle

END

- ▶ Press the **END** key
- > The control saves the positioning block.

Define the cycle

- Press the **CYCL DEF** key
- Press the **DRILLING/ THREAD** soft key
- Press the **200** soft key
- > The control starts the dialog for cycle definition.
- Enter the cycle parameters
- Confirm each entry with the **ENT** key
- > The control displays a graphic illustrating the respective cycle parameter.

Call the cycle at the machining positions

- Press the **G** key on the alphanumeric keyboard
- Enter **0**
- > The control executes the NC block in rapid traverse.
- Press the **ENT** key
- Enter the coordinates of the first position
- Press the **ENT** key
- Press the **G40** soft key
- > The control does not activate radius compensation.
- Enter **M99**, cycle call
- Press the **END** key
- > The control saves the NC block.
- Press the **G** key
- Enter **0**
- Press the **ENT** key
- Enter the coordinates of the second position
- Press the **ENT** key
- Press the **G40** soft key
- > The control does not activate radius compensation.
- Enter **M99**, cycle call
- Press the **END** key
- > The control saves the NC block.
- Program all positions and call them with **M99**

Retract the tool

G
- Press the **G** key on the alphanumeric keyboard
- Enter **0**

ENT
- Press the **ENT** key
- > The control executes the NC block in rapid traverse.

Z
- Press the **Z** axis key
- Enter the retraction value (e.g., 250 mm)

ENT
- Press the **ENT** key

G40
- Press the **G40** soft key
- > The control does not activate radius compensation.
- Enter a miscellaneous function **M**, such as **M30** for program end

END
- Press the **END** key
- > The control saves the positioning block and ends the NC program.

Example

%C200 G71 *	
N10 G30 G17 X+0 Y+0 Z-40*	Workpiece blank definition
N20 G31 X+100 Y+100 Z+0*	
N30 T5 G17 S4500*	Tool call
N40 G00 G90 Z+250 G40 M3*	Retract the tool; turn on spindle
N50 G200 DRILLING	Define the cycle
Q200=2 ;SET-UP CLEARANCE	
Q201=-20 ;DEPTH	
Q206=250 ;FEED RATE FOR PLNGNG	
Q202=5 ;PLUNGING DEPTH	
Q210=0 ;DWELL TIME AT TOP	
Q203=-10 ;SURFACE COORDINATE	
Q204=20 ;2ND SET-UP CLEARANCE	
Q211=0.2 ;DWELL TIME AT DEPTH	
Q395=0 ;DEPTH REFERENCE	
N60 G00 X+10 Y+10 G40 M8 M99*	Turn on coolant; call cycle
N70 G00 X+10 Y+90 G40 M99*	Call the cycle
N80 G00 X+90 Y+10 G40 M99*	Call the cycle
N90 G00 X+90 Y+90 G40 M99*	Call the cycle
N100 G00 Z+250 M30*	Retract the tool, end program
N99999999 %C200 G71 *	

Further information on this topic

- Creating a new NC program
  Further information: "Creating and entering NC programs", Page 87
- Cycle programming
  Further information: User's Manual for **Programming of Machining Cycles**

3

Fundamentals

3.1 The TNC 620

HEIDENHAIN TNC controls are workshop-oriented contouring controls that enable you to program conventional milling and drilling operations right at the machine in easy-to-use Klartext conversational language. They are designed for milling, drilling, and boring machines, as well as for machining centers, with up to 6 axes. You can also change the angular position of the spindle under program control.

Keyboard and screen layout are clearly arranged in such a way that the functions are fast and easy to use.

HEIDENHAIN Klartext and DIN/ISO

HEIDENHAIN Klartext, the dialog-guided programming language for workshops, is an especially easy method of writing programs. Programming graphics illustrate the individual machining steps for programming the contour. If no NC-dimensioned drawing is available, then the FK free contour programming will help. Workpiece machining can be graphically simulated either during a test run or during a program run.

It is also possible to program in ISO format.

You can also enter and test one NC program while another NC program is machining a workpiece.

Compatibility

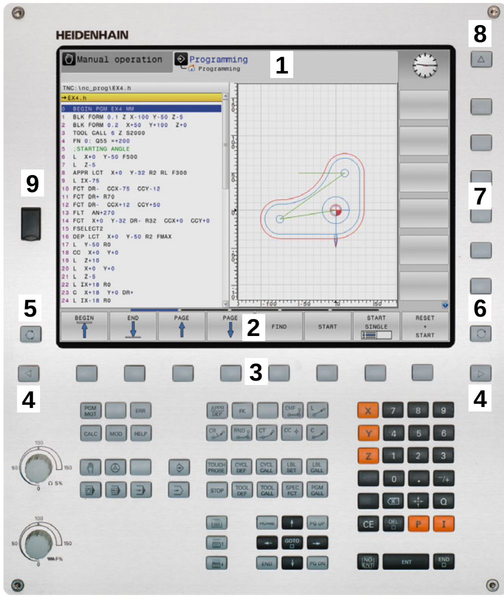
NC programs created on HEIDENHAIN contouring controls (starting from the TNC 150 B) may not always run on the TNC 620. If the NC blocks contain invalid elements, the control will mark these as ERROR blocks or with error messages when the file is opened.

> Please also note the detailed description of the differences between the iTNC 530 and the TNC 620.
> **Further information:** "Differences between the TNC 620 and the iTNC 530", Page 512

3.2 Visual display unit and operating panel

Display screen

The control is available either as a compact version or with a separate display unit and operating panel. Both variants of the control come with a 15-inch TFT color flat-panel display.



1 Header
When the control is on, the screen displays the selected operating modes in the header: The machine operating mode at left and the programming mode at right. The currently active mode is displayed in the larger field of the header, where the dialog prompts and messages also appear (exception: if the control only displays graphics).

2 Soft keys
In the footer the control indicates additional functions in a soft-key row. You can select these functions by pressing the keys immediately below them. The thin bars immediately above the soft-key row indicate the number of soft-key rows that can be called with the keys to the right and left that are used to switch the soft keys. The bar representing the active soft-key row is blue

3 Soft-key selection keys

4 Keys for switching the soft keys

5 Setting the screen layout

6 Key for switchover between machine operating modes, programming modes, and a third desktop

7 Soft-key selection keys for machine tool builders

8 Keys for switching the soft keys for machine tool builders

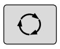
9 USB connection

> If you are using a TNC 620 with touch control, you can replace some keystrokes with gestures.
>
> **Further information:** "Operating the touchscreen", Page 459

Setting the screen layout

You select the screen layout yourself. In the **Programming** operating mode, for example, you can have the control show the NC program blocks in the left window while the right window displays programming graphics. You could also display the program structure in the right window instead, or display only the NC program blocks in one large window. The available screen windows depend on the selected operating mode.

Setting up the screen layout:



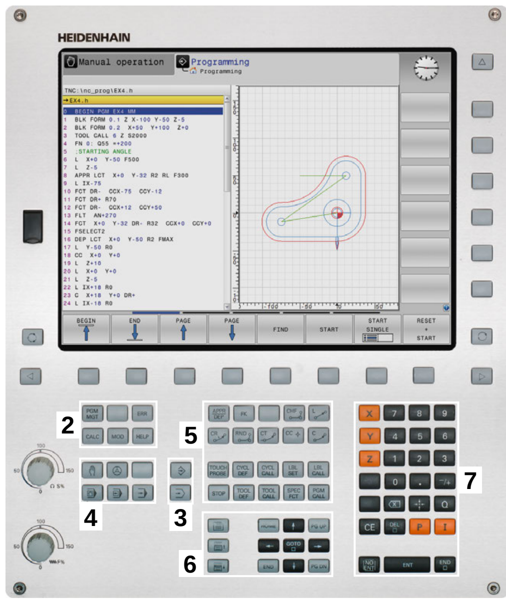
- Press the **screen layout** key: The soft-key row shows the available layout options
  Further information: "Modes of operation", Page 70

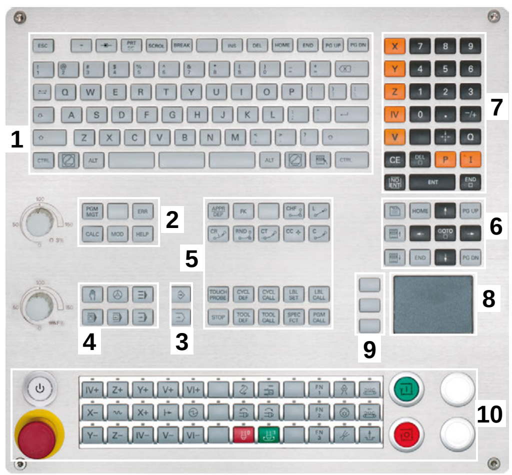
PROGRAM + GRAPHICS

- Select the desired screen layout with a soft key

Control panel

The TNC 620 can be supplied with an integrated operating panel. As an alternative, the TNC 620 is also available with a separate display unit and an external operating panel with alphabetic keyboard.





1 Alphabetic keyboard for entering texts and file names, as well as for ISO programming
2
   - File management
   - Calculator
   - MOD function
   - HELP function
   - Show error messages
   - Toggle between the operating modes
3 Programming modes
4 Machine operating modes
5 Initiating programming dialogs
6 Navigation keys and **GOTO** jump command
7 Numerical input and axis selection
8 Touchpad
9 Mouse buttons
10 Machine operating panel
   More information Machine manual

The functions of the individual keys are described on the inside front cover.

> If you are using a TNC 620 with touch control, you can replace some keystrokes with gestures.
>
> **Further information:** "Operating the touchscreen", Page 459

Refer to your machine manual!

Some machine tool builders do not use the standard HEIDENHAIN operating panel.

External keys, e.g.**NC START** or **NC STOP**, are described in your machine manual.

Cleaning

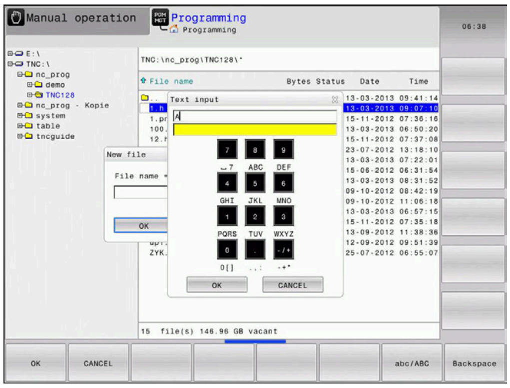
Refer to your machine manual!

Follow the cleaning instructions of the machine tool builder.

The keyboard unit and the integrated machine operating panel must be cleaned only with anionic or nonionic cleaning agents.

Screen keypad

If you are using the compact version of the control (without alphabetic keyboard), you can enter letters and special characters with the screen keypad or with an alphabetic keyboard connected to the USB port.



Entering text with the screen keypad

Proceed as follows to use the screen keypad:

GOTO

- ▶ Press the **GOTO** key if you want to enter letters, e.g. a program name or directory name, using the screen keypad.
- > The control opens a window in which the numeric keypad of the control is displayed with the corresponding letters assigned.

8

- ▶ Press the numerical key until the cursor is on the desired letter
- ▶ Wait until the control transfers the selected character before you enter the next character

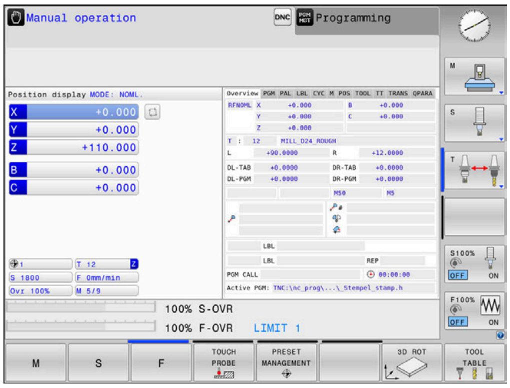
OK

- ▶ Use the **OK** soft key to load the text into the open dialog field

Use the **abc/ABC** soft key to select upper or lower case. If your machine tool builder has defined additional special characters, you can call them with the **SPECIAL CHARACTERS** soft key and insert them. Use the **BACKSPACE** soft key to delete individual characters.

3.3 Modes of operation

Manual Operation and El. Handwheel



In the **Manual operation** mode of operation, you can set up the machine. You can position the machine axes manually or incrementally, and you can set presets.

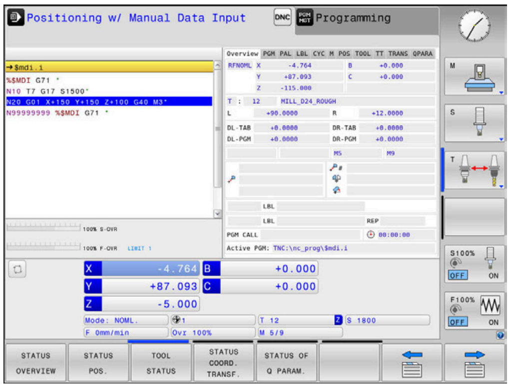
If option 8 is active, you can tilt the working plane.

The **Electronic handwheel** operating mode supports manual traverse of machine axes with the HR electronic handwheel.

Soft keys for selecting the screen layout

Soft key	Window
POSITION	Positions
POSITION + STATUS	Left: positions, right: status display
POSITION + WORKPIECE	Left: positions, right: workpiece (option 20)

Positioning with Manual Data Input



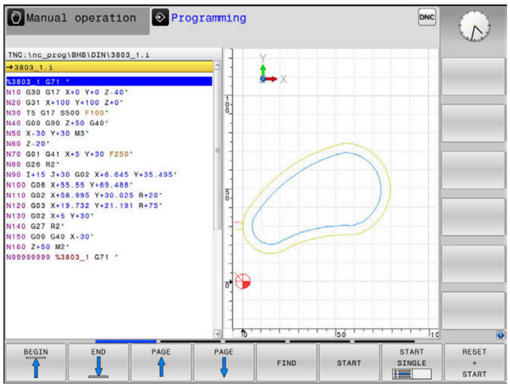
This mode of operation is used for programming simple traversing movements, such as for face milling or pre-positioning.

Soft keys for selecting the screen layout

Soft key	Window
PGM	NC program
PROGRAM + STATUS	Left: NC program, right: status display
PROGRAM + WORKPIECE	Left: NC program, right: workpiece (option 20)

Programming

In this mode of operation you create NC programs. The FK free programming feature, the various cycles and the Q parameter functions help you with programming and add necessary information. If desired, you can have the programming graphics show the programmed paths of traverse.

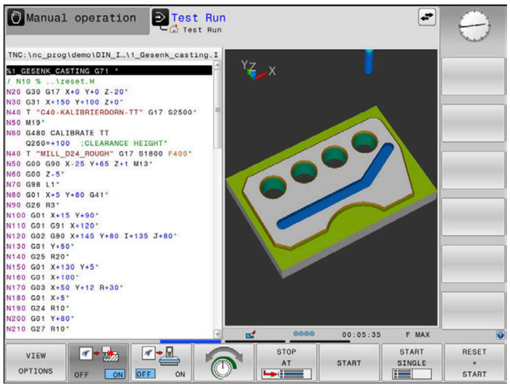


Soft keys for selecting the screen layout

Soft key	Window
PGM	NC program
PROGRAM + SECTS	Left: NC program, right: program structure
PROGRAM + GRAPHICS	Left: NC program, right: programming graphics

Test Run

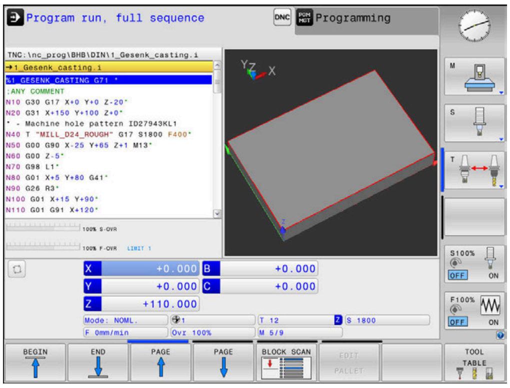
In the **Test Run** operating mode, the control simulates NC programs and program sections in order to check them for errors, such as geometrical incompatibilities, missing or incorrect data within the NC program, or violations of the working space. This simulation is supported graphically in different display modes. (option 20)



Soft keys for selecting the screen layout

Soft key	Window
PGM	NC program
PROGRAM + STATUS	Left: NC program, right: status display
PROGRAM + WORKPIECE	Left: NC program, right: workpiece (option 20)
WORKPIECE	Workpiece (Option 20)

Program Run, Full Sequence and Program Run, Single Block



In the **Program Run Full Sequence** operating mode, the control runs an NC program continuously to its end or to a manual or programmed stop. You can resume program run after an interruption.

In the **Program Run Single Block** operating mode, you execute each NC block separately by pressing the **NC start** key. With point pattern cycles and **CYCL CALL PAT**, the control stops after each point. The workpiece blank definition will be interpreted as a separate NC block.

Soft keys for selecting the screen layout

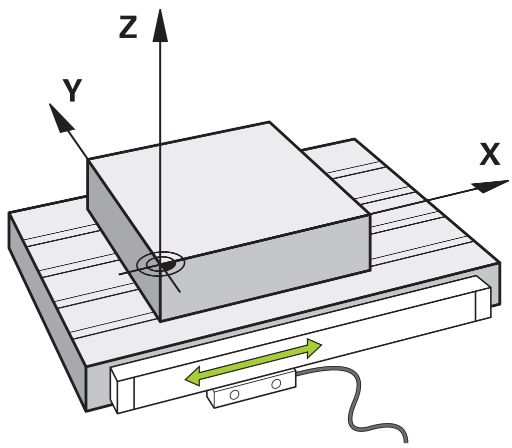
Soft key	Window
PGM	NC program
PROGRAM + SECTS	Left: NC program, right: structure
PROGRAM + STATUS	Left: NC program, right: status display
PROGRAM + WORKPIECE	Left: NC program, right: workpiece (option 20)
WORKPIECE	Workpiece (option 20)

Soft keys for screen layout with pallet tables(option 22 Pallet management)

Soft key	Window
PALLET	Pallet table
PROGRAM + PALLET	Left: NC program, right: pallet table
PALLET + STATUS	Left: pallet table, right: status display
PALLET + GRAPHICS	Left: pallet table, right: graphics
BPM	Batch Process Manager

3.4 NC fundamentals

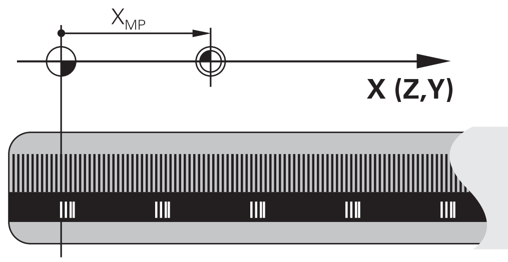
Position encoders and reference marks



The machine axes are equipped with position encoders that register the positions of the machine table or tool. Linear axes are usually equipped with linear encoders, rotary tables and tilting axes with angle encoders.

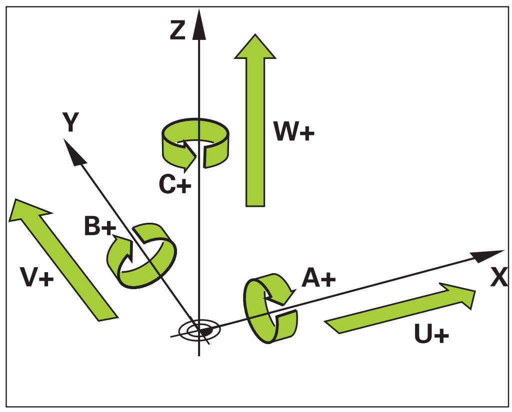
When a machine axis moves, the corresponding position encoder generates an electrical signal. The control evaluates this signal and calculates the precise actual position of the machine axis.

If there is a power interruption, the calculated position will no longer correspond to the actual position of the machine slide. To recover this assignment, incremental position encoders are provided with reference marks. When a reference mark is crossed over, a signal identifying a machine-based reference point is transmitted to the control. This enables the control to re-establish the assignment of the displayed position to the current machine position. For linear encoders with distance-coded reference marks, the machine axes need to move by no more than 20 mm, for angle encoders by no more than 20°.



With absolute encoders, an absolute position value is transmitted to the control immediately upon switch-on. In this way the assignment of the actual position to the machine slide position is re-established directly after switch-on.

Programmable axes



In the default setting, the programmable axes of the control are in accordance with the axis definitions specified in DIN 66217.

The designations of the programmable axes are given in the table below.

Principal axis	Parallel axis	Rotary axis
X	U	A
Y	V	B
Z	W	C

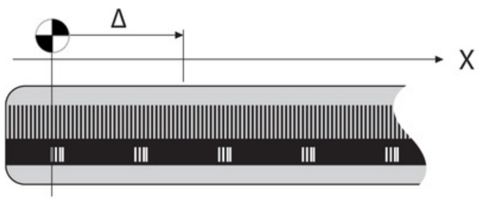
Refer to your machine manual!

The number, designation and assignment of the programmable axes depend on the machine.

Your machine tool builder can define further axes, such as PLC axes.

Reference systems

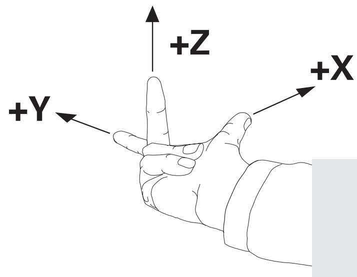
For the control to move an axis in accordance with a defined path, it requires a **reference system**.



A paraxially mounted linear encoder on a machine tool serves as a simple reference system for linear axes. The linear encoder represents a **number ray**, a one-dimensional coordinate system.

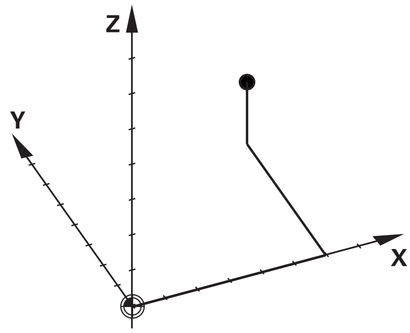
To approach a point on the **plane**, the control requires two axes and therefore a reference system with two dimensions.

To approach a point in **space**, the control requires three axes and therefore a reference system with three dimensions. If these three axes are arranged perpendicularly to each other, this creates a **three-dimensional Cartesian coordinate system**.



> According to the right-hand rule the fingertips point in the positive directions of the three principal axes.

For a point to be uniquely determined in space, a **coordinate origin** is needed in addition to the arrangement of the three dimensions. The common intersection serves as the coordinate origin in a 3-D coordinate system. This intersection has the coordinates **X+0**, **Y+0**, and **Z+0**.



In order, for example, for the control to always perform a tool change at the same position, as well as always execute a machining operation referenced to the current workpiece position, the control must be able to differentiate between different reference systems.

The control differentiates between the following reference systems:

- Machine coordinate system M-CS:
  Machine **C**oordinate **S**ystem
- Basic coordinate system B-CS:
  Basic **C**oordinate **S**ystem
- Workpiece coordinate system W-CS:
  Workpiece **C**oordinate **S**ystem
- Working plane coordinate system WPL-CS:
  Working **Pl**ane **C**oordinate **S**ystem
- Input coordinate system I-CS:
  Input **C**oordinate **S**ystem
- Tool coordinate system T-CS:
  Tool **C**oordinate **S**ystem

> All reference systems build upon each other. They are subject to the kinematic chain of the specific machine tool.
>
> The machine coordinate system is the reference system.

Machine coordinate system M-CS

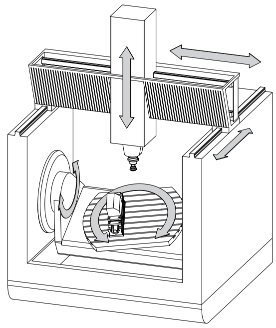
The machine coordinate system corresponds to the description of kinematics and therefore to the actual mechanical design of the machine tool.

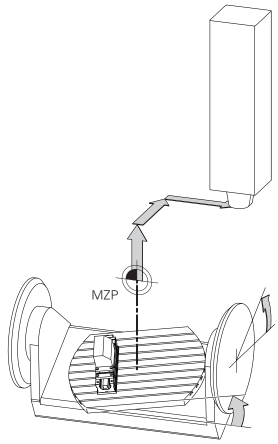
Because the mechanics of a machine tool never precisely correspond to a Cartesian coordinate system, the machine coordinate system consists of several one-dimensional coordinate systems. These one-dimensional coordinate systems correspond to the physical machine axes that are not necessarily perpendicular to each other.

The position and orientation of the one-dimensional coordinate systems are defined with the aid of translations and rotations based on the spindle tip in the description of kinematics.

The position of the coordinate origin, the machine datum, is defined by the machine manufacturer during machine configuration. The values in the machine configuration define the zero positions of the encoders and the corresponding machine axes. The machine datum does not necessarily have to be located in the theoretical intersection of the physical axes. It can therefore also be located outside of the traverse range.

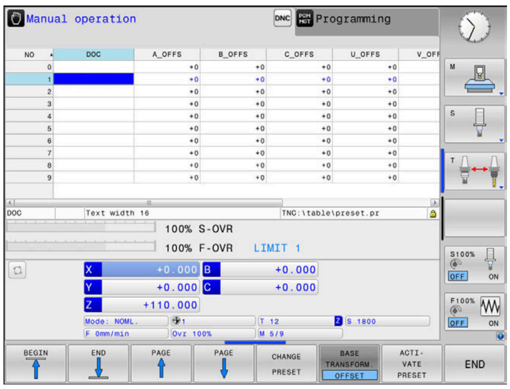
Because the machine configuration values cannot be modified by the user, the machine coordinate system is used for determining constant positions, e.g. the tool change point.





Machine datum (MZP)

Soft key	Application
	The user can define shifts in the machine coordinate system according to the specific axis with use of the **OFFSET** values of the preset table.



The machine tool builder configures the **OFFSET** columns of the preset management in accordance with the machine.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

NOTICE

Danger of collision!

Your control may feature an additional pallet preset table, depending on the machine. In this table the machine tool builder can define **OFFSET** values that take effect before the **OFFSET** values you specify in the preset table become effective. The **PAL** tab of the additional status display indicates whether a pallet preset is active, and which one. Since the **OFFSET** values of the pallet preset table are neither shown nor editable, there is a risk of collision during all movements!

- Refer to the machine tool builder's documentation
- Use pallet presets only in conjunction with pallets
- Check the display of the **PAL** tab before you start machining

> Another feature is **OEM-OFFSET**, which is available only to the machine tool builder. **OEM-OFFSET** can be used to define additive axis shifts for rotary and parallel axes.
>
> The sum of all **OFFSET** values (from all the above **OFFSET** input options) results in the difference between the **ACTL.** position and the **RFACTL** position of an axis.

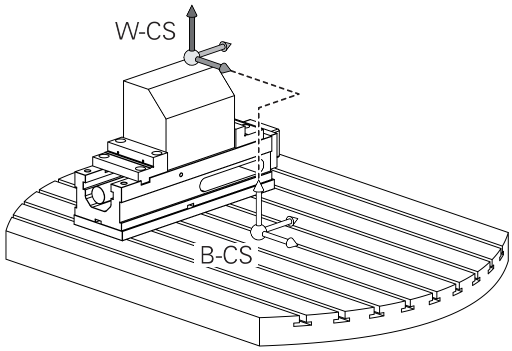
The control converts all movements in the machine coordinate system, independent of the reference system used for value input.

Example of a 3-axis machine tool with a Y axis as oblique axis, not arranged perpendicularly to the ZX plane:

- In the **Positioning w/ Manual Data Input** operating mode, run an NC block with **L IY+10**
- > The control determines the required axis nominal values from the defined values.
- > During positioning the control moves the **Y and Z** machine axes.
- > The **RFACTL** and **RFNOML** displays show movements of the Y axis and Z axis in the machine coordinate system.
- > The **ACTL.** and **NOML.** displays only show one movement of the Y axis in the input coordinate system.
- In the **Positioning w/ Manual Data Input** operating mode, run an NC block with **L IY-10 M91**
- > The control determines the required axis nominal values from the defined values.
- > During positioning the control only moves the **Y** machine axis.
- > The **RFACTL** and **RFNOML** displays only show one movement of the Y axis in the machine coordinate system.
- > The **ACTL.** and **NOML.** displays show movements of the Y axis and Z axis in the input coordinate system.

The user can program positions related to the machine datum, e.g. by using the miscellaneous function **M91**.

Basic coordinate system B-CS

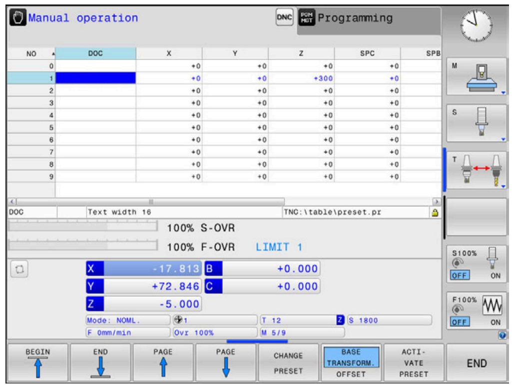


The basic coordinate system is a 3-D Cartesian coordinate system. Its coordinate origin is the end of the kinematics model.

The orientation of the basic coordinate system in most cases corresponds to that of the machine coordinate system. There may be exceptions to this if a machine manufacturer uses additional kinematic transformations.

The kinematic model and thus the position of the coordinate origin for the basic coordinate system is defined by the machine manufacturer in the machine configuration. The user cannot modify the machine configuration values.

The basic coordinate system serves to determine the position and orientation of the workpiece coordinate system.



Soft key	Application
BASE TRANSFORM. OFFSET	The user determines the position and orientation of the workpiece coordinate system by using a 3-D touch probe, for example. The control saves the values determined with respect to the basic coordinate system as **BASE TRANSFORM.** values in the preset management.

The machine tool builder configures the **BASE TRANSFORM.** columns of the preset management in accordance with the machine.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

NOTICE

Danger of collision!

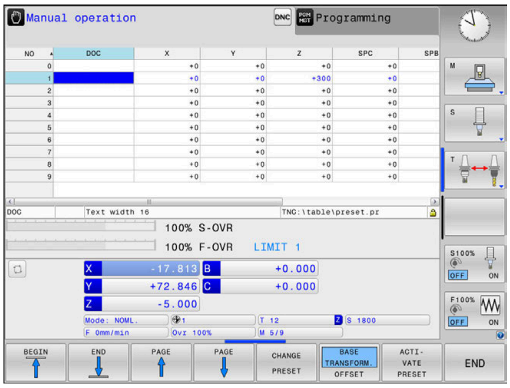
Your control may feature an additional pallet preset table, depending on the machine. In this table the machine tool builder can define **BASE TRANSFORM.** values that take effect before the **BASE TRANSFORM.** values you specify in the preset table become effective. The **PAL** tab of the additional status display indicates whether a pallet preset is active, and which one. Since the **BASE TRANSFORM.** values of the pallet preset table are neither visible nor editable, there is danger of collision during all movements!

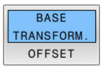
- Refer to the machine tool builder's documentation
- Use pallet presets only in conjunction with pallets
- Check the display of the **PAL** tab before you start machining

Workpiece coordinate system W-CS

The workpiece coordinate system is a 3-D Cartesian coordinate system. Its coordinate origin is the active reference point.

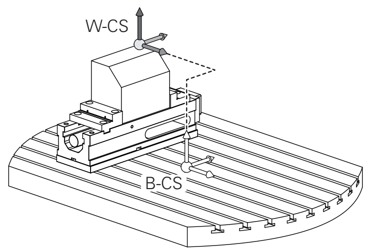
The position and orientation of the workpiece coordinate system depend on the **BASE TRANSFORM.** values of the active line in the preset table.



Soft key	Application
	The user determines the position and orientation of the workpiece coordinate system by using a 3-D touch probe, for example. The control saves the values determined with respect to the basic coordinate system as **BASE TRANSFORM.** values in the preset management.

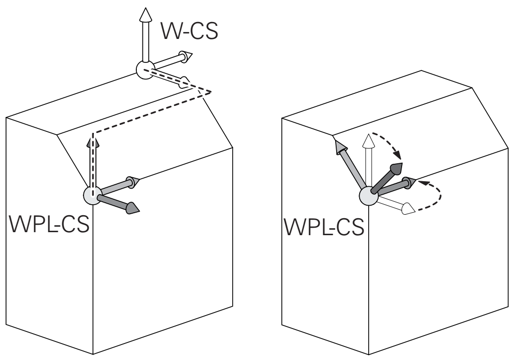
Further information: User's Manual for **Setup, Testing and Running NC Programs**

In the workpiece coordinate system the user defines the position and orientation of the working plane coordinate system with use of transformations.



Transformations in the workpiece coordinate system:

- **3D ROT** functions
  - **PLANE** functions
  - Cycle **G80 WORKING PLANE**
- Cycle **G53/G54 DATUM SHIFT** (shifting **before** tilting the working plane)
- Cycle **G28 MIRRORING** (mirroring **before** tilting the working plane)



> The result of transformations built up on each other depends on the programming sequence.
>
> In every coordinate system, program only the specified (recommended) transformations. This applies to both setting and resetting the transformations. Any other use may lead to unexpected or undesired results. Please observe the following programming notes.
>
> Programming notes:
>
> - Transformations (mirroring and shifting) that are programmed before the **PLANE** functions (except for **PLANE AXIAL**) will change the position of the tilt datum (origin of the working plane coordinate system WPL-CS) and the orientation of the rotary axes
>   - If you just program a shift, then only the position of the tilt datum will change
>   - If you just program mirroring, then only the orientation of the rotary axes will change
> - When used in conjunction with **PLANE AXIAL** and Cycle **G80**, the programmed transformations (mirroring, rotation, and scaling) do not affect the position of the tilt datum or the orientation of the rotary axes

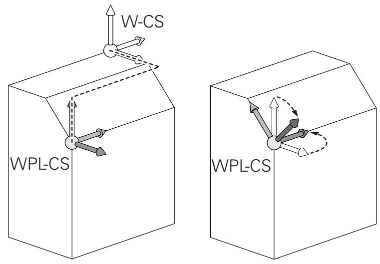
Without active transformations in the workpiece coordinate system, the position and orientation of the working plane coordinate system and workpiece coordinate system are identical.

There are no transformations in the workpiece coordinate system on 3-axis machine tools or with pure 3-axis machining. The **BASE TRANSFORM.** values of the active line of the preset table have a direct effect on the working plane coordinate system with this assumption.

Other transformations are of course possible in the working plane coordinate system

Further information: "Working plane coordinate system WPL-CS", Page 80

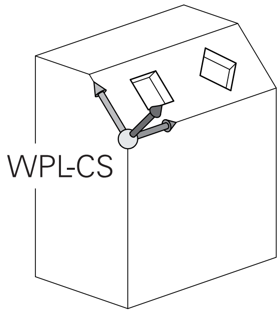
Working plane coordinate system WPL-CS



The working plane coordinate system is a 3-D Cartesian coordinate system.

The position and orientation of the working plane coordinate system depend on the active transformations in the workpiece coordinate system.

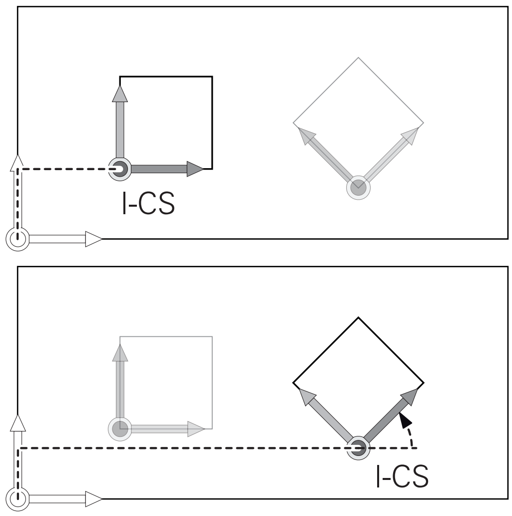
> Without active transformations in the workpiece coordinate system, the position and orientation of the working plane coordinate system and workpiece coordinate system are identical.
>
> There are no transformations in the workpiece coordinate system on 3-axis machine tools or with pure 3-axis machining. The **BASE TRANSFORM.** values of the active line of the preset table have a direct effect on the working plane coordinate system with this assumption.



In the working plane coordinate system the user defines the position and orientation of the input coordinate system with use of transformations.

Transformations in the working plane coordinate system:

- Cycle **G53/G54 DATUM SHIFT**
- Cycle **G28 MIRRORING**
- Cycle **G73 ROTATION**
- Cycle **G72 SCALING FACTOR**
- **PLANE RELATIVE**



> As a **PLANE** function, the **PLANE RELATIVE** is effective in the workpiece coordinate system and aligns the working plane coordinate system.
>
> The values of additive tilting always relate to the current working plane coordinate system.

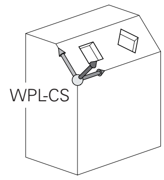
> The result of transformations built up on each other depends on the programming sequence.

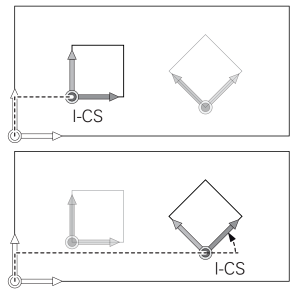
> Without active transformations in the working plane coordinate system, the position and orientation of the input coordinate system and working plane coordinate system are identical.
>
> In addition, there are no transformations in the workpiece coordinate system on 3-axis machine tools or with pure 3-axis machining. The **BASE TRANSFORM.** values of the active line of the preset table have a direct effect on the input coordinate system with this assumption.

Input coordinate system I-CS

The input coordinate system is a 3-D Cartesian coordinate system.

The position and orientation of the input coordinate system depend on the active transformations in the working plane coordinate system.





> Without active transformations in the working plane coordinate system, the position and orientation of the input coordinate system and working plane coordinate system are identical.
>
> In addition, there are no transformations in the workpiece coordinate system on 3-axis machine tools or with pure 3-axis machining. The **BASE TRANSFORM.** values of the active line of the preset table have a direct effect on the input coordinate system with this assumption.

With the aid of positioning blocks in the input coordinate system, the user defines the position of the tool and therefore the position of the tool coordinate system.

> The **NOML.**, **ACTL.**, **LAG**, and **ACTDST** displays are also based on the input coordinate system.

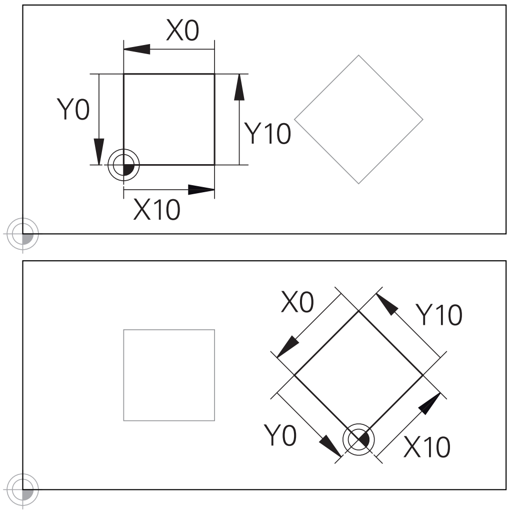
Positioning blocks in input coordinate system:

- Paraxial positioning blocks
- Positioning blocks with Cartesian or polar coordinates

Example

```
N70  X+48 R+*
```

```
N70  G01 X+48 Y+102 Z-1.5 R0*
```

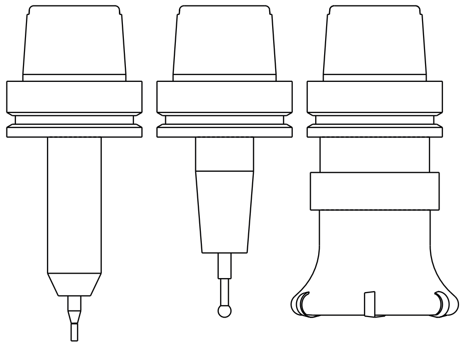


A contour referencing the input coordinate system origin can easily be transformed any way you need.

> Orientation of the tool coordinate system can be performed in various reference systems.
>
> **Further information:** "Tool coordinate system T-CS", Page 82

Tool coordinate system T-CS

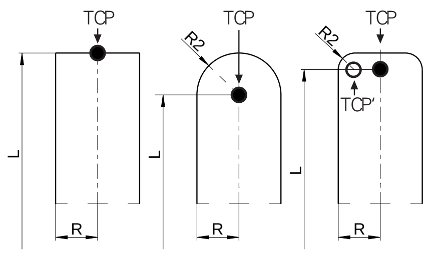
The tool coordinate system is a 3-D Cartesian coordinate system. Its coordinate origin is the tool reference point. The values of the tool table, **L** and **R** with milling tools and **ZL**, **XL** and **YL** with turning tools, are referenced to this point.



Further information: User's Manual for **Setup, Testing and Running NC Programs**

In accordance with the values from the tool table, the coordinate origin of the tool coordinate system is shifted to the tool center point TCP. TCP stands for **T**ool **C**enter **P**oint.

If the NC program is not referenced to the tool tip, the tool center point must be shifted. The required shift is implemented in the NC program using the delta values during a tool call.

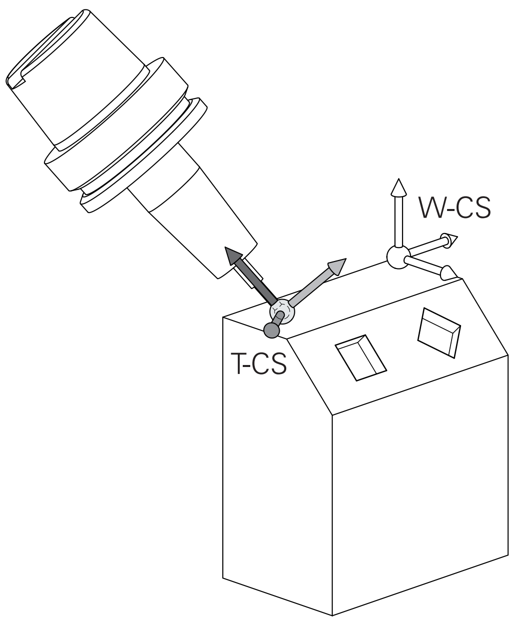


> The position of the TCP as shown in the diagram is obligatory in conjunction with the 3-D tool compensation.

> With the aid of positioning blocks in the input coordinate system, the user defines the position of the tool and therefore the position of the tool coordinate system.

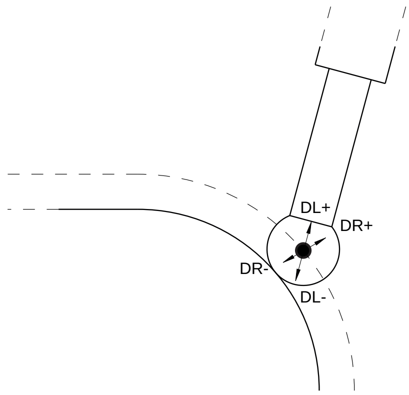
If miscellaneous function **M128** is active, the orientation of the tool coordinate system depends on the tool's current angle of inclination.

Tool angle of inclination in the machine coordinate system:



Example

```
N70 G01 X+10 Y+45 A+10 C+5 R0 M128*
```



With the shown positioning blocks with vectors, 3-D tool compensation is possible with compensation values **DL**, **DR** and **DR2** from the **T** block or from the **.tco** compensation table.

The methods of function of the compensation values depend on the type of tool.

The control detects the various tool types with the columns **L**, **R** and **R2** of the tool table:

- $R2_{TAB} + DR2_{TAB} + DR2_{PROG} = 0$
  → end mill
- $R2_{TAB} + DR2_{TAB} + DR2_{PROG} = R_{TAB} + DR_{TAB} + DR_{PROG}$
  → radius cutter or ball cutter
- $0 < R2_{TAB} + DR2_{TAB} + DR2_{PROG} < R_{TAB} + DR_{TAB} + DR_{PROG}$
  → toroid cutter or toroidal cutter

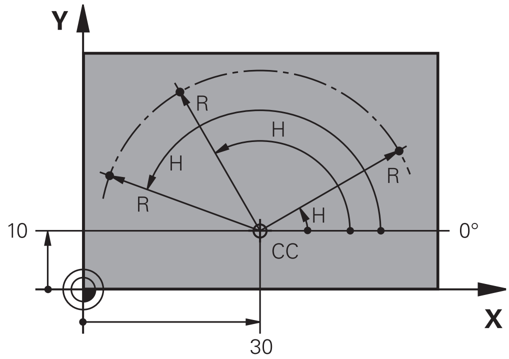
Without the **TCPM** function or miscellaneous function **M128**, orientation of the tool coordinate system and input coordinate system is identical.

Designation of the axes on milling machines

The X, Y and Z axes on your milling machine are also referred to as tool axis, principal axis (1st axis) and secondary axis (2nd axis). The assignment of the tool axis is decisive for the assignment of the principal and secondary axes.

Tool axis	Principal axis	Secondary axis
X	Y	Z
Y	Z	X
Z	X	Y

Polar coordinates

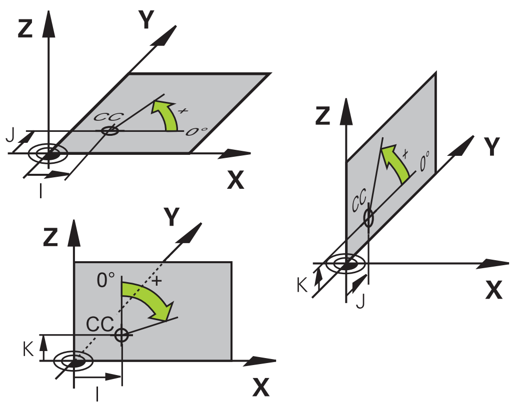


If the production drawing is dimensioned in Cartesian coordinates, you write the NC program using Cartesian coordinates. For parts containing circular arcs or angles, it is often simpler to give the dimensions in polar coordinates.

While the Cartesian coordinates X, Y and Z are three-dimensional and can describe points in space, polar coordinates are two-dimensional and describe points in a plane. Polar coordinates have their datum at a circle center (CC), or pole. A position in a plane can be clearly defined by the:

- Polar Radius, the distance from the circle center CC to the position, and the
- Polar Angle, the value of the angle between the angle reference axis and the line that connects the circle center CC with the position.

Setting the pole and the angle reference axis



The pole is set by entering two Cartesian coordinates in one of the three planes. These coordinates also set the reference axis for the polar angle H.

Coordinates of the pole (plane)	Angle reference axis
X/Y	+X
Y/Z	+Y
Z/X	+Z

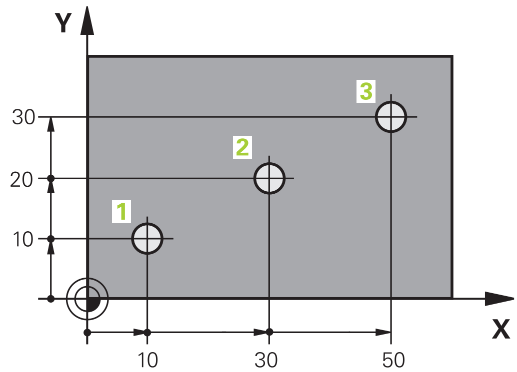
Absolute and incremental workpiece positions

Absolute workpiece positions

Absolute coordinates are position coordinates that are referenced to the datum of the coordinate system (origin). Each position on the workpiece is unambiguously defined by its absolute coordinates.

Example 1: Holes dimensioned in absolute coordinates

Hole 1	Hole 2	Hole 3
X = 10 mm	X = 30 mm	X = 50 mm
Y = 10 mm	Y = 20 mm	Y = 30 mm

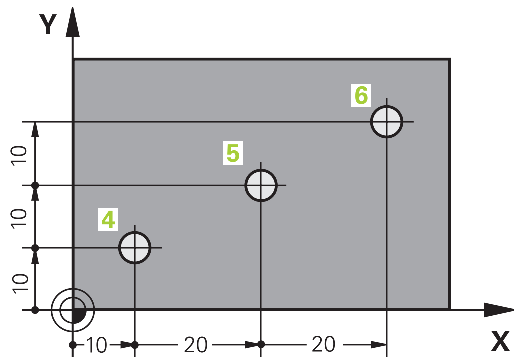


Incremental workpiece positions

Incremental coordinates are referenced to the last programmed nominal position of the tool, which serves as the relative (imaginary) datum. When you write an NC program in incremental coordinates, you thus program the tool to move by the distance between the previous and the subsequent nominal positions. This is why they are also referred to as chain dimensions.

To program a position in incremental coordinates, enter the G91 function before the axis.

Example 2: Holes dimensioned in incremental coordinates



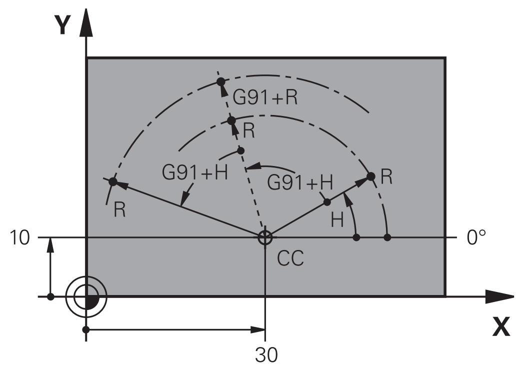
Absolute coordinates of hole 4
X = 10 mm
Y = 10 mm

Hole 5, with respect to 4	Hole 6, with respect to 5
G91 X = 20 mm	G91 X = 20 mm
G91 Y = 10 mm	G91 Y = 10 mm

Absolute and incremental polar coordinates

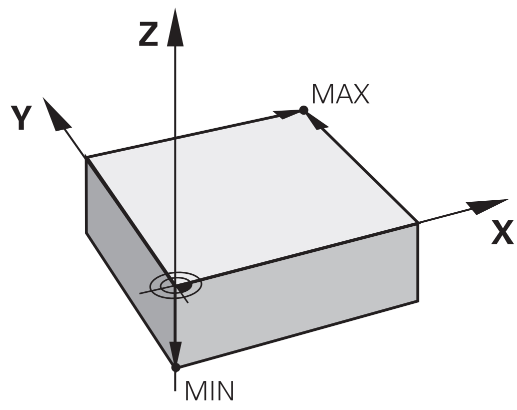
Absolute coordinates always refer to the pole and the angle reference axis.

Incremental polar coordinates always refer to the last programmed nominal position of the tool.



Selecting the preset

A production drawing specifies a certain form element of the workpiece (usually a corner) as the absolute reference point (datum). When setting the preset, first align the workpiece along the machine axes, and move the tool to a known position in each axis relative to the workpiece. For each position, set the display of the control either to zero or to a known position value. You thereby assign the workpiece to the reference system that is applicable for the control's display or your NC program.



If the production drawing is dimensioned in relative reference points, simply use the coordinate transformation cycles.

Further information: User's Manual for **Programming of Machining Cycles**

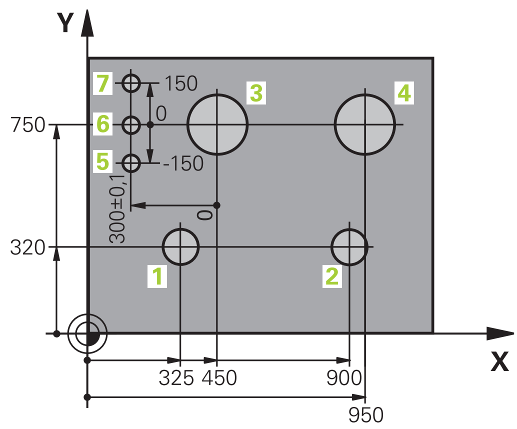
If the production drawing is not dimensioned for NC programming, then select a position or corner of the workpiece as a reference point from which the dimensions of the remaining workpiece positions can be determined.

A particularly convenient way of setting the presets is with a 3-D touch probe from HEIDENHAIN.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Example

The workpiece drawing shows holes (**1** to **4**), whose dimensions are shown relative to an absolute preset with the coordinates X=0 Y=0. The coordinates of holes **5** to **7** refer to the relative preset with the absolute coordinates X=450 Y=750. A **Datum shift** allows you to temporarily shift the datum to the position X = 450, Y = 750 in order for you to program the holes (**5** to **7**) without further calculations.



3.5 Creating and entering NC programs

Structure of an NC program in DIN/ISO format

An NC program consists of a series of NC blocks. The illustration at right shows the elements of an NC block.

The control numbers the NC blocks of an NC program automatically, depending on the setting in the machine parameter **blockIncrement** (105409). The **blockIncrement** machine parameter (105409) defines the block number increment.

The first NC block of an NC program is identified by **%**, the program name, and the active unit of measure.

The subsequent NC blocks contain information on

- The workpiece blank
- Tool calls
- Approaching a safe position
- Feed rates and spindle speeds, as well as
- Path contours, cycles and other functions

The last block of a program is identified by **N99999999**, the program name, and the active unit of measure.

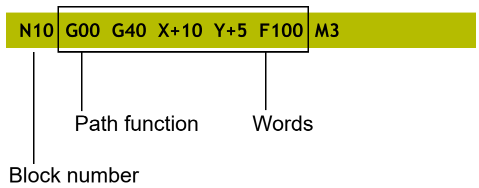
NOTICE

Danger of collision!

The control does not automatically check whether collisions can occur between the tool and the workpiece. There is danger of collision during the approach movement after a tool change!

- If necessary, program an additional safe auxiliary position

NC block

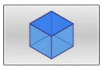
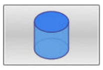


Defining the workpiece blank: G30/G31

Immediately after creating a new NC program, you define an unmachined workpiece blank. If you wish to define the blank at a later stage, then press the **SPEC FCT** key, the **PROGRAM DEFAULTS** soft key, and then the **BLK FORM** soft key. The control needs this definition for its graphical simulations.

> You only need to define the workpiece blank if you wish to run a graphic test for the NC program.

The control can depict various types of blank forms:

Soft key	Function
	Define a rectangular blank
	Define a cylindrical blank
	Define a rotationally symmetric blank of any shape
	Load STL file as workpiece blank Optionally load an additional STL file as finished part

Rectangular blank

The sides of the cuboid lie parallel to the X, Y and Z axes. This blank is defined by two of its corner points:

- MIN point G30: the smallest X, Y and Z coordinates of the blank form, entered as absolute values.
- MAX point G31: the largest X, Y and Z coordinates of the blank form, entered as absolute or incremental values

Example

%NEW G71 *	Program begin, name, unit of measure
N10 G30 G17 X+0 Y+0 Z-40*	Spindle axis, MIN point coordinates
N20 G31 X+100 Y+100 Z+0*	MAX point coordinates
N99999999 %NEW G71 *	Program end, name, unit of measure

Cylindrical blank

The cylindrical blank form is defined by the dimensions of the cylinder:

- X, Y or Z: Rotation axis
- D, R: Diameter or radius of the cylinder (with positive algebraic sign)
- L: Length of the cylinder (with positive algebraic sign)
- DIST: Shifting along the rotational axis
- DI, RI: Inside diameter or inside radius for a hollow cylinder

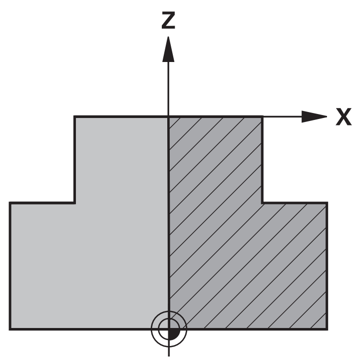
> The parameters **DIST** and **RI** or **DI** are optional and need not be programmed.

Example

%NEW G71 *	Program begin, name, unit of measure
N10 BLK FORM CYLINDER Z R50 L105 DIST+5 RI10*	Spindle axis, radius, length, distance, inside radius
N99999999 %NEW G71 *	Program end, name, unit of measure

Rotationally symmetric blank of any shape

You define the contour of the rotationally symmetric blank in a subprogram. Use X, Y or Z as the rotation axis.



In the workpiece blank definition you refer to the contour description:

- DIM_D, DIM-R: Diameter or radius of the rotationally symmetrical blank form
- LBL: Subprogram with the contour description

The contour description may contain negative values in the rotation axis but only positive values in the reference axis. The contour must be closed, i.e. the contour beginning corresponds to the contour end.

If you define a rotationally symmetric blank with incremental coordinates, the dimensions are then independent of the diameter programming.

> The subprogram can be designated with a number, an alphanumeric name, or a QS parameter.

Example

%NEW G71 *	Program begin, name, unit of measure
N10 BLK FORM ROTATION Z DIM_R LBL1*	Spindle axis, manner of interpretation, subprogram number
N20 M30*	End of main program
N30 G98 L1*	Subprogram start
N40 G01 X+0 Z+1*	Starting point of contour
N50 G01 X+50*	Programming in the positive direction of the principal axis
N60 G01 Z-20*	
N70 G01 X+70*	
N80 G01 Z-100*	
N90 G01 X+0*	
N100 G01 Z+1*	Contour end
N110 G98 L0 *	End of subprogram
N99999999 %NEW G71 *	Program end, name, unit of measure

STL files as workpiece blank and optional finished part

Integrating STL files as workpiece blank and finished part is particularly convenient in combination with CAM programs, where the required 3-D models are available in addition to the NC program.

> Missing 3-D models, such as semifinished parts with multiple, separate machining steps, can be created directly on the control with the **EXPORT WORKPIECE** soft key in the **Test Run** operating mode.
>
> The file size depends on the complexity of the geometry.
>
> **Further information:** User's Manual for **Setup, Testing and Running NC Programs**

> Please note that the STL files are limited in respect of the number of permitted triangles:
>
> - 20,000 triangles per STL file in ASCII format
> - 50,000 triangles per STL file in binary format
>
> Binary files are loaded faster by the control.

In the workpiece blank definition you refer to the desired STL files by indicating the path. Use the **SELECT FILE** soft key if you want the control to take over the path information automatically.

If you do not wish to load a finished part, then close the dialog after the workpiece blank definition.

> The path of the STL file can also be entered directly as text or with a QS parameter.

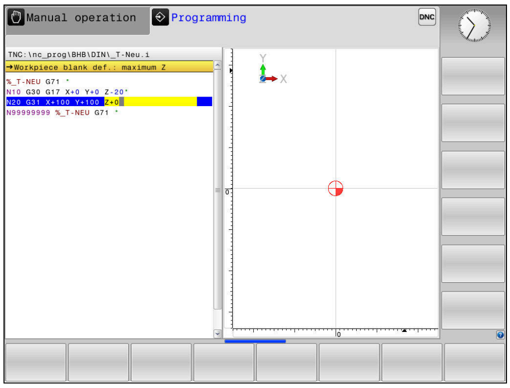
Example

%NEU G71 *	Program beginning, name, unit of measure
N10 BLK FORM FILE "TNC:\...stl" TARGET "TNC:\...stl"*	Indication of path to the workpiece blank, path to the optional finished part
N99999999 %NEU G71 *	Program end, name, unit of measure

> If the NC program and the 3-D models are in a folder or in a defined folder structure, relative paths make it easier to move the files later.
>
> **Further information:** "Programming notes", Page 241

Creating a new NC program

An NC program is always entered in **Programming** mode. Example for creating a program:



- Operating mode: Press the **Programming** key

PGM MGT

- Press the **PGM MGT** key
- > The control opens the file manager.

Select the directory in which you wish to store the new NC program:

FILE NAME = NEW.I

ENT

- Enter the new program name
- Press the **ENT** key

MM

- Select the unit of measure: Press the **MM** or **INCH** soft key
- > The control switches the screen layout and initiates the dialog for defining the **BLK FORM** (workpiece blank).

- Select a rectangular workpiece blank: Press the soft key for a rectangular blank form

Working plane in graphic: XY

G17

- Enter the spindle axis, e.g. **G17**

Workpiece blank def.: Minimum

ENT

- Enter in sequence the X, Y and Z coordinates of the MIN point and confirm each of your entries with the **ENT** key

Workpiece blank def.: Maximum

ENT

- Enter in sequence the X, Y and Z coordinates of the MAX point and confirm each of your entries with the **ENT** key

Example

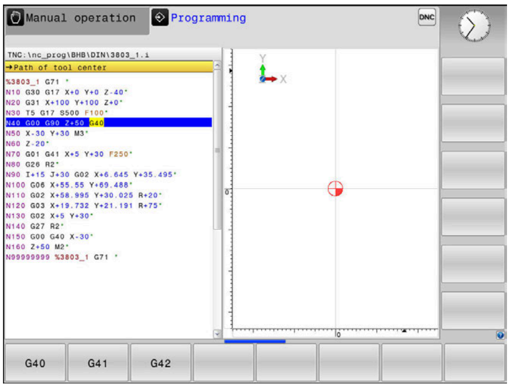
%NEW G71 *	Program begin, name, unit of measure
N10 G30 G17 X+0 Y+0 Z-40*	Spindle axis, MIN point coordinates
N20 G31 X+100 Y+100 Z+0*	MAX point coordinates
N99999999 %NEW G71 *	Program end, name, unit of measure

The control automatically generates the first and last NC blocks of the NC program.

> If you do not wish to define a workpiece blank, then cancel the dialog at **Working plane in graphic: XY** using the **DEL** key!

Programming tool movements in DIN/ISO

To program an NC block, pressing the **SPEC FCT** key. Press the **PROGRAM FUNCTIONS** soft key, and then the **DIN/ISO** soft key. You can also use the gray path function keys to get the corresponding G code.



> If you enter ISO functions on a keyboard connected through a USB port, make sure that capitalization is active.

Example of a positioning block

G

- Press the **G** key
- Enter **1** and press the **ENT** key to open the NC block

ENT

COORDINATES ?

X

- **10** (enter the target coordinate for the X axis)

Y

- **20** (enter the target coordinate for the Y axis)

ENT

- Go to the next question with **ENT**.

Path of tool center

G

- Enter **40** and confirm with the **ENT** key to traverse without tool radius compensation

Alternative:

G41

G42

- Move the tool to the left or to the right of the programmed contour: Press the **G41** or **G42** soft key

Feed rate F=?

- **100** (enter a feed rate of 100 mm/min for this path contour)

ENT

- Go to the next question with **ENT**.

MISCELLANEOUS FUNCTION M ?

- **3** (enter the miscellaneous function **M3 Spindle on**)

END

- With the **END** key, the control ends this dialog.

Example

```
N30 G01  G40 X+10  Y+5 F100 M3*
```

Actual position capture

The control enables you to transfer the current tool position into the NC program,for example during

- Positioning-block programming
- Cycle programming

To transfer the correct position values, proceed as follows:

- Place the input box at the position in the NC block where you want to insert a position value

- Select the actual-position-capture function
- > In the soft-key row the control displays the axes whose positions can be transferred.

- Select the axis
- > The control writes the current position of the selected axis into the active input box.

> In the working plane the control always captures the coordinates of the tool center, even though tool radius compensation is active.
>
> The control takes the active tool length compensation into account and always captures the coordinate of the tool tip in the tool axis.
>
> The control keeps the soft-key row for axis selection active until the **actual position capture** key is pressed again. This behavior remains in effect even if you save the current NC block or open a new NC block with a path function key. If you have to choose an input alternative via soft key (e.g. for radius compensation), then the control closes the soft-key row for axis selection.
>
> The **Actual position capture** function is not permitted when the **Tilt working plane** function is active.

Editing an NC program

> You cannot edit the active NC program while it is being run.

While you are creating or editing a NC program, you can select any desired line in the NC program or individual words in an NC block with the arrow keys or the soft keys:

Soft key / key	Function
PAGE	Go to previous page
PAGE	Go to next page
BEGIN	Go to beginning of program
END	Go to end of program
	Change the position of the current NC block on the screen. Press this soft key to display additional NC blocks that are programmed before the current NC block No function if the NC program is fully visible on the screen
	Change the position of the current NC block on the screen. Press this soft key to display additional NC blocks that are programmed after the current NC block No function if the NC program is fully visible on the screen
	Move from one NC block to the next NC block
	Select individual words in an NC block
GOTO	Select a specific NC block **Further information:** "Using the GOTO key", Page 184

Soft key / key	Function
CE	■ Set the selected word to zero ■ Erase an incorrect number ■ Delete the (clearable) error message
NO ENT	Delete the selected word

Soft key / key	Function
DEL ◻	■ Delete the selected NC block ■ Erase cycles and program sections
INSERT LAST NC BLOCK	Insert the NC block that you last edited or deleted

Inserting an NC block at any desired location

- ▶ Select the NC block after which you want to insert a new NC block
- ▶ Initiate the dialog

Saving changes

The control normally saves changes automatically if you switch the operating mode or if you select the file manager. If you deliberately want to save changes to the NC program, proceed as follows:

- ▶ Select the soft-key row with the saving functions

STORE

- ▶ Press the **STORE** soft key
- > The control saves all changes made since the last time you saved the program.

Saving an NC program to a new file

You can save the contents of the currently active NC program under a different program name. Proceed as follows:

- ▶ Select the soft-key row with the saving functions

SAVE AS

- ▶ Press the **SAVE AS** soft key
- > The control opens a window in which you can enter the directory and the new file name.
- ▶ If necessary, select the target directory with the **SWITCH** soft key
- ▶ Enter the file name
- ▶ Confirm with the **OK** soft key or the **ENT** key, or abort the process by pressing the **CANCEL** soft key

> ℹ The file saved with **SAVE AS** can also be found in the file manager by pressing the **LAST FILES** soft key.

Undoing changes

You can undo all changes made since the last time you saved the program. Proceed as follows:

- ▶ Select the soft-key row with the saving functions

CANCEL CHANGE

- ▶ Press the **CANCEL CHANGE** soft key
- > The control opens a window in which you can confirm or cancel this action.
- ▶ Reject the changes with the **YES** soft key or **ENT** key, or cancel the process with the **NO** soft key

Editing and inserting words

- Select a word in an NC block
- Overwrite it with the new value
- > The dialog is available while the word is highlighted.
- To accept the change, press the **END** key

If you want to insert a word, press the horizontal arrow key repeatedly until the desired dialog appears. You can then enter the desired value.

Looking for the same words in different NC blocks

→ ▶ Select a word in an NC block: Press the arrow key repeatedly until the desired word is highlighted

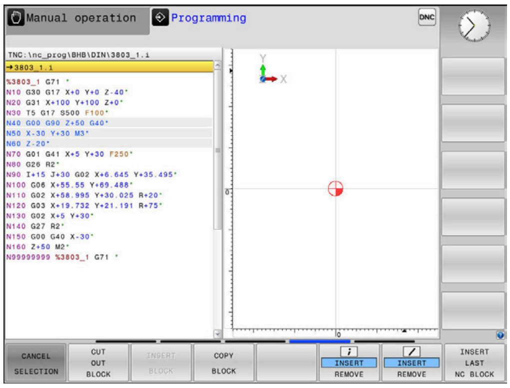
↓ ▶ Select an NC block with the arrow keys
- Arrow down: search forwards
- Arrow up: search backwards

The word that is highlighted in the new NC block is the same as the one you selected previously.

> **i** If you start a search in a very long NC program, the control shows a progress indicator. You can cancel the search at any time, if necessary.

Marking, copying, cutting and inserting program sections

The control provides the following functions for copying program sections within an NC program or into another NC program:



Soft key	Function
SELECT BLOCK	Switch the marking function on
CANCEL SELECTION	Switch the marking function off
CUT OUT BLOCK	Cut the marked block
INSERT BLOCK	Insert the block that is stored in the buffer memory
COPY BLOCK	Copy the marked block

To copy a program section, proceed as follows:

- ▶ Select the soft key row containing the marking functions
- ▶ Select the first NC block of the section you wish to copy
- ▶ Mark the first NC block: Press the **SELECT BLOCK** soft key.
- > The control highlights the NC block in color and displays the **CANCEL SELECTION** soft key.
- ▶ Place the cursor on the last NC block of the program section you wish to copy or cut.
- > The control shows the marked NC blocks in a different color. You can end the marking function at any time by pressing the **CANCEL SELECTION** soft key.
- ▶ Copy the selected program section: Press the **COPY BLOCK** soft key. Cut the selected program section: Press the **CUT OUT BLOCK** soft key.
- > The control stores the selected block.

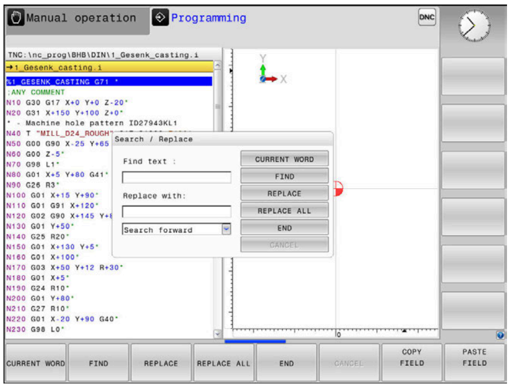
> ℹ If you want to transfer a program section to another NC program, you now need to select the desired NC program in the file manager.

- ▶ Use the arrow keys to select the NC block after which you want to insert the copied/cut section
- ▶ Insert the saved program section: Press the **INSERT BLOCK** soft key
- ▶ End the marking function: Press the **CANCEL SELECTION** soft key

The control's search function

The search function of the control enables you to search for any text within an NC program and replace it by a new text, if required.

Finding any text



FIND

- ▶ Select the search function
- > The control superimposes the search window and displays the available search functions in the soft-key row.
- ▶ Enter the text to be searched for, e.g.: **TOOL**
- ▶ Select forwards search or backwards search

FIND

- ▶ Start the search process
- > The control moves to the next NC block containing the text you are searching for

FIND

- ▶ Repeat the search process
- > The control moves to the next NC block containing the text you are searching for

END

- ▶ Terminate the search function: Press the END soft key

Finding/Replacing any text

NOTICE

Caution: Data may be lost!

The **REPLACE** and **REPLACE ALL** functions overwrite all of the found syntax elements without a confirmation prompt. The original file is not automatically backed up by the control before the replacement process. As a result, NC programs may be irreversibly damaged.

- Back up the NC programs, if required, before you start the replacement
- Be appropriately careful when using **REPLACE** and **REPLACE ALL**

The **FIND** and **REPLACE** functions cannot be used in the active NC program while the program is running. These functions are also not available if write protection is active.

- Select the NC block containing the word you wish to find

FIND

- Select the search function
- > The control superimposes the search window and displays the available search functions in the soft-key row.
- Press the **CURRENT WORD** soft key
- > The control loads the first word of the current NC block. If required, press the soft key again to load the desired word.

FIND

- Start the search process
- > The control moves to the next occurrence of the text you are searching for.

REPLACE

- To replace the text and then move to the next occurrence of the text, press the **REPLACE** soft key. Or, to replace all text occurrences, press the **REPLACE ALL** soft key. Or, to skip the text and move to its next occurrence, press the **FIND** soft key

END

- Terminate the search function: Press the END soft key

3.6 File management

Files

Files in the control	Type
NC programs	
in HEIDENHAIN format	.H
in DIN/ISO format	.I
Compatible NC programs	
HEIDENHAIN unit programs	.HU
HEIDENHAIN contour programs	.HC
Tables for	
Tools	.T
Tool changers	.TCH
Datums	.D
Points	.PNT
Presets	.PR
Touch probes	.TP
Backup files	.BAK
Dependent data (e.g. structure items)	.DEP
Freely definable tables	.TAB
Pallets	.P
Texts as	
ASCII files	.A
Text files	.TXT
HTML files, e.g. result logs of touch probe cycles	.HTML
Help files	.CHM
CAD files as	
ASCII files	.DXF .IGES .STEP

When you write an NC program on the control, you must first enter a program name. The control saves the NC program to the internal memory as a file with the same name. The control can also save texts and tables as files.

The control provides a special file management window in which you can easily find and manage your files. Here you can call, copy, rename and erase files.

With the control, you can manage and save files up to a total size of **2 GB**.

> Depending on the setting, the control generates backup files with the extension *.bak after editing and saving of NC programs. This reduces the available memory space.

File names

When you store NC programs, tables and texts as files, the control adds an extension to the file name, separated by a point. This extension indicates the file type.

File name	File type
PROG20	.I

File names, drive names and directory names on the control must comply with the following standard: The Open Group Base Specifications Issue 6 IEEE Std 1003.1, 2004 Edition (POSIX Standard).

The following characters are permitted:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z 0 1 2 3 4 5 6 7 8 9 _ -

The following characters have special meanings:

Character	Meaning
.	The last period (dot) in a file name is the extension separator
\ and **/**	Directory separators
:	Separates the drive name from the directory

Do not use any other characters. This helps to prevent file transfer problems, etc.

> The names of tables and table columns must start with a letter and must not contain an arithmetic operator (e.g., **+**).

> The maximum permitted path length is 255 characters. The path length consists of the drive characters, the directory name and the file name, including the extension.
>
> **Further information:** "Paths", Page 103

Displaying externally generated files on the control

The control features several additional tools which you can use to display the files shown in the table below. Some of the files can also be edited.

File types	Type
PDF files Excel tables Internet files	pdf xls csv html
Text files	txt ini
Graphics files	bmp gif jpg png

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Directories

To ensure that you can easily find your NC programs and files, we recommend that you organize your internal memory into directories (folders). You can divide a directory into further directories, which are called subdirectories. With the **-/+** key or **ENT** you can show or hide the subdirectories.

Paths

A path indicates the drive and all directories and subdirectories under which a file is saved. The individual names are separated by a backslash ****.

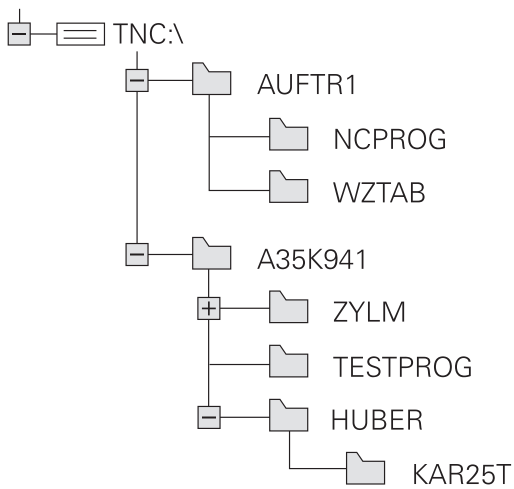
> The maximum permitted path length is 255 characters. The path length consists of the drive characters, the directory name and the file name, including the extension.

Example

The directory AUFTR1 was created on the **TNC** drive. Then, in the AUFTR1 directory, the directory NCPROG was created and the NC program PROG1.H was copied into it. The NC program now has the following path:

TNC:\AUFTR1\NCPROG\PROG1.I

The chart at right illustrates an example of a directory display with different paths.



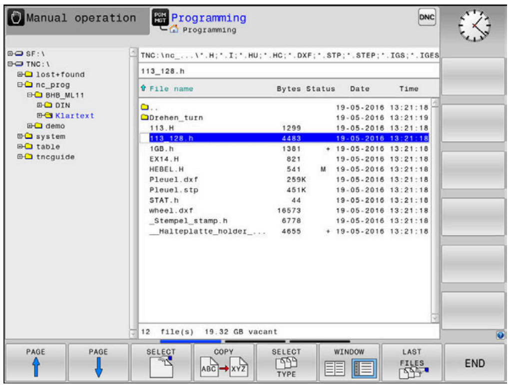
Overview: Functions of the file manager

Soft key	Function	Page
COPY ABC → XYZ	Copy a single file	108
SELECT TYPE	Display a specific file type	106
NEW FILE	Create new file	108
LAST FILES	Display the last 10 files that were selected	111
DELETE	Delete a file	112
TAG	Tag a file	113
RENAME ABC = XYZ	Rename file	114
PROTECT	Protect a file against editing and erasure	115
UNPROTECT	Cancel file protection	115
ADAPT NC PGM / TABLE	Import file of an iTNC 530	See the User's Manual for Setup, Testing and Running NC Programs
	Customize table view	357
NET	Manage network drives	See the User's Manual for Setup, Testing and Running NC Programs
SELECT EDITOR	Select the editor	115
SORT	Sort files by properties	114
COPY DIR	Copy a directory	111
DELETE ALL	Delete directory with all its subdirectories	
UPDATE TREE	Refresh directory	
RENAME ABC = XYZ	Rename a directory	
NEW DIRECTORY	Create a new directory	

Calling the file manager

PGM MGT

- Press the **PGM MGT** key
- > The control displays the file management window (see figure for default setting. If the control displays a different screen layout, press the **WINDOW** soft key).



The narrow window on the left shows the available drives and directories. Drives designate devices with which data are stored or transferred. A drive is the internal memory of the control. Other drives are the interfaces (RS232, Ethernet) to which you can connect a PC for example. A directory is always identified by a folder symbol to the left and the directory name to the right. Subdirectories are shown to the right of and below their parent directories. If there are subdirectories, you can show or hide them using the **-/+** key.

If the directory tree is longer than the screen, navigate using the scroll bar or a connected mouse.

The wide window on the right shows you all files that are stored in the selected directory. Each file is shown with additional information, illustrated in the table below.

Display	Meaning
File name	File name and file type
Bytes	File size in bytes
Status	File properties:
E	File is selected in the **Programming** operating mode
S	File is selected in the **Test Run** operating mode
M	The file is selected in a Program Run operating mode
+	File has non-displayed dependent files with the extension DEP, e.g. with use of the tool usage test
	File is protected against erasing and editing
	File is protected against erasing and editing, because it is being run
Date	Date that the file was last edited
Time	Time that the file was last edited

To display the dependent files, set the machine parameter **dependentFiles** (no. 122101) to **MANUAL**.

Selecting drives, directories and files

PGM MGT

- Call the file manager by pressing the **PGM MGT** key

Navigate with a connected mouse or use the arrow keys or the soft keys to move the cursor to the desired position on the screen:

- Moves the cursor from the left to the right window, and vice versa

- Moves the cursor up and down within a window

PAGE

PAGE

- Moves the cursor one page up or down within a window

Step 1: Select drive

- Move the highlight to the desired drive in the left window

SELECT

- Select a drive: Press the **SELECT** soft key, or

ENT

- Press the **ENT** key

Step 2: Select a directory

- Move the highlight to the desired directory in the left window
- > The right-hand window automatically shows all files stored in the highlighted directory

Step 3: Select a file

- Press the **SELECT TYPE** soft key
- Press the **SHOW ALL** soft key
- Move the highlight to the desired file in the right window
- Press the **SELECT** soft key, or
- Press the **ENT** key
- > The control opens the selected file in the operating mode from which you called the file manager.

> If you enter the first letter of the file you are looking for in the file manager, the cursor automatically jumps to the first NC program with the same letter.

Filtering the display

To filter the displayed files, proceed as follows:

- Press the **SELECT TYPE** soft key
- Press the soft key for the desired file type

Alternative:

- Press the **SHOW ALL** soft key
- > The control displays all files in this folder.

Alternative:

- Use wildcards, such as **4*.H**
- > The control will show all files of file type .h whose name starts with 4.

Alternative:

- Enter the file name extension, e.g. ***.H;*.D**
- > The control will show all files of file type .h and .d.

Any display filter you have set will remain effective even after a control restart,

Creating a new directory

- Move the highlight in the left window to the directory in which you want to create a subdirectory

- Press the **NEW DIRECTORY** soft key
- Enter a directory name

- Press the **ENT** key

- Press the **OK** soft key to confirm or

- Press the **CANCEL** soft key to abort

Creating new file

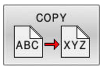
- Select the directory in the left window in which you wish to create the new file
- Position the cursor in the right window

- Press the **NEW FILE** soft key
- Enter the file name with extension

- Press the **ENT** key

Copying a single file

- Move the cursor to the file you wish to copy



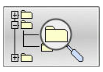
- Press the **COPY** soft key to select the copying function
- > The control opens a pop-up window.

Copying files into the current directory

- Enter the name of the destination file.

- Press the **ENT** key or the **OK** soft key
- > The control copies the file to the active directory. The original file is retained.

Copying files into another directory



- Press the **Target Directory** soft key to select the target directory from a pop-up window

- Press the **ENT** key or the **OK** soft key
- > The control copies the file under the same name to the selected directory. The original file is retained.

> **i** When you start the copying process with the **ENT** key or the **OK** soft key, the control displays a pop-up window with a progress indicator.

Copying files into another directory

- Select a screen layout with two equally sized windows

In the right window

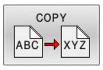
- Press the **SHOW TREE** soft key
- Move the cursor to the directory into which you wish to copy the files, and display the files in this directory with the **ENT** key

In the left window

- Press the **SHOW TREE** soft key
- Select the directory with the files that you want to copy, and display the files with the **SHOW FILES** soft key

- Press the Tag soft key: Call the file tagging functions

- Press the Tag soft key: Position the cursor on the file you wish to copy and tag. You can tag several files in this way, if desired



- Press the Copy soft key: Copy the tagged files into the target directory

Further information: "Tagging files", Page 113

If you have tagged files in both the left and right windows, the control copies from the directory in which the cursor is located.

Overwriting files

If you copy files to a directory in which other files are stored under the same name, the control will ask whether the files in the target directory should be overwritten:

- Overwrite all files (**Existing files** field selected): Press the **OK** soft key, or
- To leave the files as they are, press the **CANCEL** soft key

If you want to overwrite a protected file, select the **Protected files** field, or cancel the process.

Copying a table

Importing lines to a table

If you are copying a table into an existing table, you can overwrite individual lines with the **REPLACE FIELDS** soft key. Prerequisites:

- The target table must exist
- The file to be copied must only contain the lines you want to replace
- Both tables must have the same file extension

NOTICE

Caution: Data may be lost!

The **REPLACE FIELDS** function overwrites all lines of the target file that are contained in the copied table without a confirmation prompt. The original file is not automatically backed up by the control before the replacement process. As a consequence, tables may be irreversibly damaged.

- ▶ Back up the tables, if required, before you start the replacement
- ▶ Be accordingly careful when using **REPLACE FIELDS**

Example

With a tool presetter you have measured the length and radius of ten new tools. The tool presetter then generates the TOOL_Import.T tool table with 10 lines (for the 10 tools).

Proceed as follows:

- ▶ Copy this table from the external data medium to any directory
- ▶ Copy the externally created table to the existing table TOOL.T using the control's file manager.
- > The control asks you whether you want to overwrite the existing TOOL.T tool table.
- ▶ Press the **YES** soft key
- > The control will completely overwrite the current TOOL.T tool table. After this copying process the new TOOL.T table consists of 10 lines.
- ▶ Alternative: Press the **REPLACE FIELDS** soft key
- > The control overwrites the 10 lines in the TOOL.T file. The data of the other lines is not changed.

Extracting lines from a table

You can select one or more lines in a table and save them in a separate table.

Proceed as follows:

- ▶ Open the table from which you want to copy lines
- ▶ Use the arrow keys to select the first line to be copied
- ▶ Press the **MORE FUNCTIONS** soft key
- ▶ Press the **TAG** soft key
- ▶ Select additional lines, if required
- ▶ Press the **SAVE AS** soft key
- ▶ Enter a name for the table in which the selected lines are to be saved

Copying a directory

- ▶ Move the highlight in the right window onto the directory you want to copy
- ▶ Press the **COPY** soft key
- > The control opens the window for selecting the target directory.
- ▶ Select the target directory and confirm with the **ENT** key or the **OK** soft key
- > The control copies the selected directory and all its subdirectories to the selected target directory.

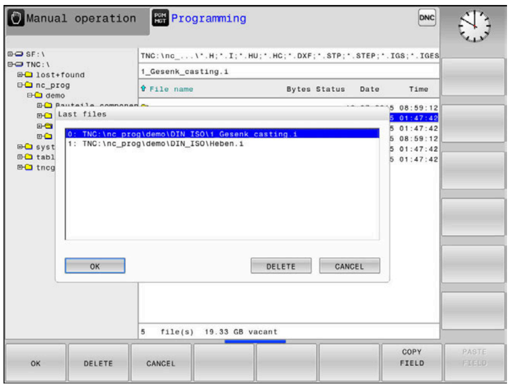
Choosing one of the last files selected

PGM MGT

▶ Call the file manager: Press the **PGM MGT** key.

LAST FILES

▶ Display the last ten files selected: Press the **LAST FILES** soft key



Press the arrow keys to move the cursor to the file you wish to select:

↑ ↑

▶ Moves the cursor up and down within a window

OK

▶ Select the file: Press the **OK** soft key, or

ENT

▶ Press the **ENT** key

> The **COPY FIELD** soft key allows you to copy the path of a marked file. You can reuse the copied path later (e.g., when calling a program with the **PGM CALL** key).

Deleting a file

NOTICE

Caution: Data may be lost!

The **DELETE** function permanently deletes the file. The control does not perform an automatic backup of the file prior to deletion (e.g., there is no recycle bin). Files are thereby irreversibly deleted.

- Regularly back up important data to external drives

Proceed as follows:

- Move the cursor to the file you want to delete

- Press the **DELETE** soft key
- > The control asks whether you want to delete the file.
- Press the **OK** soft key
- > The control deletes the file.
- Alternative: Press the **CANCEL** soft key
- > The control aborts the procedure.

Deleting a directory

NOTICE

Caution: Data may be lost!

The **DELETE ALL** function permanently deletes all files of the directory. The control does not perform an automatic backup of the files prior to deletion (e.g., there is no recycle bin). Files are thereby irreversibly deleted.

- Regularly back up important data to external drives

Proceed as follows:

- Move the cursor to the directory you want to delete

- Press the **DELETE ALL** soft key
- > The control inquires whether you really intend to delete the directory and all its subdirectories and files.
- Press the **OK** soft key
- > The control deletes the directory.
- Alternative: Press the **CANCEL** soft key
- > The control aborts the procedure.

Tagging files

Soft key	Tagging function
TAG FILE	Tag a single file
TAG ALL FILES	Tag all files in the directory
UNTAG FILE	Untag a single file
UNTAG ALL FILES	Untag all files
COPY ABC → XYZ	Copy all tagged files

Some functions, such as copying or erasing files, can not only be used for individual files, but also for several files at once. To tag several files, proceed as follows:

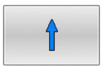
- Move the cursor to the first file

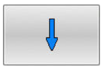
TAG

- To display the tagging functions, press the **TAG** soft key

TAG FILE

- To tag a file, press the **TAG FILE** soft key



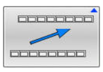


- Move the cursor to other files

TAG FILE

- To tag another file, press the **TAG FILE** soft key, etc.

To copy tagged files:

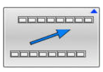


- Leave the active soft-key row

COPY ABC → XYZ

- Press the **COPY** soft key

To delete tagged files:



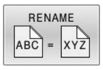
- Leave the active soft-key row

DELETE

- Press the **DELETE** soft key

Renaming a file

- Move the cursor to the file you wish to rename



- Select the function for renaming: Press the **RENAME** soft key
- Enter the new file name; the file type cannot be changed
- To rename: Press the **OK** soft key or the **ENT** key

Sorting files

- Select the folder in which you wish to sort the files

- Press the **SORT** soft key
- Select the soft key with the corresponding display criterion
  - **SORT BY NAME**
  - **SORT BY SIZE**
  - **SORT BY DATE**
  - **SORT BY TYPE**
  - **SORT BY STATUS**
  - **UNSORTED**

Additional functions

Protecting a file and canceling file protection

- Place the cursor on the file you want to protect

- Select the additional functions:
  Press the **MORE FUNCTIONS** soft key

- Activate file protection:
  Press the **PROTECT** soft key

> The file is tagged with the "protected" symbol.

- Cancel file protection:
  Press the **UNPROTECT** soft key

Selecting the editor

- Place the cursor on the file you want to open

- Select the additional functions:
  Press the **MORE FUNCTIONS** soft key

- Select the editor:
  Press the **SELECT EDITOR** soft key
- Mark the desired editor
  - **TEXT EDITOR** for text files (e.g., **.A** or **.TXT**)
  - **PROGRAM EDITOR** for NC programs **.H** and **.I**
  - **TABLE EDITOR** for tables (e.g., **.TAB** or **.T**)
  - **BPM EDITOR** for pallet tables **.P**
- Press the **OK** soft key

Connecting and removing USB storage devices

The control automatically detects connected USB devices with a supported file system.

To remove a USB device, proceed as follows:

- Move the cursor to the left-hand window
- Press the **MORE FUNCTIONS** soft key
- Remove the USB device

Further information: User's Manual for **Setup, Testing and Running NC Programs**

ADVANCED ACCESS RIGHTS

The **ADVANCED ACCESS RIGHTS** function can only be used in connection with user administration. This function requires the **public** directory.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Upon the first activation of user administration, the **public** directory below the TNC partition will be connected.

> Access rights can only be defined for files located in the **public** directory.
>
> For all files stored on the TNC partition instead of the **public** directory, the **user** function user will automatically be assigned as the owner.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

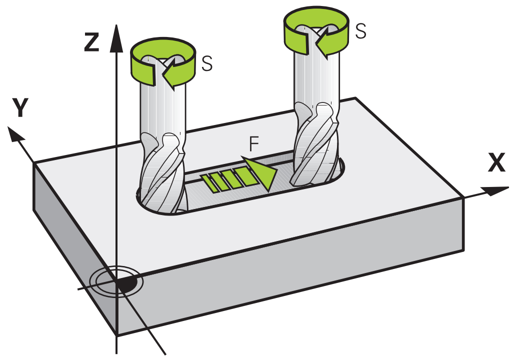
4

Tools

4.1 Entering tool-related data

Feed rate F

The feed rate **F** is the speed at which the tool center point moves. The maximum feed rates can be different for the individual axes and are set in machine parameters.



Input

You can enter the feed rate in the **T** block and in every positioning block.

Further information: "Programming tool movements in DIN/ISO", Page 92

You enter the feed rate **F** in mm/min in millimeter programs, and in 1/10 inch/min in inch-programs, for resolution reasons.

Rapid traverse

If you wish to program rapid traverse, enter **G00.**

> To move your machine at rapid traverse, you can also program the corresponding numerical value, e.g. **G01 F30000**. Unlike **G00**, this rapid traverse remains in effect not only in the individual block but in all blocks until you program a new feed rate.

Duration of effect

A feed rate entered as a numerical value remains in effect until an NC block with a different feed rate is reached. **G00** is only effective in the NC block in which it is programmed. After the NC block with **G00** is executed, the feed rate will return to the last feed rate entered as a numerical value.

Changing during program run

You can adjust the feed rate during the program run with the feed rate potentiometer F.

The feed-rate potentiometer only reduces the programmed feed rate, and not the feed rate calculated by the control.

Spindle speed S

The spindle speed S is entered in revolutions per minute (rpm) in a **T** block (tool call). Instead, you can also define the cutting speed Vc in meters per minute (m/min).

Programmed change

In the NC program, you can change the spindle speed in a **T** block by entering only the new spindle speed.

Proceed as follows:

S

- Press the **S** key on the alphabetic keyboard
- Enter the new spindle speed

> In the following cases the control changes only the speed:
> - **T** block without tool name, tool number, and tool axis
> - **T** block without tool name, tool number, with the same tool axis as in the previous **T** block
>
> In the following cases the control runs the tool-change macro and inserts a replacement tool if necessary:
> - **T** block with tool number
> - **T** block with tool name
> - **T** block without tool name or tool number, with a changed tool axis direction

Changing during program run

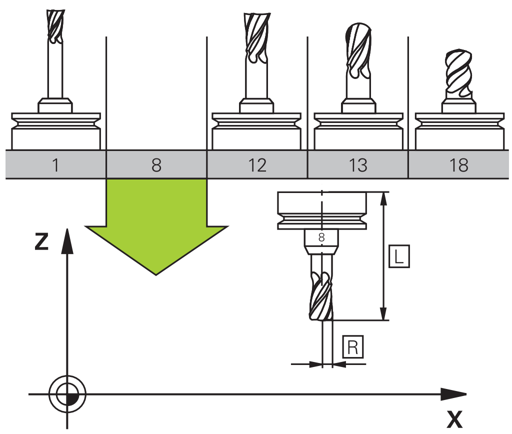
You can adjust the spindle speed during program run with the spindle speed potentiometer S.

4.2 Tool data

Requirements for tool compensation

You usually program the coordinates of path contours as they are dimensioned in the workpiece drawing. To allow the control to calculate the tool center path (i.e. the tool compensation) you must also enter the length and radius of each tool you are using.

You can enter tool data either directly in the NC program with **G99** or separately in a tool tables. In a tool table, you can also enter additional data for the specific tool. The control will consider all the data entered for the tool when executing the NC program.



Tool number, tool name

Each tool is identified by a number between 0 and 32767. If you are working with tool tables, you can also enter a tool name for each tool. Tool names can have up to 32 characters.

Permitted characters: # $ % & , - _ . 0 1 2 3 4 5 6 7 8 9 @ A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

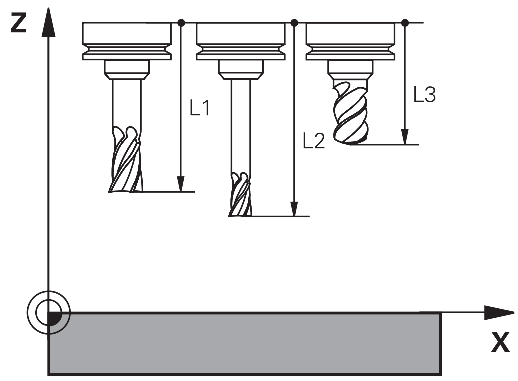
The control automatically replaces lowercase letters with corresponding uppercase letters during saving.

Impermissible characters: <blank space> ! " ' ( ) * + : ; < = > ? [/] ^ ` { | } ~

The tool number 0 is automatically defined as the zero tool with the length L=0 and the radius R=0. In tool tables, tool T0 should also be defined with L=0 and R=0.

Tool length L

Always enter the tool length **L** as an absolute value based on the tool reference point.



The absolute tool length is essential for the control in order to perform numerous functions (e.g., material removal simulation or **Dynamic Collision Monitoring (DCM)**).

The absolute length of the touch probe is always referenced to the tool reference point. The machine tool builder usually defines the spindle nose as the tool reference point.

Measuring the tool length

You can measure your tools in the machine (e.g., with a tool touch probe) or externally with a tool presetter. If such measurements are not possible, you can determine the tool length.

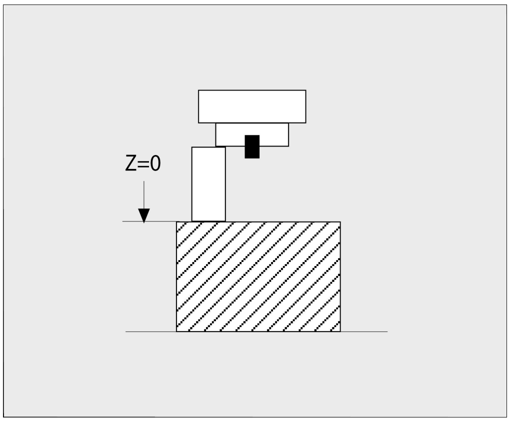
You have the following options for determining the tool length:

- With a gauge block
- With a calibration pin (inspection tool)

> Before you determine tool length, you have to set the preset in the spindle axis.

Determining the tool length with a gauge block

> You can only set the preset with a gauge block if the tool reference point is at the spindle nose.
>
> Place the preset on the surface you want to touch off with the tool. This surface might have to be created first.



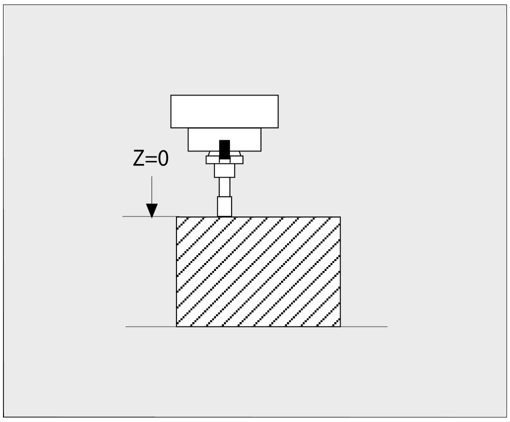
Proceed as follows to set the datum with a gauge block:

- ▶ Place the gauge block on the machine table
- ▶ Position the spindle nose next to the gauge block
- ▶ Gradually move in **Z+** direction until you can just slide the gauge block under the spindle nose
- ▶ Set the datum in **Z**

To determine the tool length, proceed as follows:

- ▶ Insert the tool
- ▶ Touch off the surface
- > The control displays the absolute tool length as the actual position in the position display.

Determining the tool length with a calibration pin and a tool setter



Proceed as follows to set the preset with a calibration pin and a tool setter:

- ▶ Clamp the tool setter onto the machine table.
- ▶ Bring the flexible inner ring of the tool setter to the same height as the fixed outer ring.
- ▶ Set the gauge to 0
- ▶ Move the calibration pin onto the flexible inner ring.
- ▶ Set the datum in **Z**

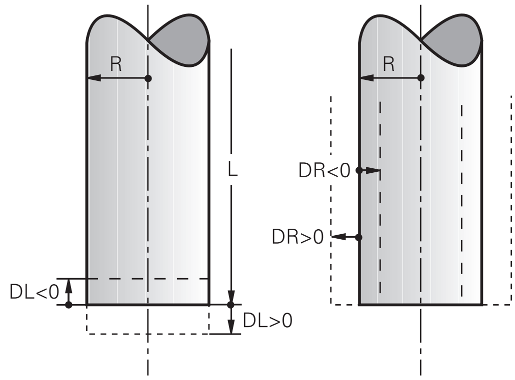
To determine the tool length, proceed as follows:

- ▶ Insert the tool
- ▶ Move the tool onto the flexible inner ring until the gauge displays 0.
- > The control displays the absolute tool length as the actual position in the position display.

Tool radius R

You can enter the tool radius R directly.

Delta values for lengths and radii



Delta values are offsets in the length and radius of a tool.

A positive delta value represents a tool oversize (**DL**, **DR**>0). For a machining operation with an oversize, enter the value for the oversize in the NC program with **T** or with the help of a compensation table.

A negative delta value describes a tool undersize (**DL**, **DR**<0). An undersize is entered in the tool table for wear.

Delta values are usually entered as numerical values. In a **T** block, you can also assign the values to Q parameters.

Input range: You can enter a delta value with up to ± 99.999 mm.

> Delta values from the tool table influence the graphical representation of the clearing simulation.
>
> Delta values from the NC program do not change the depicted size of the **tool** in the simulation. However, the programmed delta values move the **tool** in the simulation by the amount of the defined value.

> Delta values from the **T** block influence the position display depending on the optional machine parameter **progToolCallDL** (no. 124501; branch **CfgPositionDisplay** no. 124500).

Entering tool data into the NC program

> Refer to your machine manual!
>
> The machine tool builder determines the scope of functions of the **G99** function.

The number, length, and radius of a specific tool are defined in the **G99** block of the NC program:

Proceed as follows for the definition:

TOOL DEF

- press the **TOOL DEF** key.
- **Tool length**: Compensation value for the tool length
- **Tool radius**: Compensation value for the tool radius

Example

```
N40 G99 T5 L+10 R+5*
```

Calling the tool data

Before you can call the tool, you have to define it in a **G99** block or in the tool table.

A **T** in the NC program is programmed with the following data:

- Press the **TOOL CALL** key
- **Tool number**: Enter the number or name of the tool. With the **TOOL NAME** soft key, you can enter a name. With the **QS** soft key, you enter a string parameter. The control automatically puts the tool name in quotation marks. You must first assign a tool name to a string parameter. The names refer to an entry in the active tool table TOOL.T.

- Alternative: Press the **SELECT** soft key
- > The control opens a window where you can select a tool directly from the TOOL.T tool table.
- To call a tool with other compensation values, enter a decimal point followed by the index you defined in the tool table.
- **Working spindle axis X/Y/Z**: Enter the tool axis
- **Spindle speed S**: Enter the spindle speed S in revolutions per minute (rpm) Alternatively, you can define the cutting speed Vc in meters per minute (m/min). Press the **VC** soft key
- **Feed rate F**: Enter feed rate **F** in millimeters per minute (mm/min). The feed rate is effective until you program a new feed rate in a positioning block or in a **T** block
- **Tool length oversize DL**: Enter the delta value for the tool length
- **Tool radius oversize DR**: Enter the delta value for the tool radius
- **Tool radius oversize DR2**: Enter the delta value for the tool radius 2

In the following cases the control changes only the speed:

- **T** block without tool name, tool number, and tool axis
- **T** block without tool name, tool number, with the same tool axis as in the previous **T** block

In the following cases the control runs the tool-change macro and inserts a replacement tool if necessary:

- **T** block with tool number
- **T** block with tool name
- **T** block without tool name or tool number, with a changed tool axis direction

Tool selection in the pop-up window

If you open a pop-up window for tool selection, the control marks all tools available in the tool magazine green.

You can search for a tool in the pop-up window:

GOTO

- Press the **GOTO** key
- Alternative: Press the **FIND** soft key
- Enter the tool name or tool number

ENT

- Press the **ENT** key
- > The control goes to the first tool that matches the entered search string.

The following functions can be used with a connected mouse:

- You can sort the data in ascending or descending order by clicking a column of the table head.
- You can arrange the columns in any sequence you want by clicking a column of the table head and then moving it with the mouse key pressed down

The pop-up windows displayed for a tool number search and a tool name search can be configured separately. The sort order and the column widths are retained when the control is switched off.

Tool call

Call tool number 5 in the tool axis Z with a spindle speed of 2500 rpm and a feed rate of 350 mm/min. The tool length and tool radius 2 are to be programmed with an oversize of 0.2 and 0.05 mm, the tool radius with an undersize of 1 mm.

Example

```
N20 T  5.2 G17  S2500 DL+0.2  DR-1*
```

The character **D** preceding **L**, **R** and **R2** designates delta values.

Preselection of tools

> Refer to your machine manual!
> The preselection of tools with **G51** can vary depending on the individual machine tool.

If you are working with tool tables, use a **G51** block to preselect the next tool. Simply enter the tool number, or a Q parameter, or type the tool name in quotation marks.

Tool change

Automatic tool change

Refer to your machine manual!

The tool change function can vary depending on the individual machine tool.

If your machine tool has automatic tool changing capability, the program run is not interrupted. When the control reaches a tool call with **T**, it replaces the inserted tool by another from the tool magazine.

Automatic tool change if the tool life expires: M101

Refer to your machine manual!

The function of **M101** can vary depending on the individual machine tool.

When the specified tool life has expired, the control can automatically insert a replacement tool and continue machining with it. Activate the miscellaneous function **M101** for this. **M101** is reset with **M102.**

Enter the respective tool life after which machining is to be continued with a replacement tool in the **TIME2** column of the tool table. In the **CUR_TIME** column the control enters the current tool life.

If the current tool life is higher than the value entered in the **TIME2** column, a replacement tool will be inserted at the next possible point in the program no later than one minute after expiration of the tool life. The change is made only after the NC block has been completed.

NOTICE

Danger of collision!

During an automatic tool change with **M101**, the control always retracts the tool in the tool axis first. There is danger of collision when retracting tools for machining undercuts, such as side milling cutters or T-slot milling cutters!

- Deactivate the tool change with **M102**

After the tool change the control positions the tool according to the following logic, unless otherwise specified by the machine tool builder:

- If the target position in the tool axis is below the current position, the tool axis is positioned last
- If the target position in the tool axis is above the current position, the tool axis is positioned first

Input parameter BT (block tolerance)

Depending on the NC program, the machining time can increase as a result of the tool life verification and calculation of the automatic tool change. You can influence this with the optional input parameter **BT** (block tolerance).

If you enter the **M101** function, the control continues the dialog by requesting **BT**. Here you define the number of NC blocks (1 to 100) by which the automatic tool change may be delayed. The resulting time period by which the tool change is delayed depends on the content of the NC blocks (e.g. feed rate, path). If you do not define **BT**, the control uses the value 1 or, if applicable, a default value defined by the machine manufacturer.

> The higher the value of **BT**, the smaller will be the effect of an extended program duration through the **M101** function. Please note that this will delay the automatic tool change!
>
> Use the formula **BT = 10: Average machining time of an NC block in seconds** to calculate a suitable starting value for **BT**. Round the result up to an integer value. If the calculated result is greater than 100, use the maximum input value of 100.
>
> If you want to reset the current age of a tool (e.g. after changing the indexable inserts), enter the value 0 in the CUR_TIME column.

Prerequisites for a tool change with M101

> As replacement tools, use only tools with the same radius. The control does not automatically check the radius of the tool.
>
> If you want the control to check the radius of the replacement tool, enter **M108** in the NC program.

The control performs the automatic tool change at a suitable point in the program. The automatic tool change is not performed:

- During execution of machining cycles
- While radius compensation (**G41**/**G42**) is active
- Directly after an approach function **APPR**
- Directly before a departure function **DEP**
- Directly before and after **G24** and **G25**
- During execution of macros
- During execution of a tool change
- Directly after a **T** block or **G99**
- During execution of SL cycles

Overtime for tool life

This function must be enabled and adapted by the machine tool builder.

The tool condition at the end of planned tool life depends on e.g. the tool type, machining method and workpiece material. In the **OVRTIME** column of the tool table, enter the time in minutes for which the tool is permitted to be used beyond the tool life.

The machine manufacturer specifies whether this column is enabled and how it is used during tool search.

Prerequisites for NC blocks with surface-normal vectors and 3-D compensation

The active radius (**R** + **DR**) of the replacement tool must not deviate from the radius of the original tool. You can enter the delta values (**DR**) either in the tool table or in the NC program (compensation table or **T** block). If deviations occur, the control displays a message and does not replace the tool. You can suppress this message with the M function **M107,** and reactivate it with **M108.**

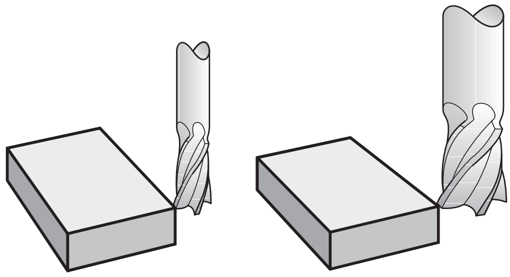
4.3 Tool compensation

Introduction

The control adjusts the tool path by the compensation value for the tool length in the spindle axis. In the machining plane, it compensates the tool radius.

If you are writing the NC program directly on the control, the tool radius compensation is effective only in the working plane.

The control accounts for the compensation value in up to five axes including the rotary axes.



Tool length compensation

Length compensation becomes effective automatically as soon as a tool is called. To cancel length compensation, call a tool with the length L=0 (e.g. **T 0**).

NOTICE

Danger of collision!

The control uses the defined tool lengths for tool length compensation. Incorrect tool lengths will result in an incorrect tool length compensation. The control does not perform a length compensation and a collision check for tools with a length of **0** and after **T 0**. Danger of collision during subsequent tool positioning movements!

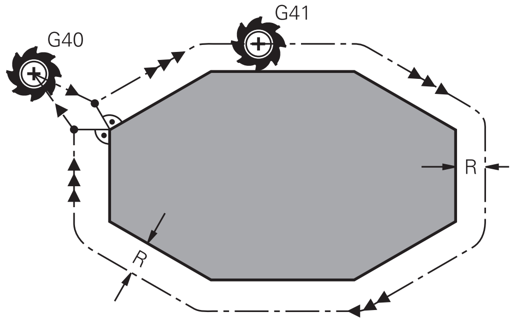
- Always define the actual tool length of a tool (not just the difference)
- Use **T 0** only to empty the spindle

With length compensation, delta values from both the NC program and the tool table are considered.

Compensation value = **L** + $\mathbf{DL}_{TAB}$ + $\mathbf{DL}_{Prog}$ with

L:	Tool length **L** from **G99** block or tool table
$\mathbf{DL}_{TAB}$:	Oversize for length **DL** in the tool table
$\mathbf{DL}_{Prog}$:	Oversize **DL** for length from **T** block or from the compensation table The most recently programmed value takes effect. **Further information:** "Compensation table", Page 339

Tool radius compensation



An NC block can contain the following types of tool radius compensation:

- **G41** or **G42** for radius compensation of any contouring function
- **G40**, if there is no radius compensation

> The control shows an active tool compensation in the general status display.

The radius compensation takes effect as soon as a tool is called and is moved with one of the abovementioned types of tool radius compensation within a straight-line block or within a paraxial movement in the working plane.

> The control automatically cancels radius compensation in the following cases:
> - Straight-line block with **G40**
> - **DEP** function for departing from the contour
> - Selection of a new NC program via **PGM MGT**

For radius compensation, the control takes the delta values from both the **T** block and the tool table into account:

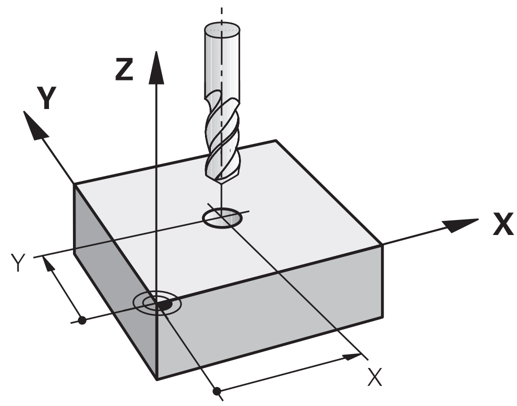
Compensation value = **R** + $\mathbf{DR}_{TAB}$ + $\mathbf{DR}_{Prog}$ with

R:	Tool radius **R** from **G99** block or tool table
$\mathbf{DR}_{TAB}$:	Oversize for radius **DR** in the tool table
$\mathbf{DR}_{Prog}$:	Oversize **DR** for radius from **T** block or from the compensation table **Further information:** "Compensation table", Page 339

Movements without radius compensation: G40

The tool center moves in the working plane to the programmed coordinate.

Applications: Drilling and boring, pre-positioning

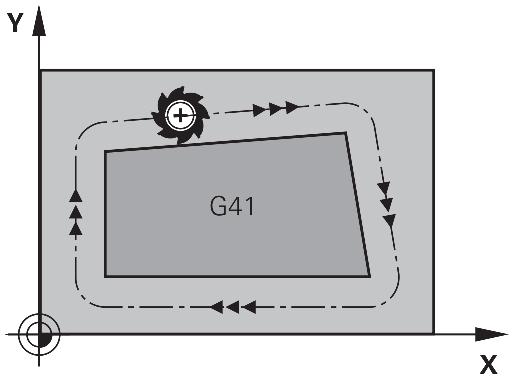


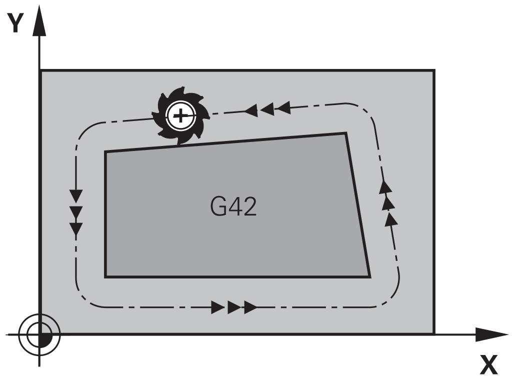
Contouring with radius compensation: G42 and G41

G42: The tool moves to the right of the programmed contour

G41: The tool moves to the left of the programmed contour

The tool center moves along the contour at a distance equal to the radius. **Right** or **left** are to be understood as based on the direction of tool movement along the workpiece contour.





> Between two NC blocks with different radius compensations **G42** and **G41** you must program at least one traversing block in the working plane without radius compensation (that is, with **G40**).
>
> The control does not put radius compensation into effect until the end of the NC block in which it is first programmed.
>
> When radius compensation is activated with **G42/G41**, and in the case of cancellation with **G40**, the control always positions the tool perpendicularly to the programmed start or end point. Position the tool before the first contour point or after the last contour point such that the contour does not incur damage.

Entering radius compensation

Radius compensation is entered in a **G01** block. Enter the coordinates of the target point and confirm your entry with the **ENT** key.

G41
- Select tool movement to the left of the programmed contour: Press the **G41** soft key, or

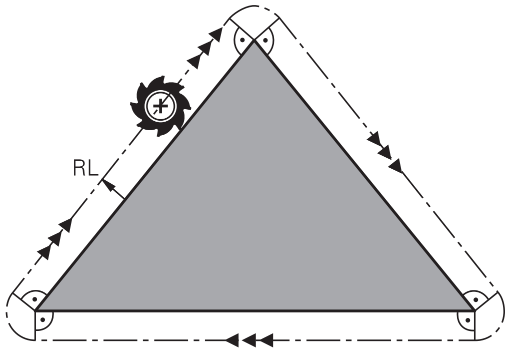
G42
- Select tool movement to the right of the contour: Press the **G42** soft key, or

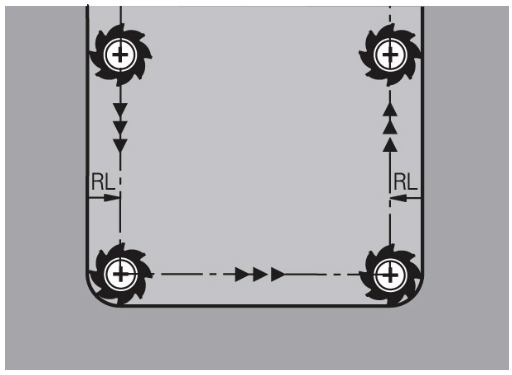
G40
- Select tool movement without radius compensation or cancel radius compensation: Select function **G40**

END
- Terminate the NC block: Press the **END** key

Radius compensation: Machining corners

- Outside corners:
  If you program radius compensation, the control moves the tool around outside corners on a transitional arc. If necessary, the control reduces the feed rate at outside corners to reduce machine stress, for example at very great changes of direction
- Inside corners:
  The control calculates the intersection of the tool center paths at inside corners under radius compensation. From this point it then starts the next contour element. This prevents damage to the workpiece at the inside corners. The permissible tool radius, therefore, is limited by the geometry of the programmed contour.





NOTICE

Danger of collision!

The control needs safe positions for contour approach and departure. These positions must enable the control to perform compensating movements when radius compensation is activated and deactivated. Incorrect positions can lead to contour damage. Danger of collision during machining!

- Program safe approach and departure positions at a sufficient distance from the contour
- Consider the tool radius
- Consider the approach strategy

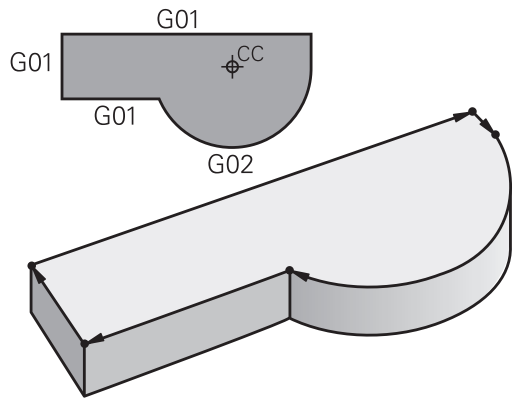
5

Programming contours

5.1 Tool movements

Path functions

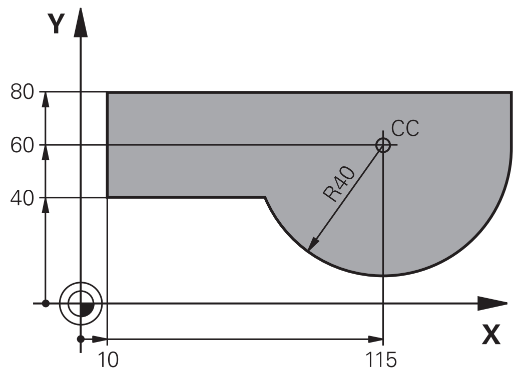
A workpiece contour is usually composed of several contour elements such as straight lines and circular arcs. With the path functions, you can program the tool movements for **straight lines** and **circular arcs**.



FK free contour programming (option 19)

If a production drawing is not dimensioned for NC and the dimensions given are not sufficient for creating a part program, you can program the workpiece contour with the FK free contour programming. The control calculates the missing data.

With FK programming, you also program tool movements for **straight lines** and **circular arcs**.



Miscellaneous functions M

With the control's miscellaneous functions you can affect

- the program run, e.g., a program interruption
- the machine functions, such as switching spindle rotation and coolant supply on and off
- the path behavior of the tool

Subprograms and program section repeats

If a machining sequence occurs several times in a program, you can save time and reduce the chance of programming errors by entering the sequence once and then defining it as a subprogram or program-section repeat. If you wish to execute a specific NC program section only under certain conditions, you also define this machining sequence as a subprogram. In addition, you can have an NC program call a separate NC program for execution.

Further information: "Subprograms and program section repeats", Page 235

Programming with Q parameters

Instead of programming numerical values in an NC program, you enter markers called Q parameters. You can use the Q parameters for programming mathematical functions that control program execution or describe a contour.

In addition, programming with Q parameters enables you to measure with the 3-D touch probe during the program run.

Further information: "Programming Q parameters", Page 253

5.2 Fundamentals of path functions

Programming tool movements for machining

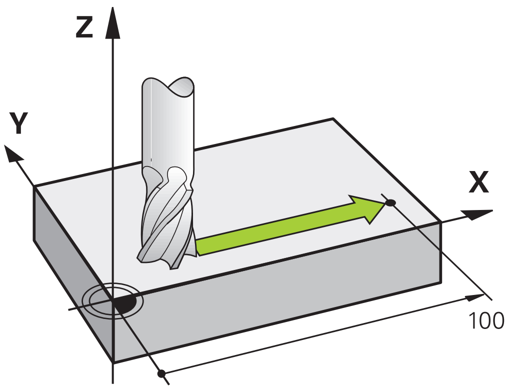
You create an NC program by programming the path functions for the individual contour elements in sequence You do this by entering the coordinates of the end points of the contour elements given in the production drawing. The control calculates the actual path of the tool from these coordinates, and from the tool data and radius compensation.

The control moves all machine axes programmed in the NC block of a path function simultaneously.

Movement parallel to the machine axes

If the NC block contains one coordinate, the control moves the tool parallel to the programmed machine axis.

Depending on the individual machine, the machining program is executed by movement of either the tool or the machine table on which the workpiece is clamped. Path contours are programmed as if the tool were moving.



Example

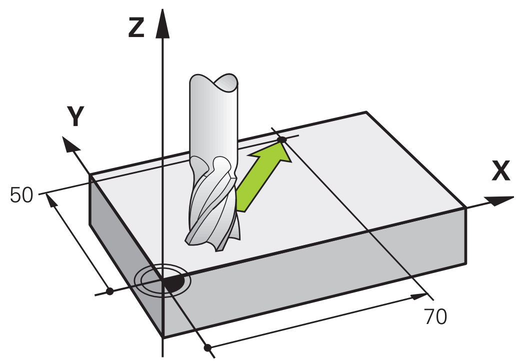
```
N50 G00 X+100*
```

N50	Block number
G00	Path function **straight line at rapid traverse**
X+100	Coordinate of the end point

The tool retains the Y and Z coordinates and moves to the position X=100.

Movement in the main planes

If the NC block contains two coordinates, the control moves the tool in the programmed plane.



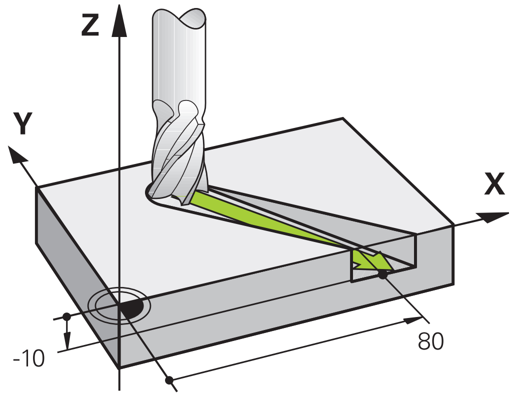
Example

```
N50 G00 X+70  Y+50*
```

The tool retains the Z coordinate and moves on the XY plane to the position X=70, Y=50.

Three-dimensional movement

If the NC block contains three coordinates, the control moves the tool spatially to the programmed position.



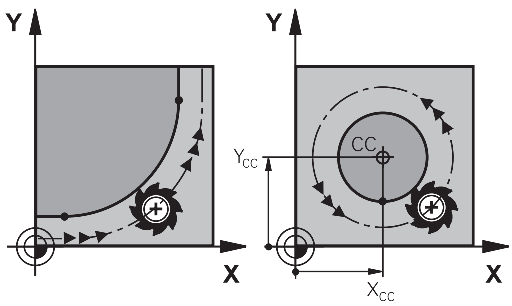
Example

```
N50 G01 X+80  Y+0 Z-10*
```

Circles and circular arcs

The control moves two machine axes simultaneously on a circular path relative to the workpiece. You can define a circular movement by entering the circle center with **I** and **J**.

Use the path functions for circular arcs to program circles in the working plane. You define the main plane based on the spindle axis in the **T**.



Spindle axis	Main plane
(G17)	**XY**, also UV, XV, UY
(G18)	**ZX**, also WU, ZU, WX
(G19)	**YZ**, also VW, YW, VZ

Circular motion in another plane

You can also use the **Tilt the working plane** function or Q parameters to program circular motions that do not lie in the main plane.

Further information: "The PLANE function: Tilting the working plane (option 8)", Page 369

Further information: "Principle and overview of functions", Page 254

Direction of rotation DR for circular movements

When a circular path has no tangential transition to another contour element, enter the direction of rotation as follows:

Clockwise direction of rotation: **G02/G12**

Counterclockwise direction of rotation: **G03/G13**

Radius compensation

The radius compensation must be in the NC block in which you move to the first contour element. You cannot activate radius compensation in an NC block for a circular path. It must be activated beforehand in a straight-line block.

Further information: "Path contours — Cartesian coordinates", Page 150

Pre-positioning

NOTICE

Danger of collision!

The control does not automatically check whether collisions can occur between the tool and the workpiece. Incorrect pre-positioning can also lead to contour damage. There is danger of collision during the approach movement!

- Program a suitable pre-position
- Check the sequence and contour with the aid of the graphic simulation

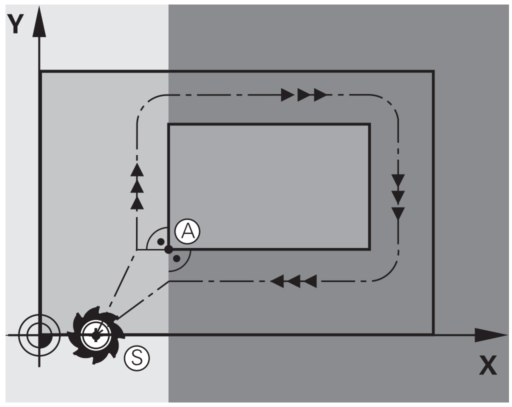
5.3 Approaching and departing a contour

Starting point and end point

The tool approaches the first contour point from the starting point. The starting point must be:

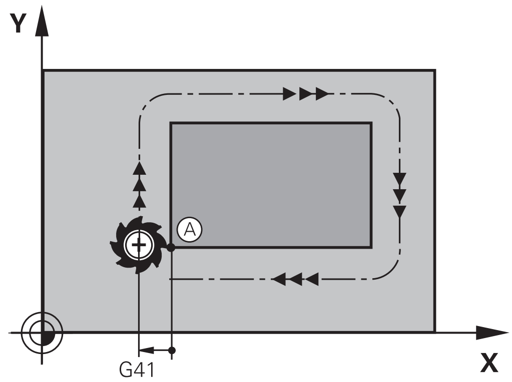
- Programmed without radius compensation
- Approachable without danger of collision
- Close to the first contour point

Example in the figure on the right:
If you set the starting point in the dark gray area, the contour will be damaged when the first contour element is approached.



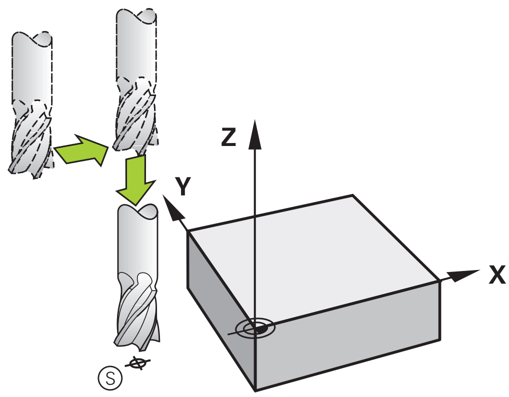
First contour point

You need to program a radius compensation for the tool movement to the first contour point.



Approaching the starting point in the spindle axis

When the starting point is approached, the tool must be moved to the working depth in the spindle axis. If danger of collision exists, approach the starting point in the spindle axis separately.



Example

```
N40 G00  Z-10*
N30 G01  X+20  Y+30  G41 F350*
```

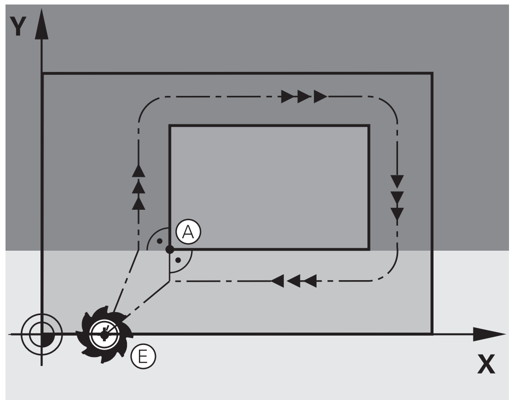
End point

The end point should be selected so that it is:

- Approachable without danger of collision
- Near to the last contour point
- In order to make sure the contour will not be damaged, the optimal ending point should lie on the extended tool path for machining the last contour element

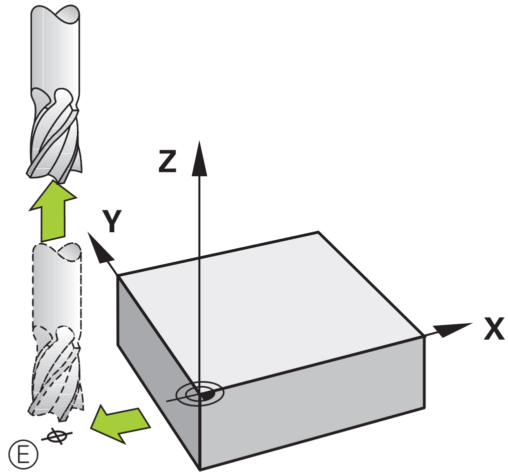
Example in the figure on the right:
If you set the end point in the dark gray area, the contour will be damaged when the end point is approached.

Departing the end point in the spindle axis:
Program the departure from the end point in the spindle axis separately.



Example

N50 G01 G40 X+60 Y+70 F700*
N60 G00 Z+250*

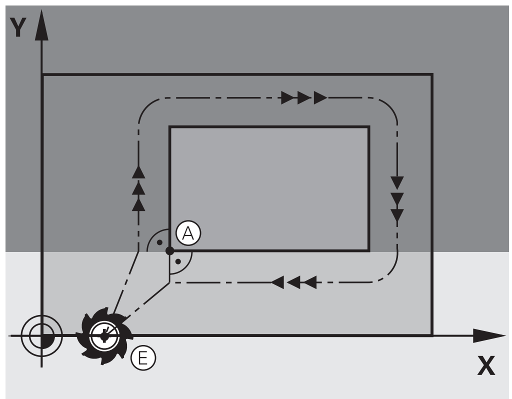


Common starting and end points

Do not program any radius compensation if the starting point and end point are the same.

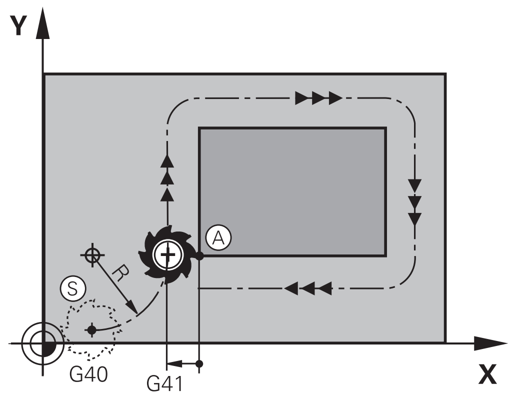
In order to make sure the contour will not be damaged, the optimal starting point should lie between the extended tool paths for machining the first and last contour elements.

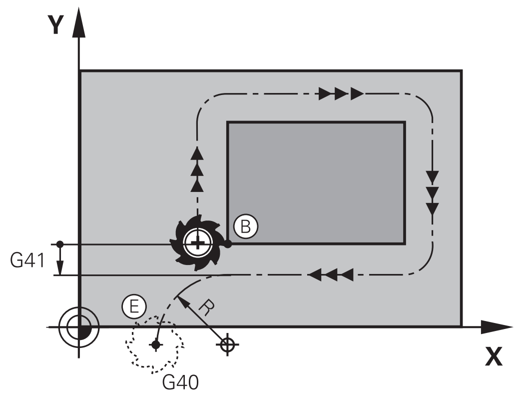
Example in the figure on the right:
If you set the end point in the dark gray area, the contour will be damaged when the contour is approached/departed.



Tangential approach and departure

With **G26** (figure at center right), you can program a tangential approach to the workpiece, and with **G27** (figure at lower right) a tangential departure. In this way you can avoid dwell marks.





Starting point and end point

The starting point and the end point lie outside the workpiece, close to the first and last contour points. They are to be programmed without radius compensation.

Approach

- **G26** is entered after the NC block in which the first contour element is programmed: This will be the first NC block with radius compensation **G41/G42**

Departure

- **G27** after the NC block in which the last contour element is programmed: This will be the last NC block with radius compensation **G41/G42**

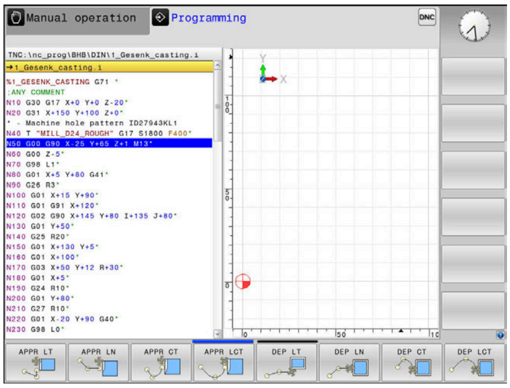
> The radius for **G26** and **G27** must be selected so that the control can execute the circular path between the starting point and the first contour point, as well as the last contour point and the end point.

Example

N50 G00 G40 G90 X-30 Y+50*	Starting point
N60 G01 G41 X+0 Y+50 F350*	First contour point
N70 G26 R5*	Tangential approach with radius R = 5 mm
. . .	
Program contour blocks	
. . .	Last contour point
N210 G27 R5*	Tangential departure with radius R = 5 mm
N220 G00 G40 X-30 Y+50*	End point

Overview: Types of paths for contour approach and departure

The functions for contour approach **APPR** and departure **DEP** are activated with the **APPR/DEP** key. You can then select the following path forms with the corresponding soft keys:



Approach	Departure	Function
APPR LT	DEP LT	Straight line with tangential connection
APPR LN	DEP LN	Straight line perpendicular to a contour point
APPR CT	DEP CT	Circular arc with tangential connection
APPR LCT	DEP LCT	Circular arc with tangential connection to the contour. Approach and departure to an auxiliary point outside the contour on a tangentially connecting line

Approaching and departing a helix

The tool approaches and departs a helix on its extension by moving in a circular arc that connects tangentially to the contour. You program helical approach and departure with the **APPR CT** and **DEP CT** functions.

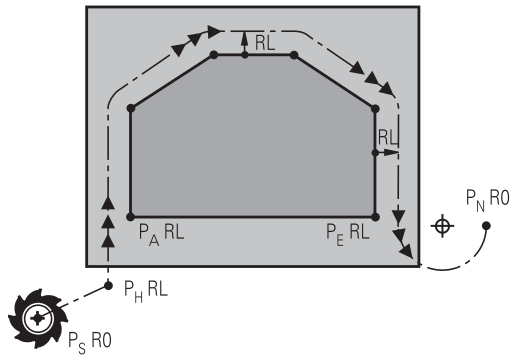
Important positions for approach and departure

NOTICE

Danger of collision!

The control traverses from the current position (starting point P_S) to the auxiliary point P_H at the last feed rate entered. If you programmed **G00** in the last positioning block before the approach function, the control also approaches the auxiliary point P_H at rapid traverse.

- Program a feed rate other than **G00** before the approach function



R0=G40; RL=G41; RR=G42

- Starting point P_S
  You program this position in the block before the APPR block. P_S lies outside the contour and is approached without radius compensation (G40).
- Auxiliary point P_H
  Some of the paths for approach and departure go through an auxiliary point P_H that the control calculates from your input in the APPR or DEP block.
- First contour point P_A and last contour point P_E
  You program the first contour point P_A in the APPR block. The last contour point P_E can be programmed with any path function. If the APPR block also includes the Z coordinate, the control moves the tool simultaneously to the first contour point P_A.
- End point P_N
  The position P_N lies outside of the contour and results from your input in the DEP block. If the DEP block also includes the Z coordinate, the control moves the tool simultaneously to the end point P_N.

Designation	Meaning
APPR	Approach
DEP	Departure
L	Line
C	Circle
T	Tangential (smooth connection)
N	Normal (perpendicular)

NOTICE

Danger of collision!

The control does not automatically check whether collisions can occur between the tool and the workpiece. Incorrect pre-positioning and incorrect auxiliary points P_H can also lead to contour damage. There is danger of collision during the approach movement!

- Program a suitable pre-position
- Check the auxiliary point P_H, the sequence and the contour with the aid of the graphic simulation

With the **APPR LT**, **APPR LN** and **APPR CT** functions, the control moves the tool to the auxiliary point P_H at the last programmed feed rate (which can also be **FMAX**). With the **APPR LCT** function, the control moves to the auxiliary point P_H at the feed rate programmed with the APPR block. If no feed rate is programmed yet before the approach block, the control generates an error message.

Polar coordinates

You can also program the contour points for the following approach/departure functions over polar coordinates:

- APPR LT becomes APPR PLT
- APPR LN becomes APPR PLN
- APPR CT becomes APPR PCT
- APPR LCT becomes APPR PLCT
- DEP LCT becomes DEP PLCT

Select by soft key an approach or departure function, then press the orange **P** key.

Radius compensation

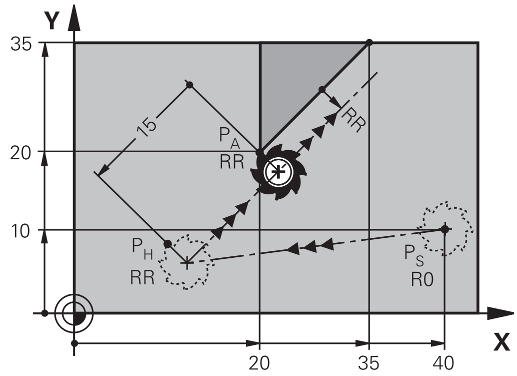
The tool radius compensation is programmed together with the first contour point P_A in the APPR block. The DEP blocks automatically discard the tool radius compensation.

If you program **APPR LN** or **APPR CT** with **G40**, the control stops the machining/simulation with an error message.

This method of function differs from the iTNC 530 control!

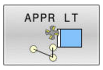
Approaching on a straight line with tangential connection: APPR LT

The tool moves on a straight line from the starting point P_S to an auxiliary point P_H. It then moves to the first contour point P_A on a straight line that connects tangentially to the contour. The auxiliary point P_H is separated from the first contour point P_A by the distance **LEN**.



R0=G40; RL=G41; RR=G42

- Use any path function to approach the starting point P_S
- Initiate the dialog with the **APPR DEP** key and **APPR LT** soft key



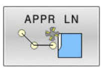
  - Coordinates of the first contour point P_A
  - **LEN**: Distance from the auxiliary point P_H to the first contour point P_A
  - Radius compensation **G41/G42** for machining

Example

N70 G00 X+40 Y+10 G40 M3*	Approach P_S without radius compensation
N80 APPR LT X+20 Y+20 Z-10 LEN15 G42 F100*	P_A with radius comp. G42, distance P_H to P_A: LEN=15
N90 G01 X+35 Y+35*	End point of the first contour element
N100 G01 ...*	Next contour element

Approaching on a straight line perpendicular to the first contour point: APPR LN

- Use any path function to approach the starting point P_S.
- Initiate the dialog with the **APPR DEP** key and **APPR LN** soft key:

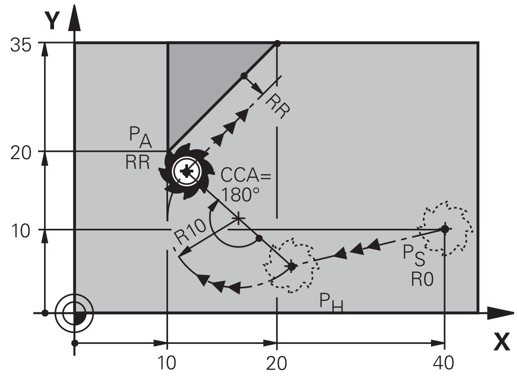


  - Coordinates of the first contour point P_A
  - Length: Distance to the auxiliary point P_H. Always enter **LEN** as a positive value
  - Radius compensation **G41/G42** for machining

Example

N70 G00 X+40 Y+10 G40 M3*	Approach PS without radius compensation
N80 APPR LN X+10 Y+20 Z-10 LEN15 G24 F100*	PA with radius comp. G42
N90 G01 X+20 Y+35*	End point of the first contour element
N100 G01 ...*	Next contour element

Approaching on a circular path with tangential connection: APPR CT

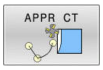


R0=G40; RL=G41; RR=G42

The tool moves on a straight line from the starting point P_S to an auxiliary point P_H. It then moves from PH to the first contour point PA following a circular arc that is tangential to the first contour element.

The arc from P_H to P_A is determined through the radius R and the center angle **CCA**. The direction of rotation of the circular arc is automatically derived from the tool path for the first contour element.

- Use any path function to approach the starting point P_S.
- Initiate the dialog with the **APPR DEP** key and **APPR CT** soft key



- Coordinates of the first contour point P_A
- Radius R of the circular arc
  - If the tool should approach the workpiece in the direction defined by the radius compensation: Enter R as a positive value
  - If the tool should approach the workpiece opposite to the radius compensation: Enter R as a negative value.
- Center angle **CCA** of the arc
  - CCA can be entered only as a positive value.
  - Maximum input value 360°
- Radius compensation **G41/G42** for machining

Example

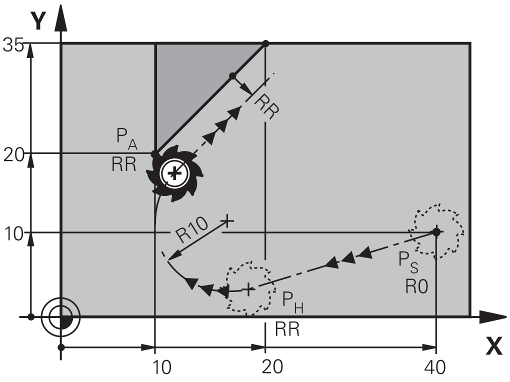
N70 G00 X+40 Y+10 G40 M3*	Approach PS without radius compensation
N80 APPR CT X+10 Y+20 Z-10 CCA180 R+10 G42 F100*	PA with radius comp. G42, radius R=10
N90 G01 X+20 Y+35*	End point of the first contour element
N100 G01 ...*	Next contour element

Approaching on a circular path with tangential connection from a straight line to the contour: APPR LCT

The tool moves on a straight line from the starting point P_S to an auxiliary point P_H. It then moves to the first contour point P_A on a circular arc. The feed rate programmed in the APPR block is effective for the entire path that the control traversed in the approach block (path P_S to P_A).

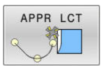
If you have programmed the coordinates of all three principal axes X, Y and Z in the approach block, the control moves the tool from the position defined before the APPR block to the auxiliary point P_H on all three axes simultaneously. Then the control moves the tool from P_H to P_A only in the working plane.

The arc is connected tangentially both to the line P_S - P_H as well as to the first contour element. Once these lines are known, the radius then suffices to completely define the tool path.



R0=G40; RL=G41; RR=G42

- Use any path function to approach the starting point P_S.
- Initiate the dialog with the **APPR DEP** key and **APPR LCT** soft key:



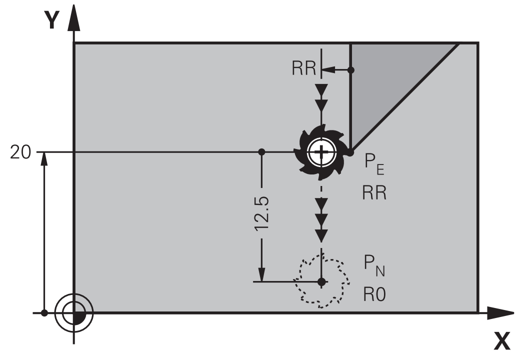
- Coordinates of the first contour point P_A
- Radius R of the circular arc. Enter R as a positive value
- Radius compensation **G41/G42** for machining

Example

N70 G00 X+40 Y+10 G40 M3*	Approach PS without radius compensation
N80 APPR LCT X+10 Y+20 Z-10 R10 G42 F100*	PA with radius comp. G42, radius R=10
N90 G01 X+20 Y+35*	End point of the first contour element
N100 G01 ...*	Next contour element

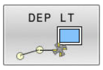
Departing in a straight line with tangential connection: DEP LT

The tool moves on a straight line from the last contour point P_E to the end point P_N. The line lies on the extension of the last contour element. P_N is separated from P_E by the distance **LEN**.



R0=G40; RL=G41; RR=G42

- Program the last contour element with the end point P_E and radius compensation
- Initiate the dialog with the **APPR DEP** key and **DEP LT** soft key



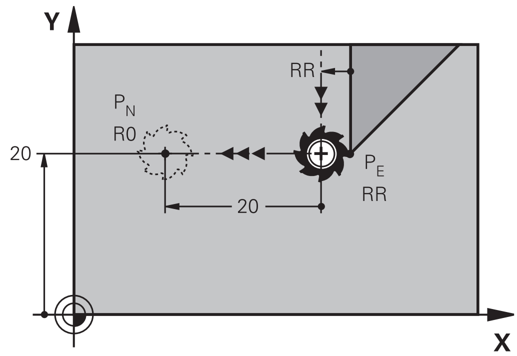
- LEN: Enter the distance from the last contour element P_E to the end point P_N.

Example

N20 G01 Y+20 G42 F100*	Last contour element: PE with radius compensation
N30 DEP LT LEN12.5 F100*	Depart contour by LEN=12.5 mm
N40 G00 Z+100 M2*	Retract in Z, return jump, end program

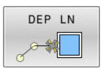
Departing in a straight line perpendicular to the last contour point: DEP LN

The tool moves on a straight line from the last contour point P_E to the end point P_N. The line departs on a perpendicular path from the last contour point P_E. P_N is separated from P_E by the distance **LEN** plus the tool radius.



R0=G40; RL=G41; RR=G42

- Program the last contour element with the end point P_E and radius compensation
- Initiate the dialog with the **APPR DEP** key and **DEP LN** soft key



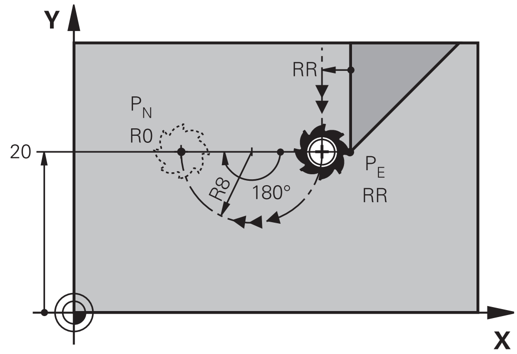
- **LEN**: Enter the distance from the last contour element to P_N. Important: Enter a positive value in **LEN**

Example

N20 G01 Y+20 G42 F100*	Last contour element: PE with radius compensation
N30 DEP LN LEN+20 F100*	Depart perpendicular to contour by LEN=20 mm
N40 G00 Z+100 M2*	Retract in Z, return jump, end program

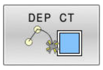
Departing on a circular path with tangential connection: DEP CT

The tool moves on a circular arc from the last contour point P_E to the end point P_N. The circular arc connects tangentially to the last contour element.



R0=G40; RL=G41; RR=G42

- Program the last contour element with the end point P_E and radius compensation
- Initiate the dialog with the **APPR DEP** key and **DEP CT** soft key



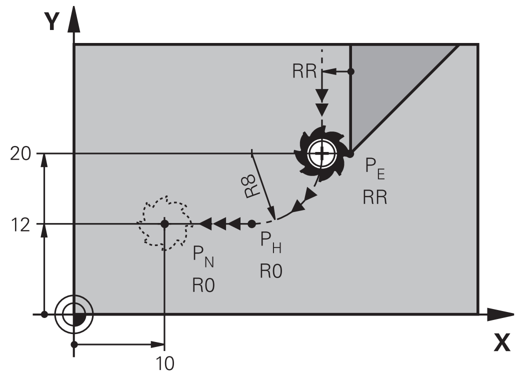
- Center angle **CCA** of the arc
- Radius R of the circular arc
  - If the tool should depart the workpiece in the direction opposite to the radius compensation: Enter R as a positive value.
  - If the tool should depart the workpiece in the direction **opposite** to the radius compensation: Enter R as a negative value.

Example

N20 G01 Y+20 G42 F100*	Last contour element: PE with radius compensation
N30 DEP CT CCA 180 R+8 F100*	Center angle=180°, arc radius=8 mm
N40 G00 Z+100 M2*	Retract in Z, return jump, end program

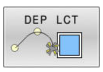
Departing on a circular arc tangentially connecting the contour and a straight line: DEP LCT

The tool moves on a circular arc from the last contour point P_S to an auxiliary point P_H. It then moves on a straight line to the end point P_N. The arc is tangentially connected both to the last contour element and to the line from P_H to P_N. Once these lines are known, the radius R suffices to unambiguously define the tool path.



R0=G40; RL=G41; RR=G42

- Program the last contour element with the end point P_E and radius compensation
- Initiate the dialog with the **APPR/DEP** key and **DEP LCT** soft key



- Enter the coordinates of the end point P_N
- Radius R of the circular arc. Enter R as a positive value

Example

N20 G01 Y+20 G42 F100*	Last contour element: PE with radius compensation
N30 DEP LCT X+10 Y+12 R+8 F100*	Coordinates PN, arc radius=8 mm
N40 G00 Z+100 M2*	Retract in Z, return jump, end program

5.4 Path contours — Cartesian coordinates

Overview of path functions

Key	Function	Tool movement	Required input	Page
L	Straight line **L** **G00** and **G01**	Straight line	Coordinates of the end point	151
CHF	Chamfer: **CHF** **G24**	Chamfer between two straight lines	Chamfer side length	152
	Circle center **CC** **I** and **J**	None	Coordinates of the circle center or pole	154
C	Circular arc **C** **G02** and **G03**	Circular arc around a circle center CC to an arc end point	Coordinates of the arc end point, direction of rotation	155
CR	Circular arc **CR** **G05**	Circular arc with a certain radius	Coordinates of the arc end point, arc radius, direction of rotation	156
CT	Circular arc **CT** **G06**	Circular arc with tangential connection to the preceding and subsequent contour elements	Coordinates of the arc end point	158
RND	Corner rounding **RND** **G25**	Circular arc with tangential connection to the preceding and subsequent contour elements	Rounding radius R	153
FK	**FK** free contour programming	Straight line or circular path with any connection to the preceding contour element	Input depends on the function	172

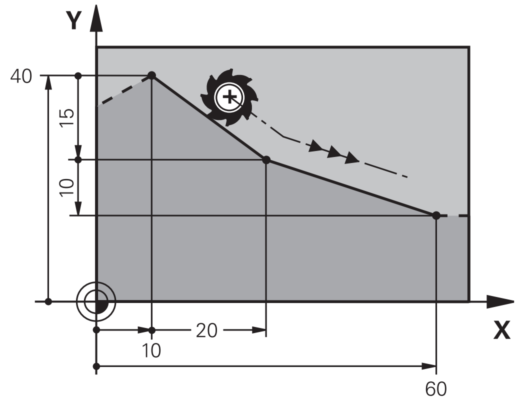
Programming path functions

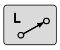
You can program path functions conveniently by using the gray path function keys. In further dialogs, you are prompted by the control to make the required entries.

> If you enter ISO functions on a keyboard connected through a USB port, make sure that capitalization is active.
> At the start of the block the control automatically writes in capitals.

Straight line in rapid traverse G00 or straight line with feed rate F G01

The control moves the tool in a straight line from its current position to the straight-line end point. The starting point is the end point of the preceding NC block.





- Press the **L** key to open a program block for a linear movement with feed rate
- **Coordinates** of the end point of the straight line, if necessary
- **Radius compensation G40/G41/G42**
- **Feed rate F**
- **Miscellaneous function M**

Movement at rapid traverse

A straight line block for a rapid traverse motion (**G00** block) can also be initiated with the **L** key:

- Press the **L** key to open a program block for a linear movement
- Press the left arrow key to switch to the input range for G codes
- Press the **G00** soft key if you want to enter a rapid traverse motion

Example

N70 G01 G41 X+10 Y+40 F200 M3*
N80 G91 X+20 Y-15*
N90 G90 X+60 G91 Y-10*

Actual position capture

You can also generate a straight-line block (**G01** block) by using the **actual position capture** key:

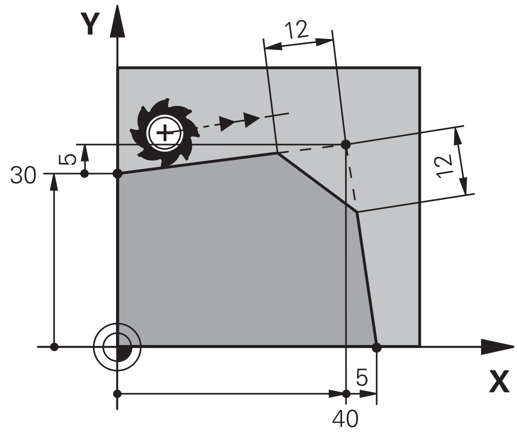
- In **Manual Operation** mode, move the tool to the position you want to capture
- Switch the screen display to programming
- Select the NC block after which you want to insert the straight line block

- Press the **actual position capture** key
- \> The control generates a straight-line block with the actual position coordinates.

Inserting a chamfer between two straight lines

The chamfer enables you to cut off corners at the intersection of two straight lines.

- The line blocks before and after the **G24** block must be in the same working plane as the chamfer.
- The radius compensation before and after the **G24** block must be the same
- The chamfer must be machinable with the current tool



CHF

- ▶ **Chamfer side length**: Length of the chamfer, and if necessary:
- ▶ **Feed rate F** (effective only in **G24** block)

Example

```
N70 G01  G41 X+0  Y+30 F300  M3*
N80 X+40  G91 Y+5*
N90 G24  R12 F250*
N100 G91  X+5 G90  Y+0*
```

You cannot start a contour with a **G24** block.

A chamfer is possible only in the working plane.

The corner point is cut off by the chamfer and is not part of the contour.

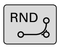
A feed rate programmed in the **G24** block is effective only in that CHF block. After the **G24** block, the previous feed rate becomes effective again.

Rounded corners G25

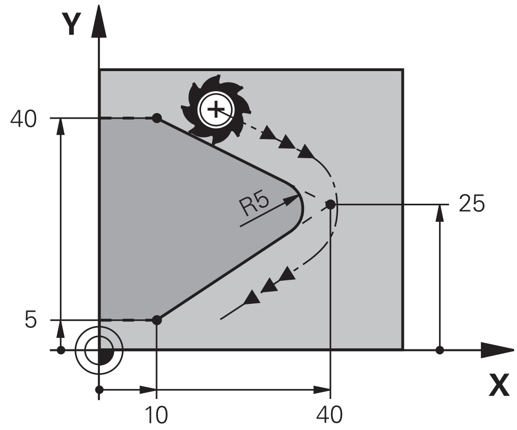
The **G25** function creates rounding arcs at contour corners.

The tool moves on an arc that connects tangentially to both the preceding and subsequent contour elements.

The rounding arc must be machinable with the called tool.



- **Rounding radius**: Enter the radius, and if necessary:
- **Feed F** (effective only in the **G25** block)

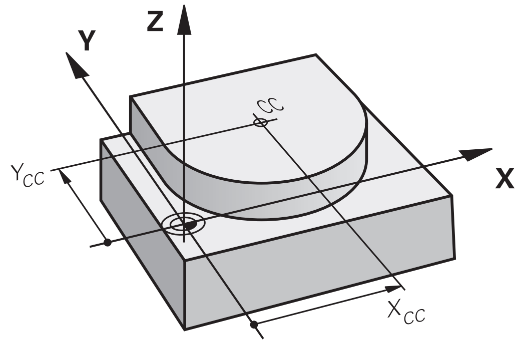


Example

```
N50 G01  X+10 Y+40  G41 F300  M3*
N60 G01  X+40 Y+25*
N70 G25  R5 F100*
N80 G01  X+10 Y+5*
```

> In the preceding and subsequent contour elements, both coordinates must lie in the plane of the rounding arc. If you machine the contour without tool-radius compensation, you must program both coordinates in the plane.
>
> The tool will not move to the corner point.
>
> A feed rate programmed in the **G25** block is effective only in that **G25** block. After the **G25** block, the previous feed rate becomes effective again.
>
> You can also use an **G25** block for a tangential contour approach.

Circle center I, J



You can define a circle center for circles that you have programmed with the **G02**, **G03**, or **G05** function. This is done in the following ways:

- Enter the Cartesian coordinates of the circle center in the working plane, or
- Use the position last programmed, or
- Take over the coordinates with the **Actual-position-capture** key

SPEC FCT

- To program the circle center, press the **SPEC FCT** key
- Press the **PROGRAM FUNCTIONS** soft key
- Press the **DIN/ISO** soft key
- Press the **I** or **J** soft key
- Enter coordinates for the circle center or, if you want to use the last programmed position, enter **G29**

Example

```
N50 I+25  J+25*
```

or

```
N10 G00 G40  X+25 Y+25*
N20 G29*
```

The program lines 10 and 20 do not refer to the illustration.

Validity

The circle center definition remains in effect until you program a new circle center.

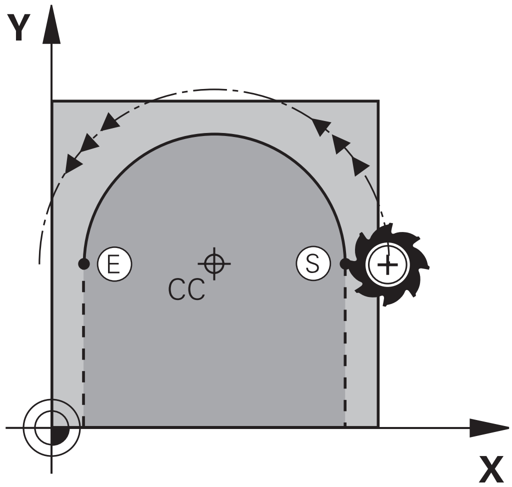
Entering the circle center incrementally

If you enter the circle center with incremental coordinates, you have programmed it relative to the last programmed position of the tool.

> The only effect of **I** and **J** is to define a position as circle center: The tool does not move to this position.
>
> The circle center is also the pole for polar coordinates.

Circular arc around circle center

Before programming a circular arc C, you must first specify the circle center **I, J**. The last programmed tool position will be the starting point of the arc.



Direction of rotation

- In clockwise direction: **G02**
- In counterclockwise direction: **G03**
- Without programmed direction: **G05**. The control traverses the circular arc with the last programmed direction of rotation.

▶ Move the tool to the starting point of the circle

J

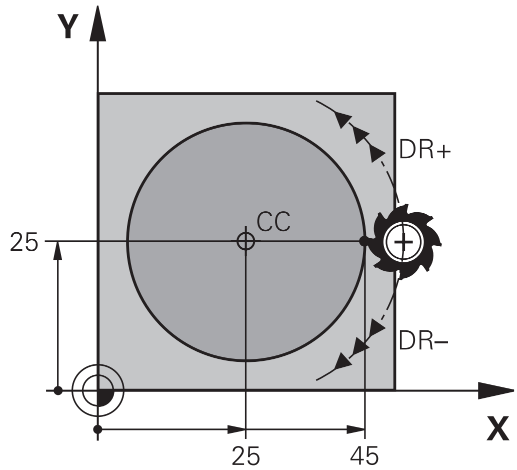
▶ Enter the **coordinates** of the circle center

I

▶ Enter the **coordinates** of the arc end point, if necessary:

▶ **Feed F**

▶ **Miscellaneous function M**



Example

N50 I+25 J+25*
N60 G01 G42 X+45 Y+25 F200 M3*
N70 G03 X+45 Y+25*

Circular motion in another plane

The control normally makes circular movements in the active working plane. However, you can also program circular arcs that do not lie in the active working plane.

Example

N30 T1 G17 S4000*
N50 I+25 K+25*
N60 G01 G42 X+45 Y+25 Z+25 F200 M3*
N70 G03 X+45 Z+25*

By simultaneously rotating these circular movements you can create spatial arcs (arcs in three axes).

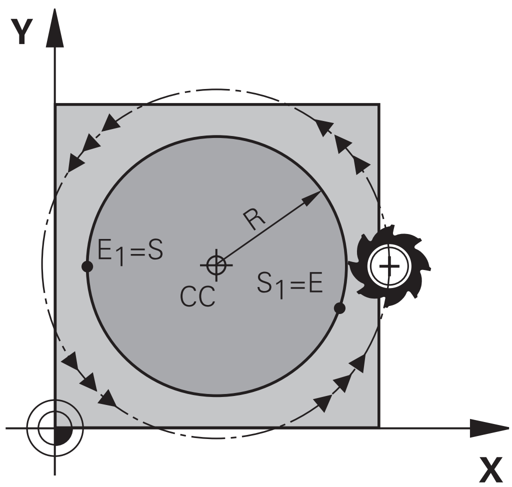
Full circle

For the end point, program the same coordinates as for the starting point.

> The starting and end points of the arc must lie on the circle.
>
> The maximum value for input tolerance is 0.016 mm. Set the input tolerance in the machine parameter **circleDeviation** (no. 200901).
>
> Smallest possible circle that the control can traverse: 0.016 mm.

Circular arc G02/G03/G05 with fixed radius

The tool moves on a circular path with the radius R.



Direction of rotation

- In clockwise direction: **G02**
- In counterclockwise direction: **G03**
- Without programmed direction: **G05**. The control traverses the circular arc with the last programmed direction of rotation.

CR

- **Coordinates** of the arc end point
- Note on **Radius R**: The algebraic sign determines the size of the arc!
- **Miscellaneous function M**
- **Feed F**

Full circle

For a full circle, program two semicircle blocks in succession:

The end point of the first semicircle is the starting point of the second. The end point of the second semicircle is the starting point of the first.

Central angle CCA and arc radius R

The starting and end points on the contour can be connected with four arcs of the same radius:

Smaller arc: CCA<180°

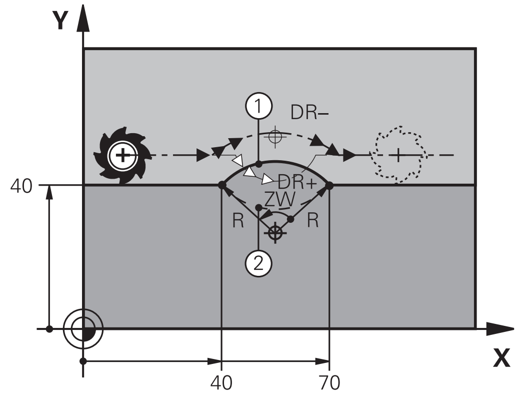
Enter the radius with a positive sign, i.e. R>0

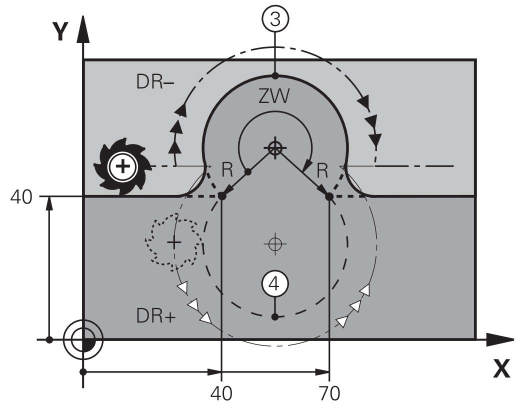
Larger arc: CCA>180°
Enter the radius with a negative sign, i.e. R<0

The direction of rotation determines whether the arc is curving outward (convex) or curving inward (concave):

Convex: Direction of rotation **G02** (with radius compensation **G41**)

Concave: Direction of rotation **G03** (with radius compensation **G41**)





> The distance from the starting and end points of the arc diameter cannot be greater than the diameter of the arc.
>
> The maximum radius is 99.9999 m.
>
> You can also enter rotary axes A, B and C.
>
> The control normally makes circular movements in the active working plane. However, you can also program circular arcs that do not lie in the active working plane. By simultaneously rotating these circular movements you can create spatial arcs (arcs in three axes).

Example

```
N100 G01 G41  X+40 Y+40  F200 M3*
N110 G02  X+70 Y+40  R+20*  (arc 1)
```

or

```
N110 G03  X+70 Y+40  R+20*  (arc 2)
```

or

```
N110 G02  X+70 Y+40  R-20*  (arc 3)
```

or

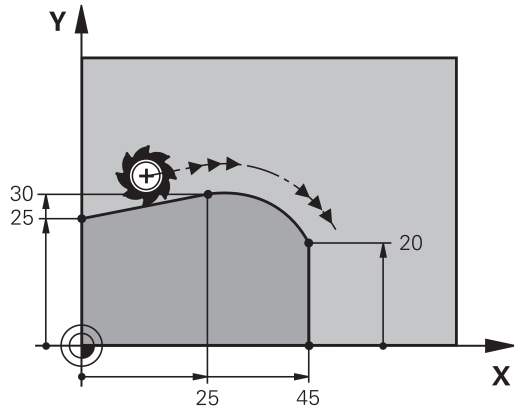
```
N110 G03  X+70 Y+40  R-20*  (arc 4)
```

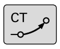
Circular arc G06 with tangential transition

The tool moves on an arc that connects tangentially to the previously programmed contour element.

A connection between two contour elements is called tangential when there is no kink or corner at the intersection between the two contours—the transition is smooth.

The contour element to which the tangential arc connects must be programmed immediately before the **G06** block. This requires at least two positioning blocks.





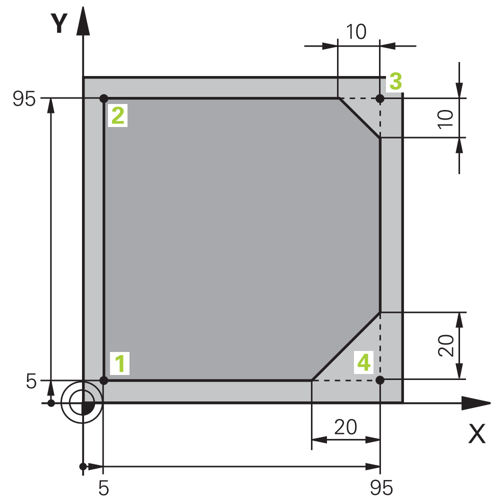
- **Coordinates** of the arc end point, and if necessary:
- **Feed F**
- **Miscellaneous function M**

Example

N70 G01 G41 X+0 Y+25 F300 M3*
N80 X+25 Y+30*
N90 G06 X+45 Y+20*
N100 G01 Y+0*

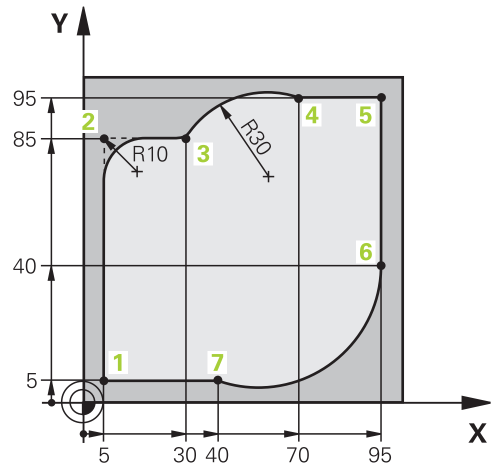
> A tangential arc is a two-dimensional operation: the coordinates in the **G06** block and in the contour element preceding it must be in the same plane of the arc!

Example: Linear movements and chamfers with Cartesian coordinates



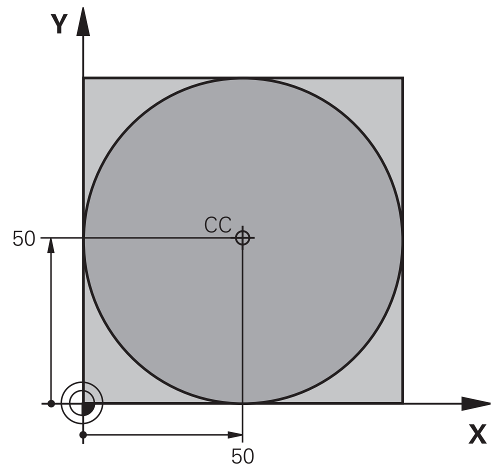
%LINEAR G71 *	
N10 G30 G17 X+0 Y+0 Z-20*	Define the workpiece blank for graphic workpiece simulation
N20 G31 G90 X+100 Y+100 Z+0*	
N30 T1 G17 S4000*	Call the tool in the spindle axis and with the spindle speed S
N40 G00 G40 G90 Z+250*	Retract the tool in the spindle axis at rapid traverse
N50 X-10 Y-10*	Pre-position the tool
N60 G01 Z-5 F1000 M3*	Move to working depth at feed rate F = 1000 mm/min
N70 G01 G41 X+5 Y+5 F300*	Approach the contour at point 1, activate radius compensation G41
N80 G26 R5 F150*	Tangential approach
N90 Y+95*	Move to point 2
N100 X+95*	Point 3: first straight line for corner 3
N110 G24 R10*	Program a chamfer with length 10 mm
N120 Y+5*	Point 4: 2nd straight line for corner 3, 1st straight line for corner 4
N130 G24 R20*	Program a chamfer with length 20 mm
N140 X+5*	Move to last contour point 1, second straight line for corner 4
N150 G27 R5 F500*	Tangential exit
N160 G40 X-20 Y-20 F1000*	Retract the tool in the working plane, cancel radius compensation
N170 G00 Z+250 M2*	Retract the tool, end program
N99999999 %LINEAR G71 *	

Example: Circular movements with Cartesian coordinates



%CIRCULAR G71 *	
N10 G30 G17 X+0 Y+0 Z-20*	Define the workpiece blank for graphic workpiece simulation
N20 G31 G90 X+100 Y+100 Z+0*	
N30 T1 G17 S4000*	Call the tool in the spindle axis and with spindle speed
N40 G00 G40 G90 Z+250*	Retract the tool in the spindle axis at rapid traverse
N50 X-10 Y-10*	Pre-position the tool
N60 G01 Z-5 F1000 M3*	Move to working depth at feed rate F = 1000 mm/min
N70 G01 G41 X+5 Y+5 F300*	Approach the contour at point 1, activate radius compensation G41
N80 G26 R5 F150*	Tangential approach
N90 Y+85*	Point 2: First straight line for corner 2
N100 G25 R10*	Insert radius with R = 10 mm, feed rate: 150 mm/min
N110 X+30*	Move to point 3: Starting point of the arc
N120 G02 X+70 Y+95 R+30*	Move to point 4: End point of the arc with G02, radius 30 mm
N130 G01 X+95*	Move to point 5
N140 Y+40*	Move to point 6
N150 G06 X+40 Y+5*	Move to point 7: End point of the arc, circular arc with tangential connection to point 6, the control automatically calculates the radius
N160 G01 X+5*	Move to last contour point 1
N170 G27 R5 F500*	Depart the contour on a circular arc with tangential connection
N180 G40 X-20 Y-20 F1000*	Retract the tool in the working plane, cancel radius compensation
N190 G00 Z+250 M2*	Retract tool in the tool axis, end of program
N99999999 %CIRCULAR G71 *	

Example: Full circle with Cartesian coordinates



%C-CC G71 *	
N10 G30 G17 X+0 Y+0 Z-20*	Workpiece blank definition
N20 G31 G90 X+100 Y+100 Z+0*	
N30 T1 G17 S3150*	Tool call
N40 G00 G40 G90 Z+250*	Retract the tool
N50 I+50 J+50*	Define the circle center
N60 X-40 Y+50*	Pre-position the tool
N70 G01 Z-5 F1000 M3*	Move to working depth
N80 G41 X+0 Y+50 F300*	Approach starting point, radius compensation G41
N90 G26 R5 F150*	Tangential approach
N100 G02 X+0*	Move to the circle end point (= circle starting point)
N110 G27 R5 F500*	Tangential exit
N120 G01 G40 X-40 Y-50 F1000*	Retract the tool in the working plane, cancel radius compensation
N130 G00 Z+250 M2*	Retract tool in the tool axis, end of program
N99999999 %C-CC G71 *	

5.5 Path contours – Polar coordinates

Overview

With polar coordinates you can define a position in terms of its angle **H** and its distance **R** relative to a previously defined pole **I, J**.

Polar coordinates are useful with:

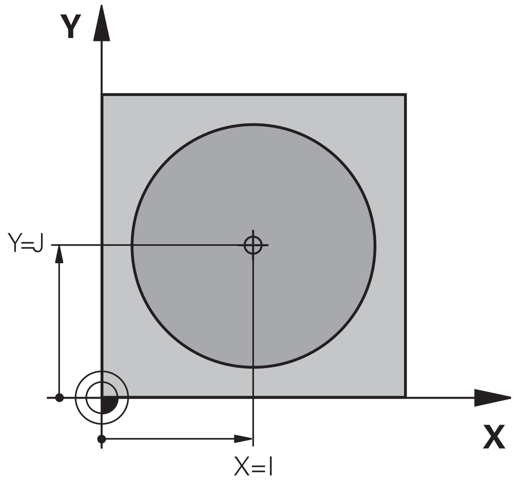
- Positions on circular arcs
- Workpiece drawing dimensions in degrees, e.g. bolt hole circles

Overview of path functions with polar coordinates

Key	Tool movement	Required input	Page
L + P	Straight line	Polar radius, polar angle of the straight-line end point	163
C + P	Circular path around circle center/pole to arc end point	Polar angle of the arc end point,	164
CR + P	Circular path corresponding to active direction of rotation	Polar angle of the circle end point	164
CT + P	Circular arc with tangential connection to the preceding contour element	Polar radius, polar angle of the arc end point	164
C + P	Combination of a circular and a linear movement	Polar radius, polar angle of the arc end point, coordinate of the end point in the tool axis	165

Datum for polar coordinates: pole I, J

You can set the pole (I, J) at any point in the NC program, before indicating positions in polar coordinates. Set the pole in the same way as you would program the circle center.



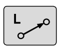
- To program a pole, press the **SPEC FCT** key.
- Press the **PROGRAM FUNCTIONS** soft key
- Press the **DIN/ISO** soft key
- Press the **I** or **J** soft key
- **Coordinates**: Enter Cartesian coordinates for the pole or, if you want to use the last programmed position, enter **G29**. Before programming polar coordinates, define the pole. You can only define the pole in Cartesian coordinates. The pole remains in effect until you define a new pole.

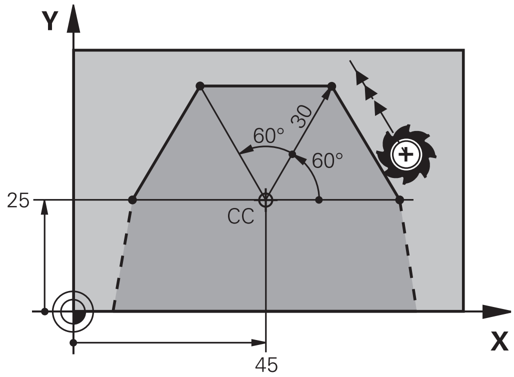
Example

```
N120 I+45  J+45*
```

Straight line in rapid traverse G10 or straight line with feed rate F G11

The tool moves in a straight line from its current position to the straight-line end point. The starting point is the end point of the preceding NC block.





- **Polar coordinate radius R**: Enter the distance from the pole CC to the straight-line end point
- **Polar-coordinates angle H**: Angular position of the straight-line end point between –360° and +360°

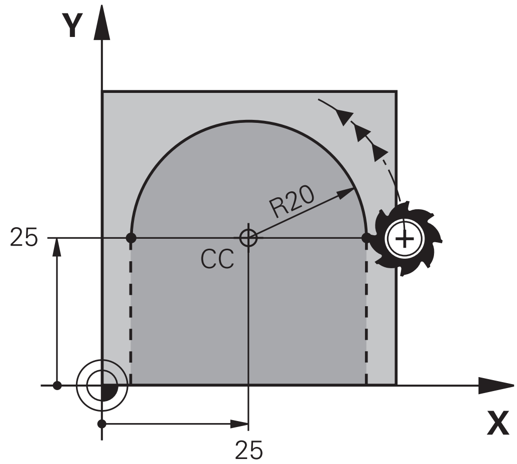
The sign of **H** depends on the angle reference axis:

- If the angle from the angle reference axis to **R** is counterclockwise: **H**>0
- If the angle from the angle reference axis to **R** is clockwise: **H**<0

Example

```
N120 I+45  J+45*
N130 G11 G42  R+30 H+0  F300 M3*
N140 H+60*
N150 G91  H+60*
N160 G90  H+180*
```

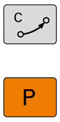
Circular path G12/G13/G15 around pole I, J



The polar coordinate radius **R** is also the radius of the arc. **R** is defined by the distance from the starting point to the pole **I, J**. The last programmed tool position will be the starting point of the arc.

Direction of rotation

- In clockwise direction: **G12**
- In counterclockwise direction: **G13**
- Without programmed direction: **G15**. The control traverses the circular arc with the last programmed direction of rotation.

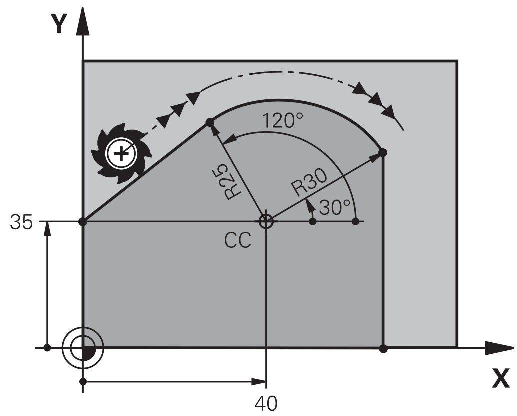


- **Polar-coordinates angle H**: Angular position of the arc end point between –99999.9999° and +99999.9999°

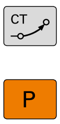
Example

```
N180 I+25  J+25*
N190 G11 G42  R+20 H+0  F250 M3*
N200 G13  H+180*
```

Circle G16 with tangential connection



The tool moves on a circular path, starting tangentially from a preceding contour element.



- **Polar coordinate radius R**: Distance between the arc end point and the pole **I, J**
- **Polar coordinate angle H**: Angular position of the arc end point.

> The pole is **not** the center of the contour arc!

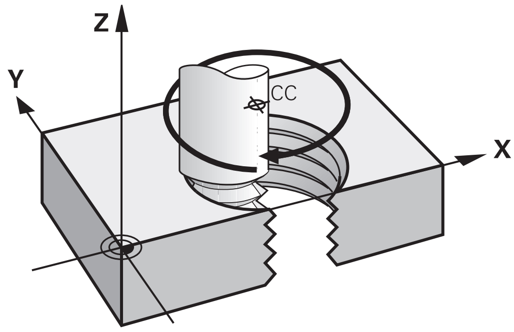
Example

```
N120 I+40  J+35*
N130 G01 G42  X+0 Y+35  F250 M3*
N140 G11  R+25 H+120*
N150 G16  R+30 H+30*
N160 G01  Y+0*
```

Helix

A helix is a combination of a circular movement in a main plane and a linear movement perpendicular to this plane. You program the circular path in a main plane.

A helix is programmed only in polar coordinates.



Application

- Large-diameter internal and external threads
- Lubrication grooves

Calculating the helix

To program a helix, you must enter the total angle through which the tool is to move on the helix in incremental dimensions, and the total height of the helix.

Thread revolutions n:	Thread revolutions + thread overrun at the start and end of the thread
Total height h:	Thread pitch P times thread revolutions n
Incremental total angle **G91 H**:	Thread revolutions x 360° + angle for beginning of thread + angle for thread overrun
Starting coordinate Z:	Pitch P times (thread revolutions + thread overrun at start of thread)

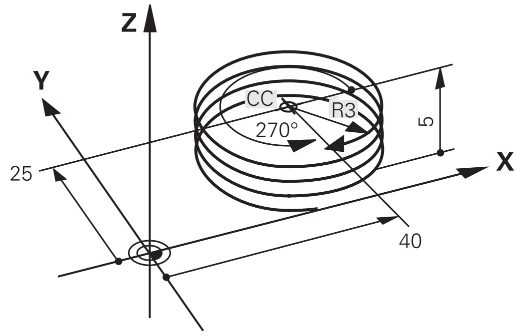
Shape of the helix

The table below illustrates in which way the shape of the helix is determined by the work direction, direction of rotation and radius compensation.

Internal thread	Work direction	Direction of rotation	Radius compensation
Right-hand	Z+	**G13**	**G41**
Left-hand	Z+	**G12**	**G42**
Right-hand	Z–	**G12**	**G42**
Left-hand	Z–	**G13**	**G41**
External thread			
Right-hand	Z+	**G13**	**G42**
Left-hand	Z+	**G12**	**G41**
Right-hand	Z–	**G12**	**G41**
Left-hand	Z–	**G13**	**G42**

Programming a helix

> Always enter the same algebraic sign for the direction of rotation and the incremental total angle **G91 h**. The tool may otherwise move in a wrong path and damage the contour.
>
> For the total angle **G91 h** you can enter a value of -99 999.9999° to +99 999.9999°.

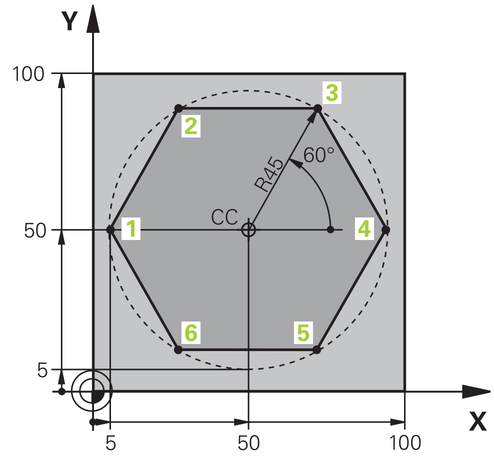


- **Polar coordinates angle:** Enter the total angle of tool traverse along the helix in incremental dimensions.
- **After entering the angle, specify the tool axis with an axis selection key**
- **Coordinate**: Enter the coordinate for the height of the helix in incremental dimensions
- **Enter the radius compensation** according to the table

Example: Thread M6 x 1 mm with 5 revolutions

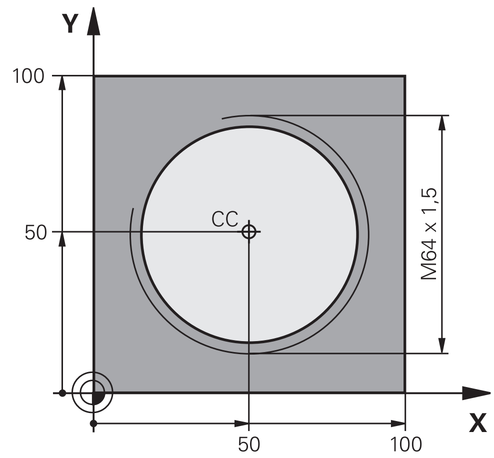
```
N120 I+40  J+25*
N130 G01  Z+0 F100  M3*
N140 G11 G41  R+3 H+270*
N150 G12 G91  H-1800 Z+5*
```

Example: Linear movement with polar coordinates



%LINEARPO G71 *	
N10 G30 G17 X+0 Y+0 Z-20*	Workpiece blank definition
N20 G31 G90 X+100 Y+100 z+0*	
N30 T1 G17 S4000*	Tool call
N40 G00 G40 G90 Z+250*	Define the preset for polar coordinates
N50 I+50 J+50*	Retract the tool
N60 G10 R+60 H+180*	Pre-position the tool
N70 G01 Z-5 F1000 M3*	Move to working depth
N80 G11 G41 R+45 H+180 F250*	Approach the contour at point 1
N90 G26 R5*	Approach the contour at point 1
N100 H+120*	Move to point 2
N110 H+60*	Move to point 3
N120 H+0*	Move to point 4
N130 H-60*	Move to point 5
N140 H-120*	Move to point 6
N150 H+180*	Move to point 1
N160 G27 R5 F500*	Tangential exit
N170 G40 R+60 H+180 F1000*	Retract the tool in the working plane, cancel radius compensation
N180 G00 Z+250 M2*	Retract in the spindle axis, end of program
N99999999 %LINEARPO G71 *	

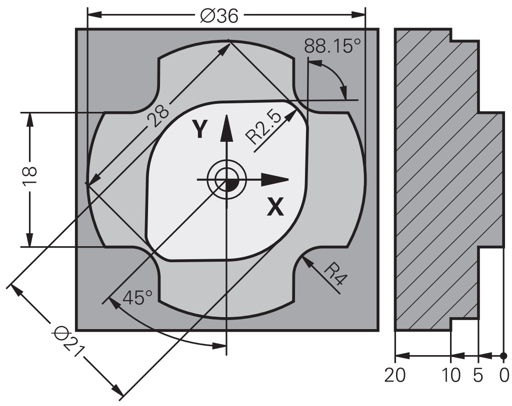
Example: Helix



%HELIX G71 *	
N10 G30 G17 X+0 Y+0 Z-20*	Workpiece blank definition
N20 G31 G90 X+100 Y+100 Z+0*	
N30 T1 G17 S1400*	Tool call
N40 G00 G40 G90 Z+250*	Retract the tool
N50 X+50 Y+50*	Pre-position the tool
N60 G29*	Transfer the last programmed position as the pole
N70 G01 Z-12,75 F1000 M3*	Move to working depth
N80 G11 G41 R+32 H+180 F250*	Approach first contour point
N90 G26 R2*	Connection
N100 G13 G91 H+3240 Z+13,5 F200*	Helical traverse
N110 G27 R2 F500*	Tangential exit
N120 G01 G40 G90 X+50 Y+50 F1000*	Retract the tool, end of program
N130 G00 Z+250 M2*	
N99999999 %HELIX G71 *	

5.6 Path contours – FK free contour programming (option 19)

Fundamentals



Workpiece drawings that are not dimensioned for NC often contain unconventional coordinate data that cannot be entered with the gray path function keys.

You can enter such dimensional data directly by using the free contour programming function FK, e.g.

- If there are known coordinates on or in proximity to the contour element
- If coordinate data refers to another contour element
- If directional data and data regarding the course of the contour are known

The control derives the contour from the known coordinate data and supports the programming dialog with the interactive FK programming graphics. The figure at upper right shows a workpiece drawing for which FK programming is the most convenient programming method.

Programming notes

You must enter all available data for every contour element. Even the data that does not change must be entered in every NC block—otherwise it will not be recognized.

Q parameters are permissible in all FK elements, except in elements with relative references (e.g. **RX** or **RAN**), or in elements that are referenced to other NC blocks.

If both FK blocks and conventional blocks are entered in an NC program, the FK contour must be fully defined before you can return to conventional programming.

Program all of the contours before combining them (e.g., with the SL cycles). You thereby ensure that the contours are correctly defined and avoid unnecessary error messages.

The control needs a fixed point that it can use as the basis for all calculations. Use the gray path function keys to program a position that contains both coordinates of the working plane immediately before programming the FK contour. Do not enter any Q parameters in this NC block.

If the first NC block of an FK contour is an **FCT** or **FLT** block, you must program at least two NC blocks with the gray path function keys before it. This fully defines the approach direction.

Do not program an FK contour immediately after an **L** command.

You cannot combine the cycle call **M89** with FK programming.

Defining the working plane

The FK free contour programming feature can only be used for programming contour elements that lie in the working plane.

The control defines the working plane for FK programming according to the following hierarchy:

1 Through the plane defined in a **FPOL** block

2 Through the working plane specified and defined in the **TOOL CALLT** block (e.g., **G17** = X/Y plane)

3 If none of this applies, then the standard X/Y plane is active

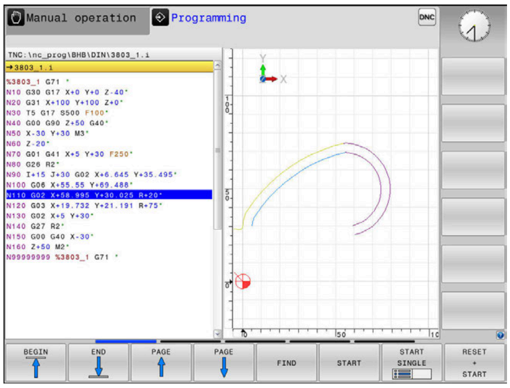
Display of the FK soft key depends on the spindle axis specified when defining the workpiece blank. If for example you enter spindle axis **G17** in the workpiece blank definition, the control only shows FK soft keys for the X/Y plane.

Switch the working plane

If you need a different working plane from the currently active plane, then proceed as follows:

- Press the **PLANE XY ZX YZ** soft key
- > The control then displays the FK soft keys in the newly selected plane.

FK programming graphics



> To use graphical support during FK programming, select the **PROGRAM + GRAPHICS** screen layout.
> **Further information:** "Programming", Page 71

> Program all of the contours before combining them (e.g., with the SL cycles). You thereby ensure that the contours are correctly defined and avoid unnecessary error messages.

Incomplete coordinate data often is not sufficient to fully define a workpiece contour. In this case, the control indicates the possible solutions in the FK graphic. You can then select the contour that matches the drawing.

The control uses various colors in the FK graphics:

- **blue:** uniquely specified contour element
  The last FK element is only shown in blue after the departure movement.
- **violet:** not yet uniquely specified contour element
- **ocher:** tool midpoint path
- **red:** rapid traverse
- **green:** more than one solution is possible

If the data permit several possible solutions and the contour element is displayed in green, select the correct contour element as follows:

- Press the **SHOW SOLUTION** soft key repeatedly until the correct contour element is displayed. Use the zoom function if you cannot distinguish between possible solutions in the standard view

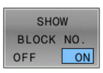
- If the displayed contour element matches the drawing, then select this contour element with the **SELECT SOLUTION** soft key

If you do not yet wish to define a green contour element, then press the **START SINGLE** soft key to continue the FK dialog.

> You should define the green contour elements as soon as possible with **SELECT SOLUTION** to limit ambiguity for the subsequent contour elements.

Showing block numbers in the graphic window

To show a block number in the graphic window:



- Set the **SHOW BLOCK NO.** soft key to **ON**

Initiating the FK dialog

Proceed as follows to open the FK dialog:

FK

- Press the **FK** key
- > The control then displays the soft-key row with the FK functions.

If you initiate the FK dialog with one of these soft keys, the control shows additional soft-key rows. You can use them to enter known coordinates, directional data, and data regarding the course of the contour.

Soft key	FK element
FLT	Straight line with tangential connection
FL	Straight line without tangential connection
FCT	Circular arc with tangential connection
FC	Circular arc without tangential connection
FPOL	Pole for FK programming
PLANE XY ZX YZ	Select the working plane

Terminating the FK dialog

Proceed as follows to exit the soft-key row for FK programming:

END

- Press the **END** soft key

Alternative:

FK

- Press the **FK** key again

Pole for FK programming

FK

- To display the soft keys for free contour programming, press the **FK** key

FPOL

- To initiate the dialog for defining the pole, press the **FPOL** soft key
- > The control displays the axis soft keys of the active working plane.
- Enter the pole coordinates using these soft keys

> **i** The pole for FK programming remains active until you define a new one using FPOL.

Free straight line programming

Straight line without tangential connection

- To display the soft keys for free contour programming, press the **FK** key
- To initiate the dialog for free programming of straight lines, press the **FL** soft key
- > The control displays additional soft keys.
- Enter all known data in the NC block by using these soft keys
- > The FK graphic displays the programmed contour element in violet until sufficient data is entered. If the entered data describes several solutions, the graphic will display the contour element in green.
  Further information: "FK programming graphics", Page 171

Straight line with tangential connection

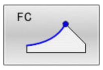
If the straight line connects tangentially to another contour element, initiate the dialog with the soft key:

- To display the soft keys for free contour programming, press the **FK** key
- To initiate the dialog, press the **FLT** soft key
- Enter all known data in the NC block by using the soft keys

Free circular path programming

Circular arc without tangential connection

- To display the soft keys for free contour programming, press the **FK** key

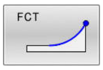


- To initiate the dialog for free programming of circular arcs, press the **FC** soft key
- > The control displays soft keys with which you can enter direct data on the circular arc or data on the circle center.
- Enter all known data in the NC block by using these soft keys
- > The FK graphic displays the programmed contour element in violet until sufficient data is entered. If the entered data describes several solutions, the graphic will display the contour element in green.
  Further information: "FK programming graphics", Page 171

Circular arc with tangential connection

If the circular arc connects tangentially to another contour element, initiate the dialog with the **FCT** soft key:

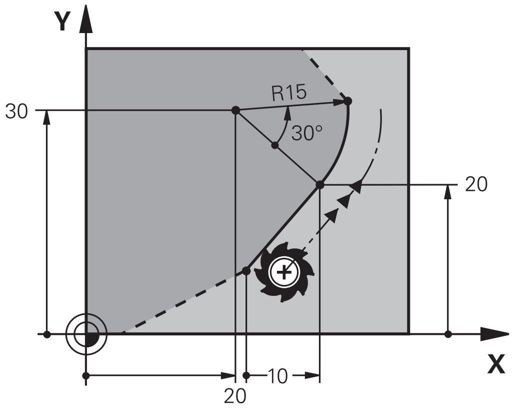
- To display the soft keys for free contour programming, press the **FK** key

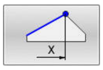
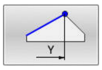
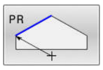
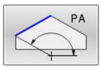


- To initiate the dialog, press the **FCT** soft key
- Enter all known data in the NC block by using the soft keys

Input possibilities

End point coordinates

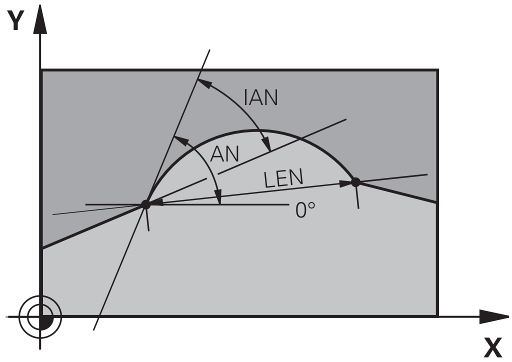


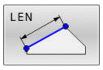
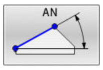
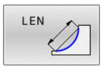
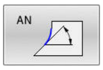
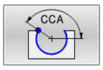
Soft keys		Known data
		Cartesian coordinates X and Y
		Polar coordinates referenced to FPOL

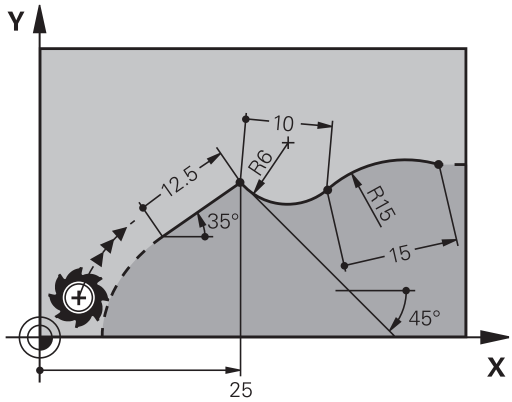
Example

```
N70 FPOL  X+20 Y+30*
N80 FL  IX+10 Y+20  G42 F100*
N90 FCT PR+15 IPA+30  DR+ R15*
```

Direction and length of contour elements



Soft keys	Known data
	Length of a straight line
	Gradient angle of a straight line
	Chord length LEN of an arc
	Gradient angle AN of an entry tangent
	Center angle of an arc



NOTICE

Danger of collision!

Incremental gradient angles **IAN** are referenced by the control to the direction of the previous traversing block. NC programs from previous control models (including iTNC 530) are not compatible. There is danger of collision during the execution of imported NC programs!

- Check the sequence and contour with the aid of the graphic simulation
- Adapt imported NC programs if required

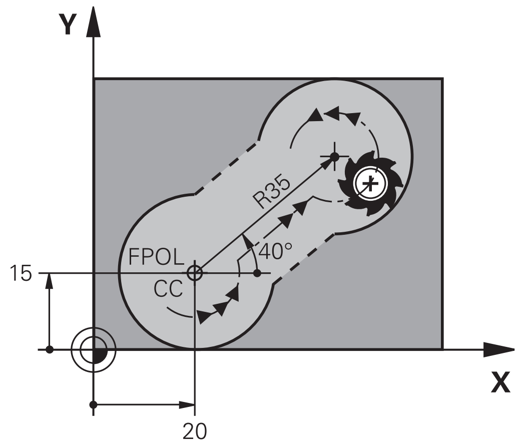
Example

```
N20 FLT  X+25 LEN 12.5  AN+35 G41  F200*
N30 FC  DR+ R6  LEN 10 AN-45*
N40 FCT  DR- R15  LEN 15*
```

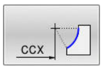
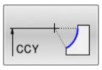
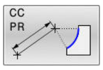
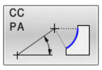
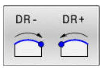
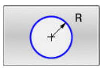
Circle center CC, radius and direction of rotation in the FC/FCT block

The control calculates a circle center for free-programmed arcs from the data you enter. This makes it possible to program full circles in an NC block with FK programming.

If you wish to define the circle center in polar coordinates you must use FPOL, not **CC**, to define the pole. FPOL is entered in Cartesian coordinates and remains in effect until the TNC encounters a NC block in which another **FPOL** is defined.



> A programmed or automatically calculated circle center or pole is effective only in connected conventional or FK sections. If an FK section splits up two conventionally programmed sections, the information about a circle center or pole will be lost. The two conventionally programmed sections must each have their own (if necessary, identical) CC blocks. Conversely, this information will also be lost if there is a conventional section between two FK sections.

Soft keys		Known data
		Circle center in Cartesian coordinates
		Center point in polar coordinates
		Rotational direction of the arc
		Radius of an arc

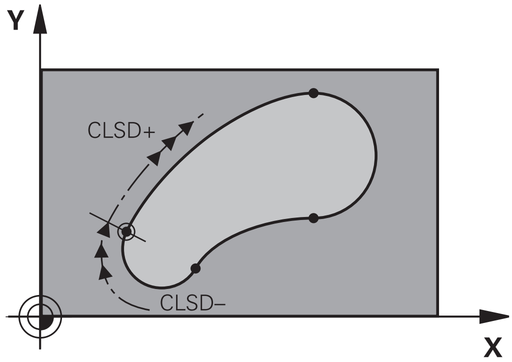
Example

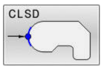
```
N10 FC  CCX+20 CCY+15  DR+ R15*
N20 FPOL  X+20 Y+15*
N30 FL  AN+40*
N40 FC  DR+ R15  CCPR+35 CCPA+40*
```

Closed contours

You can identify the beginning and end of a closed contour with the **CLSD** soft key. This reduces the number of possible solutions for the last contour element.

Enter **CLSD** as an addition to another contour data entry in the first and last NC blocks of an FK section.



Soft key	Known data	
	Beginning of contour:	CLSD+
	End of contour:	CLSD–

Example

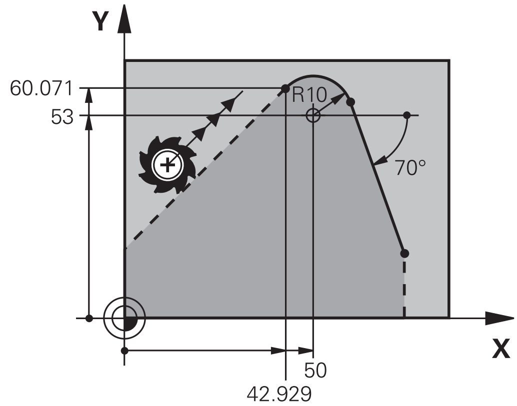
```
N10 G01  X+5 Y+35  G41 F500  M3*
N20 FC  DR- R15  CLSD+ CCX+20  CCY+35*
...
N30 FCT  DR- R+15  CLSD-*
```

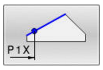
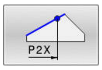
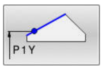
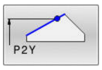
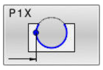
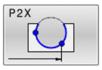
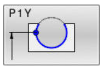
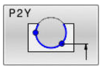
Auxiliary points

For both free-programmed straight lines and free-programmed circular arcs, you can enter the coordinates of auxiliary points that are located on the contour or in its proximity.

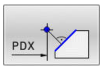
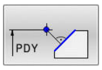
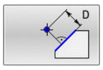
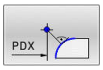
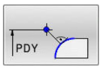
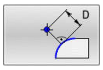
Auxiliary points on a contour

The auxiliary points are located on the straight line, the extension of the straight line, or on the circular arc.



Soft keys		Known data
		X coordinate of an auxiliary point P1 or P2 of a straight line
		Y coordinate of an auxiliary point P1 or P2 of a straight line
		X coordinate of an auxiliary point P1, P2 or P3 of a circular path
		Y coordinate of an auxiliary point P1, P2 or P3 of a circular path

Auxiliary points near a contour

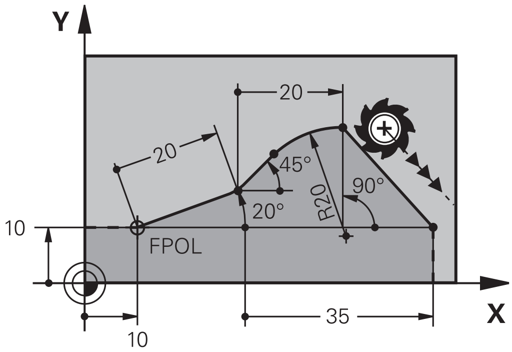
Soft keys		Known data
		X and Y coordinates of the auxiliary point near a straight line
		Distance of auxiliary point to straight line
		X and Y coordinates of an auxiliary point near a circular arc
		Distance of auxiliary point to circular arc

Example

```
N10 FC  DR- R10  P1X+42.929 P1Y+60.071*
N20 FLT  AN-70 PDX+50  PDY+53 D10*
```

Relative data

Relative data are values based on another contour element. The soft keys and program words for relative entries begin with the letter **R**. The figure on the right shows the dimensional data that should be programmed as relative data.



> The coordinates and angles for relative data are always programmed in incremental dimensions. You must also enter the NC block number of the contour element on which the data are based.
>
> The block number of the contour element on which the relative data are based can only be located up to 64 positioning blocks before the NC block in which you program the reference.
>
> If you delete an NC block on which relative data are based, the control will display an error message. Change the NC program first before you delete this NC block.

Data relative to NC block N: End point coordinates

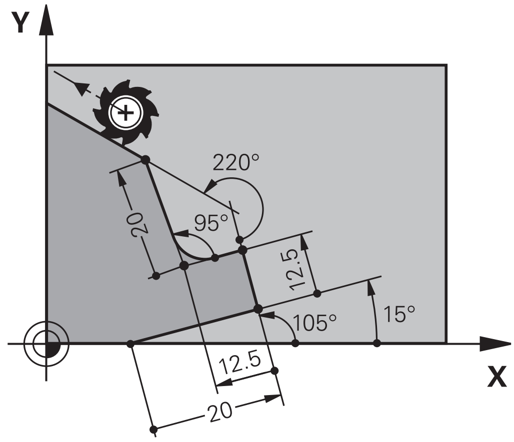
Soft keys		Known data
RX N...	RY N...	Cartesian coordinates relative to NC block N
RPR N...	RPA N...	Polar coordinates relative to NC block N

Example

```
N10 FPOL  X+10 Y+10*
N20 FL  PR+20 PA+20*
N30 FL  AN+45*
N40 FCT  IX+20 DR-  R20 CCA+90  RX 20*
N50 FL  IPR+35 PA+0  RPR 20*
```

Data relative to NC block N: Direction and distance of the contour element

Soft key	Known data
RAN N...	Angle between a straight line and another element or between the entry tangent of the arc and another element
PAR N...	Straight line parallel to another contour element
DP	Distance from a straight line to a parallel contour element

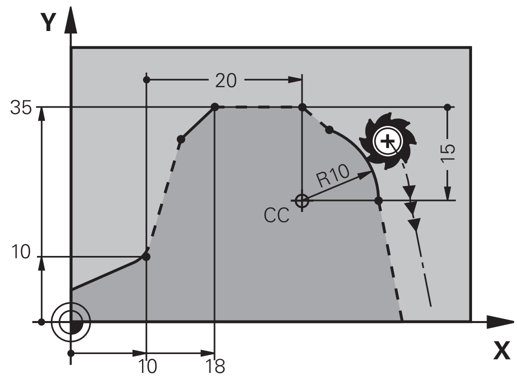


Example

```
N10 FL  LEN 20 AN+15*
N20 FL  AN+105 LEN 12.5*
N30 FL  PAR 10  DP 12.5*
N40 FSELECT 2*
N50 FL  LEN 20 IAN+95*
N60 FL  IAN+220 RAN 20*
```

Data relative to NC block N: Circle center CC

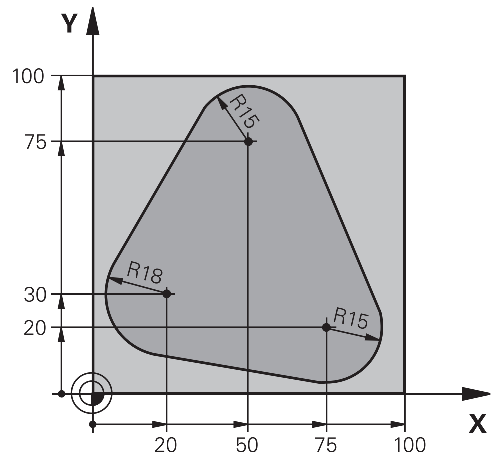
Soft key		Known data
RCCX N...	RCCY N...	Cartesian coordinates of the circle center relative to NC block N
RCCPR N...	RCCPA N...	Polar coordinates of the circle center relative to NC block N



Example

```
N10 FL  X+10 Y+10  G41*
N20 FL  ...*
N30 FL  X+18 Y+35*
N40 FL  ...*
N50 FL  ...*
N60 FC  DR- R10  CCA+0 ICCX+20  ICCY-15 RCCX10  RCCY30*
```

Example: FK programming 1



%FK1 G71 *	
N10 G30 G17 X+0 Y+0 Z-20*	Workpiece blank definition
N20 G31 X+100 Y+100 Z+0*	
N30 T 1 G17 S500*	Tool call
N40 G00 G90 Z+250 G40 M3*	Retract the tool
N50 G00 X-20 Y+30 G40*	Pre-positioning the tool
N60 G01 Z-10 G40 F1000*	Move to working depth
N70 APPR CT X+2 Y+30 CCA90 R+5 G41 F250*	Approach the contour on a circular arc with tangential connection
N80 FC DR- R18 CLSD+ CCX+20 CCY+30*	FK contour section:
N90 FLT*	Program all known data for each contour element
N100 FCT DR- R15 CCX+50 CCY+75*	
N110 FLT*	
N120 FCT DR- R15 CCX+75 CCY+20*	
N130 FLT*	
N140 FCT DR- R18 CLSD- CCX+20 CCY+30*	
N150 DEP CT CCA90 R+5 F2000*	Depart the contour on a circular arc with tangential connection
N160 G00 X-30 Y+0*	
N170 G00 Z+250 M2*	Retract the tool, end of program
N99999999 %FK1 G71 *	

6

Programming aids

6.1 GOTO function

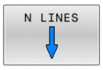
Using the GOTO key

Jumping with the GOTO key

Use the **GOTO** key to jump to a specific location in the NC program, regardless of the active operating mode.

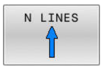
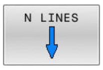
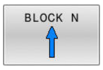
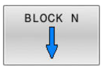
Proceed as follows:

- Press the **GOTO** key
- > The control opens a pop-up window.
- Enter a number



- Select the jump statement by soft key, e.g. move down the number of lines entered

The control provides the following options:

Soft key	Function
	Move up the number of lines entered
	Move down the number of lines entered
	Jump to the block number entered
	Jump to the block number entered

> Use the **GOTO** function only during programming and testing of NC programs. Use the block scan function during program run.
>
> **Further information:** User's Manual for **Setup, Testing and Running NC Programs**

Quick selection with the GOTO key

With the **GOTO** key, you can open the Smart Select window that makes it easy for you to select special functions or cycles.

Proceed as follows to select special functions:

- Press the **SPEC FCT** key

- Press the **GOTO** key
- > The control displays a pop-up window showing a structural view of the special functions
- Select the desired function

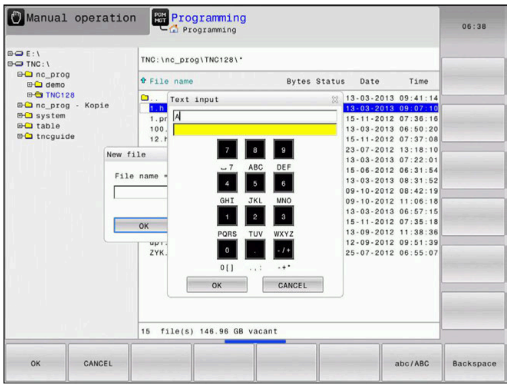
Further information: User's Manual for **Programming of Machining Cycles**

Opening the selection window with the GOTO key

When the control provides a selection menu, you can use the **GOTO** key to open the selection window. This allows you to view the available entries.

6.2 Screen keypad

If you are using the compact version of the control (without alphabetic keyboard), you can enter letters and special characters with the screen keypad or with an alphabetic keyboard connected to the USB port.



Entering text with the screen keypad

Proceed as follows to use the screen keypad:

- Press the **GOTO** key if you want to enter letters, e.g. a program name or directory name, using the screen keypad.
- > The control opens a window in which the numeric keypad of the control is displayed with the corresponding letters assigned.

- Press the numerical key until the cursor is on the desired letter
- Wait until the control transfers the selected character before you enter the next character

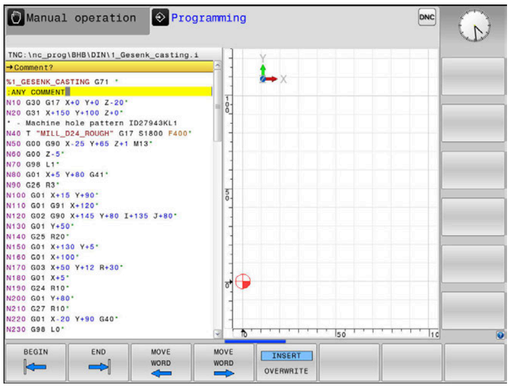
- Use the **OK** soft key to load the text into the open dialog field

Use the **abc/ABC** soft key to select upper or lower case. If your machine tool builder has defined additional special characters, you can call them with the **SPECIAL CHARACTERS** soft key and insert them. Use the **BACKSPACE** soft key to delete individual characters.

6.3 Display of NC programs

Syntax highlighting

The control displays syntax elements with various colors according to their meaning. Color-highlighting makes the NC programs easier to read and clearer.



Color highlighting of syntax elements

Use	Color
Standard color	Black
Display of comments	Green
Display of numerical values	Blue
Display of the block number	Violet
Display of FMAX	Orange
Display of the feed rate	Brown

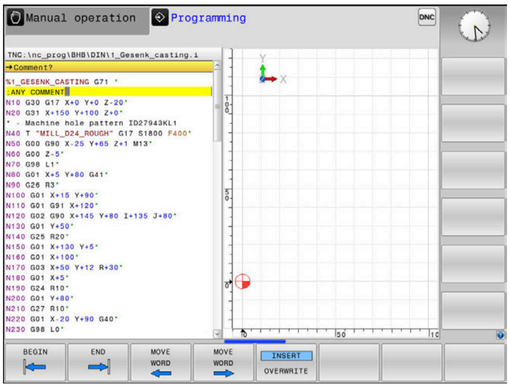
Scrollbar

Screen content can be shifted with the mouse using the scroll bar at the right edge of the program window. In addition, the size and position of the scrollbar indicates program length and cursor position.

6.4 Adding comments

Application

You can add comments to an NC program to explain program steps or make general notes.



> The control shows long comments in different ways, depending on the machine parameter **lineBreak** (no. 105404). It either wraps the comment lines or displays the **>>** symbol to indicate additional content.
>
> The last character in a comment block must not have any tilde(~).

You can add comments in different ways.

Entering comments during programming

- Enter the data for an NC block
- Press the semicolon key **;** on the alphabetic keyboard
- > The control displays the dialog prompt **Comment?**
- Enter the comment
- Press the **END** key to conclude the NC block

Inserting comments after program entry

- Select the NC block to which you want to add the comment
- Select the last word in the NC block with the right arrow key:
- Press the semicolon key **;** on the alphabetic keyboard
- > The control displays the dialog prompt **Comment?**
- Enter the comment
- Press the **END** key to conclude the NC block

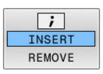
Entering a comment in a separate NC block

- Select the NC block after which you want to insert the comment
- Initiate the programming dialog with the semicolon key (**;**) on the alphabetic keyboard
- Enter your comment and conclude the NC block by pressing the **END** key

Commenting out an existing NC block

Proceed as follows to change an existing NC block to a comment:

- Select the NC block to be commented out



- Press the **INSERT COMMENT** soft key

Alternative:

- Press the **<** key on the alphabetic keyboard
- > The control inserts a semicolon **;** at the beginning of the block.
- Press the **END** key

Changing a comment for an NC block

Proceed as follows to change a commented-out NC block to an active NC block:

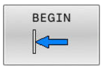
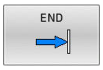
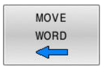
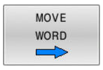
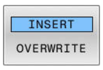
- Select the comment block you want to change

- Press the **REMOVE COMMENT** soft key

Alternative:

- Press the **>** key on the alphabetic keyboard
- > The control removes the semicolon **;** at the beginning of the block.
- Press the **END** key

Functions for editing a comment

Soft key	Function
	Jump to beginning of comment
	Jump to end of comment
	Jump to the beginning of a word. Use a space to separate words
	Jump to the end of a word. Use a space to separate words
	Switch between paste and overwrite mode

6.5 Freely editing an NC program

Certain syntax elements, such as LN blocks, cannot be entered directly in the NC editor by using the available keys and soft keys.

To prevent the use of an external text editor, the control offers the following possibilities:

- Free syntax input using the control's integrated text editor
- Free syntax input using the **?** key in the NC editor

Free syntax input using the control's integrated text editor

To add syntax to an existing NC program, proceed as follows:

PGM MGT

- Press the **PGM MGT** key
- > The control opens the file manager.

MORE FUNCTIONS

- Press the **MORE FUNCTIONS** soft key

SELECT EDITOR

- Press the **SELECT EDITOR** soft key
- > The control opens a selection window.

OK

- Select the **TEXT EDITOR** option
- Confirm your selection with **OK**
- Add the desired syntax

The control does not check the syntax in the text editor. Check your entries in the NC editor when you are finished.

Free syntax input using the ? key in the NC editor

To use this function you will need a alphabetic keyboard connected via USB.

To add syntax to an existing, open NC program, proceed as follows:

⇧

?/

- Enter **?**
- > The control opens a new NC block.

END

- Add the desired syntax
- Confirm your entry with **END**

After confirmation, the control checks the syntax. Errors will result in **ERROR** blocks.

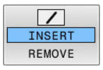
6.6 Skipping NC blocks

Insert a slash (/)

You can optionally hide NC blocks.

To hide NC blocks in the **Programming** mode, proceed as follows:

- Select the desired NC block



- Press the **INSERT** soft key
- > The control inserts a slash (/).

Delete the slash (/)

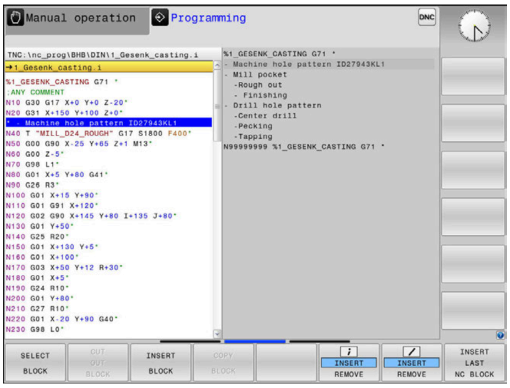
To show NC blocks again in the **Programming** mode, proceed as follows:

- Select the hidden NC block

- Press the **REMOVE** soft key
- > The control removes the slash (/).

6.7 Structuring NC programs

Definition and applications



The control enables you to comment NC programs in structuring blocks. Structuring blocks are texts with up to 252 characters and are used as comments or headlines for the subsequent program lines.

With the aid of appropriate structuring blocks, you can organize long and complex NC programs in a clear and comprehensible manner.

This function is particularly convenient if you want to change the NC program later. Structuring blocks can be inserted into the NC program at any point.

Structure blocks can also be displayed in a separate window, and be edited or added to, as desired. Use the appropriate screen layout for this.

The control manages the inserted structure items in a separate file (extension: .SEC.DEP). This speeds navigation in the program structure window.

The **PROGRAM + SECTS** screen layout can be selected in the following operating modes:

- **Program run, single block**
- **Program run, full sequence**
- **Programming**

Displaying the program structure window / Changing the active window

- Display structure window: For this screen layout press the **PROGRAM + SECTS** soft key

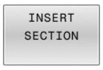
- Change the active window: Press the **CHANGE WINDOW** soft key

Inserting a structure block in the program window

- Select the NC block after which you want to insert the structuring block

- Press the **SPEC FCT** key

- Press the **PROGRAMMING AIDS** soft key



- Press the **INSERT SECTION** soft key
- Enter the structuring text

- Change the structuring depth (indenting) via soft key

> You can indent structure items only during editing.

> You can also insert structure blocks with the key combination **Shift + 8**.

Selecting blocks in the program structure window

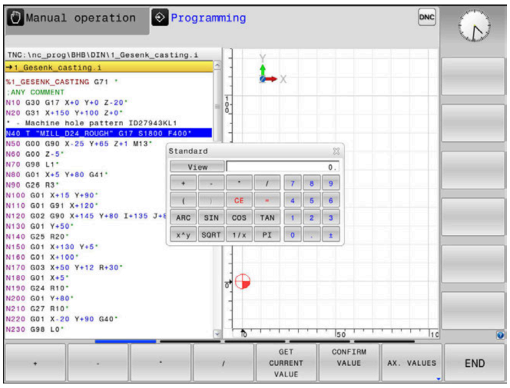
If you are scrolling through the program structure window block by block, the control at the same time automatically moves the corresponding NC blocks in the program window. This way you can quickly skip large program sections.

6.8 Calculator

Operation

The control features a calculator with the most important mathematical functions.

- To show the calculator, press the **CALC** key
- Select the arithmetic functions: Select the command via soft key or enter it with an alphanumeric keyboard
- To close the calculator, press the **CALC** key



Calculate function	Command (soft key)
Addition	+
Subtraction	–
Multiplication	*
Division	/
Calculating with parentheses	( )
Arc cosine	ARC
Sine	SIN
Cosine	COS
Tangent	TAN
Exponent	X^Y
Square root	SQRT
Inverted function	1/x
PI (3.14159265359)	PI
Add value to buffer memory	M+
Save value to buffer memory	MS
Retrieve buffer memory contents	MR
Delete buffer memory contents	MC
Natural logarithm	LN
Logarithm	LOG
Exponential function	e^x
Check the algebraic sign	SGN
Calculate the absolute value	ABS
Truncate decimal places	INT
Truncate digits before the decimal point	FRAC
Modulo	MOD
Select view	View
Delete value	CE

Calculate function	Command (soft key)
Unit of measure	MM or INCH
Show angular value in radians (default: angular value in degrees)	RAD
Select numerical value notation	DEC (decimal) or HEX (hexadecimal)

Transferring the calculated value into the NC program

- With the arrow keys, select the word into which the calculated value is to be transferred
- Show the calculator by pressing the **CALC** key, and perform the desired calculation
- Press the **CONFIRM VALUE** soft key
- > The control transfers the value into the active input field and closes the calculator.

> You can also transfer values from an NC program into the calculator. When you press the **GET CURRENT VALUE** soft key or the **GOTO** key, the control transfers the value from the active input field to the calculator.
>
> The calculator remains in effect even after a change in operating modes. Press the **END** soft key to close the calculator.

Functions in the pocket calculator

Soft key	Function
AX. VALUES	Transfer the nominal or reference value of the respective axis position into the calculator
GET CURRENT VALUE	Transfer the numerical value from the active input field into the calculator
CONFIRM VALUE	Transfer the numerical value from the calculator into the active input field
COPY FIELD	Copy the numerical value from the calculator
PASTE FIELD	Insert the copied numerical value into the calculator
CUTTING DATA CALCULATOR	Open the cutting data calculator

> You can also move the calculator with the arrow keys of your alphabetic keyboard. If you have connected a mouse you can also position the calculator with this.

6.9 Cutting data calculator

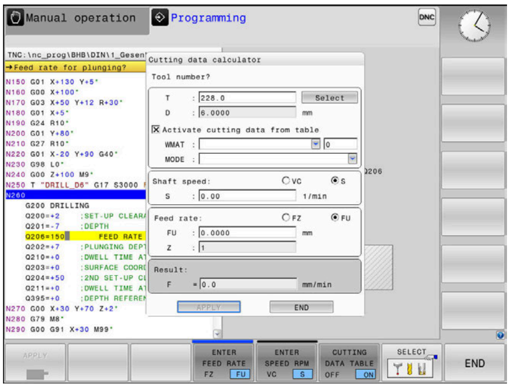
Application

With the cutting data calculator you can calculate the spindle speed and the feed rate for a machining process. Then you can load the calculated values into an opened feed rate or spindle speed dialog box in the NC program.

To open the cutting data calculator, press the **CUTTING DATA CALCULATOR** soft key.

The control shows the soft key if you

- press the **CALC** key
- When defining spindle speeds, press **CALC** soft key
- Define feed rates
- Press the **F** soft key in **Manual Operation** mode
- Press the **S** soft key in **Manual Operation** mode



Display modes of the cutting data calculator

The cutting data calculator is displayed with different input fields depending on whether you calculate a spindle speed or a feed rate:

Window for spindle speed calculation:

Abbrev.	Meaning
T:	Tool number
D:	Diameter of the tool
VC:	Cutting speed
S=	Result for spindle speed

If you open the speed calculator in a dialog where the tool is already defined, the speed calculator automatically applies the tool number and diameter. You only need to enter **VC** in the dialog field.

Window for feed rate calculation:

Abbrev.	Meaning
T:	Tool number
D:	Diameter of the tool
VC:	Cutting speed
S:	Spindle speed
Z:	Number of teeth
FZ:	Feed per tooth
FU:	Feed per revolution
F=	Result for feed rate

You can transfer the feed rate from the **T** block into subsequent NC blocks by pressing the **F AUTO** soft key. If you have to change the feed rate later, you only need to adjust the feed rate value in the **T** block.

Functions of the cutting data calculator

You have the following possibilities depending on where you open the cutting data calculator:

Soft key	Function
APPLY	Transfer the value from the cutting data calculator into the NC program
CALCULATE FEEDRATE F SPEED S	Toggle between feed-rate calculation and spindle-speed calculation
ENTER FEED RATE FZ FU	Toggle between feed per tooth and feed per revolution
ENTER SPEED RPM VC S	Toggle between spindle speed and cutting speed
CUTTING DATA TABLE OFF ON	Activate or deactivate working with cutting data tables
SELECT	Select a tool from the tool table
↓	Move the cutting data calculator in the direction of the arrow
POCKET CALCULATOR	Switch to the calculator
INCH	Use inch values in the cutting data calculator
END	Close the cutting data calculator

Working with cutting data tables

Application

If you store tables for materials, cutting materials, and cutting data on the control, then the cutting data calculator can use the values in these tables.

Proceed as follows before working with automatic calculation of the spindle speed and feed rate:

- Enter the type of workpiece material in the table WMAT.tab
- Enter the type of cutting material in the file TMAT.tab
- Enter the combination of workpiece material and cutting material in a cutting data table
- Define the tool with the necessary values in the tool table
  - Tool radius
  - Number of teeth
  - Cutting material
  - Cutting data table

Workpiece material WMAT

Define the workpiece materials in the WMAT.tab table. You must save this table in the directory **TNC:\table**.

This table contains the column **WMAT** for the material and a column called **MAT_CLASS**; here you categorize the materials into material classes with the same cutting conditions, e.g. according to DIN EN 10027-2.

Enter the workpiece material as follows in the cutting data calculator:

- Select the cutting data calculator
- Select **Activate cutting data from table** in the pop-up window
- Select **WMAT** from the drop-down menu

TNC:\table\WMAT.TAB

NR	WMAT	MAT_CLASS
1		10
2	1.0038	10
3	1.0044	10
4	1.0114	10
5	1.0177	10
6	1.0143	10
7	St 37-2	10
8	St 37-3 N	10
9	X 14 CrMo S 17	20
10	1.1404	20
11	1.4305	20
12	V2A	21
13	1.4301	21
14	AlCu4PBMg	100
15	Aluminium	100
16	PTFE	200

Cutting material TMAT

Cutting materials are defined in the TMAT.tab table. You must save this table in the directory **TNC:\table**.

You assign the cutting material in the **TMAT** column of the tool table. You can create columns with other names, such as **ALIAS1** and **ALIAS2** in order to enter alternative names for the same cutting material.

Cutting data table

Define the combinations of workpiece material and cutting material with the corresponding cutting data in a table with the file extension .CUT. You must save this table in the directory **TNC:\system\Cutting-Data**.

You assign the appropriate cutting data table in the **CUTDATA** column of the tool table.

TNC:\system\Cutting-Data\CUTDATA.CUT

NR	MAT_CLASS	MODE	TMAT	VC	FTYPE
0	10	Rough	HSS	28	
1	10	Rough	VHM	70	
2	10	Finish	HSS	30	
3	10	Finish	VHM	70	
4	10	Rough	HSS coated	78	
5	10	Finish	HSS coated	82	
6	20	Rough	VHM	90	
7	20	Finish	VHM	82	
8	100	Rough	HSS	150	
9	100	Finish	HSS	145	
10	100	Rough	VHM	450	
11	100	Finish	VHM	440	
12					
13					
14					

> Use this simplified table if you use tools that have only a single diameter, or if the diameter is not relevant to the feed rate, i.e. for indexable inserts.

The cutting data table contains the following columns:

- **MAT_CLASS**: Material class
- **MODE**: Machining mode, such as finishing
- **TMAT**: Cutting material
- **VC**: Cutting speed
- **FTYPE**: Type of feed rate **FZ** or **FU**
- **F**: Feed rate

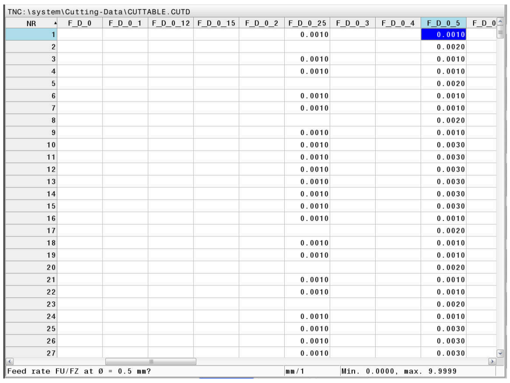
Diameter-dependent cutting data table

In many cases the diameter of the tool determines which cutting data you can use. Use the cutting data table with the file extension .CUTD for this purpose. You must save this table in the directory **TNC:\system\Cutting-Data**.

You assign the appropriate cutting data table in the **CUTDATA** column of the tool table.

The diameter-dependent cutting data table contains the following additional columns:

- **F_D_0**: Feed rate for Ø 0 mm
- **F_D_0_1**: Feed rate for Ø 0.1 mm
- **F_D_0_12**: Feed rate for Ø 0.12 mm
- ...



TNC:\system\Cutting-Data\CUTTABLE.CUTD

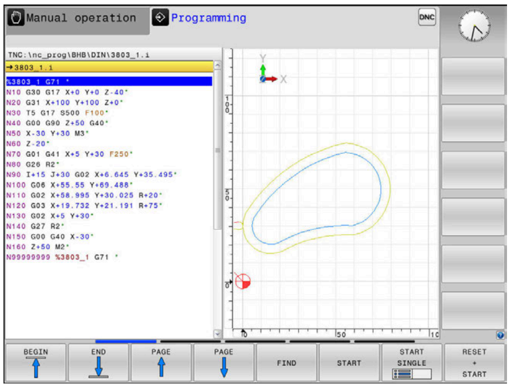
NR	F_D_0	F_D_0_1	F_D_0_12	F_D_0_15	F_D_0_2	F_D_0_25	F_D_0_3	F_D_0_4	F_D_0_5	F_D_0
1						0.0010			0.0010	
2									0.0020	
3						0.0010			0.0010	
4						0.0010			0.0010	
5									0.0020	
6						0.0010			0.0010	
7						0.0010			0.0010	
8									0.0020	
9						0.0010			0.0010	
10						0.0010			0.0030	
11						0.0010			0.0030	
12						0.0010			0.0030	
13						0.0010			0.0030	
14						0.0010			0.0030	
15						0.0010			0.0030	
16						0.0010			0.0010	
17									0.0020	
18						0.0010			0.0010	
19						0.0010			0.0010	
20									0.0020	
21						0.0010			0.0010	
22						0.0010			0.0010	
23									0.0020	
24						0.0010			0.0010	
25						0.0010			0.0030	
26						0.0010			0.0030	
27						0.0010			0.0030	

Feed rate FU/FZ at Ø = 0.5 mm? mm/1 Min. 0.0000, max. 9.9999

> You don't need to fill in all columns. If a tool diameter is between two defined columns, the control linearly interpolates the feed rate.

6.10 Programming graphics

Activating and deactivating programming graphics



While you are writing an NC program, you can have the control generate a 2-D pencil-trace graphic of the programmed contour.

- ▶ Press the **Screen layout** key
- ▶ Press the **PROGRAM + GRAPHICS** soft key
- > The control shows the NC program to the left and graphics to the right.

- ▶ Set the **AUTO DRAW** soft key to **ON**
- > While you are entering the program lines, the control generates each programmed movement in the graphics window in the right screen half.

If you do not want the control to generate graphics during programming, then set the **AUTO DRAW** soft key to **OFF**.

> **i** If **AUTO DRAW** is set to **ON**, then the control ignores the following program content when creating 2-D pencil-trace graphics:
> - Program section repetitions
> - Jump commands
> - M functions, such as M2 or M30
> - Cycle calls
> - Warnings due to locked tools
>
> Therefore, only use automatic drawing during contour programming.

The control resets the tool data when you reopen an NC program or press the **RESET + START** soft key.

The control uses various colors in the programming graphics:

- **blue:** completely defined contour element
- **violet:** not yet completely defined contour element, can still be modified by e.g. an RND
- **light blue:** holes and threads
- **ocher:** tool midpoint path
- **red:** rapid traverse

Further information: "FK programming graphics", Page 171

Generating a graphic for an existing NC program

- Use the arrow keys to select the NC block up to which you want the graphic to be generated, or press **GOTO** and enter the desired block number

RESET + START

- Reset previously active tool data, and generate graphic: Press the **RESET + START** soft key

Additional functions:

Soft key	Function
RESET + START	Reset previously active tool data. Generate programming graphics
START SINGLE	Generate programming graphic blockwise
START	Generate a complete programming graphic, or complete it after **RESET + START**
STOP	Stop the programming graphics. This soft key only appears while the control is generating the programming graphics
VIEWS	Selecting views ■ Plan view ■ Front view ■ Page view
SHOW TOOL PATHS OFF ON	Display or hide tool paths
SHOW FMAX PATHS OFF ON	Display or hide tool paths in rapid traverse

Block number display ON/OFF

▷

- Shift the soft-key row

SHOW BLOCK NO. OFF ON

- Show block numbers: Set the **SHOW BLOCK NO.** soft key to **ON**
- Hide block numbers: Set the **SHOW BLOCK NO.** soft key to **OFF**

Erasing the graphic

▷

- Shift the soft-key row

CLEAR GRAPHICS

- Erase the graphic: Press the **CLEAR GRAPHICS** soft key

Showing grid lines

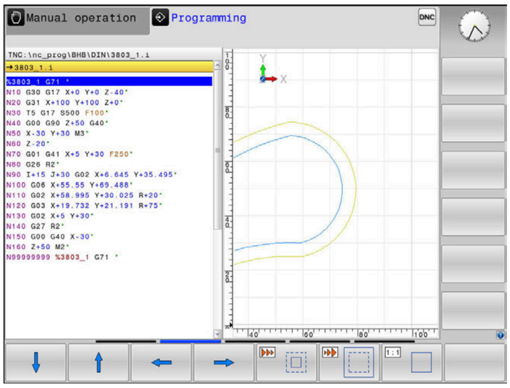
▷

- Shift the soft-key row

OFF ON

- Show grid lines: Press the **Show grid lines** soft key

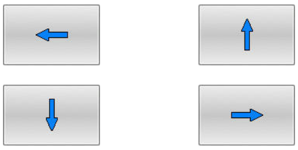
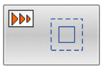
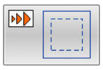
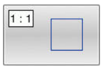
Magnification or reduction of details



You can select the graphics display

▶ Shift the soft-key row

The following functions are available:

Soft key	Function
	Shift section
	Reduce section
	Enlarge section
	Reset section

The **RESET BLK FORM** soft key allows you to restore the original section.

You can also use the mouse to change the graphic display. The following functions are available:

- To shift the displayed model, hold down the center mouse button or the mouse wheel, and move the mouse. If you press the shift key at the same time, then you will be able to shift the model only horizontally or vertically.
- To zoom in on a certain area, mark a zoom area by holding the left mouse button down. After you release the left mouse button, the control zooms in on the defined area.
- To rapidly magnify or reduce any area, rotate the mouse wheel backwards or forwards.

6.11 Error messages

Display of errors

The control displays error messages in the following cases, for example:

- Incorrect data input
- Logical errors in the NC program
- Contour elements that are impossible to machine
- Incorrect use of touch probes
- Hardware updates

When an error occurs, the control displays it in the header.

The control uses different icons and text colors for different error classes.

Icon	Text color	Error class
	Red	Errors
	Red	Errors Question type
	Yellow	Warning
	Green	Notes
	Blue	Information

The control displays an error message in the header until it is cleared or replaced by a higher-priority error (higher error class). Information that appears only briefly is always displayed.

The control displays long and multi-line error messages in abbreviated form. The complete information on all pending errors is shown in the error window.

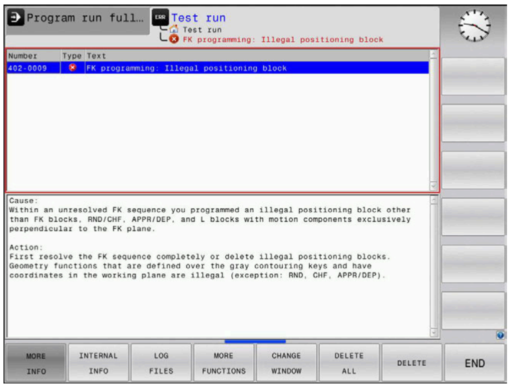
An error message that contains an NC block number was caused by an error in the indicated NC block or in the preceding NC block.

Opening the error window

When you open the error window, the complete information on all pending errors will be shown.

- ▶ Press the **ERR** key
- \> The control opens the error window and displays all accumulated error messages.

Detailed error messages



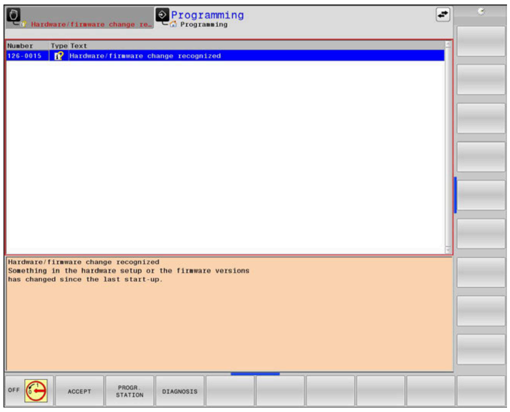
The control displays possible causes of the error and suggestions for solving the problem:

- Open the error window
- Position the cursor on the corresponding error message

- Press the **MORE INFO** soft key
- > The control opens a window with information on the error cause and corrective action.

- Exit the info: Press the **MORE INFO** soft key again

High-priority error messages



When an error message occurs at switch-on of the control due to hardware changes or updates, the control will automatically open the error window. The control displays an error of the question type.

You can correct this error only by pressing the corresponding soft key to acknowledge the question. If necessary, the control continues the dialog until the cause or correction of the error has been clearly determined.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

If a rare **processor check error** should occur, the control will automatically open the error window. You cannot correct such an error.

Proceed as follows:

- Shut down the control
- Restart

INTERNAL INFO soft key

The **INTERNAL INFO** soft key supplies information on the error message. This information is only required if servicing is needed.

- Open the error window
- Position the cursor on the corresponding error message

- Press the **INTERNAL INFO** soft key
- > The control opens a window with internal information about the error.

- Exit the detailed information: Press the **INTERNAL INFO** soft key again

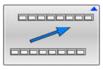
FILTER soft key

The **FILTER** soft key allows you to group identical warnings and error messages in the error window. The grouping makes the list of messages shorter and easier to read.

- Open the error window

- Press the **MORE FUNCTIONS** soft key

- Press the **FILTER** soft key
- > The control groups identical warnings and error messages.
- > The number of occurrences of the individual messages is indicated in parentheses in the respective line.



- Exit the filter: Press the **GO BACK** soft key

ACTIVATE AUTOMATIC SAVING soft key

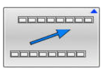
Using the **ACTIVATE AUTOMATIC SAVING** soft key, you can specify error numbers that cause the control to save a service file if an error with that number occurs.

- Open the error window

- Press the **MORE FUNCTIONS** soft key

- Press the **ACTIVATE AUTOMATIC SAVING** soft key
- > The control opens the **ACTIVATE AUTOMATIC SAVING** pop-up window.
- Define the entries
  - **Error number**: Enter the desired error number
  - **active:** Enable this option to automatically create the service file
  - **Comment:** Enter a comment on this error number, if required

- Press the **STORE** soft key
- > If an error with the specified error number occurs, a service file will be saved automatically.



- Press the **GO BACK** soft key

Deleting errors

Clearing errors automatically

The control can automatically clear pending warning or error messages when an NC program is selected or restarted. The machine tool builder specifies in the optional machine parameter **CfgClearError** (no. 130200) whether these messages will automatically be cleared.

The factory default setting of the control defines that warning and error messages in the **Test Run** and **Programming** operating modes will be cleared automatically from the error window. Messages issued in the machine operating modes will not be cleared.

Clearing errors outside of the error window

CE

- Press the **CE** key
- > The control clears the errors or notes being displayed in the header.

In certain situations you cannot use the **CE** key for clearing the errors because the key is used for other functions.

Clearing errors

- Open the error window
- Position the cursor on the corresponding error message

DELETE

- Press the **DELETE** soft key

DELETE ALL

- As an alternative, clear all errors: Press the **DELETE ALL** soft key

If the cause of the error has not been corrected, the error message cannot be cleared. In this case, the error message remains in the window.

Error log

The control stores errors occurred and important events (e.g., system start) in an error log. The capacity of the error log is limited. When the log is full, the control uses a second file. When this is also full, the first error log is deleted and newly written etc. If required, switch from **CURRENT FILE** to **PREVIOUS FILE** to view the history.

- Open the error window

- Press the **LOG FILES** soft key

- Open the error log file: Press the **ERROR LOG** soft key

- Set the previous error log if required: Press the **PREVIOUS FILE** soft key

- Set the current error log if required: Press the **CURRENT FILE** soft key

The oldest entry is at the beginning of the log file, and the most recent entry is at the end.

Keystroke log

The control stores each key pressed and important events (e.g., system start) in a keystroke log. The capacity of the keystroke log is limited. When the keystroke log is full, the control switches to a second keystroke log. When this is also full, the first keystroke log is deleted and newly written, etc. If required, switch from **CURRENT FILE** to **PREVIOUS FILE** to view the history of the inputs.

LOG FILES

- Press the **LOG FILES** soft key

KEYSTROKE LOG

- Open the keystroke log file: Press the **KEYSTROKE LOG** soft key

PREVIOUS FILE

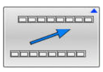
- Set the previous keystroke log if required: Press the **PREVIOUS FILE** soft key

CURRENT FILE

- Set the current keystroke log if required: Press the **CURRENT FILE** soft key

The control saves each key pressed during operation in a keystroke log. The oldest entry is at the beginning, and the most recent entry is at the end of the file.

Overview of the keys and soft keys for viewing the log

Soft key/ Keys	Function
BEGIN	Go to beginning of keystroke log
END	Go to end of keystroke log
FIND	Find text
CURRENT FILE	Current keystroke log
PREVIOUS FILE	Previous keystroke log
 	Up/down one line
	Return to main menu

Informational texts

If an operating error occurred, e.g. pressing an impermissible key or entering a value outside of a validity range, the control displays an information text in the header to inform you of the operating error. The control deletes this information text with the next valid entry.

Saving service files

If necessary, you can save the current status of the control and make it available to a service technician for evaluation. A group of service files is saved (error and keystroke logs as well as other files that contain information about the current status of the machine and the machining).

> In order to facilitate sending service files via email, the control will only save active NC programs with a size of up to 10 MB in the service file. If the NC program is bigger, it will not be added to the created service file.

If you repeat the **SAVE SERVICE FILES** function with the same file name, the previously saved group of service files will be overwritten. Therefore, use a different file name when re-executing the function.

Saving service files

ERR

- Open the error window

LOG FILES

- Press the **LOG FILES** soft key

SAVE SERVICE FILES

- Press the **SAVE SERVICE FILES** soft key
- > The control opens a pop-up window in which you can enter a file name or a complete path for the service file.

OK

- Press the **OK** soft key
- > The control saves the service file.

Closing the error window

To close the error window again, proceed as follows:

END

- Press the **END** soft key

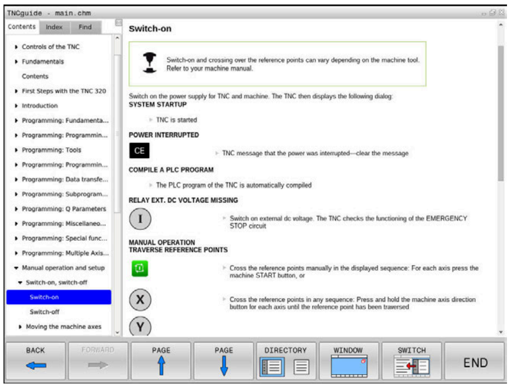
ERR

- Alternative: Press the **ERR** key
- > The control closes the error window.

6.12 TNCguide context-sensitive help system

Application

> Before you can use the TNCguide, you need to download the help files from the HEIDENHAIN home page
>
> **Further information:** "Downloading current help files", Page 214



The **TNCguide** context-sensitive help system contains the user documentation in HTML format. The TNCguide is called with the **HELP** key, and the control often immediately displays the information specific to the condition from which the help was called (context-sensitive call). Even if you are editing an NC block and press the **HELP** key, you are usually brought to the exact place in the documentation that describes the corresponding function.

> The control tries to start the TNCguide in the language that you have selected as the conversational language. If the required language version is not available, the control automatically opens the English version.

The following user documentation is available in TNCguide:

- User's Manual for Klartext Programming (**BHBKlartext.chm**)
- User's Manual for ISO programming (**BHBIso.chm**)
- User's Manual for Setup, Testing and Running NC Programs (**BHBoperate.chm**)
- User's Manual for Programming of Machining Cycles (**BHBcycle.chm**)
- User's Manual for Programming of Measuring Cycles for Workpieces and Tools (**BHBtchprobe.chm**)
- User's Manual for the TNCdiag application, if necessary (**TNCdiag.chm**)
- List of All Error Messages **(errors.chm)**

In addition, the **main.chm** "book" file is available, in which all existing .chm files are shown in one place.

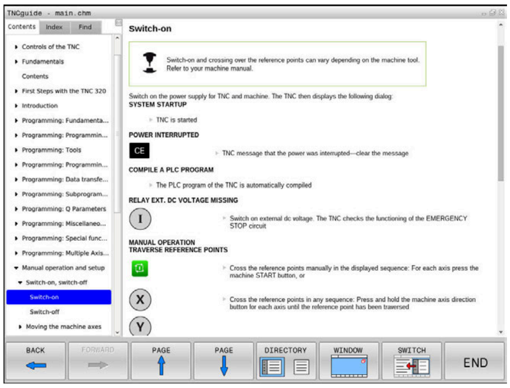
> As an option, your machine tool builder can embed machine-specific documentation in **TNCguide**. These documents then appear as a separate book in the **main.chm** file.

Working with TNCguide

Calling TNCguide

You have several options for starting the TNCguide:

- Use the **HELP** key
- First click the help symbol in the lower right-hand corner of the screen, then click the appropriate soft key
- Open a help file (.chm file) via the file management. The control can open any .chm file, even if it is not saved in the control's internal memory



> On the Windows programming station, the TNCguide is opened in the internally defined standard browser.

For many soft keys there is a context-sensitive call through which you can go directly to the description of the soft key's function. This functionality requires using a mouse.

Proceed as follows:

- ▶ Select the soft-key row containing the desired soft key
- ▶ Click with the mouse on the help symbol that the control displays just above the soft-key row
- > The mouse pointer turns into a question mark.
- ▶ Move the question mark to the soft key for which you want an explanation
- > The control opens the TNCguide. If there is no entry point for the selected soft key, then the control opens the book file **main.chm**. You can search for the desired explanation using full text search or by using the navigation.

Even if you are editing an NC block, context-sensitive help is available:

- ▶ Select any NC block
- ▶ Select the desired word
- ▶ Press the **HELP** key.
- > The control opens the Help system and shows the description of the active function. This does not apply for miscellaneous functions or cycles from your machine tool builder.

Navigating in the TNCguide

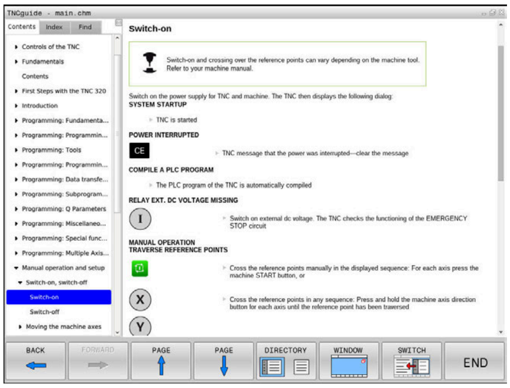
It's easiest to use the mouse to navigate in TNCguide. A table of contents appears on the left side of the screen. By clicking the rightward pointing triangle you open subordinate sections, and by clicking the respective entry you open the individual pages. It is operated in the same manner as the Windows Explorer.

Linked text positions (cross references) are shown underlined and in blue. Clicking the link opens the associated page.

Of course you can also operate TNCguide through keys and soft keys. The following table contains an overview of the corresponding key functions.

Soft key	Function
↑ ↓	■ If the table of contents at left is active: Select the entry above it or below it ■ If the text window at right is active: Move the page downward or upward if texts or graphics are not shown completely
→	■ If the table of contents at left is active: Open up the table of contents ■ If the text window at right is active: No function
←	■ If the table of contents at left is active: Close the table of contents ■ If the text window at right is active: No function
ENT	■ If the table of contents at left is active: Use the cursor key to show the selected page ■ If the text window at right is active: If the cursor is on a link, jump to the linked page
	■ If the table of contents at left is active: Switch the tab between the display of the table of contents, display of the subject index, and the full-text search function and switching to the screen half at right ■ If the text window at right is active: Jump back to the window at left
	■ If the table of contents at left is active: Select the entry above it or below it ■ If the text window at right is active: Jump to next link
BACK	Select the page last shown
FORWARD	Page forward if you have used the **Select page last shown** function
PAGE ↑	Move up by one page
PAGE ↓	Move down by one page

Soft key	Function
DIRECTORY	Display or hide table of contents
WINDOW	Switch between full-screen display and reduced display. With the reduced display you can see some of the rest of the control window
SWITCH	The focus is switched internally to the control application so that you can operate the control when the TNCguide is open. If the full screen is active, the control reduces the window size automatically before the change of focus
END	Exit TNCguide



Subject index

The most important subjects in the Manual are listed in the subject index (**Index** tab). You can select them directly by mouse or with the arrow keys.

The left side is active.

- Select the **Index** tab
- Use the arrow keys or the mouse to select the desired keyword

Alternative:

- Enter the first few characters
- > The control synchronizes the subject index and creates a list in which you can find the subject more easily.
- Use the **ENT** key to call the information on the selected keyword

Full-text search

On the **Find** tab, you can search all of TNCguide for a specific word.

The left side is active.

- Select the **Find** tab
- Activate the **Find:** entry field
- Enter the search word
- Press the **ENT** key
- > The control lists all sources containing the word.
- Use the arrow keys to navigate to the desired source
- Press the **ENT** key to go to the selected source

> **i** The full-text search only works for single words.
>
> If you activate the **Search only in titles** function, the control searches only through headings and ignores the body text. To activate the function, use the mouse or select it and then press the space bar to confirm.

Downloading current help files

You'll find the help files for your control software on the HEIDENHAIN homepage:
http://content.heidenhain.de/doku/tnc_guide/html/en/index.html

Navigate to the suitable help file as follows:

- TNC Controls
- Series, e.g. TNC 600
- Desired NC software number, e.g.TNC 620 (81760x-07)
- Select the desired language version from the **TNCguide online help** table
- Download the ZIP file
- Extract the ZIP file
- Move the extracted CHM files to the **TNC:\tncguide\en** directory or the respective language subdirectory on the control

> When using **TNCremo** to transfer the CHM files to the control, select the binary mode for files with the **.chm** extension.

Language	TNC directory
German	**TNC:\tncguide\de**
English	**TNC:\tncguide\en**
Czech	**TNC:\tncguide\cs**
French	**TNC:\tncguide\fr**
Italian	**TNC:\tncguide\it**
Spanish	**TNC:\tncguide\es**
Portuguese	**TNC:\tncguide\pt**
Swedish	**TNC:\tncguide\sv**
Danish	**TNC:\tncguide\da**
Finnish	**TNC:\tncguide\fi**
Dutch	**TNC:\tncguide\nl**
Polish	**TNC:\tncguide\pl**
Hungarian	**TNC:\tncguide\hu**
Russian	**TNC:\tncguide\ru**
Chinese (simplified)	**TNC:\tncguide\zh**
Chinese (traditional)	**TNC:\tncguide\zh-tw**
Slovenian	**TNC:\tncguide\sl**
Norwegian	**TNC:\tncguide\no**
Slovak	**TNC:\tncguide\sk**
Korean	**TNC:\tncguide\kr**
Turkish	**TNC:\tncguide\tr**
Romanian	**TNC:\tncguide\ro**

7

Miscellaneous functions

7.1 Entering miscellaneous functions M and STOP

Fundamentals

With the control's miscellaneous functions—also called M functions—you can affect:

- the program run, e.g. a program interruption
- the machine functions, such as switching spindle rotation and coolant supply on and off
- The path behavior of the tool

You can enter up to four M (miscellaneous) functions at the end of a positioning block or in a separate NC block. The control displays the following dialog question: **Miscellaneous function M ?**

You usually enter only the number of the miscellaneous function in the programming dialog. With some miscellaneous functions, the dialog is extended so that you can enter the required parameters for this function.

In the **Manual operation** and **Electronic handwheel** operating modes, the M functions are entered with the **M** soft key.

Effectiveness of miscellaneous functions

Please note that some M functions become effective at the start of a positioning block, and others at the end, regardless of their position in the NC block.

Miscellaneous functions come into effect in the NC block in which they are called.

Some miscellaneous functions are effective only in the NC block in which they are programmed. Unless the miscellaneous function is only effective blockwise, you must either cancel it in a subsequent NC block with a separate M function, or it is automatically canceled by the control at the end of the program.

> If multiple functions were programmed in a single NC block, the execution sequence is as follows:
> - M functions taking effect at the start of the block are executed before those taking effect at the end of the block
> - If all M functions are effective at the start or end of the block, execution takes place in the sequence as programmed

Entering a miscellaneous function in a STOP block

If you program a **STOP** block, the program run or test run is interrupted at the block, e.g. for a tool inspection. You can also enter an M (miscellaneous) function in a **STOP** block:

STOP

- ▶ To program an interruption of program run, press the **STOP** key
- ▶ Enter a miscellaneous function **M** if required

Example

```
N87 G38*
```

7.2 Miscellaneous functions for program run inspection, spindle and coolant

Overview

> Refer to your machine manual!
> The machine manufacturer can influence the behavior of the miscellaneous functions described below.

M	Effect	Effective at block	
		Start	End
M0	Program STOP Spindle STOP		■
M1	Optional program STOP Spindle STOP if necessary Coolant OFF if necessary (function defined by the machine tool builder)		■
M2	STOP program run Spindle STOP Coolant off Return jump to block 1 Clear status display Functional scope depends on machine parameter **resetAt** (no. 100901)		■
M3	Spindle ON clockwise	■	
M4	Spindle ON counterclockwise	■	
M5	Spindle STOP		■
M6	Tool change Spindle STOP Program STOP		■

> Since this function varies depending on the machine tool builder, HEIDENHAIN recommends that you use the **TOOL CALL** function for tool changes.

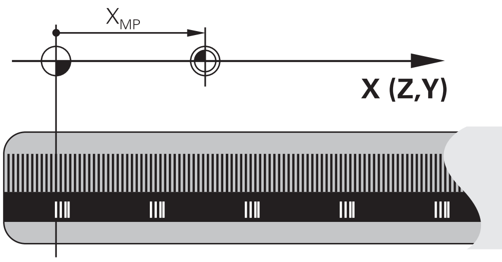
M	Effect	Start	End
M8	Coolant ON	■	
M9	Coolant OFF		■
M13	Spindle ON clockwise Coolant ON	■	
M14	Spindle ON counterclockwise Coolant ON	■	
M30	Same as M2		■

7.3 Miscellaneous functions for coordinate entries

Programming machine-referenced coordinates: M91/ M92

Scale datum

On the scale, a reference mark indicates the position of the scale datum.



Machine datum

The machine datum is required for the following tasks:

- Define the axis traverse limits (software limit switches)
- Approach machine-referenced positions (such as tool change positions)
- Set a workpiece preset

The distance in each axis from the scale datum to the machine datum is defined by the machine tool builder in a machine parameter.

Standard behavior

The control references the coordinates to the workpiece datum.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Behavior with M91—Machine datum

If you want the coordinates in a positioning block to be referenced to the machine datum, enter M91 into these NC blocks.

> If you program incremental coordinates in an M91 block, enter them with respect to the last programmed M91 position. If no M91 position is programmed in the active NC block, then enter the coordinates with respect to the current tool position.

The coordinate values on the control's screen are referenced to the machine datum. Switch the display of coordinates in the status display to REF.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Behavior with M92 – Additional machine reference point

Refer to your machine manual!

In addition to the machine datum, the machine tool builder can also define an additional machine-based position as a machine reference point (machine preset).

For each axis, the machine tool builder defines the distance between the machine preset and the machine datum.

If you want the coordinates in positioning blocks to be based on the machine preset, enter M92 into these NC blocks.

Radius compensation remains the same in blocks that are programmed with **M91** or **M92**. The tool length will **not** be taken into account.

Effect

M91 and M92 are effective only in the blocks in which M91 and M92 have been programmed.

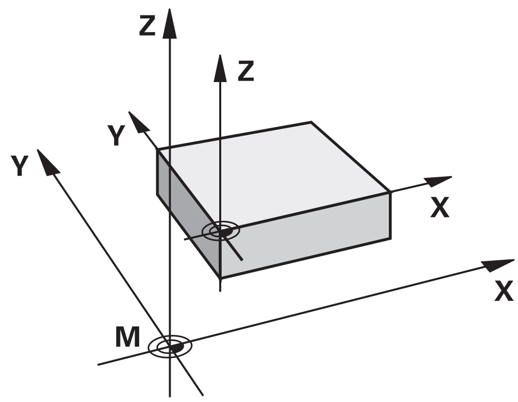
M91 and M92 take effect at the start of block.

Workpiece preset

If you want the coordinates to always be referenced to the machine datum, you can inhibit presetting for one or more axes.

If preset setting is disabled for all axes, the control no longer displays the **SET PRESET** soft key in **Manual operation** mode.

The figure shows coordinate systems with the machine and workpiece datum.



M91/M92 in the Test Run mode

In order to be able to graphically simulate M91/M92 movements, you need to activate working space monitoring and display the workpiece blank referenced to the defined preset.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Moving to positions in a non-tilted input coordinate system with a tilted working plane: M130

Standard behavior with a tilted working plane

The control references the coordinates in the positioning blocks to the tilted working plane coordinate system.

Further information: "Working plane coordinate system WPL-CS", Page 80

Behavior with M130

Despite an active tilted working plane, the control references the coordinates in straight line blocks to the non-tilted input coordinate system.

M130 ignores only the **Tilt the working plane** function, but takes into account active transformations before and after tilting. This means that, when calculating the position, the control considers the axis angles of the rotary axes that are not in their zero position.

Further information: "Input coordinate system I-CS", Page 81

NOTICE

Danger of collision!

The function **M130** is only effective blockwise. The control executes the subsequent machining operations in the tilted working plane coordinate system again. Danger of collision during machining!

- Check the sequence and positions using a graphic simulation

Programming notes

- The function **M130** is allowed only if the **Tilt the working plane** function is active.
- If the function **M130** is combined with a cycle call, the control will interrupt machining with an error message.

Effect

M130 functions blockwise in straight-line blocks without tool radius compensation.

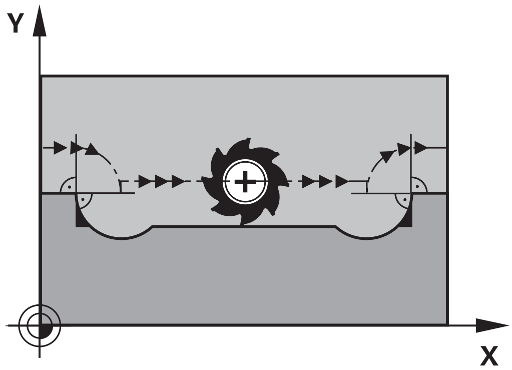
7.4 Miscellaneous functions for path behavior

Machining small contour steps: M97

Standard behavior

The control inserts a transition arc at outside corners. For very small contour steps, the tool would damage the contour.

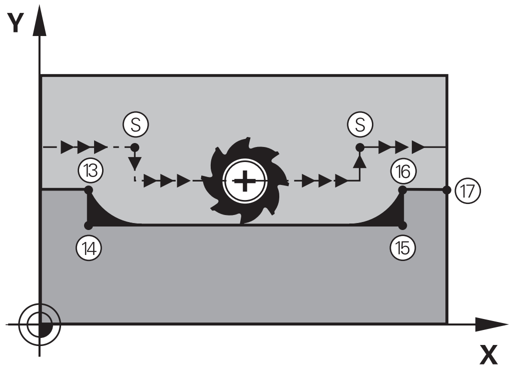
In such cases, the control interrupts the program run and generates the **Tool radius too large** error message.



Behavior with M97

The control determines a path intersection for the contour elements—such as inner corners—and moves the tool above this point.

Program **M97** in the same NC block as the outside corner.



> HEIDENHAIN recommends using the much more powerful **M120 LA** function instead of **M97**. **Further information:** "Pre-calculating radius-compensated contours (LOOK AHEAD): M120 (option 21)", Page 226

Effect

M97 is effective only in the NC block in which **M97** is programmed.

> The control does not completely finish the corner when it is machined with **M97**. You may wish to rework the contour with a smaller tool.

Example

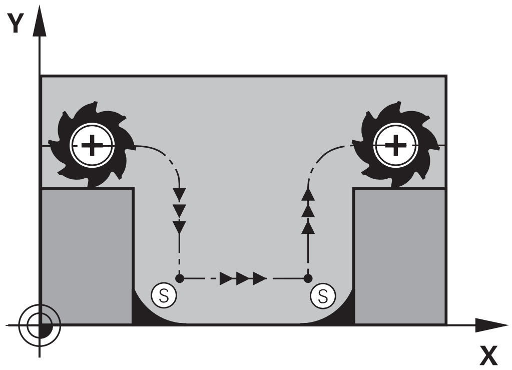
N50 G99 G01 ... R+20*	Large tool radius
...	
N130 X ... Y ... F ... M97*	Move to contour point 13
N140 G91 Y-0.5 ... F ...*	Machine small contour step 13 to 14
N150 X+100 ...*	Move to contour point 15
N160 Y+0.5 ... F ... M97*	Machine small contour step 15 to 16
N170 G90 X ... Y ... *	Move to contour point 17

Machining open contour corners: M98

Standard behavior

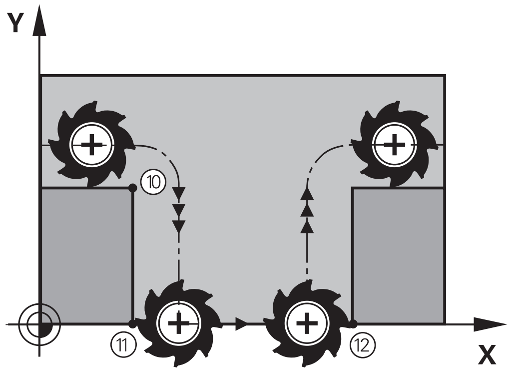
The control calculates the intersections of the cutter paths at inside corners and moves the tool in the new direction at those points.

If the contour is open at the corners, however, this will result in incomplete machining.



Behavior with M98

With the **M98** miscellaneous function, the control temporarily suspends radius compensation to ensure that both corners are completely machined:



Effect

M98 is effective only in the NC blocks in which **M98** is programmed.

M98 becomes effective at the end of the block.

Example: Move to the contour points 10, 11 and 12 in succession

N100 G01 G41 X ... Y ... F ...*
N110 X ... G91 Y ... M98*
N120 X+ ...*

Feed rate factor for plunging movements: M103

Standard behavior

The control moves the tool at the last programmed feed rate, regardless of the direction of traverse.

Behavior with M103

The control reduces the feed rate when the tool moves in the negative direction of the tool axis. The feed rate for plunging FZMAX is calculated from the last programmed feed rate FPROG and a factor F%:

FZMAX = FPROG x F%

Programming M103

If you program **M103** in a positioning block, the control continues the dialog by prompting you for the F factor.

Effect

M103 becomes effective at the start of the block.
Cancel **M103**: Program **M103** once again without a factor.

> The **M103** is also effective with an active tilted working plane coordinate system. The feed rate reduction is then effective in the negative direction when moving the **tilted** tool axis.

Example

The feed rate for plunging is to be 20% of the feed rate in the plane.

...	Actual contouring feed rate (mm/min):
N170 G01 G41 X+20 Y+20 F500 M103 F20*	500
N180 Y+50*	500
N190 G91 Z-2.5*	100
N200 Y+5 Z-5*	141
N210 X+50*	500
N220 G90 Z+5*	500

Feed rate in millimeters per spindle revolution: M136

Standard behavior

The control moves the tool at the feed rate F in mm/min programmed in the NC program

Behavior with M136

In NC programs based on inch units, **M136** is not allowed in combination with the alternative **FU** feed rate.

The spindle is not permitted to be controlled when **M136** is active.

It is not possible to combine **M136** with an oriented spindle stop. The control cannot calculate the feed rate because the spindle does not rotate during an oriented spindle stop.

With **M136**, the control does not move the tool in mm/min, but rather at the feed rate F in millimeters per spindle revolution programmed in the NC program. If you change the spindle speed by using the potentiometer, the control changes the feed rate accordingly.

Effect

M136 becomes effective at the start of the block.

You can cancel **M136** by programming **M137**.

Feed rate for circular arcs: M109/M110/M111

Standard behavior

The control applies the programmed feed rate to the path of the tool center.

Behavior for circular arcs with M109

For inside and outside machining of circular arcs, the control keeps the feed rate at the cutting edge constant.

NOTICE

Caution: Danger to the tool and workpiece!

If the **M109** function is active, the control might significantly increase the feed rate when machining very small outside corners (acute angles). There is a risk of tool breakage or workpiece damage during machining.

- Do not use **M109** for machining very small outside corners (acute angles)

Behavior for circular arcs with M110

With circular arcs, the control only keeps the feed rate constant for inside machining operations. The feed rate will not be adjusted for outside machining of circular arcs.

> If you program **M109** or **M110** with a number > 200 before calling a machining cycle, the adjusted feed rate will also be effective for circular arcs within these machining cycles. The initial state is restored after finishing or canceling a machining cycle.

Effect

M109 and **M110** become effective at the start of the block. **M109** and **M110** can be canceled with **M111**.

Pre-calculating radius-compensated contours (LOOK AHEAD): M120 (option 21)

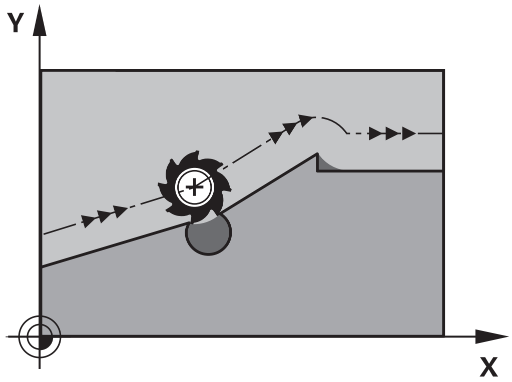
Standard behavior

If the tool radius is larger than the contour step that needs to be machined with radius compensation, then the control interrupts program run and issues an error message. **M97** inhibits the error message, but this results in dwell marks and will also move the corner.

Further information: "Machining small contour steps: M97", Page 221

The control might damage the contour in case of undercuts.

Behavior with M120



The control checks radius-compensated contours for undercuts and tool path intersections, and calculates the tool path in advance from the current NC block. Areas of the contour that would be damaged by the tool will not be machined (shown darker in the figure). You can also use **M120** to calculate the tool radius compensation for digitized data or data from an external programming system. This means that you can compensate for deviations from the theoretical tool radius.

The number of NC blocks (99 max.) to be calculated in advance can be defined with **LA** (**L**ook **A**head) following **M120**. Note that the larger the number of NC blocks you choose, the higher the block processing time will be.

Input

If you define **M120** in a positioning block, the control continues the dialog and prompts you for the number of **LA** NC blocks to be calculated in advance.

Effect

Program the function **M120** in an NC block that also contains an **G41** or **G42** radius compensation. This way, you can achieve consistent programming, resulting in clearly structured programs. You can deactivate the function **M120** with the following NC syntax:

- **G40**
- **M120 LA0**
- **M120** without **LA**
- **%**
- Cycle **G80** or **PLANE** functions

M120 becomes effective at the start of the block and remains effective beyond the milling cycles (option 19).

Restrictions

- After an external or internal stop, you have to use a block scan to be able to re-approach the contour. Before the block scan, you need to cancel **M120**—otherwise the control will issue an error message.
- If you want to approach the contour on a tangential path, you must use the function **APPR LCT**. The NC block with **APPR LCT** must contain only the coordinates of the working plane.
- If you want to depart the contour on a tangential path, you must use the function **DEP LCT**. The NC block with **DEP LCT** must contain only the coordinates of the working plane.
- Before using the following functions, you have to cancel **M120** and the radius compensation:
  - Cycle **G62 TOLERANCE**
  - Cycle **G80 WORKING PLANE**
  - **PLANE** function
  - **M114**
  - **M128**

Superimposing handwheel positioning during program run: M118 (option 21)

Standard behavior

> Refer to your machine manual!
> Your machine tool builder must have prepared the control for this function.

In the Program Run operating modes, the control moves the tool as defined in the NC program.

Behavior with M118

M118 permits manual corrections by handwheel during the program run. For this purpose, you program **M118** and enter an axis-specific value (linear or rotary axis).

Input

If you enter **M118** in a positioning block, the control continues the dialog for this block by prompting you for the axis-specific values. Use the orange axis keys or the alphabetic keyboard for entering the coordinates.

Effect

To cancel handwheel positioning, program **M118** once again without coordinate input or end the NC program with **M30** / **M2**.

> If the program aborts, handwheel positioning will also be canceled.

M118 becomes effective at the start of the block.

Example

You want to be able to use the handwheel during program run to move the tool in the working plane X/Y by ±1 mm and in the rotary axis B by ±5° from the programmed value:

```
N250 G01  G41 X+0  Y+38.5 F125  M118 X1  Y1 B5*
```

> When programmed in an NC program, **M118** is always effective in the machine coordinate system.
> The **POS HR** tab of the additional status display shows the **Max. val.** defined in **M118**.
> **Further information:** User's Manual for **Setup, Testing and Running NC Programs**
> The function **Handwheel superimposed** is also effective in the **Positioning w/ Manual Data Input** operating mode!

Retraction from the contour in the tool-axis direction: M140

Standard behavior

In the **Program Run Single Block** and **Program Run Full Sequence** operating modes, the control moves the tool as defined in the NC program.

Behavior with M140

With **M140 MB** (move back), you can retract the tool from the contour by a programmable distance in the direction of the tool axis.

Input

If you enter **M140** in a positioning block, the control continues the dialog and prompts you for the path the tool should use for retracting from the contour. Enter the desired path that the tool should follow when retracting from the contour, or press the **MB MAX** soft key to move to the limit of the traverse range.

> In the optional machine parameter **moveBack** (no. 200903), the machine tool builder defines how far before a limit switch or a collision object a retraction movement **MB MAX** should end.

In addition, you can program the feed rate at which the tool traverses the entered path. If you do not enter a feed rate, the control moves the tool along the entered path at rapid traverse.

Effect

M140 is effective only in the NC block in which it is programmed.

M140 becomes effective at the start of the block.

Example

NC block 250: Retract the tool by 50 mm from the contour

NC block 251: Move the tool to the limit of the traverse range

```
N250 G01  X+0 Y+38.5  F125 M140  MB50*
N251 G01  X+0 Y+38.5  F125 M140  MB MAX*
```

M140 is also effective if the **Tilt working plane** function is active. For machines with swivel heads the control then moves the tool in the tilted coordinate system.

With **M140 MB MAX** you can only retract in the positive direction.

Always define a tool call with tool axis before **M140**, otherwise the traverse direction is not defined.

NOTICE

Danger of collision!

If you use the **M118** function to modify the position of a rotary axis with the handwheel and then execute the **M140** function, the control ignores the superimposed values with the retraction movement. This results in unwanted and unpredictable movements, especially when using machines with head rotation axes. There is a danger of collision during these compensating movements!

- Do not combine **M118** with **M140** when using machines with head rotation axes.

Suppressing touch probe monitoring: M141

Standard behavior

If the stylus is deflected, the control issues an error message as soon as you want to move a machine axis.

Behavior with M141

The control moves the machine axes even if the touch probe is deflected. This function is required if you wish to write your own measuring cycle in order to retract the touch probe by means of a positioning block after it has been deflected.

NOTICE

Danger of collision!

The function **M141** suppresses the corresponding error message if the stylus is deflected. The control does not perform an automatic collision check with the stylus. Because of this behavior, you must check whether the touch probe can retract safely. There is a risk of collision if you choose the wrong direction for retraction.

- Carefully test the NC program or program section in **Program run, single block** operating mode

> **M141** functions only for movements with straight-line blocks.

Effect

M141 is effective only in the NC block in which **M141** is programmed.

M141 becomes effective at the start of the block.

Deleting basic rotation: M143

Standard behavior

The basic rotation remains in effect until it is reset or is overwritten with a new value.

Behavior with M143

The control deletes a basic rotation from the NC program.

> The function **M143** is not permitted with mid-program startup.

Effect

M143 is effective only from the NC block in which it is programmed.

M143 becomes effective at the start of the block.

> **M143** clears the entries from the **SPA**, **SPB** and **SPC** columns in the preset table. When the corresponding line is reactivated, the basic rotation is **0** in all columns.

Automatically retracting the tool from the contour at an NC stop: M148

Standard behavior

In case of an NC stop, the control stops all traverse movements. The tool stops moving at the point of interruption.

Behavior with M148

> Refer to your machine manual!
>
> This function must be configured and enabled by your machine tool builder.
>
> In the **CfgLiftOff** (no. 201400) machine parameter, the machine tool builder defines the path the control is to traverse for a **LIFTOFF** command. You can also use the **CfgLiftOff** machine parameter to deactivate the function.

Set the **Y** parameter in the **LIFTOFF** column of the tool table for the active tool. The control then retracts the tool from the contour by 2 mm max. in the direction of the tool axis.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

LIFTOFF takes effect in the following situations:

- An NC stop triggered by you
- An NC stop triggered by the software, e.g. if an error occurred in the drive system
- When a power interruption occurs

Effect

M148 remains in effect until deactivated with **M149**.

M148 becomes effective at the start of the block, **M149** at the end of the block.

Rounding corners: M197

Standard behavior

With active radius compensation, the control inserts a transition arc at outside corners. This may lead to rounding of that edge.

Behavior with M197

With the **M197** function, the contour at the corner is tangentially extended and a smaller transition arc is then inserted. When you program the **M197** function and then press the **ENT** key, the control opens the **DL** input field. In **DL**, you define the length the control by which the control extends the contour elements. With **M197**, the corner radius is reduced, the corner is rounded less and the traverse movement is still smooth.

Effect

The **M197** function acts blockwise and is only effective on outside corners.

Example

```
G01  X... Y...  RL M197 DL0.876*
```

8

Subprograms and program section repeats

8.1 Labeling subprograms and program section repeats

Subprograms and program section repeats enable you to program a machining sequence once and then run it as often as necessary.

Label

The beginnings of subprograms and program section repeats in NC programs are marked by **(G98 L)** labels.

A LABEL contains a number between 1 and 65535 or a name definable by you. Each LABEL number or LABEL name can be used only once within the NC program and is set with the **LABEL SET** key or by entering **G98**. The quantity of label names you are able to enter is limited only by the amount of internal memory.

> Do not use a label number or label name more than once!

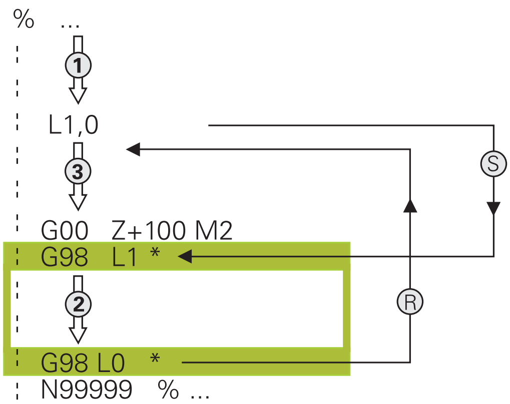
Label 0 (**G98 L0**) is used exclusively to mark the end of a subprogram and can therefore be used as often as desired.

> Before creating your NC program, compare the subprogram and program section repeat programming techniques using the so-called If-Then Decisions.
>
> You can thereby avoid possible misunderstandings and programming errors.
>
> **Further information:** "If-then decisions with Q parameters", Page 266

8.2 Subprograms

Operating sequence

1. The control executes the NC program up to the block in which a subprogram is called with **Ln,0**
2. The subprogram is then executed until the subprogram end **G98 L0**
3. The control then resumes the NC program from the NC block after the subprogram call **Ln,0**



Programming notes

- A main program can contain any number of subprograms
- You can call subprograms in any sequence and as often as desired
- A subprogram cannot call itself
- Write subprograms after the NC block with M2 or M30
- If subprograms are located in the NC program before the NC block with M2 or M30, they will be executed at least once even if they are not called

Programming the subprogram

LBL SET

- To mark the beginning: Press the **LBL SET** key
- Enter the subprogram number. If you want to use a label name, press the **LBL NAME** soft key to switch to text entry.
- Enter the text
- Mark the end: Press the **LBL SET** key and enter the label number **0**

Calling a subprogram

LBL CALL

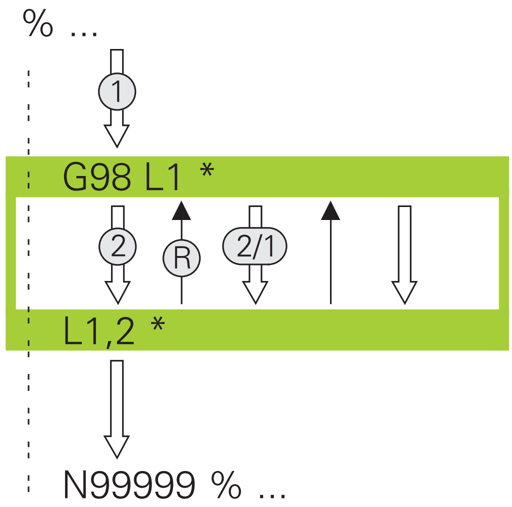
- Call a subprogram: Press the **LBL CALL** key
- Enter the subprogram number of the subprogram you wish to call. If you want to use a label name, press the **LBL NAME** soft key to switch to text entry.

> **L 0** is not permitted (Label 0 is only used to mark the end of a subprogram).

8.3 Program-section repeats

Label G98

The beginning of a program section repeat is marked by the label **G98 L**. The end of a program section repeat is identified by **Ln,m**.



Operating sequence

1. The control executes the NC program up to the end of the program section (**Ln,m**)
2. Then the program section between the called LABEL and the label call **Ln,m** is repeated the number of times entered after **m**
3. The control then resumes the NC program after the last repetition.

Programming notes

- You can repeat a program section up to 65 534 times in succession
- The total number of times the program section is executed is always one more than the programmed number of repeats, because the first repeat starts after the first machining process.

Programming a program section repeat

LBL SET

- To mark the beginning, press the **LBL SET** key and enter a LABEL NUMBER for the program section you wish to repeat. If you want to use a label name, press the **LBL NAME** soft key to switch to text entry.
- Enter the program section

Calling a program section repeat

LBL CALL

- Call a program section: Press the **LBL CALL** key
- Enter the program section number of the program section to be repeated. If you want to use a LABEL name, press the **LBL NAME** soft key to switch to text entry
- Enter the number of repeats **REP** and confirm with the **ENT** key.

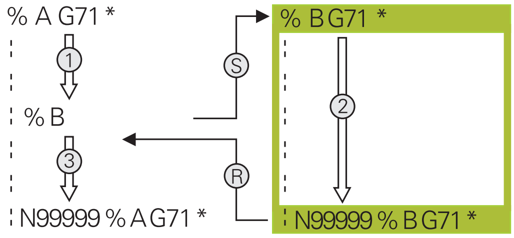
8.4 Calling an external NC program

Overview of the soft keys

When you press the **PGM CALL** key, the control displays the following soft keys:

Soft key	Function
CALL PROGRAM	Call an NC program with **%**
SELECT DATUM TABLE	Select a datum table with **%:TAB:**
SELECT POINT TABLE	Select a point table with **%:PAT:**
SELECT CONTOUR	Select a contour program with **%:CNT:**
SELECT PROGRAM	Select an NC program with **%:PGM:**
CALL SELECTED PROGRAM	Call the last selected file with **%<>%**
SELECT CYCLE	Select any NC program with **G: :** as a machining cycle **Further information:** User's Manual for **Programming of Machining Cycles**

Operating sequence



1. The control executes the NC program up to the block in which another NC program is called with **%**.
2. Then the other NC program is run from beginning to end.
3. The control then resumes the calling NC program with the NC block behind the program call.

Programming notes

- The control does not require any labels to call an NC program.
- The called NC program must not have a **%** call into the calling NC program (an endless loop ensues).
- The called NC program must not contain the miscellaneous function **M2** or **M30**. If you have defined subprograms with labels in the called NC program, then you can replace M2 or M30 with the jump function **D09 P01 +0 P02 +0 P03 99**.
- If you want to call a ISO program, enter the file type .I after the program name.
- You can also call an NC program with Cycle **G39**.
- You can also call any NC program with the function **Select the cycle** (**G: :**).
- As a rule, Q parameters are effective globally with a program call with **%**. So please note that changes to Q parameters in the called NC program can also influence the calling NC program.

> **i** While the control is running the calling NC program, the editing of all called NC programs is disabled.

Checking the called NC programs

NOTICE

Danger of collision!

The control does not automatically check whether collisions can occur between the tool and the workpiece. If you do not specifically rescind the coordinate transformations in the called NC program, these transformations will also take effect in the calling NC program. Danger of collision during machining!

- Reset used coordinate transformations in the same NC program
- Check the machining sequence using a graphic simulation if required

The control checks the called NC programs:

- If the called NC program contains the miscellaneous functions **M2** or **M30**, then the control displays a warning. The control automatically clears the warning as soon as you select another NC program.
- The control checks the called NC programs to see whether they are complete before running them. If the **N99999999** NC block is missing, the control aborts with an error message.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Path information

If the NC program you want to call is located in the same directory as the NC program you are calling it from, then you only need to enter the program name.

If the called NC program is not located in the same directory as the NC program you are calling it from, you must enter the complete path, e.g. **TNC:\ZW35\HERE\PGM1.H**

Alternatively, you can program relative paths:

- Starting from the folder of the calling NC program one folder level up **..\PGM1.H**
- Starting from the folder of the calling NC program one folder level down **DOWN\PGM1.H**
- Starting from the folder of the calling NC program one folder level up and in one other folder **..\THERE\PGM3.H**

Calling an external NC program

Calling a program with Calling a program

You can call an external NC program with the **%** function. The control runs the external NC program from the position where it was called in the NC program.

Proceed as follows:

PGM CALL

- ▶ Press the **PGM CALL** key

CALL PROGRAM

- ▶ Press the **CALL PROGRAM** soft key
- > The control starts the dialog for defining the NC program to be called.
- ▶ Enter the path name with the keyboard

Alternative:

SELECT FILE

- ▶ Press the **SELECT FILE** soft key
- > The control displays a selection window in which you can select the NC program to be called.
- ▶ Press the **ENT** key

> If the called file is located in the same directory as the file you are calling it from, you can also integrate the file name without the path. The **APPLY FILE NAME** soft key provided in the selection window of the **SELECT FILE** soft key is available for this.

Call with SELECT PROGRAM and CALL SELECTED PROGRAM

The function **%:PGM:** allows you to select an external NC program that you can separately call at a different position in the NC program. The control runs the external NC program from the position at which you called it in the NC program using **CALL SELECTED PGM%<>%**.

The **%:PGM:** function is also permitted with string parameters, so that you can dynamically control program calls.

To select the NC program, proceed as follows:

PGM CALL

- Press the **PGM CALL** key

SELECT PROGRAM

- Press the **SELECT PROGRAM** soft key
- > The control starts the dialog for defining the NC program to be called.

SELECT FILE

- Press the **SELECT FILE** soft key
- > The control displays a selection window in which you can select the NC program to be called.
- Press the **ENT** key

> If the called file is located in the same directory as the file you are calling it from, you can also integrate the file name without the path. The **APPLY FILE NAME** soft key provided in the selection window of the **SELECT FILE** soft key is available for this.

To call the selected NC program, proceed as follows:

PGM CALL

- Press the **PGM CALL** key

CALL SELECTED PROGRAM

- Press the **CALL SELECTED PROGRAM** soft key
- > The control uses **%<>%** to call the NC program that was selected last.

> If an NC program that was called using **%<>%** is missing, then the control interrupts the execution or simulation with an error message. In order to avoid undesired interruptions during program run, you can use the function **D18** (**ID10 NR110** and **NR111**) to check all paths at the beginning of the program.
> **Further information:** "D18 – Reading system data", Page 291

8.5 Nesting

Types of nesting

- Subprogram calls in subprograms
- Program-section repeats within a program-section repeat
- Subprogram calls within program-section repeats
- Program-section repeats within subprograms

> Subprograms and program-section repeats can call external NC programs as well.

Nesting depth

The nesting depth defines, among other things, how often program sections or subprograms may contain further subprograms or program section repeats.

- Maximum nesting depth for subprograms: 19
- Maximum nesting depth for external NC programs: 19, for which a **G79** has the effect of calling an external program
- You can nest program section repeats as often as desired

Subprogram within a subprogram

Example

%UPGMS G71 *	
...	
N17 L "UP1",0*	Subprogram at label G98 L1 is called
...	
N35 G00 G40 Z+100 M2*	Last program block of the
	main program with M2
N36 G98 L "UP1"	Beginning of subprogram SP1
...	
N39 L2,0*	Subprogram at label G98 L2 is called
...	
N45 G98 L0*	End of subprogram 1
N46 G98 L2*	Beginning of subprogram 2
...	
N62 G98 L0*	End of subprogram 2
N99999999 %UPGMS G71 *	

Program execution

1. Main program UPGMS is executed up to NC block 17
2. Subprogram UP1 is called, and executed up to NC block 39
3. Subprogram 2 is called, and executed up to NC block 62. End of subprogram 2 and return jump to the subprogram from which it was called.
4. Subprogram UP1 is called, and executed from NC block 40 up to NC block 45. End of subprogram 1 and return jump to the main program UPGMS.
5. Main program UPGMS is executed from NC block 18 up to NC block 35. Return jump to NC block 1 and end of program

Repeating program section repeats

Example

%REPS G71 *	
...	
N15 G98 L1*	Beginning of program section repeat 1
...	
N20 G98 L2*	Beginning of program section repeat 2
...	
N27 L2,2*	Program section call with two repeats
...	
N35 L1,1*	The program section between this NC block and G98 L1
...	(NC block 15) is repeated once
N99999999 %REPS G71 *	

Program execution

1 Main program REPS is executed up to NC block 27
2 The program section between NC block 27 and NC block 20 is repeated twice
3 Main program REPS is executed from NC block 28 up to NC block 35
4 The program section between NC block 35 and NC block 15 is repeated once (including the program section repeat between NC block 20 and NC block 27)
5 Main program REPS is executed from NC block 36 up to NC block 50. Return jump to NC block 1 and end of program

Repeating a subprogram

Example

%UPGREP G71 *	
...	
N10 G98 L1*	Beginning of program section repeat 1
N11 L2,0*	Subprogram call
N12 L1,2*	Program section call with two repeats
...	
N19 G00 G40 Z+100 M2*	Last NC block of the main program with M2
N20 G98 L2*	Beginning of subprogram
...	
N28 G98 L0*	End of subprogram
N99999999 %UPGREP G71 *	

Program execution

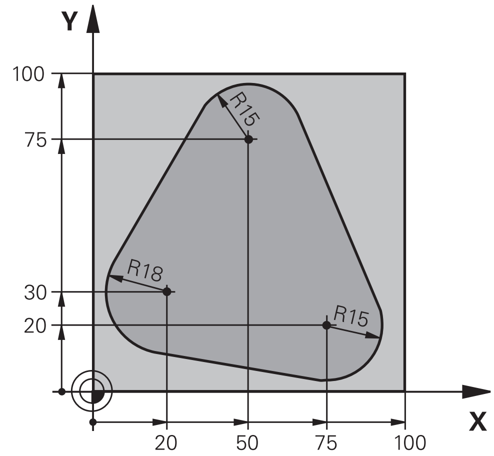
1. Main program UPGREP is executed up to NC block 11
2. Subprogram 2 is called and executed.
3. The program section between NC block 12 and NC block 10 is repeated twice. This means that subprogram 2 is repeated twice
4. Main program UPGREP is executed from NC block 13 up to NC block 19. Return jump to NC block 1 and end of program

8.6 Programming examples

Example: Milling a contour in several infeeds

Program run:

- Pre-position the tool to the workpiece surface
- Enter the infeed depth in incremental values
- Contour milling
- Repeat infeed and contour-milling

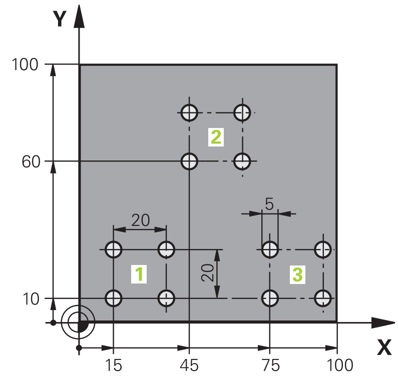


%PGMREP G71 *	
N10 G30 G17 X+0 Y+0 Z-40*	
N20 G31 G90 X+100 Y+100 Z+0*	
N30 T1 G17 S3500*	Tool call
N40 G00 G40 G90 Z+250*	Retract the tool
N50 I+50 J+50*	Set pole
N60 G10 R+60 H+180*	Pre-position in the working plane
N70 G01 Z+0 F1000 M3*	Pre-position to the workpiece surface
N80 G98 L1*	Set label for program section repeat
N90 G91 Z-4*	Incremental downfeed (in the air)
N100 G11 G41 G90 R+45 H+180 F250*	First contour point
N110 G26 R5*	Contour approach
N120 H+120*	
N130 H+60*	
N140 H+0*	
N150 H-60*	
N160 H-120*	
N170 H+180*	
N180 G27 R5 F500*	Contour departure
N190 G40 R+60 H+180 F1000*	Retract tool
N200 L1,4*	Return jump to label 1; section is repeated a total of 4 times
N200 G00 Z+250 M2*	Retract the tool, end of program
N99999999 %PGMWDH G71 *	

Example: Groups of holes

Program run:

- Approach the groups of holes in the main program
- Call the group of holes (subprogram 1) in the main program
- Program the group of holes only once in subprogram 1

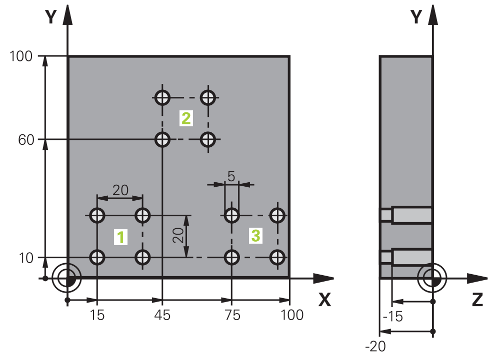


%SP1 G71 *	
N10 G30 G17 X+0 Y+0 Z-40*	
N20 G31 G90 X+100 Y+100 Z+0*	
N30 T1 G17 S3500*	Tool call
N40 G00 G40 G90 Z+250*	Retract the tool
N50 G200 DRILLING	Cycle definition: Drilling
Q200=2 ;SET-UP CLEARANCE	
Q201=-30 ;DEPTH	
Q206=300 ;FEED RATE FOR PLNGNG	
Q202=5 ;PLUNGING DEPTH	
Q210=0 ;DWELL TIME AT TOP	
Q203=+0 ;SURFACE COORDINATE	
Q204=2 ;2ND SET-UP CLEARANCE	
Q211=0 ;DWELL TIME AT DEPTH	
Q395=0 ;DEPTH REFERENCE	
N60 X+15 Y+10 M3*	Move to starting point for group 1
N70 L1,0*	Call the subprogram for the group
N80 X+45 Y+60*	Move to starting point for group 2
N90 L1,0*	Call the subprogram for the group
N100 X+75 Y+10*	Move to starting point for group 3
N110 L1,0*	Call the subprogram for the group
N120 G00 Z+250 M2*	End of main program
N130 G98 L1*	Beginning of subprogram 1: Group of holes
N140 G79*	Call cycle for 1st hole
N150 G91 X+20 M99*	Move to 2nd hole, call cycle
N160 Y+20 M99*	Move to 3rd hole, call cycle
N170 X-20 G90 M99*	Move to 4th hole, call cycle
N180 G98 L0*	End of subprogram 1
N99999999 %UP1 G71 *	

Example: Group of holes with multiple tools

Program run:

- Program the fixed cycles in the main program
- Call the complete hole pattern (subprogram 1) in the main program
- Approach the groups of holes (subprogram 2) in subprogram 1
- Program the group of holes only once in subprogram 2



%SP2 G71 *	
N10 G30 G17 X+0 Y+0 Z-40*	
N20 G31 G90 X+100 Y+100 Z+0*	
N30 T1 G17 S5000*	Centering drill tool call
N40 G00 G40 G90 Z+250*	Retract the tool
N50 G200 DRILLING	Cycle definition: Centering
Q200=2 ;SET-UP CLEARANCE	
Q201=-3 ;DEPTH	
Q206=250 ;FEED RATE FOR PLNGNG	
Q202=3 ;PLUNGING DEPTH	
Q210=0 ;DWELL TIME AT TOP	
Q203=+0 ;SURFACE COORDINATE	
Q204=10 ;2ND SET-UP CLEARANCE	
Q211=0.2 ;DWELL TIME AT DEPTH	
Q395=0 ;DEPTH REFERENCE	
N60 L1,0*	Call subprogram 1 for the entire hole pattern
N70 G00 Z+250 M6*	Tool change
N80 T2 G17 S4000*	Drill tool call
N90 D0 Q201 P01 -25*	New depth for drilling
N100 D0 Q202 P01 +5*	New plunging depth for drilling
N110 L1,0*	Call subprogram 1 for the entire hole pattern
N120 G00 Z+250 M6*	Tool change
N130 T3 G17 S500*	Reamer tool call
N140 G201 REAMING	Cycle definition: Reaming
Q200=2 ;SET-UP CLEARANCE	
Q201=-15 ;DEPTH	
Q206=250 ;FEED RATE FOR PLNGNG	
Q211=0.5 ;DWELL TIME AT DEPTH	
Q208=400 ;RETRACTION FEED RATE	
Q203=+0 ;SURFACE COORDINATE	
Q204=10 ;2ND SET-UP CLEARANCE	
N150 L1,0*	Call subprogram 1 for the entire hole pattern

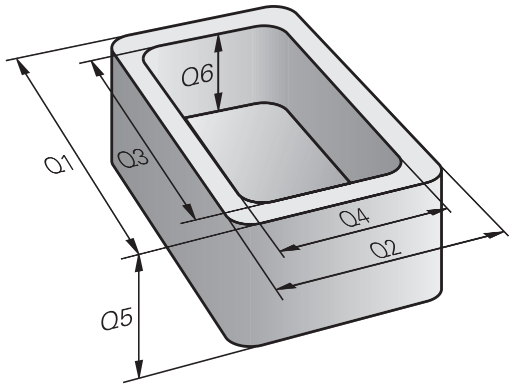
N160 G00 Z+250 M2*	End of main program
N170 G98 L1*	Beginning of subprogram 1: Entire hole pattern
N180 G00 G40 G90 X+15 Y+10 M3*	Move to starting point for group 1
N190 L2,0*	Call subprogram 2 for the group
N200 X+45 Y+60*	Move to starting point for group 2
N210 L2,0*	Call subprogram 2 for the group
N220 X+75 Y+10*	Move to starting point for group 3
N230 L2,0*	Call subprogram 2 for the group
N240 G98 L0*	End of subprogram 1
N250 G98 L2*	Beginning of subprogram 2: Group of holes
N260 G79*	Call cycle for 1st hole
N270 G91 X+20 M99*	Move to 2nd hole, call cycle
N280 Y+20 M99*	Move to 3rd hole, call cycle
N290 X-20 G90 M99*	Move to 4th hole, call cycle
N300 G98 L0*	End of subprogram 2
N310 %UP2 G71 *	

9

Programming Q parameters

9.1 Principle and overview of functions

With Q parameters you can program entire families of parts in a single NC program by programming variable Q parameters instead of fixed numerical values.



Q parameters can be used in the following ways:

- Coordinate values
- Feed rates
- Spindle speeds
- Cycle data

The control offers more ways to use Q parameters:

- Program contours that are defined through mathematical functions
- Making the execution of machining steps dependent on logical conditions

Q parameter types

Q parameters for numeric values

Q parameters are always identified with letters and numbers. The letters determine the type of Q parameter and the numbers the Q parameter range.

For more information, see the table below:

Q parameter type	Q parameter range	Meaning
Q parameters:		**Parameters affect all NC programs in the control's memory**
	0 to 99	Parameters for the **user**, if there are no overlaps with the HEIDENHAIN-SL cycles These parameters have a local effect within so-called macros and OEM cycles. This means that changes are not returned to the NC program. For this reason, use the Q parameter range 1200 to 1399 for OEM cycles!
	100 to 199	Parameters for special functions on the control that can be read by NC programs of the user or by cycles
	200 to 1199	Parameters primarily used for HEIDENHAIN cycles
	1200 to 1399	Parameters preferentially used with manufacturer cycles if values are returned to the user program
	1400 to 1599	Parameters primarily used as input parameters for manufacturer cycles
	1600 to 1999	Parameters for **users**
QL parameters:		**Parameters only effective locally within an NC program**
	0 to 499	Parameters for **users**
QR parameters:		**Parameters permanently affect all NC programs in the control's memory, including after a power interruption**
	0 to 99	Parameters for **users**
	100 to 199	Parameters for HEIDENHAIN functions (e.g., cycles)
	200 to 499	Parameters for the machine tool builder (e.g., cycles)

QR parameters will be included in backups.

If the machine tool builder did not define a specific path, the control will save the **QR** parameter values in the following path: **SYS:\runtime\sys.cfg**. This partition will only be backed up in full backups.

Machine tool builders can use the following optional machine parameters to specify the paths:

- **pathNcQR** (no. 131201)
- **pathSimQR** (no. 131202)

If the machine tool builder used the optional machine parameters to specify a path on the TNC partition, you can perform a backup with the **NC/PLC Backup** functions without entering a code number.

Q parameters for texts

QS parameters (**S** stands for string) are also available and enable you to process texts on the control.

Q parameter type	Q parameter range	Meaning
QS parameters:		**Parameters affect all NC programs in the control's** memory
	0 to 99	Parameters for the **user**, where no overlaps with the HEIDENHAIN SL cycles are present These parameters have a local effect within so-called macros and OEM cycles. This means that changes are not returned to the NC program. For this reason, use the QS parameter range 200 to 499 for OEM cycles!
	100 to 199	Parameters for special functions on the control that can be read by NC programs of the user or by cycles
	200 to 1199	Parameters primarily used for HEIDENHAIN cycles
	1200 to 1399	Parameters preferentially used with manufacturer cycles if values are returned to the user program
	1400 to 1599	Parameters primarily used as input parameters for manufacturer cycles
	1600 to 1999	Parameters for **users**

Programming notes

NOTICE

Danger of collision!

HEIDENHAIN cycles, manufacturer cycles and third-party functions use Q parameters. You can also program Q parameters within NC programs. If, when using Q parameters, the recommended Q parameter ranges are not used exclusively, then this can lead to overlapping (reciprocal effects) and thus cause undesired behavior. Danger of collision during machining!

- Only use Q parameter ranges recommended by HEIDENHAIN.
- Comply with the documentation from HEIDENHAIN, the machine tool builder, and suppliers.
- Check the machining sequence using a graphic simulation

You can mix Q parameters and numerical values within an NC program.

Q parameters can be assigned numerical values between -999 999 999 and +999 999 999. The input range is limited to 16 digits, of which 9 may be before the decimal point. Internally the control calculates numbers up to a value of 10^{10}.

You can assign a maximum of 255 characters to **QS** parameters.

The control automatically assigns some Q and QS parameters the same data, e.g., the Q parameter **Q108** is automatically assigned the current tool radius.

Further information: "Preassigned Q parameters", Page 309

The control saves numerical values internally in a binary number format (standard IEEE 754). Due to the standardized format used, the control does not represent some decimal numbers with a binary number that is 100% exact (round-off error). If you use calculated Q parameter contents for jump commands or positioning moves, then you must take this fact into consideration.

You can reset Q parameters to the status **Undefined**. If a position is programmed with a Q parameter that is undefined, the control ignores this movement.

Calling Q parameter functions

When you are writing an NC program, press the **Q** key (in the numeric keypad for numerical input and axis selection, below the **+/-** key). The control then displays the following soft keys:

Soft key	Function group	Page
BASIC ARITHM.	Basic arithmetic (assign, add, subtract, multiply, divide, square root)	260
TRIGO-NOMETRY	Trigonometric functions	263
JUMP	If/then conditions, jumps	266
DIVERSE FUNCTION	Other functions	276
FORMULA	Entering formulas directly	269
CONTOUR FORMULA	Function for machining complex contours	See the User's Manual for Programming of Machining Cycles

> If you define or assign a Q parameter, then the control shows the **Q**, **QL** and **QR** soft keys. You can use these soft keys to select the desired parameter type. Then you define the parameter number.
>
> If you have a alphabetic keyboard connected via the USB port, you can press the **Q** key to open the dialog for entering a formula.

9.2 Part families—Q parameters in place of numerical values

Application

The Q parameter function **D0: ASSIGN** allows you to assign numerical values to Q parameters. You then use a Q parameter in place of the numerical value in the NC program.

Example

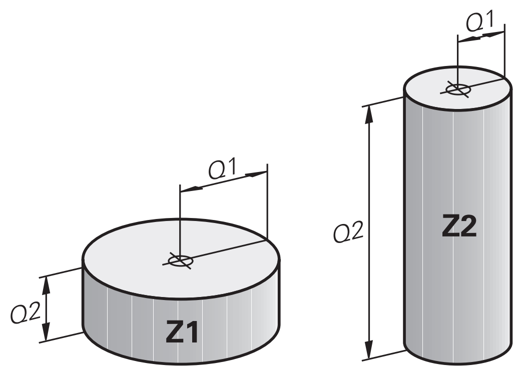
N150 D00 Q10 P01 +25*	Assign
...	Q10 is assigned the value 25
N250 G00 X +Q10*	Corresponds to G00 X +25

You need write only one program for a whole family of parts, entering the characteristic dimensions as Q parameters.

To program a particular part, you then assign the appropriate values to the individual Q parameters.

Example: Cylinder with Q parameters

Cylinder radius:	R = Q1
Cylinder height:	H = Q2
Cylinder Z1:	Q1 = +30 Q2 = +10
Cylinder Z2:	Q1 = +10 Q2 = +50



9.3 Describing contours with mathematical functions

Application

The Q parameters listed below enable you to program basic mathematical functions in a NC program:

Q

- ▶ Select the Q parameter function: Press the **Q** key in the numeric keypad
- > The Q parameter functions are displayed in the soft key row.

BASIC ARITHM.

- ▶ Press the **BASIC ARITHM.** soft key
- > The control displays the soft keys for basic mathematical functions

Overview

Soft key	Function
D0 X = Y	**D00**: ASSIGN e. g., **D00 Q5 P01 +60 *** Directly assign value Reset Q parameter value
D1 X + Y	**D01**: ADDITION e. g., **D01 Q1 P01 -Q2 P02 -5 *** Calculate and assign the sum of two values
D2 X - Y	**D02**: SUBTRACTION e. g. **D02 Q1 P01 +10 P02 +5 *** Form and assign difference between two values
D3 X * Y	**D03**: MULTIPLICATION e. g. **D03 Q2 P01 +3 P02 +3 *** Form and assign the product of two values
D4 X / Y	**D04**: DIVISION e.g., **D04 Q4 P01 +8 P02 +Q2 *** Calculate and assign the quotient of two values **Not permitted:** Division by 0
D5 SQRT	**D05**: SQUARE ROOT e.g., **D05 Q50 P01 4 *** Calculate and assign the square root of a value **Not permitted:** Square root of a negative value

You can enter the following to the right of the = sign:

- Two numbers
- Two Q parameters
- A number and a Q parameter

The Q parameters and numerical values in the equations can be entered with positive or negative signs.

Programming fundamental operations

Example: Assignment

```
N16 D00 Q5 P01 +10*
N17 D03 Q12 P01 +Q5  P02 +7*
```

Q
- ▶ Select the Q parameter function: Press the **Q** key

BASIC ARITHM.
- ▶ Select basic mathematical functions by pressing the **BASIC ARITHM.** soft key

D0 X = Y
- ▶ To select the **ASSIGN** Q parameter function: Press the **D0 X=Y** soft key
- > The control asks you for the number of the result parameter.
- ▶ Enter **5** (number of Q parameter)

ENT
- ▶ Confirm with the **ENT** key
- > The control asks you for the value or parameter.
- ▶ Enter **10** (value)

ENT
- ▶ Confirm with the **ENT** key
- > As soon as the control reads the NC block, the value **10** is assigned to the parameter **Q5**.

Example: Multiplication

Q
- ▶ Select the Q parameter function: Press the **Q** key

BASIC ARITHM.
- ▶ Select basic mathematical functions by pressing the **BASIC ARITHM.** soft key

D3 X * Y
- ▶ To select the **MULTIPLICATION** Q parameter function, press the **D3 X * Y** soft key
- > The control asks you for the number of the result parameter.
- ▶ Enter **12** (number of Q parameter)

ENT
- ▶ Confirm with the **ENT** key
- > The control asks you for the first value or parameter.
- ▶ Enter **Q5** (parameter)

ENT
- ▶ Confirm with the **ENT** key
- > The control asks you for the second value or parameter.
- ▶ Enter **7** for the second value

ENT
- ▶ Confirm with the **ENT** key

Resetting Q parameters

Example

16 D00: Q5 SET UNDEFINED*
17 D00: Q1 = Q5*

Q

- Select the Q parameter function: Press the **Q** key

BASIC ARITHM.

- Select basic mathematical functions by pressing the **BASIC ARITHM.** soft key

D0 X = Y

- To select the ASSIGN Q parameter function: Press the **D0 X = Y** soft key
- > The control asks you for the number of the result parameter.
- Enter **5** (number of Q parameter)

ENT

- Confirm with the **ENT** key
- > The control asks you for the value or parameter.

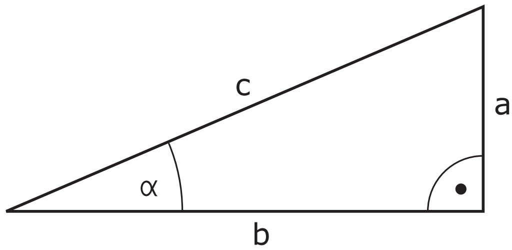
SET UNDEFINED

- Press **SET UNDEFINED**

The **D00** function also supports transfer of the value **Undefined**. If you wish to transfer the undefined Q parameter without **D00**, the control shows the error message **Invalid value**.

9.4 Trigonometric functions

Definitions



Sine: sin α = a / c
Cosine: cos α = b / c
Tangent: tanα = a / b = sin α / cos α

where

- c is the side opposite the right angle
- a is the side opposite the angle α
- b is the third side.

The control can find the angle from the tangent:

α = arctan (a / b) = arctan (sin α / cos α)

Example:

a = 25 mm

b = 50 mm

α = arctan (a / b) = arctan 0.5 = 26.57°

Furthermore:

$a^2 + b^2 = c^2$ (where $a^2 = a \times a$)

$c = \sqrt{(a^2 + b^2)}$

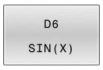
Programming trigonometric functions

You can also calculate trigonometric functions with Q parameters.

- ▶ Select the Q parameter function: Press the **Q** key in the numeric keypad
- > The Q parameter functions are displayed in the soft key row.

- ▶ Press the **TRIGONOMETRY** soft key
- > The control displays the soft keys for trigonometric functions.

Overview

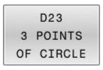
Soft key	Function
	**D06**: SINE e. g., **D06 Q20 P01 -Q5 *** Calculate and assign the sine of an angle in degrees (°)
	**D07**: COSINE e. g., **D07 Q21 P01 -Q5 *** Calculate and assign the cosine of an angle in degrees (°)
	**D08**: ROOT SUM OF SQUARES e. g., **D08 Q10 P01 +5 P02 +4 *** Calculate and assign length from two values
	**D13**: ANGLE e. g., **D13 Q20 P01 +10 P02 -Q1 *** Calculate and assign an angle with the arc tangent of the opposite and adjacent sides of the triangle or with the sine and cosine of the angle (0 < angle < 360°).

9.5 Circle calculations

Application

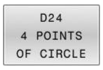
The control can use the functions for calculating circles to calculate the circle center and the circle radius from three or four given points on the circle. The calculation is more accurate if four points are used.

Application: These functions can be used, for example, if you wish to determine the location and size of a hole or a pitch circle using the programmable probing function.

Soft key	Function
	D23: Determining the CIRCLE DATA from three points Example: **D23 Q20 P01 Q30***

The coordinate pairs of three points on a circle must be saved in **Q30** and the following five parameters—in this case, up to **Q35**.

The control then saves the circle center in the principal axis (X if spindle axis is Z) in parameter **Q20**, the circle center in the minor axis (Y if spindle axis is Z) in parameter **Q21**, and the circle radius in parameter **Q22**.

Soft key	Function
	D24: Determining the CIRCLE DATA from four points Example: **D24 Q20 P01 Q30***

The coordinate pairs of four points on a circle must be saved in parameter **Q30** and the following seven parameters—in this case, up to **Q37**.

The control then saves the circle center in the principal axis (X if spindle axis is Z) in parameter **Q20**, the circle center in the minor axis (Y if spindle axis is Z) in parameter **Q21**, and the circle radius in parameter **Q22**.

> Note that **D23** and **D24** automatically overwrite the resulting parameter and the two following parameters.

9.6 If-then decisions with Q parameters

Application

In if-then decisions, the control compares a Q parameter with another Q parameter or a numerical value. If the condition is fulfilled, then the control continues the NC program at the label that is programmed after the condition.

> Before creating your NC program, compare the if-then decisions with the subprogram and program section repeat programming techniques.
>
> You can thereby avoid possible misunderstandings and programming errors.
>
> **Further information:** "Labeling subprograms and program section repeats", Page 236

If it is not fulfilled, the control continues with the next NC block.

If you want to call an NC program, then program a program call with **%** after the label.

Jump conditions

Unconditional jump

An unconditional jump is programmed by entering a conditional jump whose condition is always true. Example:

D09 P01 +10 P02 +10 P03 1*

Conditioning jumps with counters

The jump function allows you to repeat a machining operation any number of times. A Q parameter serves as a counter that increments by 1 at every program section repeat.

The jump function allows you to compare the counter with the number of desired machining operations.

> These jumps differ from the subprogram and program section repeat programming techniques.
>
> On the one hand, for example, jumps require no completed program section ending with L0. On the other hand, jumps do not take these return jump labels into consideration!

Example

%COUNTER G71 *	
;	
N20 Q1 = 0	Loaded value: Initialize counter
N30 Q2 = 3	Loaded value: Number of jumps
;	
N50 G98 L99*	Label
N60 Q1 = Q1 + 1	Initialize counter: New Q1 value = Old Q1 value + 1
N70 D12 P01 +Q1 P02 +Q2 P03 99*	Run program jumps 1 and 2
N80 D09 P01 +Q1 P02 +Q2 P03 99*	Run program jump 3
;	
N99999999 %COUNTER G71 *	

Programming if-then decisions

Possibilities for jump inputs

The following inputs are possible for the condition **IF**:

- Numbers
- Texts
- Q, QL, QR
- **QS** (string parameter)

You have three possibilities for entering the jump address **GOTO**:

- **LBL NAME**
- **LBL NUMBER**
- **QS**

The if-then decisions appear when the **JUMP** soft key is pressed. The control displays the following soft keys:

Soft key	Function
D9 IF X EQ Y GOTO	**D09**: IF EQUAL, JUMP e. g., **D09 P01 +Q1 P02 +Q3 P03 "UPCAN25" *** If both values or parameters are equal, jump to specified label
D9 IF X EQ Y GOTO IS UNDEFINED	**D09**: IF UNDEFINED, JUMP e. g., **D09 P01 +Q1 IS UNDEFINED P03 “UPCAN25“ *** If the specified parameter is undefined, then a jump is made to the specified label
D9 IF X EQ Y GOTO IS DEFINED	**D09**: IF DEFINED, JUMP e. g., **D09 P01 +Q1 IS DEFINED P03 “UPCAN25“ *** If the specified parameter is defined, then a jump is made to the specified label
D10 IF X NE Y GOTO	**D10**: IF UNEQUAL, JUMP e. g., **D10 P01 +10 P02 -Q5 P03 10 *** If both values or parameters are unequal, jump to specified label
D11 IF X GT Y GOTO	**D11**: IF GREATER, JUMP g. g., **D11 P01 +Q1 P02 +10 P03 QS5 *** If the first value or parameter is greater than the second value or parameter, jump to specified label
D12 IF X LT Y GOTO	**D12**: IF LESS, JUMP e. g., **D12 P01 +Q5 P02 +0 P03 "ANYNAME" *** If the first value or parameter is smaller than the second value or parameter, jump to specified label

9.7 Entering formulas directly

Entering formulas

Using soft keys, you can enter mathematical formulas containing multiple calculation operations directly into the NC program.

Q

- Select Q parameter function

FORMULA

- Press the **FORMULA** soft key
- Select **Q**, **QL**, or **QR**
- > The control displays the available mathematical operations in the soft-key row.

Rules for formulas

Sequence for the evaluation of a formula

If you enter a mathematical formula that contains more than one mathematical operation, the control always evaluates the individual operations in a defined sequence. A familiar example of this is the rule that multiplication/division takes place before addition/ subtraction (higher-level operations are performed first).

The control adheres to the following rules of priority for the evaluation of mathematical formulas:

Priority	Designation	Arithmetic operator
1	Remove parentheses	**( )**
2	Note the sign, calculate the function	Minus sign, **SIN**, **COS**, **LN** etc.
3	Powers	**^**
4	Multiplication and division	***** , **/**
5	Addition and subtraction	**+**, **-**

Evaluation of operations with the same priority

The control generally calculates operations with the same priority from the left to the right.

2 + 3 - 2 = (2 + 3) - 2 = 3

Exception: Concatenated powers are evaluated from right to left.

2 ^ 3 ^ 2 = 2 ^ (3 ^ 2) = 2 ^ 9 = 512

Example: Perform multiplication/division before addition/ subtraction

N120 Q1 = 5 * 3 + 2 * 10	= 35

- 1st calculation 5 * 3 = 15
- 2nd calculation 2 * 10 = 20
- 3rd calculation: 15 + 20 = 35

Example: Calculate power before addition/subtraction

N130 Q2 = SQ 10 - 3^3	= 73

- 1st calculation : 10 squared = 100
- 2nd calculation : 3 to the power of 3 = 27
- 3rd calculation: 100 – 27 = 73

Example: Calculate function before power

N140 Q4 = SIN 30 ^ 2	= 0.25

- 1st calculation: Calculate sine of 30 = 0.5
- 2nd calculation: 0.5 squared = 0.25

Example: Evaluate expression in parentheses before function

N150 Q5 = SIN (50 - 20)	= 0.5

- 1st calculation: Remove parentheses: 50 - 20 = 30
- 2nd calculation: Calculate sine of 30 = 0.5

Overview

The control displays the following soft keys:

Soft key	Linking function	Priority
+	**Addition** e.g. **Q10 = Q1 + Q5**	Addition/subtraction calculation
-	**Subtraction** e.g. **Q25 = Q7 - Q108**	Addition/subtraction calculation
*	**Multiplication** e.g. **Q12 = 5 * Q5**	Multiplication/division calculation
/	**Division** e.g. **Q25 = Q1 / Q2**	Multiplication/division calculation
(	**Opening parenthesis** e.g. **Q12 = Q1 * (Q2 + Q3)**	Expression in parentheses
)	**Closing parenthesis** e.g. **Q12 = Q1 * (Q2 + Q3)**	Expression in parentheses
SQ	**Square of a value** e.g. **Q15 = SQ 5**	Function
SQRT	**Square root** e.g. **Q22 = SQRT 25**	Function
SIN	**Sine of an angle** e.g. **Q44 = SIN 45**	Function
COS	**Cosine of an angle** e.g. **Q45 = COS 45**	Function
TAN	**Tangent of an angle** e.g. **Q46 = TAN 45**	Function
ASIN	**Arc sine** Inverse of the sine. Determines the angle from the ratio of the side opposite the angle and the hypotenuse e.g. **Q10 = ASIN (Q40 / Q20)**	Function
ACOS	**Arc cosine** Inverse of the cosine. Determines the angle from the ratio of the side adjacent to the angle and the hypotenuse e.g. **Q11 = ACOS Q40**	Function
ATAN	**Arc tangent** Inverse of the tangent. Determines the angle from the ratio of the opposite side to the adjacent side e.g. **Q12 = ATAN Q50**	Function
^	**Raising values to a power** e.g. **Q15 = 3 ^ 3**	Power
PI	**Pi constant** π = 3.14159 e.g. **Q15 = PI**	

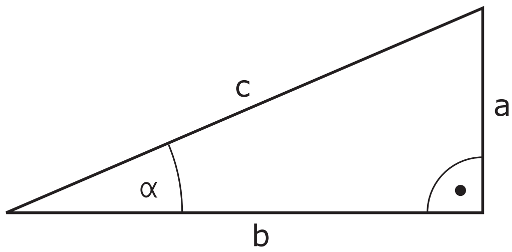
Soft key	Linking function	Priority
LN	**Natural logarithm (LN) of a number** Base = e = 2.7183 e.g. **Q15 = LN Q11**	Function
LOG	**Logarithm of a number** Base = 10 e.g. **Q33 = LOG Q22**	Function
EXP	**Exponential function (e ^ n)** Base = e = 2.7183 e.g. **Q1 = EXP Q12**	Function
NEG	**Negate values** Multiply by -1 e.g. **Q2 = NEG Q1**	Function
INT	**Truncate decimal places** Form an integer e.g. **Q3 = INT Q42** The **INT** function does not round off—it simply truncates the decimal places. **Further information:** "Example: Rounding a value", Page 315	Function
ABS	**Absolute value of a number** e.g. **Q4 = ABS Q22**	Function
FRAC	**Truncate places before the decimal point** Form a fraction e.g. **Q5 = FRAC Q23**	Function
SGN	**Check algebraic sign of a number** e.g. **Q12 = SGN Q50** If **Q50 = 0**, then **SGN Q50 = 0** If **Q50 < 0**, then **SGN Q50 = -1** If **Q50 > 0**, then **SGN Q50 = 1**	Function
%	**Calculate the modulo value (division remainder)** e. g., **Q12 = 400 % 360** Result: **Q12 = 40**	Function

Example: Trigonometric function

The lengths of the opposite side a in parameter **Q12** and the adjacent side b in **Q13** are given.

The angle α is to be calculated.

Calculate the angle α from the opposite side a and the adjacent side b by means of the arc tangent; assign result **Q25**:



Q

- Press the **Q** key

FORMULA

- Press the **FORMULA** soft key
- > The control asks you for the number of the result parameter.
- Enter **25**

ENT

- Press the **ENT** key

▷

- Scroll through the soft-key row

ATAN

- Press the **ATAN** arc tangent function soft key

◁

- Scroll through the soft-key row

(

- Press the **Opening parenthesis** soft key

Q

- Enter **12** (the parameter number)

/

- Select division

Q

- Enter **13** (the parameter number)

)

- Press the **Closing parenthesis** soft key

END

- Press the **END** key to conclude the formula entry

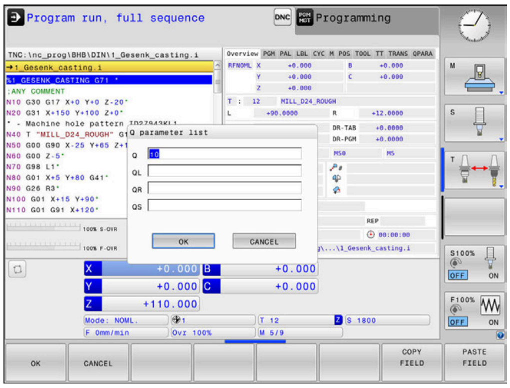
Example

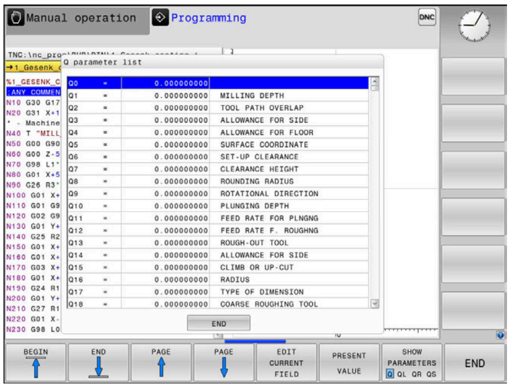
```
N10   Q25 = ATAN (Q12/Q13)
```

9.8 Checking and changing Q parameters

Procedure

You can check Q parameters in all operating modes, and also edit them.





- If needed, interrupt the program run (e.g., by pressing the **NC STOP** key and the **INTERNAL STOP** soft key), or stop the test run

Q INFO

- To call the Q parameter functions, press the **Q INFO** soft key or the **Q** key
- > The control lists all of the parameters and their corresponding current values.
- Use the arrow keys or the **GOTO** key to select the desired parameter.
- If you want to change the value, then press the **EDIT CURRENT FIELD** soft key, enter the new value, and confirm with the **ENT** key
- If you want to leave the value unchanged, then press the **PRESENT VALUE** soft key or close the dialog with the **END** key

> All of the parameters with displayed comments are used by the control within cycles or as transfer parameters.
>
> If you want to check or edit local, global or string parameters, press the **SHOW PARAMETERS Q QL QR QS** soft key. The control then displays the specific parameter type. The functions previously described also apply.

You can have Q parameters also displayed in the additional status display in all operating modes (except **Programming** mode).

- If needed, interrupt the program run (e.g., by pressing the **NC STOP** key and the **INTERNAL STOP** soft key), or stop the test run
- Display the soft key row for screen layout

PROGRAM + STATUS

- Select the layout option for the additional status display
- > In the right half of the screen, the control shows the **Overview** status form.

STATUS OF Q PARAM.

- Press the **STATUS OF Q PARAM.** soft key

Q PARAMETER LIST

- Press the **Q PARAMETER LIST** soft key
- > The control opens a pop-up window.
- For each parameter type (Q, QL, QR, QS), define the parameter numbers you wish to check. Separate single Q parameters with a comma, and connect sequential Q parameters with a hyphen, e.g. 1,3,200-208. The input range per parameter type is 132 characters

> The display in the **QPARA** tab always contains eight decimal places. The result of **Q1 = COS 89.999** is shown by the control as 0.00001745, for example. Very large or very small values are displayed by the control in exponential notation. The result of **Q1 = COS 89.999 * 0.001** is shown by the control as +1.74532925e-08, where e-08 corresponds to the factor of 10^{-8}.

9.9 Additional functions

Overview

The additional functions appear when the **DIVERSE FUNCTION** soft key is pressed. The control displays the following soft keys:

Soft key	Function	Page
D14 ERROR=	**D14** Display error messages	277
D16 F-PRINT	**D16** Formatted output of texts or Q parameter values	283
D18 SYS-DATUM READ	**D18** Read system data	291
D19 PLC=	**D19** Transfer values to the PLC	292
D20 WAIT FOR	**D20** NC and PLC synchronization	292
D26 OPEN THE TABLE	**D26** Open a freely definable table	356
D27 WRITE TO TABLE	**D27** Write to a freely definable table	356
D28 READ TABLE	**D28** Read from a freely definable table	357
D29 PLC LIST=	**D29** Transfer up to eight values to the PLC	293
D37 EXPORT	**D37** Export local Q parameters or QS parameters into a calling NC program	293
D38 TRANSMIT	**D38** Send information from the NC program	294

D14 – Displaying error messages

With the **D14** error function, you can output error messages under program control. The messages are predefined by the machine tool builder or by HEIDENHAIN. If the control encounters an NC block with **FN 14: ERRORD14** during program run or test run, it will interrupt the run and display an error message. You must then restart the NC program.

Error number range	Standard dialog
0 ... 999	Machine-dependent dialog
1000 ... 1199	Internal error messages

Example

The control is intended to display a message if the spindle is not switched on.

```
N180 D14  P01 1000*
```

The following is a complete list of the **D14** error messages. Please be aware that not all error messages are available, depending on the model of your control.

Error message predefined by HEIDENHAIN

Error number	Text
1000	Spindle?
1001	Tool axis is missing
1002	Tool radius too small
1003	Tool radius too large
1004	Range exceeded
1005	Start position incorrect
1006	ROTATION not permitted
1007	SCALING FACTOR not permitted
1008	MIRROR IMAGE not permitted
1009	Datum shift not permitted
1010	Feed rate is missing
1011	Input value incorrect
1012	Incorrect sign
1013	Entered angle not permitted
1014	Touch point inaccessible
1015	Too many points
1016	Contradictory input
1017	CYCL incomplete
1018	Plane wrongly defined
1019	Wrong axis programmed
1020	Wrong rpm

Error number	Text
1021	Radius comp. undefined
1022	Rounding-off undefined
1023	Rounding radius too large
1024	Program start undefined
1025	Excessive nesting
1026	Angle reference missing
1027	No fixed cycle defined
1028	Slot width too small
1029	Pocket too small
1030	Q202 not defined
1031	Q205 not defined
1032	Q218 must be greater than Q219
1033	CYCL 210 not permitted
1034	CYCL 211 not permitted
1035	Q220 too large
1036	Q222 must be greater than Q223
1037	Q244 must be greater than 0
1038	Q245 must not equal Q246
1039	Angle range must be under 360°
1040	Q223 must be greater than Q222
1041	Q214: 0 not permitted
1042	Traverse direction not defined
1043	No datum table active
1044	Position error: center in axis 1
1045	Position error: center in axis 2
1046	Hole diameter too small
1047	Hole diameter too large
1048	Stud diameter too small
1049	Stud diameter too large
1050	Pocket too small: rework axis 1
1051	Pocket too small: rework axis 2
1052	Pocket too large: scrap axis 1
1053	Pocket too large: scrap axis 2
1054	Stud too small: scrap axis 1
1055	Stud too small: scrap axis 2
1056	Stud too large: rework axis 1
1057	Stud too large: rework axis 2
1058	TCHPROBE 425: length exceeds max

Error number	Text
1059	TCHPROBE 425: length below min
1060	TCHPROBE 426: length exceeds max
1061	TCHPROBE 426: length below min
1062	TCHPROBE 430: diameter too large
1063	TCHPROBE 430: diameter too small
1064	No measuring axis defined
1065	Tool breakage tolerance exceeded
1066	Enter Q247 unequal to 0
1067	Enter Q247 greater than 5
1068	Datum table?
1069	Enter Q351 unequal to 0
1070	Thread depth too large
1071	Missing calibration data
1072	Tolerance exceeded
1073	Block scan active
1074	ORIENTATION not permitted
1075	3-D ROT not permitted
1076	Activate 3-D ROT
1077	Enter depth as negative
1078	Q303 in meas. cycle undefined!
1079	Tool axis not allowed
1080	Calculated values incorrect
1081	Contradictory meas. points
1082	Incorrect clearance height
1083	Contradictory plunge type
1084	This fixed cycle not allowed
1085	Line is write-protected
1086	Oversize greater than depth
1087	No point angle defined
1088	Contradictory data
1089	Slot position 0 not allowed
1090	Enter an infeed not equal to 0
1091	Switchover of Q399 not allowed
1092	Tool not defined
1093	Tool number not permitted
1094	Tool name not permitted
1095	Software option not active
1096	Kinematics cannot be restored

Error number	Text
1097	Function not permitted
1098	Contradictory workpc. blank dim.
1099	Measuring position not allowed
1100	Kinematic access not possible
1101	Meas. pos. not in traverse range
1102	Preset compensation not possible
1103	Tool radius too large
1104	Plunging type is not possible
1105	Plunge angle incorrectly defined
1106	Angular length is undefined
1107	Slot width is too large
1108	Scaling factors not equal
1109	Tool data inconsistent
1110	MOVE not possible
1111	Presetting not allowed!
1112	Thread angle too small!
1113	3-D ROT status is contradictory!
1114	Configuration is incomplete
1115	No turning tool is active
1116	Tool orientation is inconsistent
1117	Angle not possible!
1118	Radius too small!
1119	Thread runout too short!
1120	Contradictory meas. points
1121	Too many limits
1122	Machining strategy with limits not possible
1123	Machining direction not possible
1124	Check the thread pitch!
1125	Angle cannot be calculated
1126	Eccentric turning not possible
1127	No milling tool is active
1128	Insufficient length of cutting edge
1129	Gear definition is inconsistent or incomplete
1130	No finishing allowance provided
1131	Line does not exist in table
1132	Probing process not possible
1133	Coupling function not possible

Error number	Text
1134	Machining cycle is not supported by this NC software
1135	Touch probe cycle is not supported by this NC software
1136	NC program aborted
1137	Touch probe data incomplete
1138	LAC function not possible
1139	Rounding radius or chamfer is too large!
1140	Axis angle not equal to tilt angle
1141	Character height not defined
1142	Excessive character height
1143	Tolerance error: Workpiece rework
1144	Tolerance error: Workpiece scrap
1145	Faulty dimension definition
1146	Illegal entry in compensation table
1147	Transformation not possible
1148	Tool spindle incorrectly configured
1149	Offset of the turning spindle unknown
1150	Global program settings are active
1151	Faulty configuration of OEM macros
1152	The combination of programmed oversizes is not possible
1153	Measured value not captured
1154	Check the monitoring of the tolerance
1155	Hole is smaller than the stylus tip
1156	Preset cannot be set
1157	Alignment of a rotary table is not possible
1158	Alignment of rotary axes is not possible
1159	Infeed limited to length of cutting edge
1160	Machining depth defined as 0
1161	Tool type is unsuitable
1162	Finishing allowance not defined
1163	Machine datum could not be written
1164	Spindle for synchronization could not be ascer-tained
1165	Function is not possible in the active operating mode
1166	Oversize defined too large
1167	Number of teeth not defined

Error number	Text
1168	Machining depth does not increase monotonously
1169	Infeed does not decrease monotonously
1170	Tool radius not defined correctly
1171	Mode for retraction to clearance height not possible
1172	Gear wheel definition incorrect
1173	Probing object contains different types of dimension definition
1174	Dimension definition contains impermissible characters
1175	Actual value in dimension definition faulty
1176	Starting point of hole too deep
1177	Dimension def.: Nominal value missing for manual pre-positioning
1178	A replacement tool is not available
1179	OEM macro is not defined
1180	Measurement not possible with auxiliary axis
1181	Start position not possible with modulo axis
1182	Function only possible if door is closed
1183	Number of possible records exceeded
1184	Inconsistent machining plane due to axis angle with basic rot.
1185	Transfer parameter contains an impermissible value
1186	Tooth width RCUTS is defined too large
1187	Usable length LU of the tool is too small
1188	The defined chamfer is too large
1189	Chamfer angle cannot be machined with the active tool
1190	The allowances do not define any stock removal
1191	Spindle angle not unique

D16 – Formatted output of text and Q parameter values

Fundamentals

With the function **D16**, you can save Q parameter values and output formatted texts (e.g. in order to save measurement reports).

You can output the values as follows:

- Save them to a file on the control
- Display them on the screen in a pop-up window
- Save them to an external file
- Print them using a connected printer

Procedure

Proceed as follows in order to output Q-parameter values and texts:

- Create a text file that defines the output format and contents
- In the NC program, use the function **D16** in order to output the log

If you output the values to a file, the maximum size of the output file will be 20 KB.

Changing the output path of the log file

If you wish to save the measurement results in another directory, then you must modify the output path of the log file.

Change the output path as follows:

MOD

- Press the **MOD** key
- Enter the code number 123
- Select the parameter **Paths for the end user** (**CfgUserPath**)
- Select the parameter **FN 16 output path for execution** (**fn16DefaultPath**)
- > The control opens a pop-up window.
- Select the output path for the machine operating modes
- Select the parameter **FN 16 output path for the Programming and Test Run op. modes** (**fn16DefaultPathSim**)
- > The control opens a pop-up window.
- Select the output path for the **Programming** and **Test Run** operating modes

Creating a text file

To output the formatted texts and Q parameter values, use the control's text editor to create a text file. Define the format and Q parameters to be output in this file.

Proceed as follows:

PGM MGT

- Press the **PGM MGT** key

NEW FILE

- Press the **NEW FILE** soft key
- Create a file with the extension **.A**

Available functions

Use the following formatting functions for creating a text file:

Special characters	Function
"..........."	Define output format for texts and variables between the quotation marks
%F	Format for Q parameters, QL, and QR: ■ Define %: format ■ F: Floating (decimal number), format for Q, QL, QR
9.3	Format for Q parameters, QL, and QR: ■ Total of 9 characters, including decimal separator ■ Of these, 3 are decimal places
%S	Format for text variable QS
%RS	Format for text variable QS Assumes the subsequent without any changes or formatting
%D or **%I**	Format for integer
,	Separation character between output format and parameter
;	End of block character
*****	Beginning of a comment line Comments are not shown in the log
%"	Output quotation marks
%%	Output percent sign
****	Output backslash
\n	Output line break
+	Q parameter value, right-aligned
-	Q parameter value, left-aligned

Example

Input	Meaning
"X1 = %+9.3F", Q31;	Format for Q parameter: ■ **"X1 =**: The text **X1 =** is output ■ **%**: Specify the format ■ **+**: Number right-aligned ■ **9.3**: Total of 9 characters; 3 of them are decimal places ■ **F**: Floating (decimal number) ■ **, Q31**: Output the value from **Q31** ■ **;**: End of block

The following functions allow you to include the following additional information in the protocol log file:

Keyword	Function
CALL_PATH	Gives the path for the NC program where you will find the D16 function. Example: "Measuring program: %S",CALL_PATH;
M_CLOSE	Closes the file to which you are writing with D16. Example: M_CLOSE;
M_APPEND	Upon renewed output, appends the log to the existing log. Example: M_APPEND;
M_APPEND_MAX	Upon renewed output, appends the log to the existing log until the maximum specified file size in kilobytes is exceeded. Example: M_APPEND_MAX20;
M_TRUNCATE	Overwrites the log upon renewed output. Example: M_TRUNCATE;
M_EMPTY_HIDE	Prevents empty lines from being inserted into the log if QS parameters are not defined or empty. Example: M_EMPTY_HIDE;
M_EMPTY_SHOW	Inserts empty lines into the log if QS parameters are not defined. Resets M_EMPTY_HIDE. Example: M_EMPTY_SHOW;
L_ENGLISH	Outputs the text only for English conversational language
L_GERMAN	Outputs the text only for German conversational language
L_CZECH	Outputs text only for Czech conversational language
L_FRENCH	Outputs text only for French conversational language

Keyword	Function
L_ITALIAN	Outputs text only for Italian conversational language
L_SPANISH	Outputs text only for Spanish conversational language
L_PORTUGUE	Outputs text only for Portuguese conversational language
L_SWEDISH	Outputs text only for Swedish conversational language
L_DANISH	Outputs text only for Danish conversational language
L_FINNISH	Outputs text only for Finnish conversational language
L_DUTCH	Outputs text only for Dutch conversational language
L_POLISH	Outputs text only for Polish conversational language
L_HUNGARIA	Outputs text only for Hungarian conversational language
L_CHINESE	Outputs text only for Chinese conversational language
L_CHINESE_TRAD	Outputs text only for Chinese (traditional) conversational language
L_SLOVENIAN	Outputs text only for Slovenian conversational language
L_NORWEGIAN	Outputs text only for Norwegian conversational language
L_ROMANIAN	Outputs text only for Romanian conversational language
L_SLOVAK	Outputs text only for Slovakian conversational language
L_TURKISH	Outputs text only for Turkish conversational language
L_ALL	Display text independently of the conversational language
HOUR	Number of hours from the real-time clock
MIN	Number of minutes from the real-time clock
SEC	Number of seconds from the real-time clock
DAY	Day from the real-time clock
MONTH	Month as a number from the real-time clock
STR_MONTH	Month as a string abbreviation from the real-time clock
YEAR2	Two-digit year from the real-time clock

Keyword	Function
YEAR4	Four-digit year from the real-time clock

Example

Example of a text file to define the output format:

"MEASURING LOG OF IMPELLER CENTER OF GRAVITY";
"DATUM: %02d.%02d.%04d",DAY,MONTH,YEAR4;
"TIME: %02d:%02d:%02d",HOUR,MIN,SEC;
"NO. OF MEASURED VALUES: = 1";
"X1 = %9.3F", Q31;
"Y1 = %9.3F", Q32;
"Z1 = %9.3F", Q33;
L_GERMAN;
"Werkzeuglänge beachten";
L_ENGLISH;
"Remember the tool length";

Example

Example of a text file that outputs a log file of variable length:

"MEASURING LOG";
“%S“,QS1;
M_EMPTY_HIDE;
“%S“,QS2;
“%S“,QS3;
M_EMPTY_SHOW;
“%S“,QS4;
M_CLOSE;

Example of an NC program that defines only **QS3**:

```
N70 Q1 = 100
N80 QS3 = "Pos 1: " || TOCHAR( DAT+Q1 )*
N90 D16 P01 TNC:\D16.a / SCREEN:
```

Example of a screen output with two empty lines resulting from **QS1** and **QS4**:

Activating D16 output in an NC program

Within the **D16** you specify the output file that contains the texts to be output.

The control generates the output file:

- at the end of the program (**G71**),
- if a program is canceled (**NC STOP** key)
- as a result of the command **M_CLOSE**

Enter the path of the source and the path of the output file in the D16.

Proceed as follows:

Q
- Press the **Q** key.

DIVERSE FUNCTION
- Press the **DIVERSE FUNCTION** soft key

D16 F-PRINT
- Press the **D16 F-PRINT** soft key

SELECT FILE
- Press the **SELECT FILE** soft key
- Select the source, i.e. the text file in which the output file is defined

ENT
- Confirm with the **ENT** key

- Enter the output path.

> If the called file is located in the same directory as the file you are calling it from, you can also integrate the file name without the path. The **APPLY FILE NAME** soft key provided in the selection window of the **SELECT FILE** soft key is available for this.

Path entries in the D16 function

If you enter only the file name as the path for the log file, the control saves the log file in the directory in which the NC program with the **D16** function is located.

Program relative paths as an alternative to complete paths:

- Starting from the folder of the calling file one folder level down **D16 P01 MASKE\MASKE1.A/ PROT\PROT1.TXT**
- Starting from the folder of calling file one folder level up and in another folder **D16 P01 ..\MASKE\MASKE1.A/ ..\PROT1.TXT**

> Operating and programming notes:
> - If you output the same file more than once in the NC program, the control appends the current output to the end of the contents already output within the target file.
> - In the **D16** block, program the format file and the log file, each with the extension for the file type.
> - The file name extension of the log file determines the file type of the output (e.g., TXT, A, XLS, HTML).
> - Use **D18** to receive much information that is relevant and interesting in log files, such as the number of the touch-probe cycle last used.
>   **Further information:** "D18 – Reading system data", Page 291

Enter the source or the target with parameters

You can enter the source file and the output file as Q parameters or as QS parameters. For this purpose you previously define the desired parameter in the NC program.

Further information: "Assigning string parameters", Page 297

Enter Q parameters in the **D16** function with the following syntax so that the control can detect the Q parameters:

Input	Function
:'QS1'	Set QS parameters with preceding colon and between single quotation marks
:'QL3'.txt	Specify additional file name extension for the target file if required

> If you want to output a path with a QS parameter to a log file, then use the function **%RS**. This ensures that the control does not interpret the special characters as formatting characters.

Example

```
N90 D16 P01 TNC:\MASKE\MASKE1.A/ TNC:\PROT1.TXT
```

The control creates the file PROT1.TXT:

MEASURING LOG OF IMPELLER CENTER OF GRAVITY

DATE: July 15, 2015

TIME: 8:56:34 AM

NO. OF MEASURED VALUES : = 1

X1 = 149.360

Y1 = 25.509

Z1 = 37.000

Remember the tool length

Displaying messages on the control screen

You can also use the function **D16** to display any messages from the NC program in a pop-up window on the control screen. This makes it easy to display explanatory texts, including long texts, at any point in the NC program in a way that the user has to react to them. You can also display Q-parameter contents if the protocol description file contains such instructions.

For the message to appear on the control screen, you need only enter **SCREEN:** as the output path.

Example

```
N90 D16 P01 TNC:\MASKE\MASKE1.A/SCREEN:
```

If the message has more lines than fit in the pop-up window, you can use the arrow keys to page in the window.

> If you output the same file more than once in the NC program, the control appends the current output to the end of the contents already output within the target file.
>
> If you want to overwrite the previous pop-up window, program the function **M_CLOSE** or **M_TRUNCATE**.

Closing the pop-up window

You can close the pop-up window in the following ways:

- Press the **CE** key
- Controlled by the program with the output path **sclr:**

Example

```
N90 D16 P01 TNC:\MASKE\MASKE1.A/SCLR:
```

Exporting messages

With the **D16** function you can also store log files externally.

To do so you must enter the target path in the **D16** function.

Example

```
N90 D16 P01 TNC:\MSK\MSK1.A / PC325:\LOG\PRO1.TXT
```

> If you output the same file more than once in the NC program, the control appends the current output to the end of the contents already output within the target file.

Printing messages

You can also use the function **D16** to print any messages on a connected printer.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

In order for the messages to be sent to the printer, you must enter **Printer:** as the name of the log file and then enter the corresponding file name.

The control saves the file in the **PRINTER:** path until the file is printed.

Example

```
N90 D16 P01 TNC:\MASKE\MASKE1.A\PRINTER:\DRUCK1
```

D18 – Reading system data

With the **D18** function, you can read system data and save them to Q parameters. The selection of the system datum occurs via a group number (ID no.), a system data number, and, if necessary, an index.

> The read values of the function **D18** are always output by the control in **metric** units regardless of the NC program's unit of measure.
>
> As an alternative, you can use **TABDATA READ** to read out data from the active tool table. In this case, the control will automatically convert the table values to the unit of measure used in the NC program.

Further information: "System data", Page 474

Example: Assign the value of the active scaling factor for the Z axis to Q25.

```
N55 D18 Q25 ID210 NR4 IDX3*
```

D19 – Transferring values to the PLC

NOTICE

Danger of collision!

Changes to the PLC can result in undesired behavior and serious errors (e.g., inoperability of the control). For this reason, access to the PLC is protected by password. This function provides HEIDENHAIN as well as your machine tool builder and suppliers with the ability to communicate with the PLC from an NC program. It is not recommended for the machine operator or NC programmer to use this function. There is risk of collision during the execution of the function and during the subsequent machining!

- Only use the function in consultation with HEIDENHAIN, the machine tool builder, or the supplier.
- Comply with the documentation from HEIDENHAIN, the machine tool builder, and suppliers.

The **D19** function transfers up to two numerical values or Q parameters to the PLC.

D20 – NC and PLC synchronization

NOTICE

Danger of collision!

Changes to the PLC can result in undesired behavior and serious errors (e.g., inoperability of the control). For this reason, access to the PLC is protected by password. This function provides HEIDENHAIN as well as your machine tool builder and suppliers with the ability to communicate with the PLC from an NC program. It is not recommended for the machine operator or NC programmer to use this function. There is risk of collision during the execution of the function and during the subsequent machining!

- Only use the function in consultation with HEIDENHAIN, the machine tool builder, or the supplier.
- Comply with the documentation from HEIDENHAIN, the machine tool builder, and suppliers.

With the **D20** function you can synchronize the NC and PLC during a program run. The NC stops machining until the condition that you have programmed in the **D20** block is fulfilled.

SYNC is used whenever you read, for example, system data via **D18** that require synchronization with real time. The control stops the look-ahead calculation and executes the following NC block only when the NC program has actually reached that NC block.

Example: Pause internal look-ahead calculation, read current position in the X axis

```
N32 D20 SYNC
N33 D18 Q1 ID270 NR1 IDX1*
```

D29 – Transferring values to the PLC

NOTICE

Danger of collision!

Changes to the PLC can result in undesired behavior and serious errors (e.g., inoperability of the control). For this reason, access to the PLC is protected by password. This function provides HEIDENHAIN as well as your machine tool builder and suppliers with the ability to communicate with the PLC from an NC program. It is not recommended for the machine operator or NC programmer to use this function. There is risk of collision during the execution of the function and during the subsequent machining!

- Only use the function in consultation with HEIDENHAIN, the machine tool builder, or the supplier.
- Comply with the documentation from HEIDENHAIN, the machine tool builder, and suppliers.

The **D29** function transfers up to eight numerical values or Q parameters to the PLC.

D37 - EXPORT

NOTICE

Danger of collision!

Changes to the PLC can result in undesired behavior and serious errors (e.g., inoperability of the control). For this reason, access to the PLC is protected by password. This function provides HEIDENHAIN as well as your machine tool builder and suppliers with the ability to communicate with the PLC from an NC program. It is not recommended for the machine operator or NC programmer to use this function. There is risk of collision during the execution of the function and during the subsequent machining!

- Only use the function in consultation with HEIDENHAIN, the machine tool builder, or the supplier.
- Comply with the documentation from HEIDENHAIN, the machine tool builder, and suppliers.

You need the **D37** function if you want to create your own cycles and integrate them in the control.

D38 – Send information from the NC program

The function **D38** enables you to retrieve texts and Q parameter values from the NC program and write them to the log or send them to an external application, e.g. the StateMonitor.

The syntax consists of two parts:

- **Format of transmitted text**: Output text with optional placeholders for variable values (e.g., **%f**)

> Input may be in the form of QS parameters.
> Placeholders are case-sensitive, so make sure to enter them correctly.

- **Datum for placeholder in text**: List of max. seven Q, QL, or QR variables (e.g., **Q1**)

Data transmission is through a standard TCP/IP computer network.

> For more detailed information, consult the RemoTools SDK manual.

Example

Document the values from **Q1** and **Q23** in the log.

```
D38* /"Q-Parameter Q1: %f Q23: %f" P02 +Q1 P02 +Q23*
```

Example

Define the output format for the variable values.

```
D38* /"Q-Parameter Q1: %05.1f" P02 +Q1*
```

> The control outputs the variable value as a five-digit number, of which one digit is a decimal place. The output will be padded with leading zeroes as needed.

```
D38* /"Q-Parameter Q1: % 7.3f" P02 +Q1*
```

> The control outputs the variable value as a seven-digit number, of which three digits are decimal places. The output will be padded with blank spaces as needed.

> To obtain **%** in the output text, enter **%%** at the desired position.

Example

Send information to the StateMonitor.

With function **D38**, you can enter job data, among others. This requires a job that has been created in StateMonitor and an assignment to the machine tool being used.

> Job management with the JobTerminal (option 4) is possible with StateMonitor version 1.2 or higher.

Requirements:

- Job number 1234
- Working step 1

D38* /"JOB:1234_STEP:1_CREATE"*	Create job
D38* /"JOB:1234_STEP:1_CREATE_ITEMNAME: HOLDER_ITEMID:123_TARGETQ:20" *	Alternative: Create job with part name, part number, and required quantity
D38* /"JOB:1234_STEP:1_START"*	Start job
D38* /"JOB:1234_STEP:1_PREPARATION"*	Start preparation
D38* /"JOB:1234_STEP:1_PRODUCTION"*	Production
D38* /"JOB:1234_STEP:1_STOP"*	Stop job
D38* /"JOB:1234_STEP:1_ FINISH"*	Finish job

In addition, the workpiece quantities for the job can be reported.

With the **OK**, **S**, and **R** placeholders, you can specify whether the quantity of reported workpieces has been machined correctly or not.

The **A** and **I** placeholders allow you to define how StateMonitor interprets the response. If absolute values are transferred, then StateMonitor overwrites the previously valid values. In the case of incremental values, StateMonitor increments the quantity.

D38* /"JOB:1234_STEP:1_OK_A:23"*	Actual amount (OK) absolute
D38* /"JOB:1234_STEP:1_OK_I:1"*	Actual amount (OK) incremental
D38* /"JOB:1234_STEP:1_S_A:12"*	Scrap (S) absolute
D38* /"JOB:1234_STEP:1_S_I:1"*	Scrap (S) incremental
D38* /"JOB:1234_STEP:1_R_A:15"*	Rework (R) absolute
D38* /"JOB:1234_STEP:1_R_I:1"*	Rework (R) incremental

9.10 String parameters

String processing functions

You can use the **QS** parameters to create variable character strings. You can output such character strings for example through the **D16** function to create variable logs.

You can assign a linear sequence of characters (letters, numbers, special characters and spaces) up to a length of 255 characters to a string parameter. You can also check and process the assigned or imported values using the functions described below. As in Q parameter programming, you can use a total of 2000 QS parameters.

Further information: "Principle and overview of functions", Page 254

The **STRING FORMULA** and **FORMULA** Q parameter functions contain various functions for processing the string parameters.

Soft key	Functions of the STRING FORMULA	Page
DECLARE STRING	Assigning string parameters	297
CFGREAD	Read out machine parameter	306
STRING FORMULA	Chain-linking string parameters	298
TOCHAR	Converting a numerical value to a string parameter	299
SUBSTR	Copy a substring from a string parameter	300
SYSSTR	Read system data	301

Soft key	Formula string functions	Page
TONUMB	Converting a string parameter to a numerical value	302
INSTR	Checking a string parameter	303
STRLEN	Finding the length of a string parameter	304
STRCOMP	Compare alphabetic priority	305

When you use the **STRING FORMULA** function, the result of the performed arithmetic operation is always a string. When you use the **FORMULA** function, the result of the performed arithmetic operation is always a numeric value.

Assigning string parameters

Before using string variables, you must first assign the variables. Use the **DECLARE STRING** command to do so.

SPEC FCT

- Press the **SPEC FCT** key

PROGRAM FUNCTIONS

- Press the **PROGRAM FUNCTIONS** soft key

STRING FUNCTIONS

- Press the **STRING FUNCTIONS** soft key

DECLARE STRING

- Press the **DECLARE STRING** soft key

Example

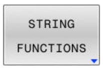
```
N30 DECLARE character string QS10 = "Workpiece"
```

Chain-linking string parameters

With the concatenation operator (string parameter **||** string parameter) you can make a chain of two or more string parameters.

- Press the **SPEC FCT** key

- Press the **PROGRAM FUNCTIONS** soft key



- Press the **STRING FUNCTIONS** soft key

- Press the **STRING FORMULA** soft key

- Enter the number of the string parameter in which the control is to save the concatenated string. Confirm with the **ENT** key.
- Enter the number of the string parameter in which the **first** substring is saved. Confirm with the **ENT** key
- > The control shows the concatenation symbol **||**
- Press the **ENT** key
- Enter the number of the string parameter in which the **second** substring is saved. Confirm with the **ENT** key
- Repeat the process until you have selected all the required substrings. Conclude with the **END** key

Example: QS10 is to include the complete text of QS12, QS13 and QS14

```
N370 QS10 =  QS12 || QS13 || QS14*
```

Parameter contents:

- **QS12**: **Workpiece**
- **QS13**: **Status:**
- **QS14**: **Scrap**
- **QS10**: **Workpiece Status: Scrap**

Converting a numerical value to a string parameter

With the **TOCHAR** function, the control converts a numerical value into a string parameter. This enables you to chain numerical values with string variables.

SPEC FCT

- Show the soft-key row with special functions

PROGRAM FUNCTIONS

- Open the function menu

STRING FUNCTIONS

- Press the String functions soft key

STRING FORMULA

- Press the **STRING FORMULA** soft key

TOCHAR

- Select the function for converting a numerical value to a string parameter
- Enter the number or the desired Q parameter to be converted by the control, and confirm with the **ENT** key
- If desired, enter the number of digits after the decimal point that the control should convert, and confirm with the **ENT** key
- Close the parenthetical expression with the **ENT** key and confirm your entry with the **END** key

Example: Convert parameter Q50 to string parameter QS11, use 3 decimal places

```
N370 QS11 = TOCHAR ( DAT+Q50 DECIMALS3 )*
```

Copying a substring from a string parameter

The **SUBSTR** function copies a definable range from a string parameter.

SPEC FCT
- Show the soft-key row with special functions

PROGRAM FUNCTIONS
- Open the function menu

STRING FUNCTIONS
- Press the String functions soft key

STRING FORMULA
- Press the **STRING FORMULA** soft key
- Enter the number of the string parameter in which the control is to save the character string. Confirm with the **ENT** key.

SUBSTR
- Select the function for cutting out a substring
- Enter the number of the QS parameter from which the substring is to be copied. Confirm with the **ENT** key
- Enter the number of the place starting from which to copy the substring, and confirm with the **ENT** key
- Enter the number of characters to be copied, and confirm with the **ENT** key
- Close the parenthetical expression with the **ENT** key and confirm your entry with the **END** key

> The first character of a text string starts internally at the 0-position

Example: A four-character substring (LEN4) is read from the string parameter QS10 beginning with the third character (BEG2)

```
N370 QS13 = SUBSTR ( SRC_QS10 BEG2 LEN4 )*
```

Reading system data

With the function **SYSSTR** you can read system data and store them in string parameters. You select the system data through a group number (ID) and a number.

Entering IDX and DAT is not required.

Group name, ID no.	Number	Meaning
Program information, 10010	1	Path of the current main program or pallet program
	2	Path of the NC program shown in the block display
	3	Path of the cycle selected with **CYCL DEF G39 PGM CALL**
	10	Path of the NC program selected with **%:PGM**
Channel data, 10025	1	Channel name
Values programmed in the tool call, 10060	1	Tool name
Current system time, 10321	1 to 16, 20	■ 1: DD.MM.YYYY hh:mm:ss ■ 2 and 16: DD.MM.YYYY hh:mm ■ 3: DD.MM.YY hh:mm ■ 4: YYYY-MM-DD hh:mm:ss ■ 5 and 6: YYYY-MM-DD hh:mm ■ 7: YY-MM-DD hh:mm ■ 8 and 9: DD.MM.YYYY ■ 10: DD.MM.YY ■ 11: YYYY-MM-DD ■ 12: YY-MM-DD ■ 13 and 14: hh:mm:ss ■ 15: hh:mm ■ 20: XX "XX" stands for the two-digit number of the current calendar week that—in accordance with ISO 8601 —is characterized by the following: ■ It comprises seven days ■ It begins with Monday ■ It is numbered sequentially ■ The first calendar week (week 01) is the week with the first Thursday of the Gregorian year.
Touch-probe data, 10350	50	Probe type of the active touch probe TS
	70	Probe type of the active touch probe TT
	73	Key name of the active touch probe TT from MP **activeTT**
Data for pallet machining, 10510	1	Name of the pallet being machined
	2	Path of the selected pallet table
NC software version, 10630	10	Version identifier of the NC software version

Group name, ID no.	Number	Meaning
Tool data, 10950	1	Tool name
	2	DOC entry of the tool
	4	Tool-carrier kinematics

Converting a string parameter to a numerical value

The **TONUMB** function converts a string parameter to a numerical value. The value to be converted should be only numerical.

> The QS parameter to be converted must contain only one numerical value. Otherwise, the control will output an error message.

Q

- Select Q parameter function

FORMULA

- Press the **FORMULA** soft key
- Enter the number of the string parameter in which the control is to save the numerical value. Confirm with the **ENT** key.

◁

- Shift the soft-key row

TONUMB

- Select the function for converting a string parameter to a numerical value
- Enter the number of the QS parameter to be converted by the control, and confirm with the **ENT** key
- Close the parenthetical expression with the **ENT** key and confirm your entry with the **END** key

Example: Convert string parameter QS11 to a numerical parameter Q82

```
N370 Q82 = TONUMB ( SRC_QS11 )*
```

Testing a string parameter

The **INSTR** function checks whether (and where) a string parameter is contained in another string parameter.

Q

- Select Q parameter function

FORMULA

- Press the **FORMULA** soft key
- Enter the number of the Q parameter for the result and confirm with the **ENT** key
- > The control saves the place at which the text to be searched for begins. It is saved in the parameter.

◁

- Shift the soft-key row

INSTR

- Select the function for checking a string parameter
- Enter the number of the QS parameter in which the text to be searched for is saved. Confirm with the **ENT** key
- Enter the number of the QS parameter to be searched for by the control, and confirm with the **ENT** key
- Enter the number of the place at which the control is to start search the substring, and confirm with the **ENT** key.
- Close the parenthetical expression with the **ENT** key and confirm your entry with the **END** key

> The first character of a text string starts internally at the 0-position
>
> If the control cannot find the required substring, it will save the total length of the string to be searched (counting starts at 1) in the result parameter.
>
> If the substring to be searched for appears multiple times, then the control returns the first place at which it finds the substring.

Example: Search through QS10 for the text saved in parameter QS13. Begin the search at the third place.

```
N370 Q50 = INSTR ( SRC_QS10 SEA_QS13 BEG2 )*
```

Finding the length of a string parameter

The **STRLEN** function returns the length of the text saved in a selectable string parameter.

Q

- Select Q parameter function

FORMULA

- Press the **FORMULA** soft key
- Enter the number of the Q parameter in which the control is to save the ascertained string length. Confirm with the **ENT** key.

◁

- Shift the soft-key row

STRLEN

- Select the function for finding the text length of a string parameter
- Enter the number of the QS parameter from which the control is to ascertain the length, and confirm with the **ENT** key
- Close the parenthetical expression with the **ENT** key and confirm your entry with the **END** key

Example: Find the length of QS15

```
N370 Q52 = STRLEN ( SRC_QS15 )*
```

If the selected string parameter is not defined the control returns the result **-1**.

Comparing alphabetic priority

The **STRCOMP** function compares string parameters for alphabetic priority.

Q

- Select Q parameter function

FORMULA

- Press the **FORMULA** soft key
- Enter the number of the Q parameter in which the control is to save the result of comparison, and confirm with the **ENT** key.

◁

- Shift the soft-key row

STRCOMP

- Select the function for comparing string parameters
- Enter the number of the first QS parameter that the control is to compare, and confirm with the **ENT** key
- Enter the number of the second QS parameter that the control is to compare, and confirm with the **ENT** key
- Close the parenthetical expression with the **ENT** key and confirm your entry with the **END** key

The control returns the following results:

- **0**: The compared QS parameters are identical
- **-1**: The first QS parameter **precedes** the second QS parameter alphabetically
- **+1:** The first QS parameter **follows** the second QS parameter alphabetically

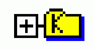
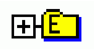
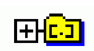
Example: QS12 and QS14 are compared for alphabetic priority

```
N370 Q52 = STRCOMP  ( SRC_QS12 SEA_QS14 )*
```

Reading out machine parameters

With the **CFGREAD** function, you can read out machine parameters of the control as numerical values or as strings. The read-out values are always output in metric units of measure.

In order to read out a machine parameter, you must use the control's configuration editor to determine the parameter name, parameter object, and, if they have been assigned, the group name and index:

Icon	Type	Meaning	Example
	**Key**	Group name of the machine parameter (if available)	CH_NC
	**Entity**	Parameter object (name begins with **Cfg**...)	**CfgGeoCycle**
	Attribute	Name of the machine parameter	**displaySpindleErr**
	**Index**	List index of a machine parameter (if available)	[0]

If you are in the configuration editor for the user parameters, you can change the display of the existing parameters. In the default setting, the parameters are displayed with short, explanatory texts.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Each time you want to interrogate a machine parameter with the **CFGREAD** function, you must first define a QS parameter with attribute, entity and key.

The following parameters are read in the CFGREAD function’s dialog:

- **KEY_QS**: Group name (key) of the machine parameter
- **TAG_QS**: Object name (entity) of the machine parameter
- **ATR_QS**: Name (attribute) of the machine parameter
- **IDX**: Index of the machine parameter

Reading a string of a machine parameter

In order to store the content of a machine parameter as a string in a QS parameter:

Q

- Press the **Q** key.

STRING FORMULA

- Press the **STRING FORMULA** soft key
- Enter the number of the string parameter in which the control is to save the machine parameter
- Press the **ENT** key
- Select the **CFGREAD** function
- Enter the numbers of the string parameters for key, entity, and attribute
- Press the **ENT** key
- Enter the number for the index, or skip the dialog with **NO ENT**, whichever applies
- Close the parenthesized expression with the **ENT** key
- Press the **END** key to conclude entry

Example: Read as a string the axis designation of the fourth axis

Parameter settings in the configuration editor
DisplaySettings
CfgDisplayData
axisDisplayOrder
[0] to [5]

Example

N140 QS11 = ""	Assign string parameter for key
N150 QS12 = "CfgDisplaydata"	Assign string parameter for entity
N160 QS13 = "axisDisplay"	Assign string parameter for parameter name
N170 QS1 = CFGREAD(KEY_QS11 TAG_QS12 ATR_QS13 IDX3)*	Read out machine parameter

Reading a numerical value of a machine parameter

Store the value of a machine parameter as a numerical value in a Q parameter:

Q

- Select Q parameter function

FORMULA

- Press the **FORMULA** soft key
- Enter the number of the Q parameter in which the control is to save the machine parameter
- Press the **ENT** key
- Select the **CFGREAD** function
- Enter the numbers of the string parameters for key, entity, and attribute
- Press the **ENT** key
- Enter the number for the index, or skip the dialog with N**NO ENT**, whichever applies
- Close the parenthesized expression with the **ENT** key
- Press the **END** key to conclude entry

Example: Read overlap factor as Q parameter

Parameter settings in the configuration editor

ChannelSettings
CH_NC
CfgGeoCycle
pocketOverlap

Example

N10 QS11 = "CH_NC"	Assign string parameter for key
N20 QS12 = "CfgGeoCycle"	Assign string parameter for entity
N30 QS13 = "pocketOverlap"	Assign string parameter for parameter name
N40 Q50 = CFGREAD(KEY_QS11 TAG_QS12 ATR_QS13)	Read out machine parameter

9.11 Preassigned Q parameters

The Q parameters **Q100** to **Q199** are assigned values by the control. The following types of information are assigned to the Q parameters:

- Values from the PLC
- Tool and spindle data
- Data on operating status
- Results of measurements from touch probe cycles etc.

The control saves the preassigned Q parameters **Q108** and **Q114** to **Q117** in the unit of measure used by the active NC program.

NOTICE

Danger of collision!

HEIDENHAIN cycles, manufacturer cycles and third-party functions use Q parameters. You can also program Q parameters within NC programs. If, when using Q parameters, the recommended Q parameter ranges are not used exclusively, then this can lead to overlapping (reciprocal effects) and thus cause undesired behavior. Danger of collision during machining!

- Only use Q parameter ranges recommended by HEIDENHAIN.
- Comply with the documentation from HEIDENHAIN, the machine tool builder, and suppliers.
- Check the machining sequence using a graphic simulation

You must not use preassigned Q parameters (QS parameters) between **Q100** and **Q199** (**QS100** and **QS199**) as calculation parameters in the NC programs.

Values from the PLC: Q100 to Q107

The control assigns values from the PLC to parameters **Q100** to **Q107** in an NC program.

Active tool radius: Q108

The active value of the tool radius is assigned to **Q108**. **Q108** is calculated from:

- Tool radius R (tool table or **G99** block)
- Delta value DR from the tool table
- Delta value DR from the NC program (compensation table or **T** block)

The control remembers the current tool radius even if the power is interrupted.

Tool axis: Q109

The value of the parameter **Q109** depends on the current tool axis:

Parameter	Tool axis
Q109 = –1	No tool axis defined
Q109 = 0	X axis
Q109 = 1	Y axis
Q109 = 2	Z axis
Q109 = 6	U axis
Q109 = 7	V axis
Q109 = 8	W axis

Spindle status: Q110

The value of the parameter **Q110** depends on the M function last programmed for the spindle.

Parameter	M function
Q110 = –1	No spindle status defined
Q110 = 0	M3: Spindle ON, clockwise
Q110 = 1	M4: Spindle ON, counterclockwise
Q110 = 2	M5 after M3
Q110 = 3	M5 after M4

Coolant on/off: Q111

Parameter	M function
Q111 = 1	M8: Coolant ON
Q111 = 0	M9: Coolant OFF

Overlap factor: Q112

The control assigns **Q112** to the overlap factor for pocket milling.

Unit of measurement for dimensions in the NC program: Q113

During nesting with **%**, the value of the parameter **Q113** depends on the dimensional data of the NC program from which the other NC programs are called.

Parameter	Dimensional data of the main program
Q113 = 0	Metric system (mm)
Q113 = 1	Imperial system (inch)

Tool length: Q114

The current value for the tool length is assigned to **Q114**.

> The control remembers the current tool length even if the power is interrupted.

Coordinates after probing during program run

The parameters **Q115** to **Q119** contain the coordinates of the spindle position at the instant of probing during programmed measurement with the 3-D touch probe. The coordinates are referenced to the preset that is active in **Manual operation** mode.

The length of the stylus and the radius of the ball tip are not compensated in these coordinates.

Parameter	Coordinate axis
Q115	X axis
Q116	Y axis
Q117	Z axis
Q118	4th axis Machine-dependent
Q119	5th axis Machine-dependent

Deviation between actual and nominal value during automatic tool measurement; for example, with the TT 160

Parameter	Deviation of actual from nominal value
Q115	Tool length
Q116	Tool radius

Tilting the working plane with workpiece angles: Coordinates calculated by the control for rotary axes

Parameter	Coordinates
Q120	A axis
Q121	B axis
Q122	C axis

Measurement results from touch probe cycles

Further information: User's Manual for **Programming of Measuring Cycles for Workpieces and Tools**

Parameters	Measured actual values
Q150	Angle of a straight line
Q151	Center in reference axis
Q152	Center in minor axis
Q153	Diameter
Q154	Pocket length
Q155	Pocket width
Q156	Length of the axis selected in the cycle
Q157	Position of the centerline
Q158	Angle in the A axis
Q159	Angle in the B axis
Q160	Coordinate of the axis selected in the cycle

Parameters	Measured deviation
Q161	Center in reference axis
Q162	Center in minor axis
Q163	Diameter
Q164	Pocket length
Q165	Pocket width
Q166	Measured length
Q167	Position of the centerline

Parameters	Determined space angle
Q170	Rotation about the A axis
Q171	Rotation about the B axis
Q172	Rotation about the C axis

Parameters	Workpiece status
Q180	Good
Q181	Rework
Q182	Scrap

Parameters	Tool measurement with the BLUM laser
Q190	Reserved
Q191	Reserved
Q192	Reserved
Q193	Reserved

Parameters	Reserved for internal use
Q195	Marker for cycles
Q196	Marker for cycles
Q197	Marker for cycles (machining patterns)
Q198	Number of the last active measuring cycle

Parameter value	Status of tool measurement with TT
Q199 = 0.0	Tool is within the tolerance.
Q199 = 1.0	Tool is worn (LTOL/RTOL is exceeded)
Q199 = 2.0	Tool is broken (LBREAK/RBREAK is exceeded)

Measurement results from touch probe cycles 14xx

Parameters	Measured actual values
Q950	1st position in the reference axis
Q951	1st position in the minor axis
Q952	1st position in the tool axis
Q953	2nd position in the reference axis
Q954	2nd position in the minor axis
Q955	2nd position in the tool axis
Q956	3rd position in the reference axis
Q957	3rd position in the minor axis
Q958	3rd position in the tool axis
Q961	Spatial angle SPA in the WPL-CS
Q962	Spatial angle SPB in the WPL-CS
Q963	Spatial angle SPC in the WPL-CS
Q964	Angle of rotation in the I-CS
Q965	Angle of rotation in the coordinate system of the rotary table
Q966	First diameter
Q967	Second diameter

Parameters	Measured deviations
Q980	1st position in the reference axis
Q981	1st position in the minor axis
Q982	1st position in the tool axis
Q983	2nd position in the reference axis
Q984	2nd position in the minor axis
Q985	2nd position in the tool axis
Q986	3rd position in the reference axis
Q987	3rd position in the minor axis
Q988	3rd position in the tool axis
Q994	Angle in the I-CS
Q995	Angle in the coordinate system of the rotary table
Q996	First diameter
Q997	Second diameter

Parameter value	Workpiece status
Q183 = -1	Not defined
Q183 = 0	Pass
Q183 = 1	Rework
Q183 = 2	Scrap

9.12 Programming examples

Example: Rounding a value

The **INT** function truncates the decimal places.

In order for the control to round correctly, rather than simply truncating the decimal places, add the value 0.5 to a positive number. For a negative number you must subtract 0.5.

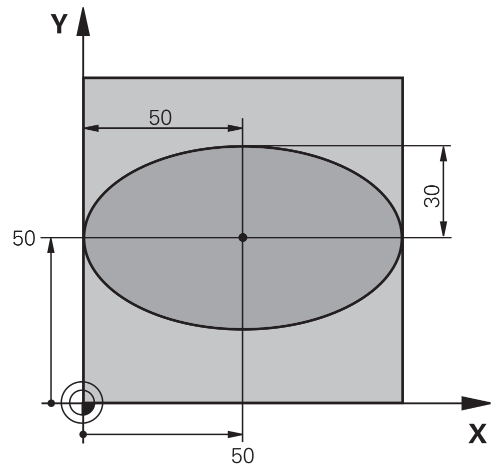
The control uses the **SGN** function to detect whether a number is positive or negative.

%ROUND G71 *	
N10 D00 Q1 P01 +34.789*	First number to be rounded
N20 D00 Q2 P01 +34.345*	Second number to be rounded
N30 D00 Q3 P01 -34.345*	Third number to be rounded
N40 ;	
N50 Q11 = INT (Q1 + 0.5 * SGN Q1)	Add the value 0.5 to Q1, then truncate the decimal places
N60 Q12 = INT (Q2 + 0.5 * SGN Q2)	Add the value 0.5 to Q2, then truncate the decimal places
N70 Q13 = INT (Q3 + 0.5 * SGN Q3)	Subtract the value 0.5 from Q3, then truncate the decimal places
N99999999 %ROUND G71 *	

Example: Ellipse

Program run

- The contour of the ellipse is approximated by many short line segments (defined in **Q7**). The more calculation steps you define for the lines, the smoother the curve becomes.
- The milling direction is determined with the starting angle and end angle in the plane:
  Machining direction is clockwise:
  Starting angle > end angle
  Machining direction is counterclockwise:
  Starting angle < end angle
- The tool radius is not taken into account



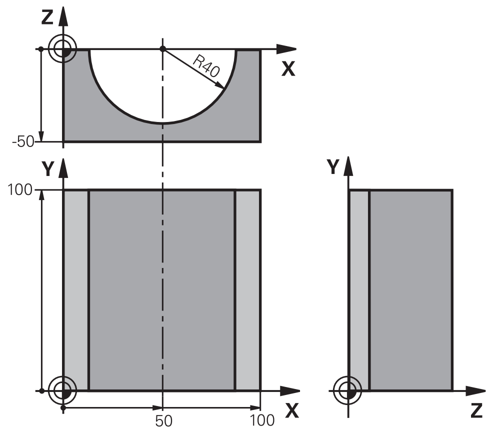
%ELLIPSE G71 *	
N10 D00 Q1 P01 +50*	Center in X axis
N20 D00 Q2 P01 +50*	Center in Y axis
N30 D00 Q3 P01 +50*	Semiaxis in X
N40 D00 Q4 P01 +30*	Semiaxis in Y
N50 D00 Q5 P01 +0*	Starting angle in the plane
N60 D00 Q6 P01 +360*	End angle in the plane
N70 D00 Q7 P01 +40*	Number of calculation steps
N80 D00 Q8 P01 +30*	Rotational position of the ellipse
N90 D00 Q9 P01 +5*	Milling depth
N100 D00 Q10 P01 +100*	Feed rate for plunging
N110 D00 Q11 P01 +350*	Feed rate for milling
N120 D00 Q12 P01 +2*	Set-up clearance for pre-positioning
N130 G30 G17 X+0 Y+0 Z-20*	Workpiece blank definition
N140 G31 G90 X+100 Y+100 Z+0*	
N150 T1 G17 S4000*	Tool call
N160 G00 G40 G90 Z+250*	Retract the tool
N170 L10.0*	Call machining operation
N180 G00 Z+250 M2*	Retract the tool, end program
N190 G98 L10*	Subprogram 10: Machining operation
N200 G54 X+Q1 Y+Q2*	Shift datum to center of ellipse
N210 G73 G90 H+Q8*	Account for rotational position in the plane
N220 Q35 = (Q6 - Q5) / Q7	Calculate angle increment
N230 D00 Q36 P01 +Q5*	Copy starting angle
N240 D00 Q37 P01 +0*	Set counter
N250 Q21 = Q3 * COS Q36	Calculate X coordinate for starting point
N260 Q22 = Q4 * SIN Q36	Calculate Y coordinate for starting point
N270 Q00 G40 X+Q21 Y+Q22 M3*	Move to starting point in the plane

N280 Z+Q12*	Pre-position in spindle axis to set-up clearance
N290 G01 Z-Q9 FQ10*	Move to working depth
N300 G98 L1*	
N310 Q36 = Q36 + Q35	Update the angle
N320 Q37 = Q37 + 1	Update the counter
N330 Q21 = Q3 * COS Q36	Calculate the current X coordinate
N340 Q22 = Q4 * SIN Q36	Calculate the current Y coordinate
N350 G01 X+Q21 Y+Q22 FQ11*	Move to next point
N360 D12 P01 +Q37 P02 +Q7 P03 1*	Unfinished? If not finished, return to LBL 1
N370 G73 G90 H+0*	Reset the rotation
N380 G54 X+0 Y+0*	Reset the datum shift
N390 G00 G40 Z+Q12*	Move to set-up clearance
N400 G98 L0*	End of subprogram
N99999999 %ELLIPSE G71 *	

Example: Concave cylinder machined with Ball-nose cutter

Program run

- This NC program works only with a Ball-nose cutter. The tool length is measured from the sphere center
- The contour of the cylinder is approximated by many short line segments (defined in **Q13**). The more line segments you define, the smoother the contour becomes.
- The cylinder is milled in longitudinal cuts (here: parallel to the Y axis).
- The milling direction is determined with the starting angle and end angle in space:
  Machining direction clockwise:
  Starting angle > end angle
  Machining direction counterclockwise:
  Starting angle < end angle
- The tool radius is compensated automatically



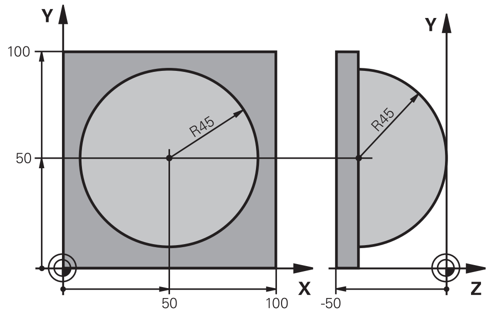
%CYLIN G71 *	
N10 D00 Q1 P01 +50*	Center in X axis
N20 D00 Q2 P01 +0*	Center in Y axis
N30 D00 Q3 P01 +0*	Center in Z axis
N40 D00 Q4 P01 +90*	Starting angle in space (Z/X plane)
N50 D00 Q5 P01 +270*	End angle in space (Z/X plane)
N60 D00 Q6 P01 +40*	Cylinder radius
N70 D00 Q7 P01 +100*	Length of the cylinder
N80 D00 Q8 P01 +0*	Rotational position in the X/Y plane
N90 D00 Q10 P01 +5*	Allowance for cylinder radius
N100 D00 Q11 P01 +250*	Feed rate for plunging
N110 D00 Q12 P01 +400*	Feed rate for milling
N120 D00 Q13 P01 +90*	Number of cuts
N130 G30 G17 X+0 Y+0 Z-50*	Workpiece blank definition
N140 G31 G90 X+100 Y+100 Z+0*	
N150 T1 G17 S4000*	Tool call
N160 G00 G40 G90 Z+250*	Retract the tool
N170 L10.0*	Call machining operation
N180 D00 Q10 P01 +0*	Reset allowance
N190 L10.0*	Call machining operation
N200 G00 G40 Z+250 M2*	Retract the tool, end program
N210 G98 L10*	Subprogram 10: Machining operation
N220 Q16 = Q6 - Q10 - Q108	Account for allowance and tool, based on the cylinder radius
N230 D00 Q20 P01 +1*	Set counter
N240 D00 q24 p01 +Q4*	Copy starting angle in space (Z/X plane)
N250 Q25 = (Q5 - Q4) / Q13	Calculate angle increment
N260 G54 X+Q1 Y+Q2 Z+Q3*	Shift datum to center of cylinder (X axis)

N270 G73 G90 H+Q8*	Account for rotational position in the plane
N280 G00 G40 X+0 Y+0*	Pre-position in the plane to the cylinder center
N290 G01 Z+5 F1000 M3*	Pre-position in the spindle axis
N300 G98 L1*	
N310 I+0 K+0*	Set pole in the Z/X plane
N320 G11 R+Q16 H+Q24 FQ11*	Move to starting position on cylinder, plunge-cutting obliquely into the material
N330 G01 G40 Y+Q7 FQ12*	Longitudinal cut in Y+ direction
N340 D01 Q20 P01 +Q20 P02 +1*	Update the counter
N350 D01 Q24 P01 +Q24 P02 +Q25*	Update solid angle
N360 D11 P01 +Q20 P02 +Q13 P03 99*	Finished? If finished, jump to end
N370 G11 R+Q16 H+Q24 FQ11*	Move on an approximated arc for the next longitudinal cut
N380 G01 G40 Y+0 FQ12*	Longitudinal cut in Y– direction
N390 D01 Q20 P01 +Q20 P02 +1*	Update the counter
N400 D01 Q24 P01 +Q24 P02 +Q25*	Update solid angle
N410 D12 P01 +Q20 P02 +Q13 P03 1*	Unfinished? If not finished, return to LBL 1
N420 G98 L99*	
N430 G73 G90 H+0*	Reset the rotation
N440 G54 X+0 Y+0 Z+0*	Reset the datum shift
N450 G98 L0*	End of subprogram
N99999999 %CYLIN G71 *	

Example: Convex sphere machined with end mill

Program run

- NC program requires an end mill.
- The contour of the sphere is approximated by many short line segments (in the Z/X plane, defined in **Q14**). The smaller you define the angle increment, the smoother the curve becomes.
- You can determine the number of contour cuts through the angle increment in the plane (defined in **Q18**).
- The tool moves upward in three-dimensional cuts.
- The tool radius is compensated automatically



%SPHERE G71 *	
N10 D00 Q1 P01 +50*	Center in X axis
N20 D00 Q2 P01 +50*	Center in Y axis
N30 D00 Q4 P01 +90*	Starting angle in space (Z/X plane)
N40 D00 Q5 P01 +0*	End angle in space (Z/X plane)
N50 D00 Q14 P01 +5*	Angle increment in space
N60 D00 Q6 P01 +45*	Sphere radius
N70 D00 Q8 P01 +0*	Starting angle of rotational position in the X/Y plane
N80 D00 Q9 p01 +360*	End angle of rotational position in the X/Y plane
N90 D00 Q18 P01 +10*	Angle increment in the X/Y plane for roughing
N100 D00 Q10 P01 +5*	Allowance in sphere radius for roughing
N110 D00 Q11 P01 +2*	Set-up clearance for pre-positioning in the spindle axis
N120 D00 Q12 P01 +350*	Feed rate for milling
N130 G30 G17 X+0 Y+0 Z-50*	Workpiece blank definition
N140 G31 G90 X+100 Y+100 Z+0*	
N150 T1 G17 S4000*	Tool call
N160 G00 G40 G90 Z+250*	Retract the tool
N170 L10.0*	Call machining operation
N180 D00 Q10 P01 +0*	Reset allowance
N190 D00 Q18 P01 +5*	Angle increment in the X/Y plane for finishing
N200 L10.0*	Call machining operation
N210 G00 G40 Z+250 M2*	Retract the tool, end program
N220 G98 L10*	Subprogram 10: Machining operation
N230 D01 Q23 P01 +Q11 P02 +Q6*	Calculate Z coordinate for pre-positioning
N240 D00 Q24 P01 +Q4*	Copy starting angle in space (Z/X plane)
N250 D01 Q26 P01 +Q6 P02 +Q108*	Compensate sphere radius for pre-positioning
N260 D00 Q28 P01 +Q8*	Copy rotational position in the plane
N270 D01 Q16 P01 +Q6 P02 -Q10*	Account for allowance in the sphere radius
N280 G54 X+Q1 Y+Q2 Z-Q16*	Shift datum to center of sphere
N290 G73 G90 H+Q8*	Account for starting angle of rotational position in the plane
N300 G98 L1*	Pre-position in the spindle axis

N310 I+0 J+0*	Set pole in the X/Y plane for pre-positioning
N320 G11 G40 R+Q26 H+Q8 FQ12*	Pre-position in the plane
N330 I+Q108 K+0*	Set pole in the Z/X plane, offset by the tool radius
N340 G01 Y+0 Z+0 FQ12*	Move to working depth
N350 G98 L2*	
N360 G11 G40 R+Q6 H+Q24 FQ12*	Move upward on an approximated arc
N370 D02 Q24 P01 +Q24 P02 +Q14*	Update solid angle
N380 D11 P01 +Q24 P02 +Q5 P03 2*	Inquire whether an arc is finished. If not finished, return to LBL 2
N390 G11 R+Q6 H+Q5 FQ12*	Move to the end angle in space
N400 G01 G40 Z+Q23 F1000*	Retract in the spindle axis
N410 G00 G40 X+Q26*	Pre-position for next arc
N420 D01 Q28 P01 +Q28 P02 +Q18*	Update rotational position in the plane
N430 D00 Q24 P01 +Q4*	Reset solid angle
N440 G73 G90 H+Q28*	Activate new rotational position
N450 D12 P01 +Q28 P02 +Q9 P03 1*	Unfinished? If not finished, return to LBL 1
N460 D09 P01 +Q28 P02 +Q9 P03 1*	
N470 G73 G90 H+0*	Reset the rotation
N480 G54 X+0 Y+0 Z+0*	Reset the datum shift
N490 G98 L0*	End of subprogram
N99999999 %SPHERE G71 *	

10

Special functions

10.1 Overview of special functions

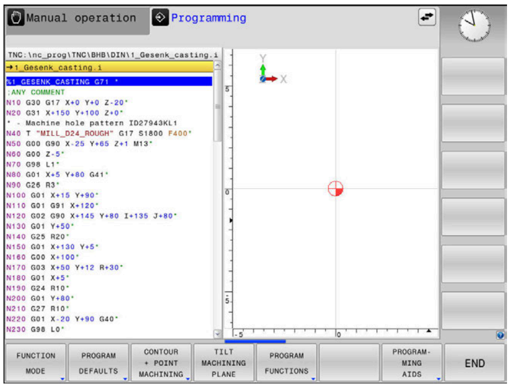
The control provides the following powerful special functions for a large number of applications:

Function	Description
Active Chatter Control (option 145)	See the User's Manual for Setup, Testing and Running NC Programs
Working with text files	Page 349
Working with freely definable tables	Page 353

Press the **SPEC FCT** key and the corresponding soft keys to access further special functions of the control. The following tables give you an overview of which functions are available.

Main menu for SPEC FCT special functions

SPEC FCT ▶ Press the **SPEC FCT** key to select the special functions



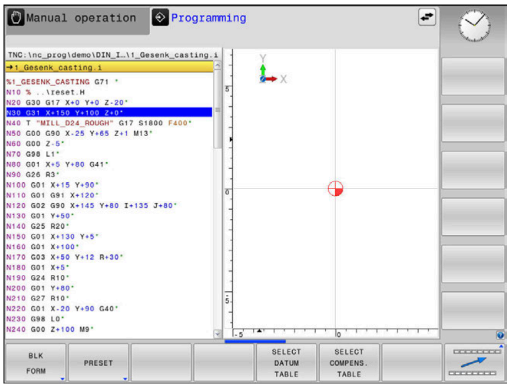
Soft key	Function	Description
FUNCTION MODE	Select machining mode or kinematics	Page 327
PROGRAM DEFAULTS	Define program defaults	Page 325
CONTOUR + POINT MACHINING	Functions for contour and point machining	Page 325
TILT MACHINING PLANE	Define the **PLANE** function	Page 372
PROGRAM FUNCTIONS	Define different DIN/ISO functions	Page 326
PROGRAM-MING AIDS	Programming aids	Page 183

After pressing the **SPEC FCT** key, you can open the **smartSelect** selection window with the **GOTO** key. The control displays a structure overview with all available functions. You can rapidly navigate with the cursor or mouse and select functions in the tree diagram. The control displays online help for the selected function in the window on the right.

Program defaults menu

PROGRAM DEFAULTS

- Press the Program Defaults soft key

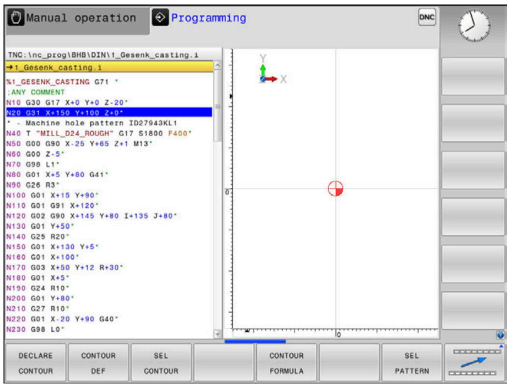


Soft key	Function	Description
BLK FORM	Define workpiece blank	Page 88
PRESET	Modifying the preset	Page 336
SELECT DATUM TABLE	Select datum table	See the User's Manual for Programming of Machining Cycles
SELECT COMPENS. TABLE	Select compensation table	Page 340

Functions for contour and point machining menu

CONTOUR + POINT MACHINING

- Press the soft key for functions for contour and point machining



Soft key	Function
DECLARE CONTOUR	Assign contour description
CONTOUR DEF	Define a simple contour formula
SEL CONTOUR	Select a contour definition
CONTOUR FORMULA	Define a complex contour formula
SEL PATTERN	Select the point file with machining positions

Further information: User's Manual for **Programming of Machining Cycles**

Menu for defining different DIN/ISO functions

PROGRAM FUNCTIONS

- Press the **PROGRAM FUNCTIONS** soft key

Soft key	Function	Description
FUNCTION TCPM	Define the positioning behavior for rotary axes	Page 407
TRANSFORM / CORRDATA	Define coordinate transformations	Page 335
FUNCTION COUNT	Define the counter	Page 347
STRING FUNCTIONS	Define string functions	Page 296
FUNCTION SPINDLE	Define pulsing spindle speed	Page 358
FUNCTION FEED	Define recurring dwell time	Page 360
FUNCTION DWELL	Define dwell time in seconds or revolutions	Page 362
FUNCTION LIFTOFF	Lift off tool at NC stop	Page 363
DIN/ISO	Define DIN/ISO functions	Page 334
INSERT COMMENT	Add comments	Page 188
TABDATA	Write and read table values	Page 342
POLARKIN	Define polar kinematics	Page 328
MONITORING	Activate component monitoring	Page 346
FUNCTION PROG PATH	Choose path interpretation	Page 414

10.2 Function mode

Program function mode

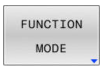
> Refer to your machine manual!
> Your machine manufacturer enables this function.

If your machine manufacturer has enabled the selection of various kinematic models, then you can switch between them using the **FUNCTION MODE** soft key.

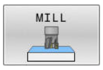
Procedure

To switch the kinematic model, proceed as follows:

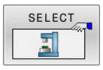
- Show the soft-key row for special functions



- Press the **FUNCTION MODE** soft key



- Press the **MILL** soft key



- Press the **SELECT KINEMATICS** soft key
- Select the desired kinematic model

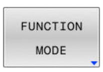
Function Mode Set

> Refer to your machine manual!
> This function must be enabled and adapted by the machine tool builder.
> Your machine tool builder defines the available options in the machine parameter **CfgModeSelect** (no. 132200).

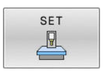
FUNCTION MODE SET allows you to activate settings defined by the machine tool builder (e.g., changes to the range of traverse) from within the NC program

To select a setting, proceed as follows:

- Show the soft-key row with special functions



- Press the **FUNCTION MODE** soft key



- Press the **SET** soft key

- Press the **SELECT** soft key, if required
- > The control opens a selection window.
- Select the desired setting

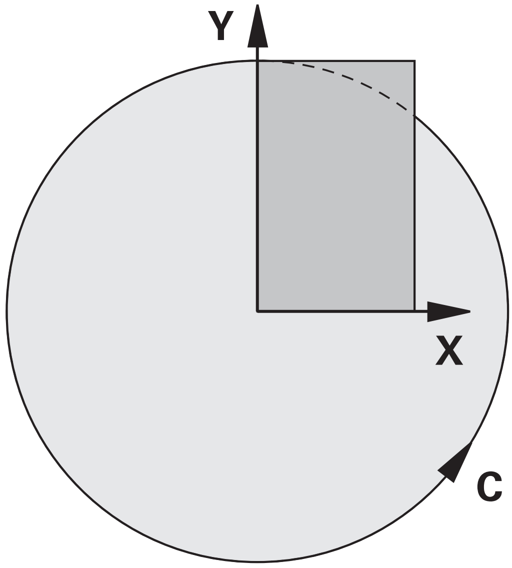
10.3 Machining with polar kinematics

Overview

In a polar kinematic model, the path contours of the working plane are performed by one linear axis and one rotary axis instead of by two linear principal axes. The working plane is defined by the linear principal axis and the rotary axis while the working space is defined by these two axes and the infeed axis.

On turning and grinding machines that have only two linear principal axes, polar kinematics enable milling operations to be performed on the front face.

On milling machines, various linear principal axes can be replaced with suitable rotary axes. For example on large machines, polar kinematics enable you to machine much larger surfaces than with only the principal axes.



Refer to your machine manual!

Your machine must be configured by the machine tool builder so that you can use polar kinematics.

A polar kinematic model consists of two linear axes and one rotary axis. The programmable axes vary depending on the machine.

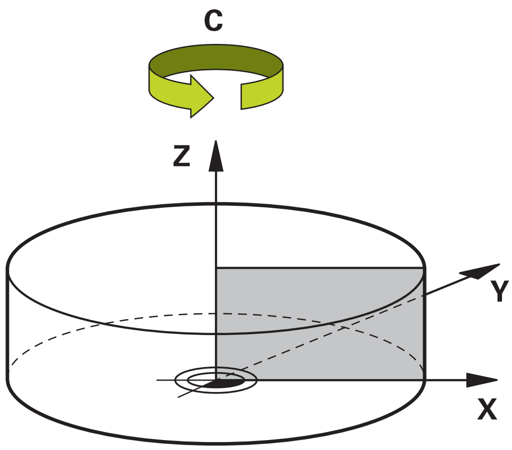
The polar rotary axis must be installed onto the table side so that it is opposite the selected linear axes and must be configured as a modulo axis. Thus, the linear axes must not be positioned between the rotary axis and the table. The maximum range of traverse of the rotary axis is limited by the software limit switches if necessary.

The principal axes X, Y, and Z as well as the possible parallel axes U, V, and W can be used as radial axes or infeed axes.

The control, combined with polar kinematics, provides the following functions:

Soft key	Function	Meaning	Page
POLARKIN AXES	**POLARKIN AXES**	Define and activate polar kinematics	329
POLARKIN OFF	**POLARKIN OFF**	Deactivate polar kinematics	332

Activating FUNCTION POLARKIN



Use the **POLARKIN AXES** function to activate the polar kinematics. The axis data define the radial axis, the infeed axis, and the polar axis. The **MODE** data influence the positioning behavior, whereas the **POLE** data define the machining at the pole. The pole is the center of rotation of the rotary axis in this case.

Notes on the axes to be selected:

- The first linear axis must be radial to the rotary axis.
- The second linear axis defines the infeed axis and must be parallel to the rotary axis.
- The rotary axis defines the polar axis and is defined last.
- Any available modulo axis that is installed onto the table side so that it is opposite the selected linear axes can be used as the rotary axis.
- The two selected linear axes thus span an area within which the rotary axis also lies.

MODE options:

Syntax	Function
POS	Seen from the center of rotation, the control performs machining in the positive direction of the radial axis. The radial axis must be prepositioned correspondingly.
NEG	Seen from the center of rotation, the control performs machining in the negative direction of the radial axis. The radial axis must be prepositioned correspondingly.
KEEP	The control remains with the radial axis on that side of the center of rotation on which the axis is positioned when the function is activated. If the radial axis is on the center of rotation upon switch-on, **POS** applies.
ANG	The control remains with the radial axis on that side of the center of rotation on which the axis is positioned when the function is activated. If you set **POLE** to **ALLOWED**, positioning through the pole is possible. The pole side is changed and a 180-degree rotation of the rotary axis is prevented.

POLE options:

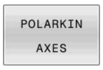
Syntax	Function
ALLOWED	The control permits machining operations at the pole
SKIPPED	The control prevents machining operations at the pole The disabled area corresponds to a circular surface with a radius of 0.001 mm (1 µm) around the pole.

Program this as follows:

- Show the soft key row with special functions

- Press the **PROGRAM FUNCTIONS** soft key

- Press the **POLARKIN** soft key



- Press the **POLARKIN AXES** soft key
- Define the axes of the polar kinematics
- Select the **MODE** option
- Select the **POLE** option

Example

```
N60 POLARKIN AXES X Z C MODE: KEEP POLE:ALLOWED*
```

If polar kinematics is active, the control displays an icon in the status display.

Icon	Mode
	Polar kinematics is active The **POLARKIN** icon hides the active **PARAXCOMP DISPLAY** icon. The control additionally displays the selected **Principal axes** on the **POS** tab of the additional status display.
No icon	Standard kinematics is active

Notes

Programming notes:

- Before activating the polar kinematics, you must program the function **PARAXCOMP DISPLAY** with at least the principal axes X, Y, and Z.

> In ISO programs, you cannot directly enter the **PARAXCOMP** functions. You program the required functions by calling an external Klartext program.
>
> HEIDENHAIN recommends defining all of the available axes within the **PARAXCOMP DISPLAY** function.

- Position the linear axis that will not be included in the polar kinematics to the coordinate of the pole, before the **POLARKIN** function. Otherwise, a non-machinable area with a radius that corresponds to at least the value of the deselected linear axis would result.
- Avoid performing machining operations at the pole or near the pole, because fluctuations in feed rate may occur in this area. For this reason, ideally use the following **POLE** option: **SKIPPED**.
- Polar kinematics cannot be combined with the following functions:
  - Traverse motions with **M91**
  - Tilting the working plane
  - **FUNCTION TCPM** or **M128**

Machining information:

The polar kinematics may require continuous motions to be divided into submotions (e.g., a linear motion that is divided into two submotions: a motion for approaching the pole and a motion for departing the pole). As a result, the distance-to-go display may differ from that of the standard kinematics.

Deactivating FUNCTION POLARKIN

Use the **POLARKIN OFF** function to deactivate the polar kinematics.

Program this as follows:

SPEC FCT

- Show the soft key row with special functions

PROGRAM FUNCTIONS

- Press the **PROGRAM FUNCTIONS** soft key

POLARKIN

- Press the **POLARKIN** soft key

POLARKIN OFF

- Press the **POLARKIN OFF** soft key

Example

```
N60 POLARKIN OFF*
```

When the polar kinematics is not active, the control does not display the corresponding icon or entries on the **POS** tab.

Note

The following scenarios lead to deactivation of the polar kinematics:

- Execution of the **POLARKIN OFF** function
- Selection of an NC program
- Reaching the end of the NC program
- Abortion of the NC program
- Selecting a kinematic model
- Restarting the control

Example: SL cycles in the polar kinematics

%POLARKIN_SL G71 *	
N10 G30 G17 X-100 Y-100 Z-30*	
N20 G31 X+100 Y+100 Z+0*	
N30 T2 G17 F2000*	
N40 % PARAXCOMP-DISPLAY_X Y Z.H	Activate **PARAXCOMP DISPLAY**
N50 G00 G90 X+0 Y+0.0011 Z+10 A+0 C+0 G40 M3*	Pre-position outside of the disabled pole area
N60 POLARKIN AXES Y Z C MODE:KEEP POLE:SKIPPED*	Activate **POLARKIN**
N70 G54 X+50 Y+50 Z+0*	Datum shift in the polar kinematics
N80 G37 P01 2*	
N90 G120 CONTOUR DATA	
Q1=-10 ;MILLING DEPTH	
Q2=+1 ;TOOL PATH OVERLAP	
Q3=+0 ;ALLOWANCE FOR SIDE	
Q4=+0 ;ALLOWANCE FOR FLOOR	
Q5=+0 ;SURFACE COORDINATE	
Q6=+2 ;SET-UP CLEARANCE	
Q7=+50 ;CLEARANCE HEIGHT	
Q8=+0 ;ROUNDING RADIUS	
Q9=+1 ;ROTATIONAL DIRECTION*	
N100 G122 ROUGH-OUT	
Q10=-5 ;PLUNGING DEPTH	
Q11=+150 ;FEED RATE FOR PLNGNG	
Q12=+500 ;FEED RATE F. ROUGHNG	
Q18=+0 ;COARSE ROUGHING TOOL	
Q19=+0 ;FEED RATE FOR RECIP.	
Q208=+99999 ;RETRACTION FEED RATE	
Q401=+100 ;FEED RATE FACTOR	
Q404=+0 ;FINE ROUGH STRATEGY*	
N110 M99	
N120 G54 X+0 Y+0 Z+0*	
N130 POLARKIN OFF*	Deactivate **POLARKIN**
N140 % PARAXCOMP-DISPLAY_OFF_XYZ.H	Deactivate **PARAXCOMP DISPLAY**
N150 G00 G90 X+0 Y+0 Z+10 A+0 C+0 G40*	
N160 M30*	
N170 G98 L2*	
N180 G01 G90 X-20 Y-20 G42*	
N190 G01 X+0 Y+20*	
N200 G01 X+20 Y-20*	
N210 G01 X-20 Y-20*	
N220 G98 L0*	
N99999999 %POLARKIN_SL G71 *	

10.4 Defining DIN/ISO functions

Overview

> If an alphanumeric keyboard is connected via a USB port, you can also enter the ISO functions directly through the alphanumeric keyboard.

The control provides soft keys with the following functions for creating DIN/ISO programs:

Soft key	Function
DIN/ISO	Select ISO functions
F	Feed rate
G	Tool movements, cycles and program functions
I	X coordinate of the circle center or pole
J	Y coordinate of the circle center or pole
L	Label call for subprogram and program section repeat
M	Miscellaneous function
N	Block number
T	Tool call
H	Polar coordinate angle
K	Z coordinate of the circle center or pole
R	Polar coordinate radius
S	Spindle speed

10.5 Defining coordinate transformations

Overview

The control offers the following functions for programming coordinate transformations:

Soft key	Function
FUNCTION CORRDATA	Select compensation tables
FUNCTION CORRDATA RESET	Reset compensation

10.6 Modifying presets

The control provides the following functions for modifying a preset directly in the NC program after it has been defined in the preset table:

- Activate the preset
- Copy the preset
- Correct the preset

Activating a preset

The function **PRESET SELECT** allows you to use a preset defined in the preset table and activate it as a new preset.

To activate the preset, use the preset number or the entry in the **Doc** column. If the entry in the **Doc** column is not unique, the control will activate the preset with the smallest preset number.

> If you program **PRESET SELECT** without optional parameters, the behavior is the same as with Cycle **G247 SET PRESET**.

Use the optional parameters to define the following:

- **KEEP TRANS**: Retain simple transformations
  - Cycle **G53/G54 DATUM SHIFT**
  - Cycle **G28 MIRRORING**
  - Cycle **G73 ROTATION**
  - Cycle **G72 SCALING FACTOR**
- **WP**: Any changes apply to the workpiece preset
- **PAL**: Any changes apply to the pallet preset (option 22)

Procedure

Proceed as follows for the definition:

- Press the **SPEC FCT** key

- Press the **PROGRAM DEFAULTS** soft key

- Press the **PRESET** soft key

- Press the **PRESET SELECT** soft key
- Define the desired preset number
- As an alternative, define the entry from the **Doc** column
- Retain the transformations where necessary
- If necessary, select the preset to which the change is to apply

Example

N30 PRESET SELECT #3 KEEP TRANS WP*	Select the preset 3 as workpiece preset and retain the transformations

Copying a preset

The function **PRESET COPY** allows you to copy a preset defined in the preset table and activate the preset copied.

To select the preset to be copied, use the preset number or the entry in the **Doc** column. If the entry in the **Doc** column is not unique, the control will select the preset with the smallest preset number.

Use the optional parameters to define the following:

- **SELECT TARGET**: Activate the copied preset
- **KEEP TRANS**: Retain simple transformations

Procedure

Proceed as follows for the definition:

SPEC FCT

- Press the **SPEC FCT** key

PROGRAM DEFAULTS

- Press the **PROGRAM DEFAULTS** soft key

PRESET

- Press the **PRESET** soft key

PRESET COPY

- Press the **PRESET COPY** soft key
- Define the preset number to be copied
- As an alternative, define the entry from the **Doc** column
- Define the new preset number
- Activate the copied preset, if necessary
- Retain the transformations where necessary

Example

N130 PRESET COPY #1 TO #3 SELECT TARGET KEEP TRANS*	Copy the preset 1 to line 3, activate the preset 3, and retain the transformations

Correcting a preset

The function **PRESET CORR** allows you to correct the active preset.

If both the basic rotation and a translation are corrected in an NC block, the control will first correct the translation and then the basic rotation.

The compensation values are given with respect to the active coordinate system.

Procedure

Proceed as follows for the definition:

SPEC FCT
- Show the soft key row with special functions

PROGRAM DEFAULTS
- Press the **PROGRAM DEFAULTS** soft key

PRESET
- Press the **PRESET** soft key

PRESET CORR
- Press the **PRESET CORR** soft key
- Define the desired compensation values

Example

N30 PRESET CORR X+10 SPC+45*	The active preset is corrected by a value of +10 mm in X, and by +45° in SPC

10.7 Compensation table

Application

With the compensation table, you can save compensations in the tool coordinate system (T-CS) or in the working plane coordinate system (WPL-CS).

The compensation table **.tco** is the alternative to compensating with **DL**, **DR**, and **DR2** in the T block. As soon as you have activated a compensation table, the control overwrites the compensation value from the T block.

The compensation tables offer the following benefits:

- Values can be changed without adapting the NC program
- Values can be changed during NC program run

If you change a value, then this change does not become active until the compensation is called again.

Types of compensation tables

Via the file name extension, you can determine in which coordinate system the control will perform the compensation.

The control offers the following compensation options via tables:

- tco (tool correction): Compensation in the tool coordinate system (T-CS)
- wco (workpiece correction): Compensation in the working plane coordinate system (WPL-CS)

Compensation via the table is an alternative to compensation in the T block. Compensation from the table overwrites an already programmed compensation in the T block.

Tool compensation via the ".tco" table

The compensations in the tables with the file name extension ".tco" compensate for the active tool. The table applies to all tool types, which is why, during creation, you also see columns that you may not need for your tool type.

> Enter only those values that are relevant to your tool. If you compensate for values that are not present with the existing tool, the control issues an error message.

The compensations have the following effects:

- In the case of milling cutters, as an alternative to the delta values in the **TOOL CALL**

Tool compensation via the ".wco" table

The compensations in the tables with the file name extension ".wco" act as a shift in the working plane coordinate system (WPL-CS).

Creating a compensation table

Before you can work with a compensation table, you must first create the respective table.

You can create a compensation table as follows:

- Switch to the **Programming** operating mode

PGM MGT

- Press the **PGM MGT** key

NEW FILE

- Press the **NEW FILE** soft key
- Enter a file name with the desired extension (e.g., Corr.tco)

ENT

- Confirm by pressing the **ENT** key
- Select the unit of measure

ENT

- Confirm by pressing the **ENT** key

APPEND N LINES AT END

- Press the **APPEND N LINES AT END** soft key
- Enter the compensation values

Activate the compensation table

Select compensation table

If you are using compensation tables, then use the function **SEL CORR-TABLE** to activate the desired compensation table from within the NC program.

To add a compensation table to the NC program, proceed as follows:

SPEC FCT

- Press the **SPEC FCT** key

PROGRAM DEFAULTS

- Press the **PROGRAM DEFAULTS** soft key

SELECT COMPENS. TABLE

- Press the **SELECT COMPENS. TABLE** soft key

TCS

- Press the soft key of the table type (e.g., **TCS**)
- Select the table

If you are working without the **SEL CORR-TABLE** function, then you must activate the desired table prior to the test run or program run.

In all operating modes, proceed as follows:

- Select the desired operating mode
- Select the desired table in the file manager
- > In **Test Run** mode, the table receives the status S; in the operating modes **Program run, single block** and **Program run, full sequence**, the table receives the status M.

Activating a compensation value

To activate a compensation value in the NC program, proceed as follows:

- Press the **SPEC FCT** key
- Press the **PROGRAM FUNCTIONS** soft key
- Press the **TRANSFORM / CORRDATA** soft key
- Press the **FUNCTION CORRDATA** soft key
- Press the soft key of the desired compensation (e.g., **TCS**)
- Enter the line number

Duration of effect of the compensation

The activated compensation stays in effect until the end of the program or until a tool change occurs.

With **FUNCTION CORRDATA RESET**, you can program the compensations to reset.

Editing a compensation table during program run

You can change the values in the active compensation table during program run. As long as the compensation table is not yet active, the control dims the soft key.

Proceed as follows:

- Press the **SELECT COMPENS. TABLES** soft key
- Press the soft key for the desired table (e.g., **COMPENS. TABLE T-CS**)
- Set the **EDIT** soft key to **ON**
- Use the arrow keys to navigate to the desired location
- Edit the value

> The changed data do not take effect until after the compensation has been activated again.

10.8 Accessing table values

Application

The **TABDATA** functions allow you to access table values.

These functions enable automated editing of compensation values from within the NC program, for example.

You can access the following tables:

- Tool table ***.t** (read-only access)
- Compensation table ***.tco** (read and write access)
- Compensation table ***.wco** (read and write access)

In each case, the active table is accessed. Read-only access is always possible, whereas write access is possible only during program run. Write access during simulation or during a block scan has no effect.

If the unit of measure used in the NC program differs from that used in the table, the control will convert the values from **millimeters** to **inches**, and vice versa.

Reading a table value

The function **TABDATA READ** allows you to read a value from a table and save it to a Q parameter.

Depending on the type of column you want to transfer, you can use **Q**, **QL**, **QR**, or **QS** to save the value. The control will automatically convert the table values to the unit of measure used in the NC program.

The control reads from the tool table that is currently active. You can read a value from a compensation table only if you have activated the table concerned.

For example, the **TABDATA READ** function enables you to pre-check the data of the tool to be used to prevent error messages from occurring during program run.

Procedure

Proceed as follows:

SPEC FCT
- Press the **SPEC FCT** key

PROGRAM FUNCTIONS
- Press the **PROGRAM FUNCTIONS** soft key

TABDATA
- Press the **TABDATA** soft key

TABDATA READ
- Press the **TABDATA READ** soft key
- Enter the Q parameter for the result

ENT
- Confirm with the **ENT** key

CORR-TCS
- Press the soft key for the desired table (e.g., **CORR-TCS**)
- Enter the column name

ENT
- Confirm with the **ENT** key
- Enter the line number of the table

ENT
- Press the **ENT** key

Example

N120 SEL CORR-TABLE TCS "TNC:\table\corr.tco"*	Activate the compensation table
N130 TABDATA READ Q1 = CORR-TCS COLUMN "DR" KEY "5"*	Save the value of line 5, column DR, from the compensation table to Q1

Writing a table value

The function **TABDATA WRITE** allows you to write a value from a Q parameter into a table

Depending on the type of column you want to write to, you can use **Q**, **QL**, **QR**, or **QS** as a transfer parameter.

In order to write into a compensation table, you need to activate the table.

You can use the **TABDATA WRITE** function after a touch probe cycle to enter a necessary tool compensation into the compensation table, for example.

Procedure

Proceed as follows:

SPEC FCT
- Press the **SPEC FCT** key

PROGRAM FUNCTIONS
- Press the **PROGRAM FUNCTIONS** soft key

TABDATA
- Press the **TABDATA** soft key

TABDATA WRITE
- Press the **TABDATA WRITE** soft key

CORR-TCS
- Press the soft key for the desired table (e.g., **CORR-TCS**)
- Enter the column name

ENT
- Confirm with the **ENT** key
- Enter the line number of the table

ENT
- Confirm with the **ENT** key
- Enter the Q parameter

ENT
- Confirm with the **ENT** key

Example

N120 SEL CORR-TABLE TCS "TNC:\table\corr.tco"*	Activate the compensation table
N130 TABDATA WRITE CORR-TCS COLUMN "DR" KEY "3" = Q1*	Write the value from Q1 into line 3, column DR, of the compensation table

Adding a table value

The function **TABDATA ADD** allows you to add a value from a Q parameter to a value contained in the table.

Depending on the type of column you want to write to, you can use **Q**, **QL**, or **QR** as a transfer parameter.

In order to write into a compensation table, you need to activate the table.

You can use the **TABDATA ADD** function to update a tool compensation value after a measurement has been repeated, for example.

Procedure

Proceed as follows:

SPEC FCT
- Press the **SPEC FCT** key

PROGRAM FUNCTIONS
- Press the **PROGRAM FUNCTIONS** soft key

TABDATA
- Press the **TABDATA** soft key

TABDATA ADDITION
- Press the **TABDATA ADDITION** soft key

CORR-TCS
- Press the soft key for the desired table (e.g., **CORR-TCS**)
- Enter the column name

ENT
- Confirm with the **ENT** key
- Enter the line number of the table

ENT
- Confirm with the **ENT** key
- Enter the Q parameter

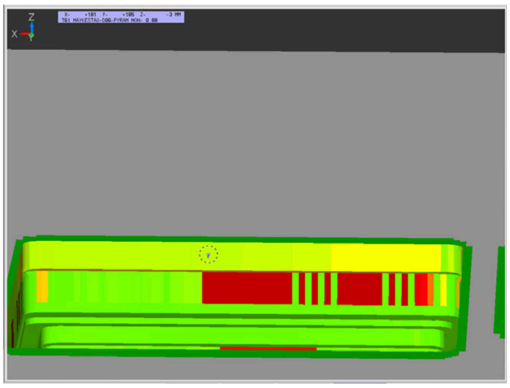
ENT
- Confirm with the **ENT** key

Example

N120 SEL CORR-TABLE TCS "TNC:\table\corr.tco"*	Activate the compensation table
N130 TABDATA ADD CORR-TCS COLUMN "DR" KEY "3" = Q1*	Add the value from Q1 to line 3, column DR, of the compensation table

10.9 Monitoring of configured machine components (option 155)

Application



> Refer to your machine manual!
> This function must be enabled and adapted by the machine tool builder.

The **MONITORING** function allows you to start and stop component monitoring from within the NC program.

The control monitors the selected component and shows the result in a heatmap on the workpiece.

A heatmap is similar to the image from an infrared camera.

- Green: component works under conditions defined as safe
- Yellow: component works under warning zone conditions
- Red: Overload condition

Starting monitoring

To start component monitoring, proceed as follows:

SPEC FCT
- Press the special functions key

PROGRAM FUNCTIONS
- Select the program functions

MONITORING
- Select Monitoring

MONITORING HEATMAP START
- Press the **MONITORING HEATMAP START** soft key

SELECT
- Select the component released by the machine manufacturer

Only one component at a time can be monitored with the heatmap. If you start the heatmap several times in a row, monitoring of the previous component is stopped.

Stopping monitoring

Monitoring is stopped with the **MONITORING HEATMAP STOP** function.

10.10 Defining a counter

Application

Refer to your machine manual!
Your machine manufacturer enables this function.

The **FUNCTION COUNT** function allows you to control a simple counter from within the NC program. For example, this function allows you to count the number of manufactured workpieces.

Proceed as follows for the definition:

SPEC FCT
- Show the soft key row with special functions

PROGRAM FUNCTIONS
- Press the **PROGRAM FUNCTIONS** soft key

FUNCTION COUNT
- Press the **FUNCTION COUNT** soft key

NOTICE

Caution: Data may be lost!

Only one counter can be managed by the control. If you execute an NC program that resets the counter, any counter progress of another NC program will be deleted.

- Please check prior to machining whether a counter is active.
- If necessary, note down the counter value and enter it again via the MOD menu after execution.

You can use Cycle **G225** to engrave the current counter value into the workpiece.
Further information: User's Manual for **Programming of Machining Cycles**

Effect in the operating mode Test Run

You can simulate the counter in the **Test Run** operating mode. Only the count you have defined directly in the NC program is effective. The count in the MOD menu remains unaffected.

Effect in the operating modes Program Run Single Block and Program Run Full Sequence

The count from the MOD menu is only effective in the **Program Run Single Block** and **Program Run Full Sequence** operating modes.
The count is retained even after a restart of the control.

Defining FUNCTION COUNT

The **FUNCTION COUNT** function provides the following possibilities:

Soft key	Function
FUNCTION COUNT INC	Increase count by 1
FUNCTION COUNT RESET	Reset counter
FUNCTION COUNT TARGET	Set the nominal count (target value) to the desired value Input value: 0–9999
FUNCTION COUNT SET	Set the counter to the desired value Input value: 0–9999
FUNCTION COUNT ADD	Increment the counter by the desired value Input value: 0–9999
FUNCTION COUNT REPEAT	Repeat the NC program starting from this label if more parts are to be machined.

Example

N50 FUNCTION COUNT RESET*	Reset the counter value
N60 FUNCTION COUNT TARGET10*	Enter the target number of parts to be machined
N70 G98 L11*	Enter the jump label
N80 G ...	Machining
N510 FUNCTION COUNT INC*	Increment the counter value
N520 FUNCTION COUNT REPEAT LBL 11*	Repeat the machining operations if more parts are to be machined
N530 M30*	
N540 %COUNT G71*	

10.11 Creating text files

Application

You can use the control’s text editor to write and edit texts. Typical applications:

- Recording test results
- Documenting working procedures
- Creating formula collections

Text files have the extension .A (for ASCII files). If you want to edit other types of files, you must first convert them into type .A files.

Opening and exiting a text file

- Operating mode: Press the **Programming** key
- To call the file manager, press the **PGM MGT** key.
- Display type .A files: Press the **SELECT TYPE** soft key and then the **SHOW ALL** soft key
- Select a file and open it with the **SELECT** soft key or **ENT** key, or open a new file by entering the new file name and confirming your entry with the **ENT** key

To leave the text editor, call the file manager and select a file of a different file type, for example an NC program.

Soft key	Cursor movements
MOVE WORD →	Move cursor one word to the right
MOVE WORD ←	Move cursor one word to the left
PAGE ↓	Go to next screen page
PAGE ↑	Go to previous screen page
BEGIN ↑	Cursor at beginning of file
END ↓	Cursor at end of file

Editing texts

Above the first line of the text editor, there is an information field showing the file name, location and line information:

File:	Name of the text file
Line:	Line in which the cursor is presently located
Column:	Column in which the cursor is presently located

The text is inserted or overwritten at the location of the cursor. You can move the cursor to any desired position in the text file by pressing the arrow keys.

You can insert a line break with the **RETURN** or **ENT** key.

Deleting and re-inserting characters, words and lines

With the text editor, you can erase words and even lines, and insert them at any desired location in the text.

- Move the cursor to the word or line that you wish to erase and insert at a different place in the text
- Press the **DELETE WORD** or **DELETE LINE** soft key: The text is removed and buffered
- Move the cursor to the location where you wish to insert the text, and press the **INSERT LINE / WORD** soft key

Soft key	Function
DELETE LINE	Delete and temporarily store a line
DELETE WORD	Delete and temporarily store a word
DELETE CHAR	Delete and temporarily store a character
INSERT LINE / WORD	Insert a line or word from temporary storage

Editing text blocks

You can copy and erase text blocks of any size, and insert them at other locations. Before any of these actions, you must first select the desired text block:

- ▶ To select a text block: Move the cursor to the first character of the text you wish to select.

SELECT BLOCK

- ▶ Press the **SELECT BLOCK** soft key
- ▶ Move the cursor to the last character of the text you wish to select. You can select whole lines by moving the cursor up or down directly with the arrow keys—the selected text is shown in a different color.

After selecting the desired text block, you can edit the text with the following soft keys:

Soft key	Function
CUT OUT BLOCK	Delete the selected block and store temporarily
COPY BLOCK	Store the selected block temporarily without erasing (copy)

If desired, you can now insert the temporarily stored block at a different location:

- ▶ Move the cursor to the location where you want to insert the temporarily stored text block

INSERT BLOCK

- ▶ Press the **INSERT BLOCK** soft key: The text block is inserted

You can insert the temporarily stored text block as often as desired

Transferring the selected block to a different file

- ▶ Select the text block as described previously

APPEND TO FILE

- ▶ Press the **APPEND TO FILE** soft key.
- > The control displays the **Destination file =** dialog prompt.
- ▶ Enter the path and the name of the destination file.
- > The control appends the selected text block to the specified file. If no target file with the specified name is found, the control creates a new file with the selected text.

Inserting another file at the cursor position

- ▶ Move the cursor to the location in the text where you wish to insert another file

READ FILE

- ▶ Press the **READ FILE** soft key.
- > The control displays the **File name =** dialog prompt.
- ▶ Enter the path and name of the file you want to insert

Finding text sections

With the text editor, you can search for words or character strings in a text. The control provides the following two options.

Finding the current text

The search function is used for finding the next occurrence of the word in which the cursor is presently located:

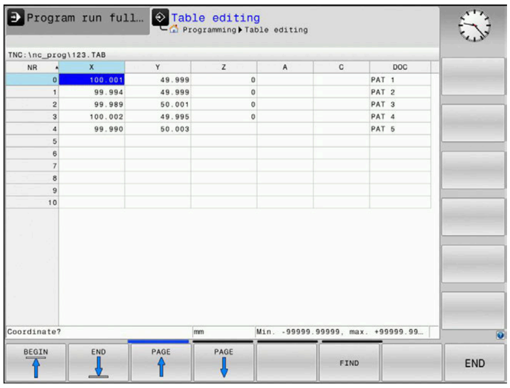
- Move the cursor to the desired word.
- Select the search function: Press the **FIND** soft key
- Press the **FIND CURRENT WORD** soft key
- Find a word: Press the **FIND** soft key
- Exit the search function: Press the **END** soft key

Finding any text

- Select the search function: Press the **FIND** soft key. The control displays the **Find text :** dialog prompt
- Enter the text that you wish to find
- Find text: Press the **FIND** soft key
- Exit the search function: Press the **END** soft key

10.12 Freely definable tables

Fundamentals



In freely definable tables you can save and read any information from the NC program. The Q parameter functions **D26** to **D28** are provided for this purpose.

You can change the format of freely definable tables, i.e. the columns and their properties, by using the structure editor. They enable you to make tables that are exactly tailored to your application.

You can also toggle between a table view (standard setting) and form view.

> The names of tables and table columns must start with a letter and must not contain an arithmetic operator (e.g., **+**).

Creating a freely definable table

Proceed as follows:

PGM MGT

- ▶ Press the **PGM MGT** key
- ▶ Enter any desired file name with the extension .TAB

ENT

- ▶ Confirm with the **ENT** key
- > The TNC displays a pop-up window with permanently saved table formats.
- ▶ Use the arrow key to select a table template, e.g. **example.tab**

ENT

- ▶ Confirm with the **ENT** key
- > The control opens a new table in the predefined format.
- ▶ To adapt the table to your requirements you have to edit the table format
  Further information: "Editing the table format", Page 354

> Refer to your machine manual!
> Machine tool builders may define their own table templates and save them in the control. When you create a new table, the control opens a pop-up window listing all available table templates.

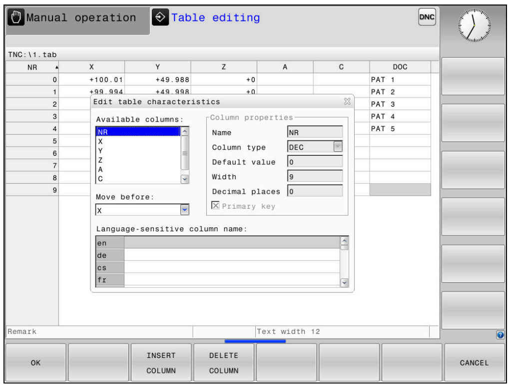
> You can also save your own table templates in the TNC. To do so, create a new table, change the table format and save the table in the **TNC:\system\proto** directory. If you then create new table, the control offers your template in the selection window for table templates.

Editing the table format

Proceed as follows:

EDIT FORMAT

- ▶ Press the **EDIT FORMAT** soft key
- > The control opens a pop-up window displaying the table structure.
- ▶ Adapt the format



The control provides the following options:

Structure command	Meaning
Available columns:	List of all columns contained in the table
Move before:	The entry highlighted in **Available columns** is moved in front of this column
Name	Column name: Is displayed in the header
Column type	**TEXT**: Text entry **SIGN**: + or - sign **BIN**: Binary number **DEC**: Decimal, positive, whole number (cardinal number) **HEX**: Hexadecimal number **INT**: Whole number **LENGTH**: Length (is converted in inch programs) **FEED**: Feed rate (mm/min or 0.1 inch/min) **IFEED**: Feed rate (mm/min or inch/min) **FLOAT**: Floating-point number **BOOL**: Logical value **INDEX**: Index **TSTAMP**: Fixed format for date and time **UPTEXT**: Text entry in upper case **PATHNAME**: Path name
Default value	Default value for the fields in this column
Width	Width of the column (number of characters)
Primary key	First table column
Language-sensitive column name	Language-sensitive dialogs

> Columns with a column type that permits letters, such as **TEXT**, can only be output or written to via QS parameters, even if the content of the cell is a number.

You can use a connected mouse or the navigation keys to move through the form.

Proceed as follows:

- ▶ Press the navigation keys to jump to the input fields

GOTO

- ▶ Press the **GOTO** key in order to open expandable menus
- ▶ Use the arrow keys to navigate within an input field

> In a table that already contains lines you can not change the table properties **Name** and **Column type**. Once you have deleted all lines, you can change these properties. If required, create a backup copy of the table beforehand.
>
> With the **CE** and **ENT** key combination, you can reset invalid values in fields with the **TSTAMP** column type.

Closing the structure editor

Proceed as follows:

OK

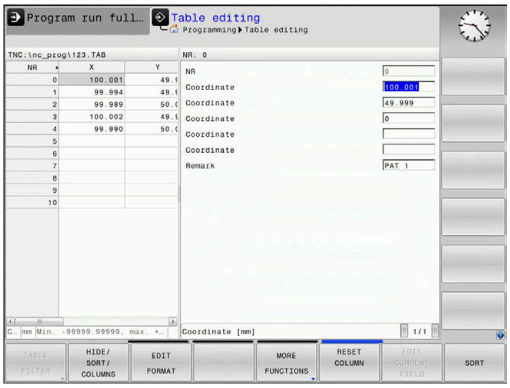
- ▶ Press the **OK** soft key
- > The control closes the editing form and applies the changes.

CANCEL

- ▶ Alternative: Press the **CANCEL** soft key
- > The control discards all entered changes.

Switching between table and form view

All tables with the **.TAB** extension can be opened in either list view or form view.



Switch the view as follows:

- ▶ Press the **Screen layout** key

FORM

- ▶ Press the soft key with the desired view

In the left half of the form view, the control lists the line numbers with the contents of the first column.

You can change the data as follows in the form view:

ENT

- ▶ Press the **ENT** key in order to switch to the next input field on the right-hand side

Selecting another row to be edited:

- ▶ Press the **Next tab** key
- > The cursor jumps to the left window.
- ▶ Use the arrow keys to select the desired row
- ▶ Press the **Next tab** key to switch back to the input window

D26 – Open a freely definable table

With the function **D26: TABOPEN** you open a freely definable table to be written to with **D27** or to be read from with **D28**.

> Only one table can be opened in an NC program at any one time. A new NC block with **D26** automatically closes the last opened table.
>
> The table to be opened must have the extension **.TAB**.

Example: Open the table TAB1.TAB, which is saved in the directory TNC:\DIR1.

```
N560 D26  TNC:\DIR1\TAB1.TAB
```

D27: Write to a freely definable table

With the **D27** function you write to the table that you previously opened with **D26**.

You can define multiple column names in a **D27** block. The column names must be written between quotation marks and separated by a comma. You define in Q parameters the value that the control is to write to the respective column.

> The **D27** function is considered only in the **Program run, single block** and **Program run, full sequence** operating modes.
>
> The **D18 ID992 NR16** function allows you to query the operating mode in which the NC program is running.
>
> If you write to more than one column in an NC block, you must save the values under successive Q parameter numbers.
>
> The control displays an error message if you try to write to a table cell that is locked or does not exist.

Use QS parameters if you want to write to a text field (such as column type **UPTEXT**). Use Q, QL, or QR parameters to write to numerical fields.

Example

You wish to write to the columns "Radius", "Depth", and "D" in line 5 of the presently opened table. The values to be written in the table are saved in the Q parameters **Q5**, **Q6**, and **Q7**.

```
N50 Q5 = 3,75
N60 Q6 = -5
N70 Q7 = 7,5
N80 D27  P01 5/“RADIUS,TIEFE,D“ = Q5
```

D28 – Read from a freely definable table

With the **D28** function you read from the table previously opened with **D26**.

You can define, i.e. read, multiple column names in a **D28** block. The column names must be written between quotation marks and separated by a comma. In the **D28** block you can define the Q parameter number in which the control is to write the value that is first read.

> If you wish to read from more than one column in an NC block, the control will save the values under successive Q parameters of the same type, such as **QL1**, **QL2**, and **QL3**.

Use QS parameters if you want to read a text field. Use Q, QL, or QR parameters to read from numerical fields.

Example

You wish to read the values of the columns **X**, **Y**, and **D** from line 6 of the presently opened table. Save the first value in the Q parameter **Q10**, the second in **Q11**, and the third value in **Q12**.

From the same row, save the column **DOC** in **QS1**.

```
N50 D28  Q10 = 6/“X,Y,D“*
N60 D28  QS1 = 6/“DOC“*
```

Adapting the table format

NOTICE

Caution: Data may be lost!

The **ADAPT NC PGM / TABLE** function changes the format of all tables permanently. The control does not perform an automatic backup of the files prior to a format change. The files will thus be permanently changed and may no longer be usable.

- Only use the function in consultation with the machine tool builder.

Soft key	Function
ADAPT NC PGM / TABLE	Adapt format of tables present after changing the control software version

> The names of tables and table columns must start with a letter and must not contain an arithmetic operator (e.g., **+**).

10.13 Pulsing spindle speed FUNCTION S-PULSE

Programming a pulsing spindle speed

Application

> Refer to your machine manual!
> Read and note the functional description of the machine tool builder.
> Follow the safety precautions.

Using the **S-PULSE FUNCTION** you can program a pulsing spindle speed, when operating at a constant spindle speed.

You can define the duration of a vibration (period length) using the P-TIME input value or a speed change in percent using the SCALE input value. The spindle speed changes in a sinusoidal form around the target value.

Procedure

Example

```
N30 FUNCTION S-PULSE P-TIME10 SCALE5*
```

Proceed as follows for the definition:

SPEC FCT
- Show the soft-key row with special functions

PROGRAM FUNCTIONS
- Press the **PROGRAM FUNCTIONS** soft key

FUNCTION SPINDLE
- Press the **FUNCTION SPINDLE** soft key

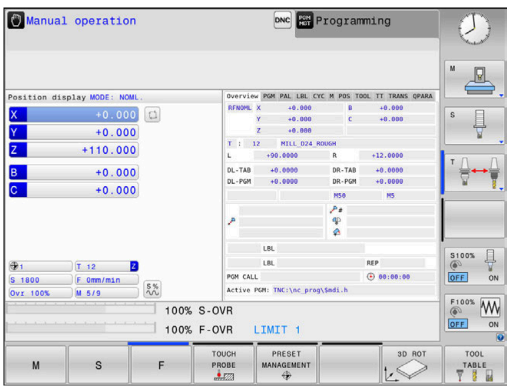
SPINDLE-PULSE
- Press the **SPINDLE-PULSE** soft key
- Define period length P-TIME
- Define speed change SCALE

> The control never exceeds a programmed speed limit. The spindle speed is maintained until the sinusoidal curve of the **S-PULSE FUNCTION** falls below the maximum speed once more.

Symbols

In the status bar, the icon indicates the condition of the pulsing shaft speed:

Icon	Function
S %	Pulsing spindle speed active



Resetting the pulsing spindle speed

Example

```
N40 FUNCTION S-PULSE RESET*
```

Use the **FUNCTION S-PULSE RESET** to reset the pulsing spindle speed.

Proceed as follows for the definition:

SPEC FCT
- Show the soft-key row with special functions

PROGRAM FUNCTIONS
- Press the **PROGRAM FUNCTIONS** soft key

FUNCTION SPINDLE
- Press the **FUNCTION SPINDLE** soft key

RESET SPINDLE-PULSE
- Press the **RESET SPINDLE-PULSE** soft key.

10.14 Dwell time FUNCTION FEED

Programming a dwell time

Application

> Refer to your machine manual!
> Read and note the functional description of the machine tool builder.
> Follow the safety precautions.

The **FUNCTION FEED DWELL** function can be used to program a recurring dwell time in seconds, e.g. to force chip breaking . Program **FUNCTION FEED DWELL** immediately prior to the machining you wish to run with chip breaking.

The **FUNCTION FEED DWELL** function is not effective with rapid traverse movements and probing motion.

NOTICE

Caution: Danger to the tool and workpiece!

When the **FUNCTION FEED DWELL** function is active, the control will repeatedly interrupt the feed movement. While the feed movement is interrupted, the tool remains at its current position, and the spindle continues to turn. During thread cutting, this behavior will cause the workpiece to become scrap. There is also a risk of tool breakage during execution!

- Deactivate the **FUNCTION FEED DWELL** function before cutting threads

Procedure

Example

```
N30 FUNCTION FEED DWELL D-TIME0.5 F-TIME5*
```

Proceed as follows for the definition:

SPEC FCT
- Show the soft-key row with special functions

PROGRAM FUNCTIONS
- Press the **PROGRAM FUNCTIONS** soft key

FUNCTION FEED
- Press the **FUNCTION FEED** soft key

FEED DWELL
- Press the **FEED DWELL** soft key
- Define the interval duration for dwelling D-TIME
- Define the interval duration for cutting F-TIME

Resetting the dwell time

> Reset the dwell time immediately following the machining with chip breaking.

Example

```
N40 FUNCTION FEED DWELL RESET*
```

Use **FUNCTION FEED DWELL RESET** to reset the recurring dwell time.

Proceed as follows for the definition:

SPEC FCT
- Show the soft-key row with special functions

PROGRAM FUNCTIONS
- Press the **PROGRAM FUNCTIONS** soft key

FUNCTION FEED
- Press the **FUNCTION FEED** soft key

RESET FEED DWELL
- Press the **RESET FEED DWELL** soft key

> You can also reset the dwell time by entering D-TIME 0.
> The control automatically resets the **FUNCTION FEED DWELL** function at the end of a program.

10.15 Dwell time FUNCTION DWELL

Programming a dwell time

Application

The **FUNCTION DWELL** function enables you to program a dwell time in seconds or define the number of spindle revolutions for dwelling.

Procedure

Example

```
N30 FUNCTION DWELL TIME10*
```

Example

```
N40 FUNCTION DWELL REV5.8*
```

Proceed as follows for the definition:

SPEC FCT
- Show the soft-key row with special functions

PROGRAM FUNCTIONS
- Press the **PROGRAM FUNCTIONS** soft key

FUNCTION DWELL
- **FUNCTION DWELL** soft key

DWELL TIME
- Press the **DWELL TIME** soft key
- Define the duration in seconds

DWELL REVOLUTIONS
- Alternatively, press the **DWELL REVOLUTIONS** soft key
- Define the number of spindle revolutions

10.16 Lift off tool at NC stop: FUNCTION LIFTOFF

Programming tool lift-off with FUNCTION LIFTOFF

Requirement

Refer to your machine manual!

This function must be configured and enabled by your machine tool builder. In the **CfgLiftOff** (no. 201400) machine parameter, the machine tool builder defines the path the control is to traverse for a **LIFTOFF** command. You can also use the **CfgLiftOff** machine parameter to deactivate the function.

In the **LIFTOFF** column of the tool table, set the **Y** parameter for the active tool.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Application

The **LIFTOFF** function is effective in the following situations:

- In case of an NC stop triggered by you
- In case of an NC stop triggered by the software, e. g. if an error has occurred in the drive system.
- In case of a power failure

The tool retracts from the contour by up to 2 mm. The control calculates the lift off direction based on the input in the **FUNCTION LIFTOFF** block.

You can program the **LIFTOFF** function in the following ways:

- **FUNCTION LIFTOFF TCS X Y Z**: Lift-off with a defined vector in the tool coordinate system
- **FUNCTION LIFTOFF ANGLE TCS SPB**: Lift-off with a defined angle in the tool coordinate system
- Lift-off in the tool axis direction with **M148**

Further information: "Automatically retracting the tool from the contour at an NC stop: M148", Page 232

Programming tool lift-off with a defined vector

Example

```
N40 FUNCTION LIFTOFF TCS X+0 Y+0.5 Z+0.5*
```

With **LIFTOFF TCS X Y Z**, you define the lift-off direction as a vector in the tool coordinate system. The control calculates the lift-off height in each axis based on the tool path defined by the machine tool builder.

Proceed as follows for the definition:

SPEC FCT

- Show the soft-key row with special functions

PROGRAM FUNCTIONS

- Press the **PROGRAM FUNCTIONS** soft key

FUNCTION LIFTOFF

- Press the **FUNCTION LIFTOFF** soft key

LIFTOFF TCS

- Press the **LIFTOFF TCS** soft key
- Enter X, Y, and Z vector components

Programming tool lift-off with a defined angle

Example

```
N40 FUNCTION LIFTOFF ANGLE TCS SPB+20*
```

With **LIFTOFF ANGLE TCS SPB**, you define the lift-off direction as a spatial angle in the tool coordinate system.

The SPB angle you enter describes the angle between Z and X. If you enter 0°, the tool lifts off in the tool Z axis direction.

Proceed as follows for the definition:

SPEC FCT

- Show the soft-key row with special functions

PROGRAM FUNCTIONS

- Press the **PROGRAM FUNCTIONS** soft key

FUNCTION LIFTOFF

- Press the **FUNCTION LIFTOFF** soft key

LIFTOFF ANGLE TCS

- Press the **LIFTOFF ANGLE TCS** soft key
- Enter the SPB angle

Resetting the lift-off function

Example

```
N40 FUNCTION LIFTOFF RESET*
```

Use the **FUNCTION LIFTOFF RESET** to reset the lift-off function.

Proceed as follows for the definition:

SPEC FCT	▶ Show the soft-key row with special functions
PROGRAM FUNCTIONS	▶ Press the **PROGRAM FUNCTIONS** soft key
FUNCTION LIFTOFF	▶ Press the **FUNCTION LIFTOFF** soft key
LIFTOFF RESET	▶ Press the **LIFTOFF RESET** soft key

> **i** You can also reset the lift-off with M149.
> The control automatically resets the **FUNCTION LIFTOFF** function at the end of a program.

11

Multiple-axis-machining

11.1 Functions for multiple axis machining

This chapter summarizes the control functions for multiple axis machining:

Control function	Description	Page
PLANE	Define machining in the tilted working plane	369
M116	Feed rate of rotary axes	400
PLANE/M128	Inclined-tool machining	399
FUNCTION TCPM	Define the behavior of the control when positioning the rotary axes (enhancement of M128)	407
M126	Shortest-path traverse of rotary axes	401
M94	Reduce display value of rotary axes	402
M128	Define the behavior of the control when positioning the rotary axes	403
M138	Selection of tilted axes	405
M144	Calculate machine kinematics	406

11.2 The PLANE function: Tilting the working plane (option 8)

Introduction

Refer to your machine manual!

The machine manufacturer must enable the functions for tilting the working plane!

You can only use the **PLANE** function in its entirety on machines having at least two rotary axes (table axes, head axes or combined axes). The **PLANE AXIAL** function is an exception. **PLANE AXIAL** can also be used on machines which have only one programmed rotary axis.

The **PLANE** functions provide powerful options to define tilted working planes in various ways.

The parameter definition of the **PLANE** functions is subdivided into two parts:

- The geometric definition of the plane, which is different for each of the available **PLANE** functions.
- The positioning behavior of the **PLANE** function, which is independent of the plane definition and is identical for all **PLANE** functions
  Further information: "Defining the positioning behavior of the PLANE function", Page 388

NOTICE

Danger of collision!

When the machine is switched on, the control tries to restore the switch-off status of the tilted plane. This is prevented under certain conditions. For example, this applies if axis angles are used for tilting while the machine is configured with spatial angles, or if you have changed the kinematics.

- ▶ If possible, reset tilting before shutting the system down
- ▶ Check the tilted condition when switching the machine back on

NOTICE

Danger of collision!

Cycle **28 MIRRORING** can have different effects in conjunction with the **Tilt working plane** function. The programming sequence, the mirrored axes, and the tilting function used are critical in this regard. There is a risk of collision during the tilting operation and subsequent machining!

- Check the sequence and positions using a graphic simulation
- Carefully test the NC program or program section in the **Program run, single block** operating mode

Examples

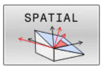
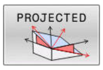
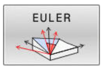
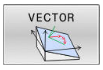
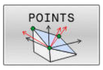
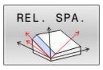
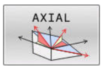
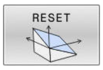
1. When Cycle **28 MIRRORING** is programmed before the tilting function without rotary axes:
   - The tilt of the **PLANE** function used (except **PLANE AXIAL**) is mirrored
   - Mirroring takes effect after tilting with **PLANE AXIAL** or Cycle **G80**
2. When Cycle **28 MIRRORING** is programmed before the tilting function with a rotary axis:
   - The mirrored rotary axis has no effect on the tilt specified in the **PLANE** function used, because only the movement of the rotary axis is mirrored

Operating and programming notes:

- The actual-position-capture function is not possible with an active tilted working plane.
- If you use the **PLANE** function when **M120** is active, the control automatically rescinds the radius compensation, which also rescinds the **M120** function.
- Always use **PLANE RESET** to cancel **PLANE** functions. Entering 0 in all **PLANE** parameters (e.g. all three spatial angles) exclusively resets the angles, but not the function.
- If you restrict the number of tilting axes with the **M138** function, your machine may provide only limited tilting possibilities. The machine tool builder will decide whether the control takes the angles of deselected axes into account or sets them to 0.
- The control only supports tilting the working plane with spindle axis Z.

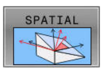
Overview

Most **PLANE** functions (except **PLANE AXIAL**) can be used to describe the desired working plane independently of the rotary axes available on your machine. The following possibilities are available:

Soft key	Function	Required parameters	Page
	**SPATIAL**	Three spatial angles: **SPA**, **SPB**, and **SPC**	374
	**PROJECTED**	Two projection angles: **PROPR** and **PROMIN** and a rotation angle **ROT**	376
	**EULER**	Three Euler angles: precession (**EULPR**), nutation (**EULNU**) and rotation (**EULROT**),	378
	**VECTOR**	Normal vector for defining the plane and base vector for defining the direction of the tilted X axis	380
	**POINTS**	Coordinates of any three points in the plane to be tilted	383
	**RELATIVE**	Single, incrementally effective spatial angle	385
	**AXIAL**	Up to three absolute or incremental axis angles **A,B,C**	386
	**RESET**	Reset the PLANE function	373

Running an animation

To familiarize yourself with the various definition possibilities of each **PLANE** function, you can start animated sequences via soft key. To do so, first enter animation mode and then select the desired **PLANE** function. While the animation plays, the control highlights the soft key of the selected **PLANE** function with a blue color.

Soft key	Function
	Switch on the animation mode
	Select the desired animation (highlighted in blue)

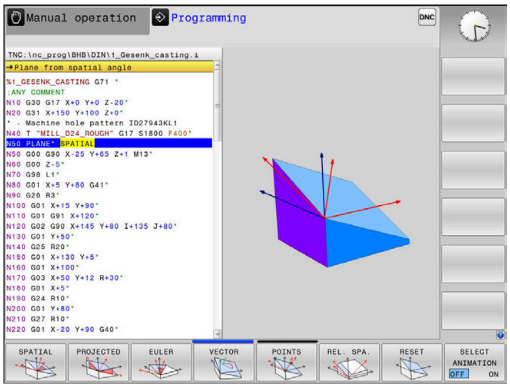
Defining the PLANE function

SPEC FCT

- Show the soft-key row with special functions

TILT MACHINING PLANE

- Press the **TILT MACHINING PLANE** soft key
- > The control displays the available **PLANE** functions in the soft-key row.
- Select the **PLANE** function



Selecting functions

- Press the soft key linked to the desired function
- > The control continues the dialog and prompts you for the required parameters.

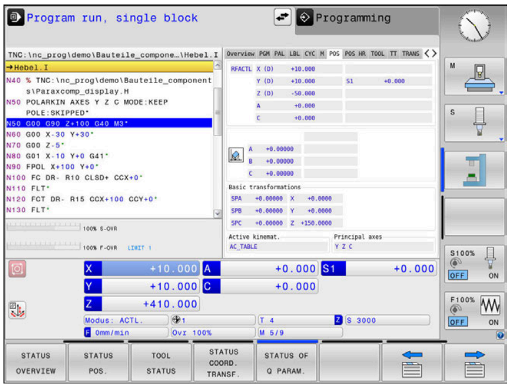
Selecting the function while animation is active

- Press the soft key linked to the desired function
- > The control plays the animation.
- To apply the currently active function, press the soft key of that function again or press the **ENT** key

Position display

As soon as a **PLANE** function (except **PLANE AXIAL**) is active, the control shows the calculated spatial angle in the additional status display.

During tilting into position (**MOVE** or **TURN** mode), the control shows, in the rotary axis, the distance to go to the calculated final position of the rotary axis in the distance-to-go display (**ACTDST** and **REFDST**).



Resetting PLANE function

Example

N10 PLANE RESET MOVE DIST50 F1000*

SPEC FCT
- Show the soft-key row with special functions

TILT MACHINING PLANE
- Press the **TILT MACHINING PLANE** soft key
- > The control displays the available **PLANE** functions in the soft-key row

RESET
- Select the reset function

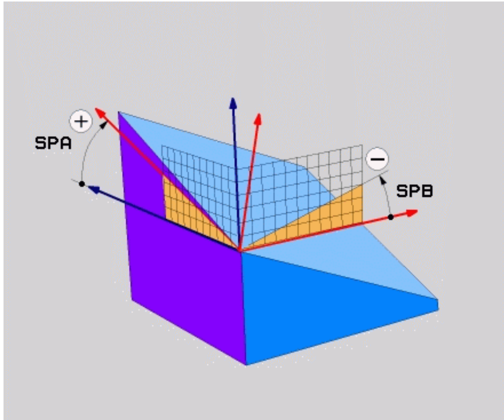
MOVE
- Specify whether the control should automatically move the tilting axes to home position (**MOVE** or **TURN**) or not (**STAY**)
  Further information: "Automatic tilting into position MOVE/TURN/STAY", Page 389

END
- Press the **END** key.

> The **PLANE RESET** function resets the active tilt and the angles (**PLANE** function or Cycle **G80**) (angle = 0 and function inactive). It does not need to be defined more than once.
>
> Deactivate tilting in the **Manual operation** mode in the 3-D ROT menu.
>
> **Further information:** User's Manual for **Setup, Testing and Running NC Programs**

Defining the working plane with the spatial angle: PLANE SPATIAL

Application



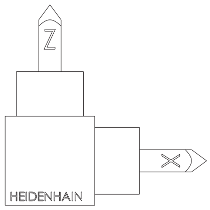
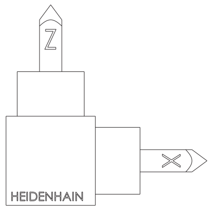
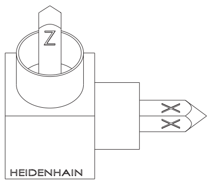
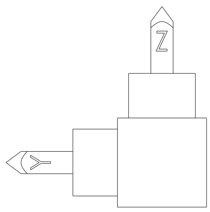
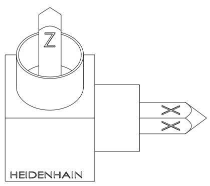
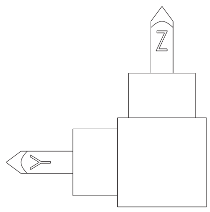
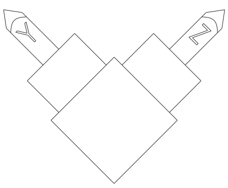
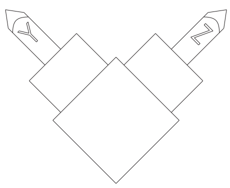
Spatial angles define a working plane through up to three rotations in the non-tilted workpiece coordinate system (**tilting sequence A-B-C**).

Most users assume three successive rotations in reverse order (**tilting sequence C-B-A**).

The result is identical for both perspectives, as the following comparison shows.

Example

```
PLANE SPATIAL SPA+45 SPB+0 SPC+90 ...
```

A-B-C	C-B-A
Home position A0° B0° C0° 	Home position A0° B0° C0° 
A+45° 	C+90° 
B+0° 	B+0° 
C+90° 	A+45° 

Comparison of the tilting orders:

- **Tilting order A-B-C:**
  1. Tilt about the non-tilted X axis of the workpiece coordinate system
  2. Tilt about the non-tilted Y axis of the workpiece coordinate system
  3. Tilt about the non-tilted Z axis of the workpiece coordinate system
- **Tilting order C-B-A:**
  1. Tilt about the non-tilted Z axis of the workpiece coordinate system
  2. Tilt about the tilted Y axis
  3. Tilt about the tilted X axis

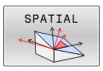
Programming notes:

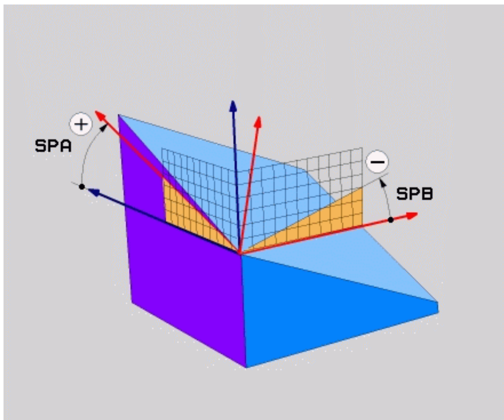
- You must always define all three spatial angles **SPA**, **SPB** and **SPC**, even if one or more have the value 0.
- Depending on the machine, Cycle **G80** requires you to enter spatial angles or axis angles. If the configuration (machine parameter setting) allows the input of spatial angles, the angle definition is the same in Cycle **G80** and in the **PLANE SPATIAL** function.
- You can select the desired positioning behavior.
  Further information: "Defining the positioning behavior of the PLANE function", Page 388

Input parameters

Example

```
N50 PLANE  SPATIAL SPA+27  SPB+0 SPC+45  .....*
```

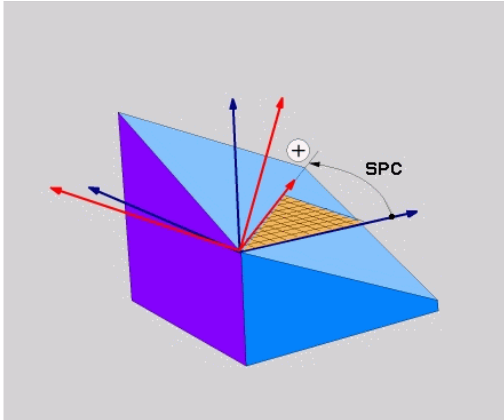




- **Spatial angle A?**: Rotational angle **SPA** about the (non-tilted) X axis. Input range from -359.9999 to +359.9999
- **Spatial angle B?**: Rotational angle **SPB** about the (non-tilted) Y axis. Input range from -359.9999 to +359.9999
- **Spatial angle C?**: Rotational angle **SPC** about the (non-tilted) Z axis. Input range from -359.9999 to +359.9999
- Continue with the positioning properties
  Further information: "Defining the positioning behavior of the PLANE function", Page 388

Abbreviations used

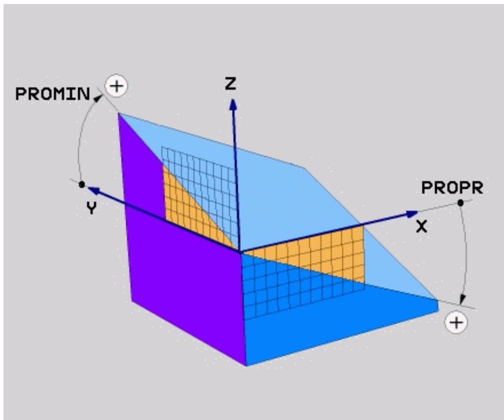
Abbreviation	Meaning
SPATIAL	In space
SPA	**Sp**atial **A**: Rotation about the (non-tilted) X axis
SPB	**Sp**atial **B**: Rotation about the (non-tilted) Y axis
SPC	**Sp**atial **C**: Rotation about the (non-tilted) Z axis



Defining the working plane with the projection angle: PLANE PROJECTED

Application

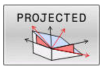
Projection angles define a machining plane through the entry of two angles that you determine by projecting the first coordinate plane (Z/X plane with tool axis Z) and the second coordinate plane (Y/Z with tool axis Z) onto the machining plane to be defined.

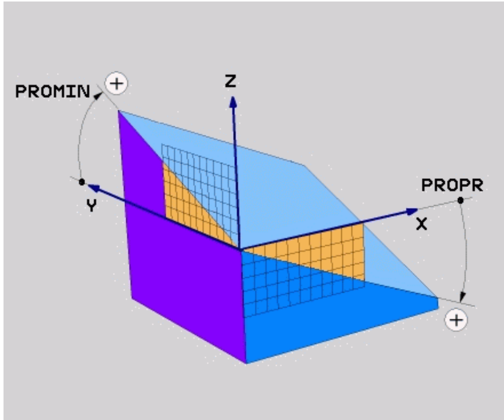


Programming notes:

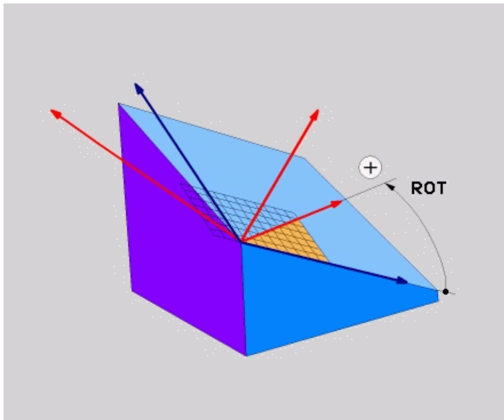
- The projection angles correspond to the angle projections on the planes of a rectangular coordinate system. The angles at the outer faces of the workpiece only are identical to the projection angles if the workpiece is rectangular. Thus, with workpieces that are not rectangular, the angle specifications from the engineering drawing often differ from the actual projection angles.
- You can select the desired positioning behavior. **Further information:** "Defining the positioning behavior of the PLANE function", Page 388

Input parameters





- **Projection angle on 1st Coordinate plane?**: Projected angle of the tilted machining plane in the 1st coordinate plane of the untilted coordinate system (Z/X for tool axis Z). Input range: from –89.9999° to +89.9999°. The 0° axis is the principal axis of the active working plane (X for tool axis Z, positive direction)
- **Proj. angle on 2nd Coordinate plane?**: Projected angle in the 2nd coordinate plane of the untilted coordinate system (Y/Z for tool axis Z). Input range: from –89.9999° to +89.9999°. The 0° axis is the minor axis of the active machining plane (Y for tool axis Z)
- **ROT angle of tilted plane?**: Rotation of the tilted coordinate system around the tilted tool axis (corresponds to a rotation with Cycle **G73**). The rotation angle provides an easy way to specify the direction of the principal axis of the working plane (X for tool axis Z, Z for tool axis Y). Input range: –360° to +360°
- Continue with the positioning properties **Further information:** "Defining the positioning behavior of the PLANE function", Page 388



Example

```
N50 PLANE  PROJECTED PROPR+24  PROMIN+24 ROT+30  .....*
```

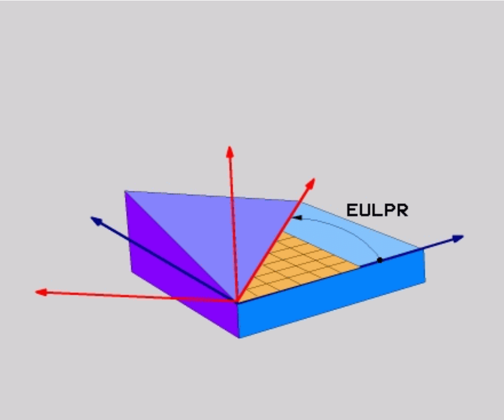
Abbreviations used:

PROJECTED	Projected
PROPR	Principal plane
PROMIN	Minor plane
ROT	Rotation

Defining the working plane with the Euler angle: PLANE EULER

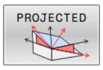
Application

Euler angles define a machining plane through up to three **rotations about the respectively tilted coordinate system**. The Swiss mathematician Leonhard Euler defined these angles.



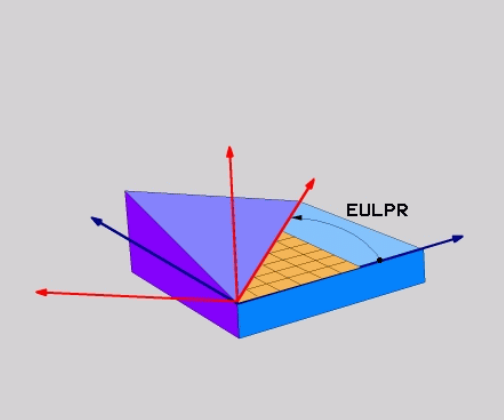
> You can select the desired positioning behavior.
> **Further information:** "Defining the positioning behavior of the PLANE function", Page 388

Input parameters



- **Rot. angle Main coordinate plane?:** Rotary angle **EULPR** around the Z axis. Please note:
  - Input range: -180.0000° to 180.0000°
  - The 0° axis is the X axis
- **Tilting angle tool axis?**: Tilting angle **EULNUT** of the coordinate system around the X axis shifted by the precession angle. Please note:
  - Input range: 0° to 180.0000°
  - The 0° axis is the Z axis
- **ROT angle of tilted plane?**: **EULROT** rotation of the tilted coordinate system around the tilted Z axis (corresponds to a rotation with Cycle **G73**). Use the rotation angle to easily define the direction of the X axis in the tilted working plane.

  Please note:
  - Input range: 0° to 360.0000°
  - The 0° axis is the X axis
- Continue with the positioning properties
  Further information: "Defining the positioning behavior of the PLANE function", Page 388

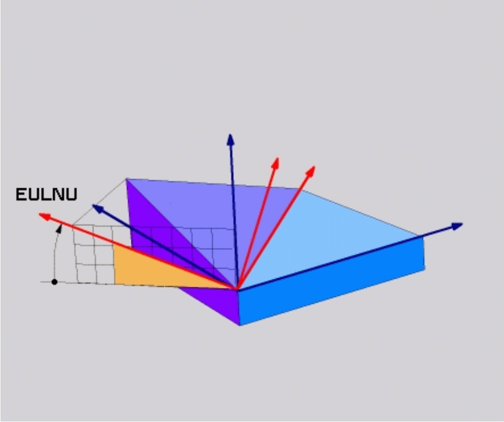


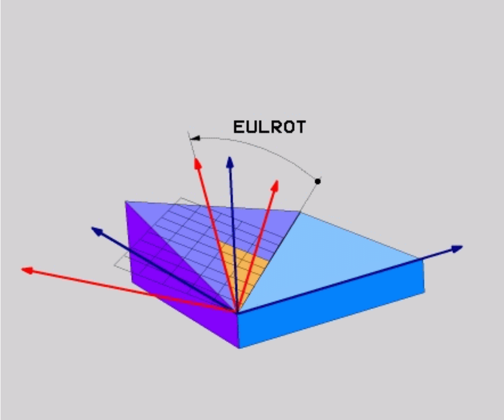
Example

```
N50 PLANE  EULER EULPR45  EULNU20 EULROT22  .....*
```

Abbreviations used

Abbreviation	Meaning
EULER	Swiss mathematician who defined these angles
EULPR	**Pr**ecession angle: angle describing the rotation of the coordinate system around the Z axis
EULNU	**Nu**tation angle: angle describing the rotation of the coordinate system around the X axis shifted by the precession angle
EULROT	**Rot**ation angle: angle describing the rotation of the tilted machining plane around the tilted Z axis

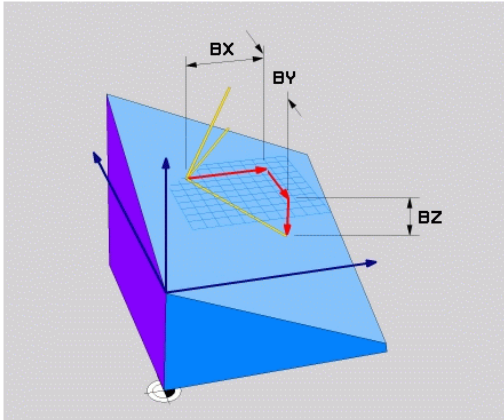




Defining the working plane with two vectors: PLANE VECTOR

Application

You can use the definition of a working plane via **two vectors** if your CAD system can calculate the base vector and normal vector of the tilted machining plane. A normalized input is not necessary. The control internally calculates the normal, so you can enter values between -9.999999 and +9.999999.



The base vector required for the definition of the machining plane is defined by the components **BX, BY** and **BZ.** The normal vector is defined by the components **NX**, **NY** and **NZ**.

Programming notes:

- The control calculates standardized vectors from the values you enter.
- The normal vector defines the slope and the orientation of the working plane. The base vector defines the orientation of the main axis X in the defined working plane. To ensure that the definition of the working plane is unambiguous, you must program the vectors perpendicular to each other. The machine tool builder defines how the control will behave for vectors that are not perpendicular.
- The programmed normal vector must not be too short, e.g. all directional components having a length of 0 or 0.0000001. In this case, the control would not be able to determine the slope. Machining is aborted and an error message is displayed. This behavior is independent of the configuration of the machine parameters.
- You can select the desired positioning behavior. **Further information:** "Defining the positioning behavior of the PLANE function", Page 388

Refer to your machine manual!

The machine tool builder configures the behavior of the control with vectors that are not perpendicular.

Alternatively to generating the default error message, the control can correct (or replace) the base vector that is not perpendicular. This correction (or replacement) does not affect the normal vector.

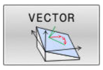
Default correction behavior of the control if the base vector is not perpendicular:

- The base vector is projected along the normal vector onto the working plane (defined by the normal vector).

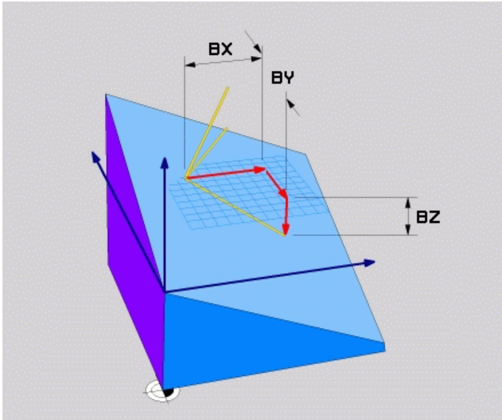
Correction behavior of the control if the base vector is not perpendicular and too short, parallel or antiparallel to the normal vector:

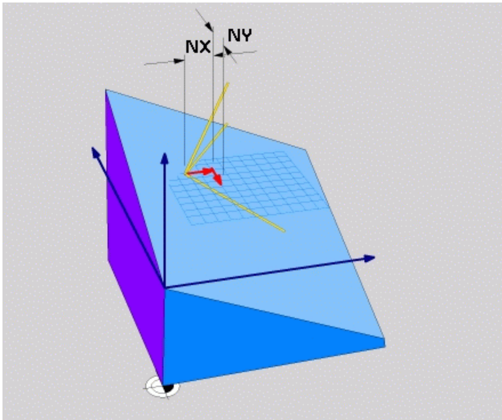
- If the normal vector has no X component, the base vector corresponds to the original X axis
- If the normal vector has no Y component, the base vector corresponds to the original Y axis

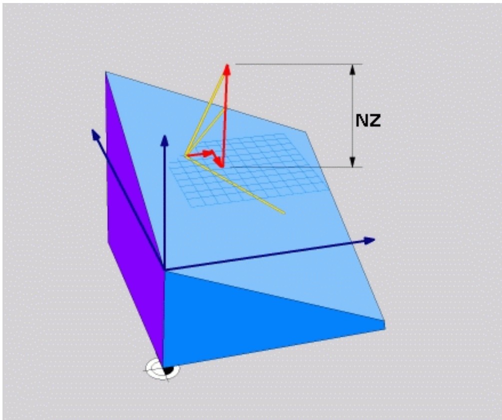
Input parameters



- **X component of base vector?**: X component **BX** of the base vector B; input range: from -9.9999999 to +9.9999999
- **Y component of base vector?**: Y component **BY** of the base vector B; input range: from -9.9999999 to +9.9999999
- **Z component of base vector?**: Z component **BZ** of the base vector B; input range: from -9.9999999 to +9.9999999
- **X component of normal vector?**: X component **NX** of the normal vector N; input range: from -9.9999999 to +9.9999999
- **Y component of normal vector?**: Y component **NY** of the normal vector N; input range: from -9.9999999 to +9.9999999
- **Z component of normal vector?**: Z component **NZ** of the normal vector N; input range: from -9.9999999 to +9.9999999
- Continue with the positioning properties
  Further information: "Defining the positioning behavior of the PLANE function", Page 388







Example

```
N50 PLANE  VECTOR BX0.8  BY-0.4 BZ-0.42  NX0.2 NY0.2
    NT0.92 ..*
```

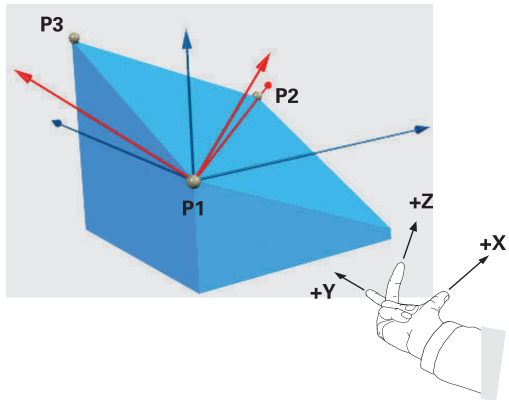
Abbreviations used

Abbreviation	Meaning
VECTOR	Vector
BX, BY, BZ	**B**ase vector : **X**, **Y**, and **Z** components
NX, NY, NZ	**N**ormal vector : **X**, **Y**, and **Z** components

Defining the working plane via three points: PLANE POINTS

Application

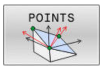
A working plane can be uniquely defined by entering **any three points P1 to P3 in this plane**. This possibility is realized in the **PLANE POINTS** function.



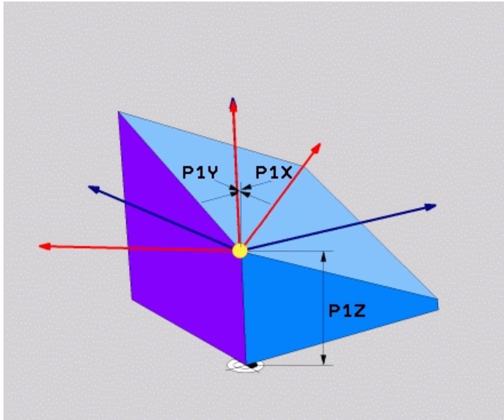
Programming notes:

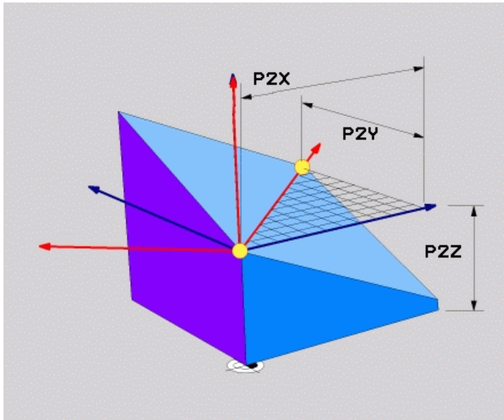
- The three points define the slope and orientation of the plane. The position of the active datum is not changed through **PLANE POINTS**.
- Point 1 and Point 2 determine the orientation of the tilted main axis X (for tool axis Z).
- Point 3 defines the slope of the tilted working plane. In the defined working plane, the Y axis is automatically oriented perpendicularly to the main axis X. The position of Point 3 thus also determines the orientation of the tool axis and consequently the orientation of the working plane. To have the positive tool axis pointing away from the workpiece, Point 3 must be located above the connection line between Point 1 and Point 2 (right-hand rule).
- You can select the desired positioning behavior.
Further information: "Defining the positioning behavior of the PLANE function", Page 388

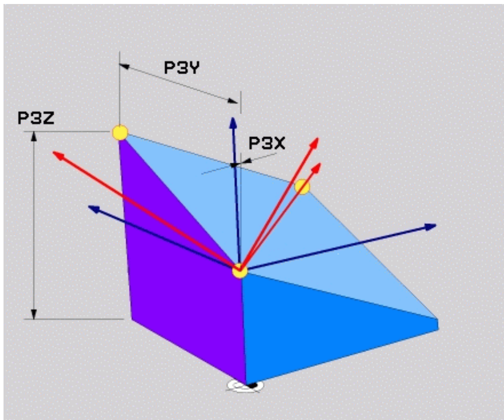
Input parameters



- **X coordinate of 1stplane point?**: X coordinate **P1X** of the 1st plane point
- **Y coordinate of 1stplane point?**: Y coordinate **P1Y** of the 1st plane point
- **Z coordinate of 1stplane point**: Z coordinate **P1Z** of the 1st plane point
- **X coordinate of 2ndplane point?**: X coordinate **P2X** of the 2nd plane point
- **Y coordinate of 2ndplane point?**: Y coordinate **P2Y** of the 2nd plane point
- **Z coordinate of 2ndplane point?**: Z coordinate **P2Z** of the 2nd plane point
- **X coordinate of 3rdplane point?**: X coordinate **P3X** of the 3rd plane point
- **Y coordinate of 3rdplane point?**: Y coordinate **P3Y** of the 3rd plane point
- **Z coordinate of 3rdplane point?**: Z coordinate **P3Z** of the 3rd plane point
- Continue with the positioning properties
  Further information: "Defining the positioning behavior of the PLANE function", Page 388







Example

```
N50 PLANE  POINTS P1X+0  P1Y+0 P1Z+20  P2X+30 P2Y+31  P2Z
     +20 P3X+0 P3Y+41  P3Z+32.5 .....*
```

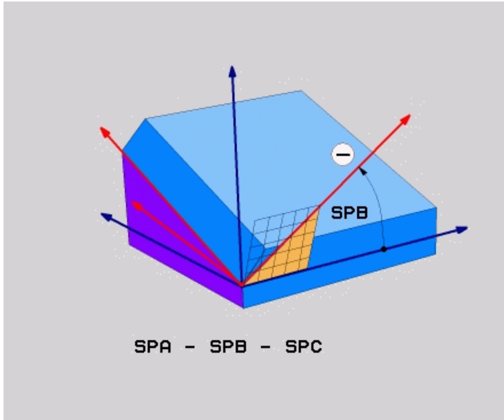
Abbreviations used

Abbreviation	Meaning
POINTS	Points

Defining the working plane via a single incremental spatial angle: PLANE RELATIV

Application

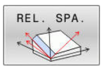
Use a relative spatial angle when an already active tilted working plane is to be tilted by **another rotation**. Example: machining a 45° chamfer on a tilted plane.



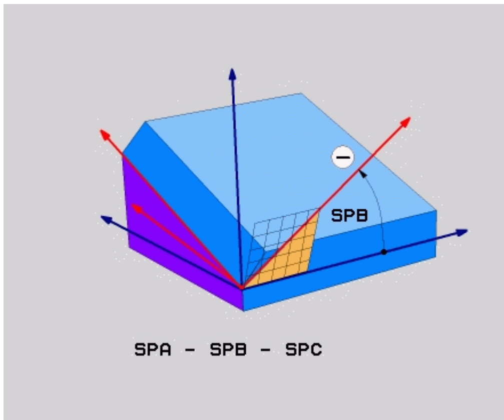
Programming notes:

- The defined angle is always in effect in respect to the active working plane, regardless of the tilting function you used before.
- You can program any number of **PLANE RELATIV** functions in a row..
- If you want to return the working plane to the orientation that was active before the **PLANE RELATIV** function, define the same **PLANE RELATIV** function again but enter the value with the opposite algebraic sign.
- If you use **PLANE RELATIV** without previous tilting, **PLANE RELATIV** will be effective directly in the workpiece coordinate system. In this case, you can tilt the original working plane by entering a defined spatial angle in the **PLANE RELATIV** function.
- You can select the desired positioning behavior. **Further information:** "Defining the positioning behavior of the PLANE function", Page 388

Input parameters



- **Incremental angle?**: Spatial angle by which the active machining plane is to be rotated. Use a soft key to select the axis to be rotated around. Input range: -359.9999° to +359.9999°
- Continue with the positioning properties **Further information:** "Defining the positioning behavior of the PLANE function", Page 388



Example

```
N50 PLANE RELATIV SPB-45 .....*
```

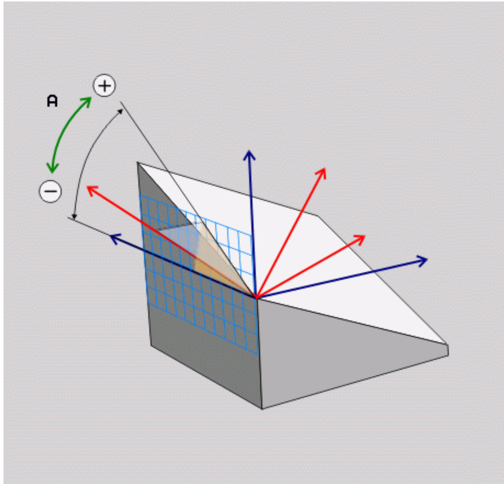
Abbreviations used

Abbreviation	Meaning
RELATIVE	Relative to

Tilting the working plane through axis angle: PLANE AXIAL

Application

The **PLANE AXIAL** function defines both the slope and the orientation of the working plane and the nominal coordinates of the rotary axes.



PLANE AXIAL can also be used on machines that have only one rotary axis.

The input of nominal coordinates (axis angle input) is advantageous in that it provides an unambiguously defined tilting situation based on defined axis positions. Spatial angles entered without an additional definition are often mathematically ambiguous. Without the use of a CAM system, entering axis angles, in most cases, only makes sense if the rotary axes are positioned perpendicularly.

Refer to your machine manual!

If your machine allows spatial angle definitions, you can continue your programming with **PLANE RELATIV** after **PLANE AXIAL**.

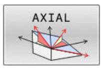
Programming notes:

- The axis angles must correspond to the axes present on the machine. If you try to program axis angles for rotary axes that do not exist on the machine, the control will generate an error message.
- Use **PLANE RESET** to reset the **PLANE AXIAL** function. Entering 0 only resets the axis angle, but does not deactivate the tilting function.
- The axis angles of the **PLANE AXIAL** function are modally effective. If you program an incremental axis angle, the control will add this value to the currently effective axis angle. If you program two different rotary axes in two successive **PLANE AXIAL** functions, the new working plane is derived from the two defined axis angles.
- **SYM** (**SEQ**), **TABLE ROT**, and **COORD ROT** have no function in conjunction with **PLANE AXIAL**.
- The **PLANE AXIAL** function does not take basic rotation into account.

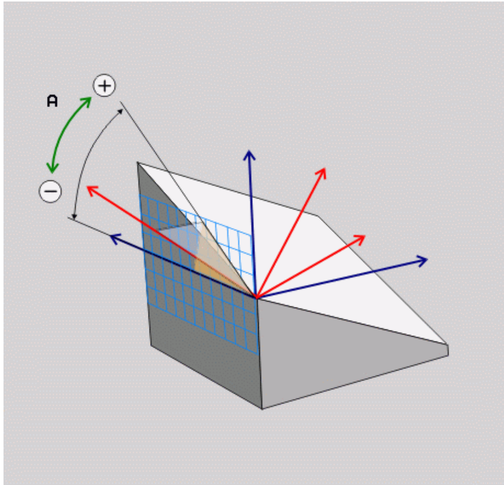
Input parameters

Example

```
N50 PLANE AXIAL B-45 .....*
```



- **Axis angle A?**: Axis angle **to which** the A axis is to be tilted. If entered incrementally, it is the angle **by which** the A axis is to be tilted from its current position. Input range: –99999.9999° to +99999.9999°
- **Axis angle B?**: Axis angle **to which** the B axis is to be tilted. If entered incrementally, it is the angle **by which** the B axis is to be tilted from its current position. Input range: –99999.9999° to +99999.9999°
- **Axis angle C?**: Axis angle **to which** the C axis is to be tilted. If entered incrementally, it is the angle **by which** the C axis is to be tilted from its current position. Input range: –99999.9999° to +99999.9999°
- Continue with the positioning properties **Further information:** "Defining the positioning behavior of the PLANE function", Page 388



Abbreviations used

Abbreviation	Meaning
AXIAL	In the axial direction

Defining the positioning behavior of the PLANE function

Overview

Independently of which PLANE function you use to define the tilted machining plane, the following functions are always available for the positioning behavior:

- Automatic positioning
- Selecting alternate tilting options (not for **PLANE AXIAL**)
- Selecting the type of transformation (not for **PLANE AXIAL**)

NOTICE

Danger of collision!

Cycle **28 MIRRORING** can have different effects in conjunction with the **Tilt working plane** function. The programming sequence, the mirrored axes, and the tilting function used are critical in this regard. There is a risk of collision during the tilting operation and subsequent machining!

- Check the sequence and positions using a graphic simulation
- Carefully test the NC program or program section in the **Program run, single block** operating mode

Examples

1. When Cycle **28 MIRRORING** is programmed before the tilting function without rotary axes:
   - The tilt of the **PLANE** function used (except **PLANE AXIAL**) is mirrored
   - Mirroring takes effect after tilting with **PLANE AXIAL** or Cycle **G80**
2. When Cycle **28 MIRRORING** is programmed before the tilting function with a rotary axis:
   - The mirrored rotary axis has no effect on the tilt specified in the **PLANE** function used, because only the movement of the rotary axis is mirrored

Automatic tilting into position MOVE/TURN/STAY

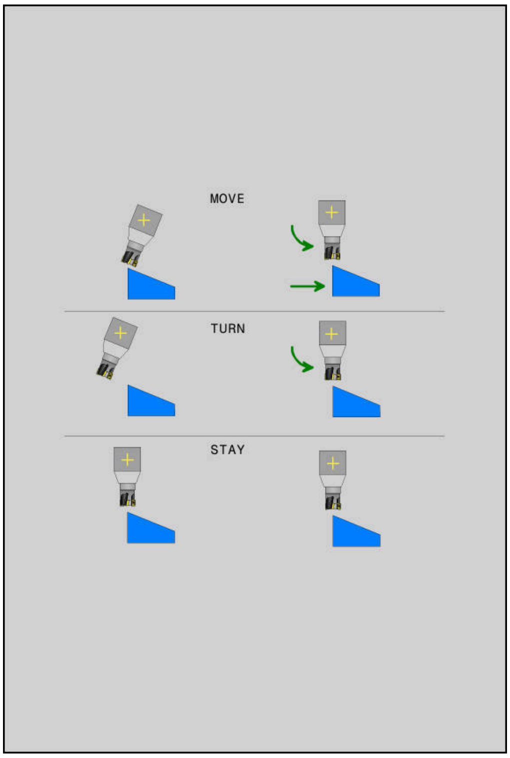
After you have entered all of the parameters for the plane definition, you must specify how the control is to tilt the rotary axes to the calculated axis value. This entry is mandatory.

The control offers the following ways of tilting the rotary axes to the calculated axis values:

- The PLANE function is to automatically tilt the rotary axes to the calculated axis values, with the relative position between the tool and the workpiece remaining the same.
- The control carries out a compensating movement in the linear axes.

- The PLANE function is to automatically tilt the rotary axes to the calculated axis values, during which only the rotary axes are positioned.
- The control does **not** carry out a compensating movement in the linear axes.

- You tilt the rotary axes into position in a subsequent, separate positioning block



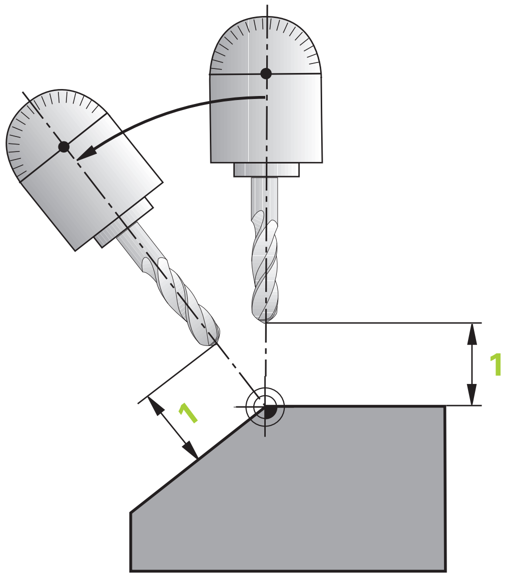
If you have selected the **MOVE** option (**PLANE** function is to automatically tilt into position with a compensation movement), then the two subsequently explained parameters **Dist. tool tip - center of rot.** and **Feed rate? F=** must still be defined.

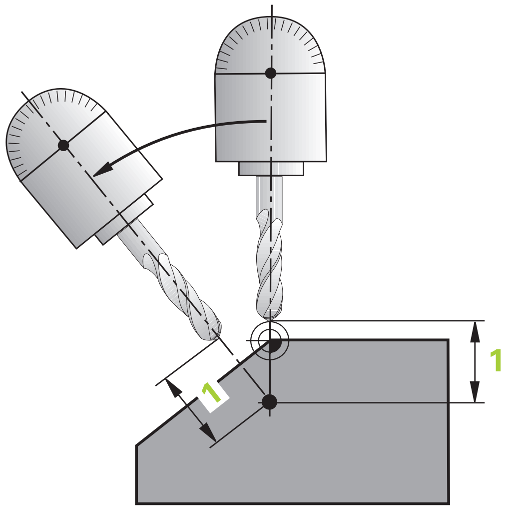
If you have selected the **TURN** option (**PLANE** function is to automatically tilt into position without compensation movement), then the subsequently explained **Feed rate?** parameter **F=** must still be defined.

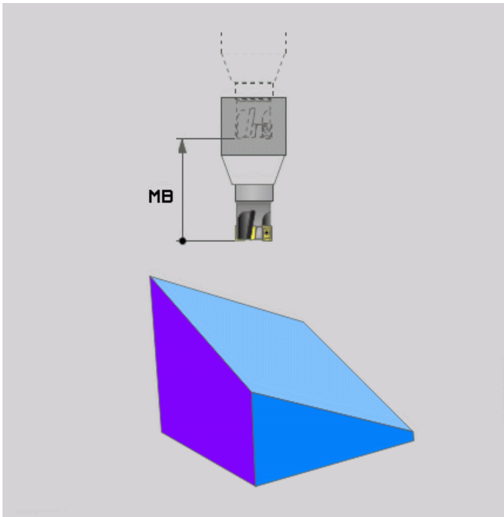
As an alternative to a feed rate **F** defined directly by a numerical value, you can also tilt the axes into position with **FMAX** (rapid traverse) or **FAUTO** (feed rate from the **T** block).

> If you use **PLANE** together with **STAY,** you have to position the rotary axes in a separate block after the **PLANE** function.

- **Dist. tool tip - center of rot.** (incremental): The **DIST** parameter shifts the center of rotation of the tilting movement relative to the current position of the tool tip.
  - If the tool is already at the specified distance from the workpiece prior to being tilted into position, then it will be at the same relative position after being tilted into position (see center figure on the right, **1** = DIST)
  - If the tool is not at the specified distance from the workpiece before being tilted into position, then it will be offset relative to the original position after being tilted into position (see lower figure on the right, **1** = DIST)
- \> The control tilts the tool (or table) relative to the tool tip.
- **Feed rate? F=**: Contour speed at which the tool is to be tilted into position
- **Retraction length in the tool axis?**: The retraction path **MB** takes effect incrementally from the current tool position in the active tool axis direction that the control approaches **before tilting**. **MB MAX** moves the tool to a position just before the software limit switch







Tilting the rotary axes into position in a separate NC block

To tilt the rotary axes into position in a separate positioning block (**STAY** option selected), proceed as follows:

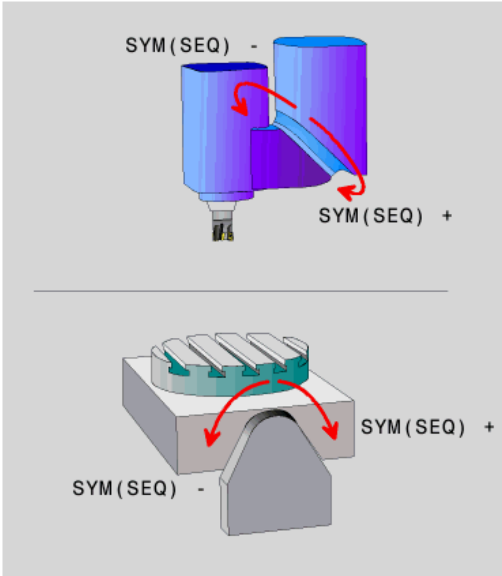
> **NOTICE**
>
> **Danger of collision!**
>
> The control does not automatically check whether collisions can occur between the tool and the workpiece. Incorrect or no pre-positioning before tilting the tool into position can lead to a risk of collision during the tilting movement!
>
> - Program a safe position before the tilting movement
> - Carefully test the NC program or program section in the **Program run, single block** operating mode

- Select any **PLANE** function, and define automatic tilting into position with **STAY**. During program run, the control calculates the position values of the rotary axes present on the machine, and stores them in the system parameters **Q120** (A axis), **Q121** (B axis), and **Q122** (C axis)
- Define the positioning block with the angular values calculated by the control

Example: Tilt a machine with a rotary table C and a tilting table A to a spatial angle of B+45

...	
N10 G00 Z+250 G40*	Position at clearance height
N20 PLANE SPATIAL SPA+0 SPB+45 SPC+0 STAY*	Define and activate the PLANE function
N30 G01 A+Q120 C+Q122 F2000*	Position the rotary axis with the values calculated by the control.
...	Define machining in the tilted working plane

Selection of tilting possibilities SYM (SEQ) +/–



Based on the position that you have defined for the working plane, the control must calculate the appropriate position of the rotary axes present on your machine. In general, there are always two possible solutions.

For the selection of one of the possible solutions, the control offers two variants: **SYM** and **SEQ**. You use soft keys to choose the variants. **SYM** is the standard variant.

The entry of **SYM** or **SEQ** is optional.

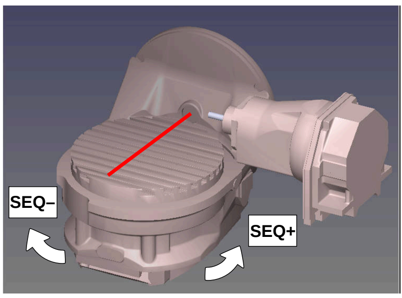
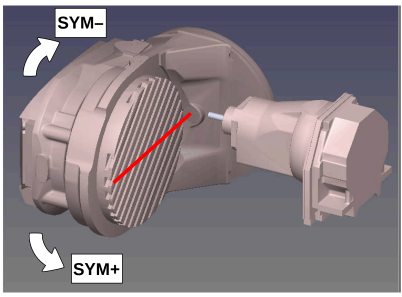
SEQ assumes that the master axis is in its home position (0°). Relative to the tool, the master axis is the first rotary axis or the last rotary axis relative to the table (depending on the machine configuration). If both possible solutions are in the positive or negative range, then the control automatically uses the closer solution (shorter path). If you need the second possible solution, then you must either pre-position the master axis (in the area of the second possible solution) before tilting the working plane, or work with **SYM**.

Unlike **SEQ**, **SYM** uses the symmetry point of the master axis as its reference. Every master axis has two symmetry positions, which are 180° apart from each other (sometimes only one symmetry position is in the traverse range).

Determine the symmetry point in the following manner:

- Perform **PLANE SPATIAL** with any spatial angle and **SYM+**
- Save the axis angle of the master axis in a Q parameter, (e.g., –100)
- Repeat the **PLANE SPATIAL** function with **SYM-**
- Save the axis angle of the master axis in a Q parameter (e.g., –80)
- Calculate the average value (e.g., –90)

The average value corresponds to the symmetry point.

Reference for SEQ	Reference for SYM
	

With the **SYM** function, you select one of the possible solutions relative to the symmetry point of the master axis:

- **SYM+** positions the master axis in the positive half-space relative to the symmetry point
- **SYM-** positions the master axis in the negative half-space relative to the symmetry point

With the **SEQ** function, you select one of the possible solutions relative to the home position of the master axis:

- **SEQ+** positions the master axis in the positive tilting range relative to home position
- **SEQ-** positions the master axis in the negative tilting range relative to home position

If the solution you have selected with **SYM** (**SEQ**) is not within the machine's range of traverse, then the control displays the **Entered angle not permitted** error message.

> If the **PLANE AXIAL** function is used, the **SYM** (**SEQ**) function has no effect.

If you do not define **SYM** (**SEQ**), then the control determines the solution as follows:

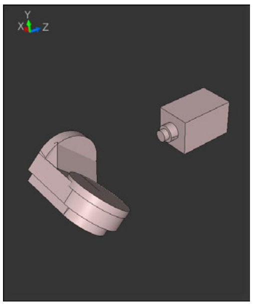
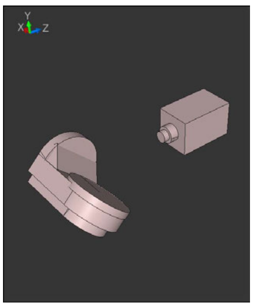
1. Check whether both possible solutions are within the traverse range of the rotary axes
2. Two possible solutions: Based on the current position of the rotary axes, choose the possible solution with the shortest path
3. One possible solution: Choose the only solution
4. No possible solution: Issue the error message **Entered angle not permitted**

Examples

Machine with C rotary axis and A tilting table. Programmed function: PLANE SPATIAL SPA+0 SPB+45 SPC+0

Limit switch	Start position	SYM = SEQ	Resulting axis position
None	A+0, C+0	Not prog.	A+45, C+90
None	A+0, C+0	+	A+45, C+90
None	A+0, C+0	–	A–45, C–90
None	A+0, C–105	Not prog.	A–45, C–90
None	A+0, C–105	+	A+45, C+90
None	A+0, C–105	–	A–45, C–90
–90 < A < +10	A+0, C+0	Not prog.	A–45, C–90
–90 < A < +10	A+0, C+0	+	Error message
–90 < A < +10	A+0, C+0	–	A–45, C–90

Machine with B rotary axis and A tilting table (limit switches: A +180 and –100). Programmed function: PLANE SPATIAL SPA-45 SPB+0 SPC+0

SYM	SEQ	Resulting axis position	Kinematics view
+		A–45, B+0	
-		Error message	**No solution in limited range**
	+	Error message	**No solution in limited range**
	-	A–45, B+0	

The position of the symmetry point is contingent on the kinematics. If you change the kinematics (such as switching the head), then the position of the symmetry point changes as well.

Depending on the kinematics, the positive direction of rotation of **SYM** may not correspond to the positive direction of rotation of **SEQ**. Therefore, ascertain the position of the symmetry point and the direction of rotation of **SYM** on each machine before programming.

Selection of the transformation type

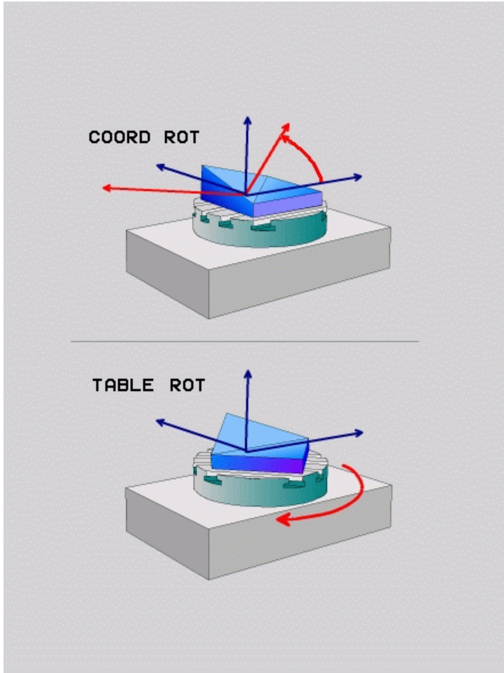
The **COORD ROT** and **TABLE ROT** transformation types influence the orientation of the working plane coordinate system through the axis position of a so-called free rotary axis.

The entry of **COORD ROT** or **TABLE ROT** is optional.

Any rotary axis becomes a free rotary axis with the following configuration:

- The rotary axis has no effect on the tool angle of inclination because the rotary axis and the tool axis are parallel in the tilting situation
- The rotary axis is the first rotary axis in the kinematic chain starting from the workpiece

The effect of the **COORD ROT** and **TABLE ROT** transformation types therefore depends on the programmed spatial angles and the machine kinematics.

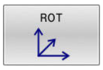
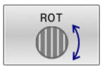


> Programming notes:
> - If no free rotary axis arises in a tilting situation, then the **COORD ROT** and **TABLE ROT** transformation types have no effect.
> - With the **PLANE AXIAL** function, the **COORD ROT** and **TABLE ROT** transformation types have no effect.

Effect with a free rotary axis

Programming notes

- For the positioning behavior with the **COORD ROT** and **TABLE ROT** transformation types, it makes no difference whether the free rotary axis is a table axis or a head axis.
- The resulting axis position of the free rotary axis depends on an active basic rotation, among other factors.
- The orientation of the working plane coordinate system also depends on a programmed rotation; for example, by means of Cycle **G73 ROTATION**.

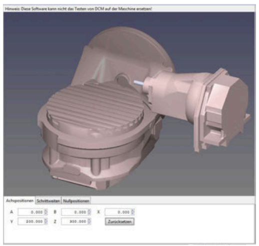
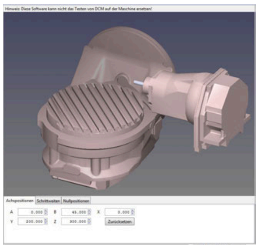
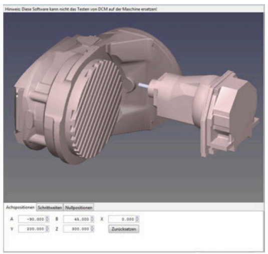
Soft key	Function
	**COORD ROT**: > The control positions the free rotary axis to 0 > The control orients the working plane coordinate system in accordance with the programmed spatial angle
	**TABLE ROT** with: ■ SPA **and** SPB **equal to** 0 ■ SPC **equal or unequal to** 0 > The control orients the free rotary axis in accordance with the programmed spatial angle > The control orients the working plane coordinate system in accordance with the basic coordinate system **TABLE ROT** with: ■ **At least** SPA **or** SPB **unequal to** 0 ■ SPC **equal or unequal to** 0 > The control does not position the free rotary axis. The position prior to tilting the working plane is maintained > Since the workpiece was not positioned, the control orients the working plane coordinate system in accordance with the programmed spatial angle

If no transformation type was selected, then the control uses the **COORD ROT** transformation type for the **PLANE** functions

Example

The following example shows the effect of the **TABLE ROT** transformation type in conjunction with a free rotary axis.

...	
N60 G00 B+45 R0*	Pre-position rotary axis
N70 PLANE SPATIAL SPA-90 SPB+20 SPC+0 TURN F5000 TABLE ROT*	Tilt the working plane
...	

Origin	**A = 0, B = 45**	**A = –90, B = 45**
		

- The control positions the B axis to the axis angle B+45
- With the programmed tilting situation with SPA–90, the B axis becomes the free rotary axis
- The control does not position the free rotary axis. The position of the B axis prior to the tilting of the working plane is maintained
- Since the workpiece was not also positioned, the control orients the working plane coordinate system in accordance with the programmed spatial angle SPB+20

Tilting the working plane without rotary axes

Refer to your machine manual!

This function must be enabled and adapted by the machine tool builder.

The machine tool builder must take the precise angle into account, e.g. the angle of a mounted angular head in the kinematics description.

You can also orient the programmed working plane perpendicularly to the tool without defining rotary axes, e.g. when adapting the working plane for a mounted angular head.

Use the **PLANE SPATIAL** function and the **STAY** positioning behavior to swivel the working plane to the angle specified by the machine tool builder.

Example of mounted angular head with permanent tool direction Y:

Example

```
N10 T 5 G17 S4500*
N20 PLANE SPATIAL SPA+0 SPB-90 SPC+0 STAY*
```

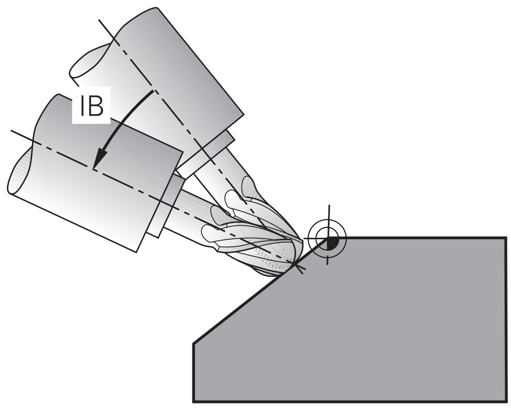
The tilt angle must be precisely adapted to the tool angle, otherwise the control will generate an error message.

11.3 Inclined-tool machining in a tilted plane (option 9)

Function

In combination with **M128** and the new **PLANE** functions, **inclined-tool machining** on a tilted machining plane is now possible. Two possibilities are available for definition:

- Inclined-tool machining via incremental traverse of a rotary axis



> Inclined-tool machining in a tilted machining plane only works with spherical cutters.
>
> **Further information:** "FUNCTION TCPM (option 9)", Page 407

Inclined-tool machining via incremental traverse of a rotary axis

- Retract the tool
- Define any PLANE function; consider the positioning behavior
- Activate M128
- Via a straight-line block, traverse to the desired incline angle in the appropriate axis incrementally

Example

...	
N12 G00 G40 Z+50*	Position at clearance height
N13 PLANE SPATIAL SPA+0 SPB-45 SPC+0 MOVE DIST50 F900*	Define and activate the PLANE function
N14 M128*	Activate M128
N15 G01 G91 F1000 B-17*	Set the incline angle
...	Define machining in the tilted working plane

11.4 Miscellaneous functions for rotary axes

Feed rate in mm/min on rotary axes A, B, C: M116 (option 8)

Standard behavior

The control interprets the programmed feed rate of a rotary axis in degrees/min (in mm programs and also in inch programs). The feed rate therefore depends on the distance from the tool center to the center of the rotary axis.

The larger this distance becomes, the greater the contouring feed rate.

Feed rate in mm/min on rotary axes with M116

Refer to your machine manual!

The machine geometry must be specified by the machine tool builder in the kinematics description.

Programming notes:

- The **M116** function can be used with table axes and head axes.
- The **M116** function also has an effect if the **Tilt working plane** function is active.
- It is not possible to combine the **M128** or **TCPM** function with **M116**. If you want to activate **M116** for an axis while the **M128** or **TCPM** function is active, then you must indirectly deactivate the compensating movement for this axis using **M138**. This is done indirectly because, with **M138**, you specify the axis for which the **M128** or **TCPM** function takes effect. Thus, **M116** automatically affects the axis that was not selected with **M138**.
  Further information: "Selecting tilting axes: M138", Page 405
- Without the **M128** or **TCPM** function, **M116** can take effect for two rotary axes at the same time.

The control interprets the programmed feed rate of a rotary axis in mm/min (or 1/10 inch/min). In this case, the control calculates the feed for the block at the start of each NC block. The feed rate of a rotary axis will not change while the NC block is executed, even if the tool moves toward the center of the rotary axis.

Effect

M116 is effective in the working plane. Reset **M116** with **M117**. At the end of the program, **M116** is automatically canceled.

M116 becomes effective at the start of the block.

Shorter-path traverse of rotary axes: M126

Standard behavior

> Refer to your machine manual!
>
> The positioning behavior of rotary axes is machine-dependent.
>
> **M126** has an effect only on modulo axes.
>
> In the case of modulo axes, the axis position begins again at 0° after the modulo length of 0° – 360° has been exceeded. This is the case for rotary axes that are mechanically capable of endless rotation.
>
> In the case of non-modulo axes, the maximum rotation is mechanically limited. The position display of the rotary axis does not switch back to the starting value (e.g., 0° – 540°).

The machine parameter **shortestDistance** (no. 300401) defines the standard behavior for the positioning of rotary axes. It is effective only for rotary axes whose position display is limited to a range of traverse of less than 360°. If the parameter is inactive, then the control traverses the programmed value from the actual position to the nominal position. If the parameter is active, then the control moves to the nominal position on the shortest path (even without **M126**).

Behavior without M126:

Without **M126**, the control moves a rotary axis whose position display is reduced to less than 360° along a long path.

Examples:

Actual position	Nominal position	Range of traverse
350°	10°	–340°
10°	340°	+330°

Behavior with M126

With **M126**, the control moves a rotary axis whose position display is reduced to less than 360° on the shortest path of traverse.

Examples:

Actual position	Nominal position	Range of traverse
350°	10°	+20°
10°	340°	–30°

Effect

M126 takes effect at the start of the block.

M127 and a program end reset **M126**.

Reducing display of a rotary axis to a value less than 360°: M94

Standard behavior

The control moves the tool from the current angular value to the programmed angular value.

Example:

Current angular value:	538°
Programmed angular value:	180°
Actual distance of traverse:	-358°

Behavior with M94

At the start of block, the control first reduces the current angular value to a value less than 360° and then moves the tool to the programmed value. If multiple rotary axes are active, **M94** will reduce the display of all rotary axes. As an alternative, you can specify a rotary axis after **M94**. The control then reduces the display of this axis only.

If you entered a traverse limit or a software limit switch is active, **M94** is ineffective for the corresponding axis.

Example: Reduce the display of all active rotary axes

```
N50 M94*
```

Example: Reduce the display of the C axis

```
N50 M94  C*
```

Example: Reduce the display of all active rotary axes and then move the tool in the C axis to the programmed value

```
M50 G00  C+180 M94*
```

Effect

M94 is effective only in the NC block where it is programmed.

M94 becomes effective at the start of the block.

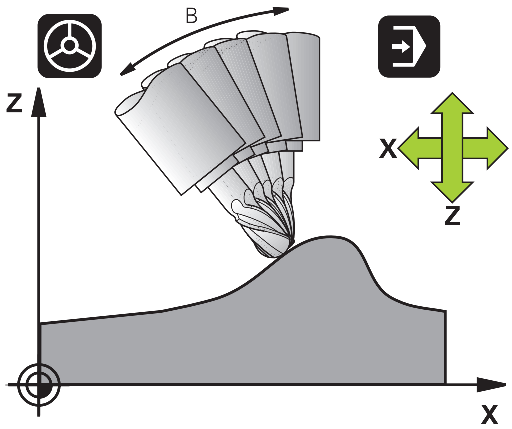
Retaining the position of the tool tip during the positioning of tilting axes (TCPM): M128 (option 9)

Standard behavior

If the inclination angle of the tool changes, this results in an offset of the tool tip compared to the nominal position. The control does not compensate for this offset. If the operator does not take this deviation into account in the NC program, offset machining is executed.

Behavior with M128 (TCPM: Tool Center Point Management)

If the position of a controlled tilting axis changes in the NC program, then the position of the tool tip relative to the workpiece remains unchanged.



NOTICE

Danger of collision!

Rotary axes with Hirth coupling must move out of the coupling to enable tilting. There is a danger of collision while the axis moves out of the coupling and during the tilting operation.

- Retract the tool before changing the position of the tilting axis

After **M128**, you can still enter a maximum feed rate at which the control will carry out the compensating movements in the linear axes.

If you want to change the position of the tilting axis with the handwheel during program run, then use **M128** in conjunction with **M118**. The superimposing of handwheel positioning is performed with active **M128**, depending on the setting in the 3D ROT menu of **Manual operation** mode, in the active coordinate system or in the non-tilted coordinate system.

Programming notes:

- Before positioning with **M91** or **M92**, and before a **T** block, reset the **M128** function
- To avoid contour damage, use only radius cutters with **M128**
- The tool length must be measured from the spherical center of the Ball-nose cutter
- If **M128** is active, then the control shows the **TCPM** symbol in the status display

M128 on tilting tables

If you program a tilting table movement while **M128** is active, then the control rotates the coordinate system accordingly. For example, if you rotate the C axis by 90° (through a positioning or datum shift) and then program a movement in the X axis, then the control executes the movement in the machine Y axis.

The control also transforms the set preset, which has been shifted by the movement of the rotary table.

M128 with three-dimensional tool compensation

If you carry out a three-dimensional tool compensation with active **M128** and active radius compensation **G41**/**G42**, then the control will automatically position the rotary axes for certain machine geometries (peripheral milling).

Effect

M128 takes effect at the start of the block, and **M129** takes effect at the end of the block. **M128** also takes effect in the manual operating modes and remains active even after a change in the operating mode. The feed rate for the compensating movement remains in effect until you program a new feed rate or reset **M128** with **M129**.

You can reset **M128** with **M129**. The control also resets **M128** when you select a new NC program in a program run mode.

Example: Perform compensation movements at a feed rate of no more than 1000 mm/min

```
N50 G01  G41 X+0  Y+38.5 IB-15 F125  M128 F1000*
```

Inclined-tool machining with non-controlled rotary axes

If your machine has non-controlled rotary axes (so-called counter axes), then you can also perform inclined machining operations with these axes in conjunction with **M128**.

Proceed as follows:

1. Manually traverse the rotary axes to the desired positions. **M128** must not be active during this operation
2. Activate **M128**: the control reads the actual values of all existing rotary axes, calculates from this the new position of the tool center point, and updates the position display
3. The control performs the necessary compensating movement in the next positioning block
4. Execute the machining operation
5. At program end, reset **M128** with **M129**, and return the rotary axes to their initial positions

> As long as **M128** is active, the control monitors the actual positions of the non-controlled rotary axes. If the actual position deviates from the value that is definable by the machine manufacturer, then the control issues an error message and interrupts program run.

Selecting tilting axes: M138

Standard behavior

With the functions **M128**, and **Tilt working plane**, the control considers those rotary axes that have been specified by the machine tool builder in the machine parameters.

Behavior with M138

The control performs the above functions only in those tilting axes that you have defined using **M138**.

> Refer to your machine manual!
>
> If you restrict the number of tilting axes with the **M138** function, your machine may provide only limited tilting possibilities. The machine tool builder will decide whether the control takes the angles of deselected axes into account or sets them to 0.

Effect

M138 becomes effective at the start of the block.

You can cancel **M138** by reprogramming it without specifying any axes.

Example

Perform the above-mentioned functions only in the tilting axis C.

```
N50 G00  Z+100 G40  M138 C*
```

Compensating the machine kinematics in ACTUAL/NOMINAL positions at end of block: M144 (Option 9)

Standard behavior

If the kinematics change, e.g. by inserting an adapter spindle or entering an inclination angle, the control will not compensate this modification. If the operator does not consider this modification to the kinematics for the NC program, machining will occur with an offset.

Behavior with M144

	Refer to your machine manual! The machine geometry must be specified by the machine tool builder in the kinematics description.

The **M144** function enables the control to consider the modification to the machine kinematics in the position display and compensate the offset of the tool tip in relation to the workpiece.

	Programming and operating notes: ■ Positioning blocks with **M91** or **M92** are permitted while **M144** is active. ■ The position display in the **Program Run Full Sequence** and **Program Run Single Block** operating modes does not change until the tilting axes have reached their final position.

Effect

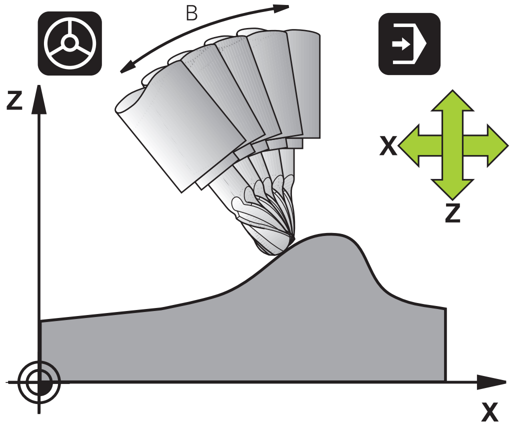
M144 becomes effective at the start of the block. **M144** does not work in connection with **M128** or the Tilt Working Plane function.

You can cancel **M144** by programming **M145**.

11.5 FUNCTION TCPM (option 9)

Function

Refer to your machine manual!
The machine geometry must be specified by the machine tool builder in the kinematics description.



FUNCTION TCPM is an improvement on the **M128** function, with which you can define the behavior of the control during the positioning of rotary axes. With **FUNCTION TCPM**, you can define the effects of various functions yourself:

- Effect of the programmed feed rate: **F TCP** / **F CONT**
- Interpretation of the rotary axis coordinates programmed in the NC program: **AXIS POS** / **AXIS SPAT**
- Type of orientation interpolation between the start and end positions: **PATHCTRL AXIS** / **PATHCTRL VECTOR**
- Optional selection of a tool reference point and a center of rotation: **REFPNT TIP-TIP** / **REFPNT TIP-CENTER** / **REFPNT CENTER-CENTER**
- Maximum feed rate at which the control performs the compensation movements in the linear axes: **F**

If **FUNCTION TCPM** is active, the control shows the **TCPM** symbol in the position display.

NOTICE

Danger of collision!

Rotary axes with Hirth coupling must move out of the coupling to enable tilting. There is a danger of collision while the axis moves out of the coupling and during the tilting operation.

- ▶ Retract the tool before changing the position of the tilting axis

Programming notes:

- Before positioning axes with **M91** or **M92,** and before a **TOOL CALL** block, reset the **FUNCTION TCPM** function.
- Use only Ball-nose cutters for face milling operations in order to avoid contour damage. In combination with other tool shapes, you should use the graphic simulation to test the NC program for possible contour damage.

Defining FUNCTION TCPM

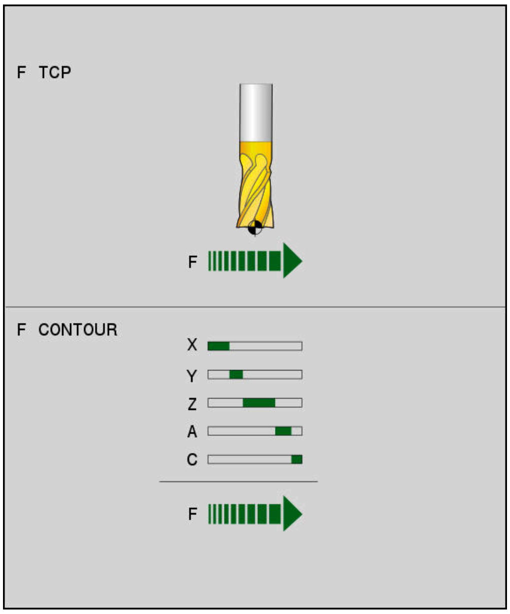
SPEC FCT ▶ Select the special functions

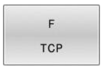
PROGRAM FUNCTIONS ▶ Select the programming aids

FUNCTION TCPM ▶ Select **FUNCTION TCPM**

Effect of the programmed feed rate

The control provides two functions for defining the effect of the programmed feed rate:





- **F TCP** determines that the programmed feed rate is interpreted as the actual relative velocity between the tool tip (**t**ool **c**enter **p**oint) and the workpiece

- **F CONT** determines that the programmed feed rate is interpreted as the contouring feed rate of the axes programmed in the respective NC block.

Example

...	
N130 FUNCTION TCPM F TCP ...	Feed rate refers to the tool tip
N140 FUNCTION TCPM F CONT ...	Feed rate is interpreted as the speed of the tool along the contour
...	

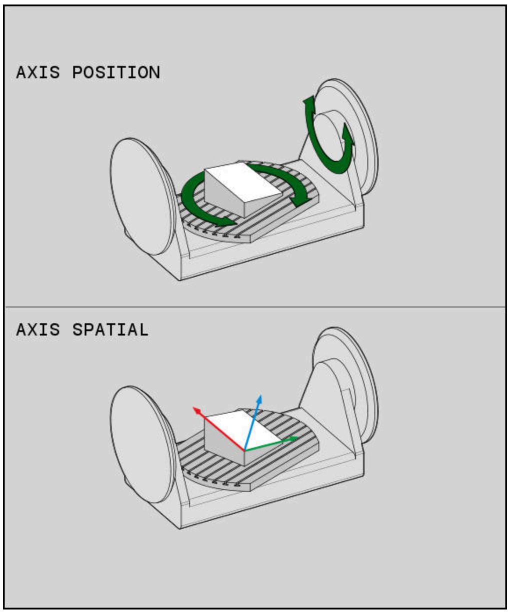
Interpretation of the programmed rotary axis coordinates

Up to now, machines with 45° swivel heads or 45° tilting tables could not easily set the angle of inclination or a tool orientation with respect to the currently active coordinate system (spatial angle). This function could only be realized through externally created NC programs with surface-normal vectors (LN blocks).

The control provides the following functionality:

- **AXIS POS** determines that the control interprets the programmed coordinates of rotary axes as the nominal position of the respective axis

- **AXIS SPAT** determines that the control interprets the programmed coordinates of rotary axes as spatial angles



Programming notes:

- The **AXIS POS** function is primarily suitable in conjunction with perpendicularly arrayed rotary axes. Only if the programmed rotary axis coordinates define the working plane correctly (e.g. programmed using a CAM system), can you also use **AXIS POS** with different machine designs (e.g. 45° swivel heads).
- The **AXIS SPAT** function is used to define spatial angles that are given with respect to the active coordinate system (which might be tilted). The defined angles have the effect of incremental spatial angles. Always program all three spatial angles in the first positioning block after the **AXIS SPAT** function, even if they are 0°.

Example

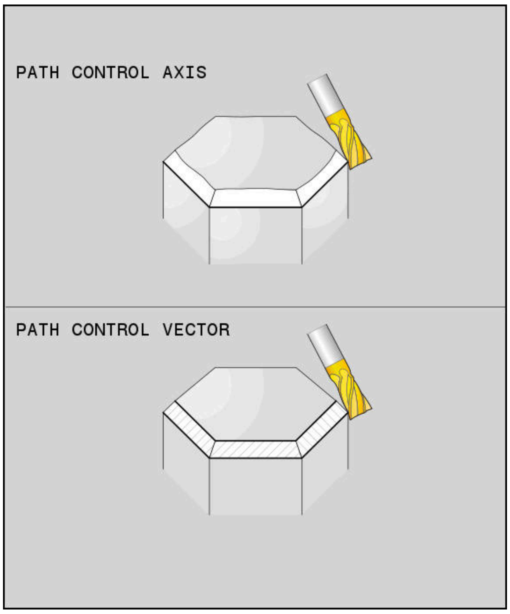
...	
N130 FUNCTION TCPM F TCP AXIS POS ...	Rotary axis coordinates are axis angles
...	
N180 FUNCTION TCPM F TCP AXIS SPAT ...	Rotary axis coordinates are spatial angles
N200 G00 A+0 B+45 C+0	Set tool orientation to B+45 degrees (spatial angle). Define spatial angles A and C with 0
...	

Orientation interpolation between the start position and end position

With these functions, you define how the tool orientation between the programmed start position and end position is to be interpolated:

- **PATHCTRL AXIS** specifies that the rotary axes between the start position and end position are to be linearly interpolated. The surfaces that arise through milling with the tool circumference (**peripheral milling**) are not necessarily level, and they depend on the machine kinematics.

- **PATHCTRL VECTOR** specifies that the tool orientation within the NC block always lies in the plane that is defined through the start orientation and end orientation. If the vector lies between the start position and end position in this plane, then milling with the tool circumference (**peripheral milling**) will produce a level surface.



In both cases, the programmed tool reference point is moved along a straight line between the start position and end position.

> To obtain the most continuous multi-axis movement possible, define Cycle **G62** with a **tolerance for rotary axes**.
>
> **Further information:** User's Manual for **Programming of Machining Cycles**

PATHCTRL AXIS

You can use the **PATHCTRL AXIS** variant for NC programs with small orientation changes per NC block. In this case, the angle **TA** in Cycle **G62** can be large.

You can use **PATHCTRL AXIS** both for face milling and also for peripheral milling.

Further information: "Running CAM programs", Page 415

> HEIDENHAIN recommends the **PATHCTRL AXIS** variant. This enables smooth motion, which has a beneficial effect on the surface quality.

PATHCTRL VECTOR

You can use the **PATHCTRL VECTOR** variant for peripheral milling with large orientation changes per NC block.

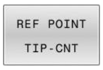
Example

...	
N130 FUNCTION TCPM F TCP AXIS SPAT PATHCTRL AXIS*	The rotary axes are linearly interpolated between the start and end positions of the NC block.
N140 FUNCTION TCPM F TCP AXIS SPAT PATHCTRL VECTOR*	The rotary axes are interpolated such that the tool vector within the NC block always lies in the plane that is specified through the start orientation and end orientation.
...	

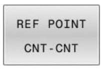
Selection of tool reference point and center of rotation

The control provides the following functions for defining the tool reference point and center of rotation:

- **REFPNT TIP-TIP**: the (theoretical) tool tip is the reference point for positioning. The center of rotation is also located at the tool tip

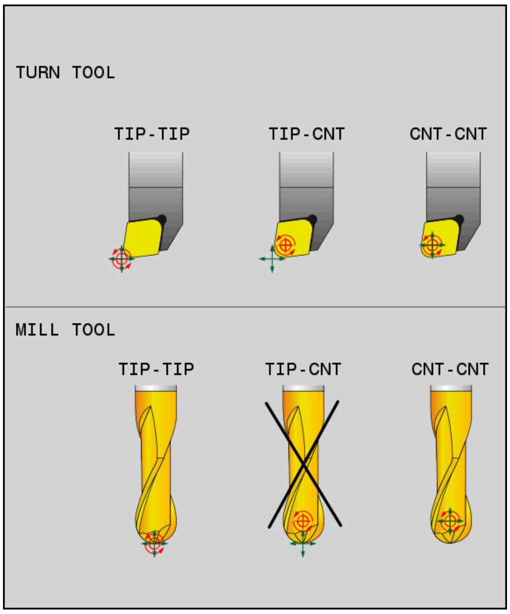


- **REFPNT TIP-CENTER**: the tool tip is the reference point for positioning. The center of rotation is located at the center of the cutting-edge radius.



- **REFPNT CENTER-CENTER**: the center of the cutting-edge radius is the reference point for positioning. The center of rotation is also located at the center of the cutting-edge radius.

The reference point is optional. If you do not enter anything, the control uses **REFPNT TIP-TIP**.



REFPNT TIP-TIP

The **REFPNT TIP-TIP** variant corresponds to the default behavior of **FUNCTION TCPM**. You can use all previously allowed cycles and functions.

REFPNT TIP-CENTER

The **REFPNT TIP-CENTER** variant is mainly intended for the use with turning tools. In this case the center of rotation and the positioning point are not coincident. In an NC block, the center of rotation (center of the cutting-edge radius) is kept in position, but at the end of the block, the tool tip will no longer be in its initial position.

The main goal of selecting this reference point is to enable machining of complex contours in turning mode with active radius compensation and simultaneously inclined tilting axes (simultaneous turning). The use of this function only makes sense for control in turning mode (Option 50). Currently, this software option is only supported on the TNC 640.

REFPNT CENTER-CENTER

You can use the **REFPNT CENTER-CENTER** variant to machine parts with a tool whose tip is used as a reference point when executing NC programs generated in a CAD/CAM software where the paths are referenced to the center of the cutting edge radius instead of the tool tip.

Previously, this functionality could only be achieved by shortening the tool with **DL**. The variant with **REFPNT CENTER-CENTER** is advantageous in that the control knows the true tool length .

If you use **REFPNT CENTER-CENTER**, to program pocket milling cycles, the control generates an error message.

Example

...	
N130 FUNCTION TCPM F TCP AXIS SPAT PATHCTRL AXIS REFPNT TIP-TIP*	Both the tool reference point and the center of rotation are located at the tool tip.
N140 FUNCTION TCPM F TCP AXIS POS PATHCTRL AXIS REFPNT CENTER-CENTER*	Both the tool reference point and the center of rotation are located at the center of the cutting-edge radius.
...	

Resetting FUNCTION TCPM

- **FUNCTION RESET TCPM** is to be used if you want to purposely reset the function within an NC program.

> When you select a new NC program in the **Program run, single block** or **Program run, full sequence** operating modes, the control automatically resets the **TCPM** function.

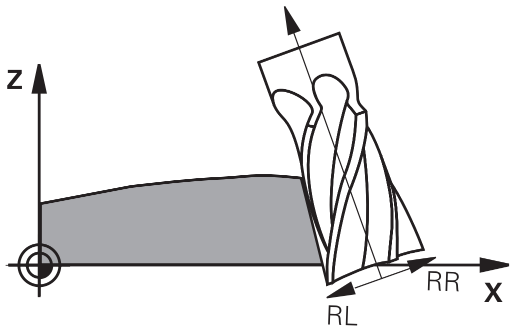
Example

...	
N250 FUNCTION RESET TCPM*	Resetting FUNCTION TCPM
...	

11.6 Peripheral Milling: 3-D radius compensation with M128 and radius compensation (G41/G42)

Application

In the case of peripheral milling, the control offsets the tool perpendicularly to the direction of motion and perpendicularly to the direction of the tool by the sum of the delta values **DR** (tool table and NC program). The direction of the compensation is defined with the radius compensation **G41/G42** (direction of movement: Y+).



For the control to be able to reach the set tool orientation, you need to activate the **M128** function and subsequently the tool radius compensation. The control then positions the rotary axes automatically in such a way that the tool can reach the orientation defined by the coordinates of the rotary axes with the active compensation.

Further information: "Retaining the position of the tool tip during the positioning of tilting axes (TCPM): M128 (option 9)", Page 403

Refer to your machine manual!

This function is only available with spatial angles. Your machine tool builder defines how these can be entered.

The control is not able to automatically position the rotary axes on all machines.

The control generally uses the defined **delta values** for 3-D tool compensation. The entire tool radius **R** + **DR**) is only taken into account if you have activated the **FUNCTION PROG PATH IS CONTOUR** function.

Further information: "Interpretation of the programmed path", Page 414

NOTICE

Danger of collision!

The rotary axes of a machine may have limited ranges of traverse, e.g. between -90° and +10° for the B head axis. Changing the tilt angle to a value of more than +10° may result in a 180° rotation of the table axis. There is a danger of collision during the tilting movement!

- Program a safe tool position before the tilting movement, if necessary.
- Carefully test the NC program or program section in the **Program run, single block** operating mode

You can define the tool orientation in a G01 block as described below.

Example: Definition of the tool orientation with M128 and the coordinates of the rotary axes

N10 G00 G90 X-20 Y+0 Z+0 B+0 C+0*	Pre-position
N20 M128*	Activate M128
N30 G01 G42 X+0 Y+0 Z+0 B+0 C+0 F1000*	Activate radius compensation
N40 X+50 Y+0 Z+0 B-30 C+0*	Position the rotary axis (tool orientation)

Interpretation of the programmed path

With the **FUNCTION PROG PATH** function, you decide whether the control will apply the 3-D radius compensation only to the delta values, just as before, or rather to the entire tool radius. If you activate **FUNCTION PROG PATH**, the programmed coordinates exactly correspond to the contour coordinates. With **FUNCTION PROG PATH OFF**, you deactivate this special interpretation.

Procedure

Proceed as follows for the definition:

SPEC FCT
- Show the soft key row with special functions

PROGRAM FUNCTIONS
- Press the **PROGRAM FUNCTIONS** soft key

FUNCTION PROG PATH
- Press the **FUNCTION PROG PATH** soft key

You have the following possibilities:

Soft key	Function
IS CONTOUR	Activate the interpretation of the programmed path as the contour The control takes the full tool radius **R + DR** and the full corner radius **R2 + DR2** into account for 3-D radius compensation.
OFF	Deactivate the special interpretation of the programmed path The control only uses the delta values **DR** and **DR2** for 3-D radius compensation.

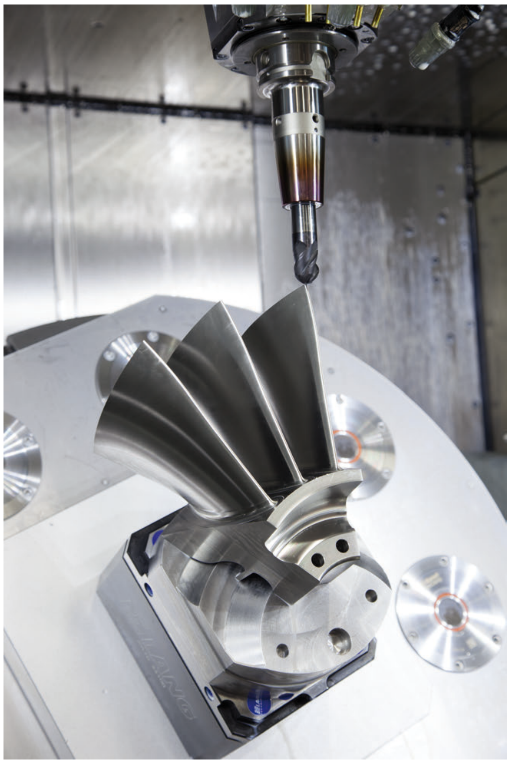
If you activate **FUNCTION PROG PATH**, the interpretation of the programmed path as the contour is effective for 3-D compensation movements until you deactivate the function.

11.7 Running CAM programs

If you create NC programs externally using a CAM system, you should pay attention to the recommendations detailed below. This will enable you to optimally use the powerful motion control functionality provided by the control and usually create better workpiece surfaces with shorter machining times. Despite high machining speeds, the control still achieves a very high contour accuracy. The basis for this is the HEROS 5 real-time operating system in conjunction with the **ADP** (Advanced Dynamic Prediction) function of the TNC 620. This enables the control to also efficiently process NC programs with high point densities.

From 3-D model to NC program

Here is a simplified description of the process for creating an NC program from a CAD model:



- **CAD: Model creation**
  Construction departments prepare a 3-D model of the workpiece to be machined. Ideally the 3-D model is designed for the center of tolerance.
- **CAM: Path generation, tool compensation**
  The CAM programmer specifies the machining strategies for the areas of the workpiece to be machined. The CAM system uses the surfaces of the CAD model to calculate the paths of the tool movements. These tool paths consist of individual points calculated by the CAM system so that each surface to be machined is approximated as nearly as possible while considering chord errors and tolerances. This way, a machine-neutral NC program is created, known as a CLDATA file (cutter location data). A postprocessor generates a machine- and control-specific NC program, which can be processed by the CNC control. The postprocessor is adapted according to the machine tool and the control. The postprocessor is the link between the CAM system and the CNC control.

> In the **BLK FORM FILE** syntax, you can integrate 3-D models in STL format as a workpiece blank and a finished part.
> **Further information:** "Defining the workpiece blank: G30/G31", Page 88

- **Control: Motion control, tolerance monitoring, velocity profile**
  The control uses the points defined in the NC program to calculate the movements of each machine axis as well as the required velocity profiles. Powerful filter functions then process and smooth the contour so that the control does not exceed the maximum permissible path deviation.
- **Mechatronics: Feed control, drive technology, machine tool**
  The motions and velocity profiles calculated by the control are realized as actual tool movements by the machine's drive system.

Considerations required for post processor configuration

Take the following points into account with post processor configuration:

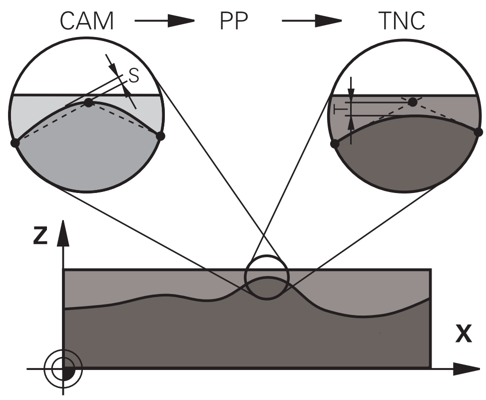
- Always set the data output for axis positions to at least four decimal places. This way you improve the quality of the NC data and avoid rounding errors, which can result in defects visible to the naked eye on the workpiece surface. Output of five decimal places may achieve improved surface quality for optical components as well as components with very large radii (i.e. small curvatures), for example molds for the automotive industry
- Always set the data output for the machining of surface normal vectors (LN blocks, only Klartext conversational programming) to exactly seven decimal places
- Avoid using successive incremental NC blocks because this may lead to the tolerances of the individual NC blocks being added together in the output
- Set the tolerance in Cycle **G62** so that in standard behavior it is at least twice as large as the chord error defined in the CAM system. Also note the information describing the functioning of Cycle **G62**
- If the chord error selected in the CAM program is too large, then, depending on the respective curvature of a contour, large distances between NC blocks can result, each with large changes of direction. During machining this leads to drops in the feed rate at the block transitions. Recurring and equal accelerations (i.e. force excitation), caused by feed-rate drops in the heterogeneous NC program, can lead to undesirable excitation of vibrations in the machine structure.
- You can also use arc blocks instead of linear blocks to connect the path points calculated by the CAM system. The control internally calculates circles more accurately than can be defined via the input format
- Do not output any intermediate points on exactly straight lines. Intermediate points that are not exactly on a straight line can result in defects visible to the naked eye on the workpiece surface
- There should be exactly one NC data point at curvature transitions (corners)
- Avoid sequences of many short block paths. Short paths between blocks are generated in the CAM system when there are large curvature transitions with very small chord errors in effect. Exactly straight lines do not require such short block paths, which are often forced by the continuous output of points from the CAM system
- Avoid a perfectly even distribution of points over surfaces with a uniform curvature, since this could result in patterns on the workpiece surface
- For 5-axis simultaneous programs: avoid the duplicated output of positions if they only differ in the tool’s angle of inclination
- Avoid the output of the feed rate in every NC block. This would negatively influence the control’s velocity profile

Useful configurations for the machine tool operator:

- In order to enable a realistic graphic simulation, use 3-D models in STL format as a workpiece blank and finished part
  Further information: "Defining the workpiece blank: G30/G31", Page 88
- In order to improve the structure of large NC programs, use the control's structuring function
  Further information: "Structuring NC programs", Page 192
- Use the control's commenting function in order to document NC programs
  Further information: "Adding comments", Page 188
- Use the comprehensive cycles of the control available for the machining of holes and simple pocket geometries
  Further information: User's Manual for **Programming of Machining Cycles**
- For fits, output the contours with **RL/RR** tool radius compensation. This makes it easy for the machine operator to make necessary compensations
  Further information: "Tool compensation", Page 128
- Separate feed rates for pre-positioning, machining, and downfeeds, and define them via Q parameters at the beginning of the program

Please note the following for CAM programming

Adapting chord errors



Programming notes:

- For finishing operations, do not set the chord error in the CAM system to a value greater than 5 µm. In Cycle **G62**, use an appropriate tolerance factor **T** of 1.3 to 3.
- For roughing operations, the total of the chord error and the tolerance **T** must be less than the defined machining oversize. In this way you can avoid contour damage.
- The specific values depend upon the dynamics of your machine.

Adapt the chord error in the CAM program, depending on the machining:

- **Roughing with preference for speed:**
  Use higher values for the chord error and the matching tolerance value in Cycle **G62**. Both values depend on the oversize required on the contour. If a special cycle is available on your machine, use the roughing mode. In roughing mode the machine generally moves with high jerk values and high accelerations
  - Normal tolerance in Cycle **G62**: Between 0.05 mm and 0.3 mm
  - Normal chord error in the CAM system: Between 0.004 mm and 0.030 mm
- **Finishing with preference for high accuracy:**
  Use smaller values for the chord error and a matching low tolerance in Cycle **G62**. The data density must be high enough for the control to detect transitions and corners exactly. If a special cycle is available on your machine, use the finishing mode. In finishing mode the machine generally moves with low jerk values and low accelerations
  - Normal tolerance in Cycle **G62**: Between 0.002 mm and 0.006 mm
  - Normal chord error in the CAM system: Between 0.001 mm and 0.004 mm
- **Finishing with preference for high surface quality:**
  Use small values for the chord error and a matching larger tolerance in Cycle **G62**. The control is then able to better smooth the contour. If a special cycle is available on your machine, use the finishing mode. In finishing mode the machine generally moves with low jerk values and low accelerations
  - Normal tolerance in Cycle **G62**: Between 0.010 mm and 0.020 mm
  - Normal chord error in the CAM system: Approx. 0.005 mm

Further adaptations

Take the following points into account with CAM programming:

- For slow machining feed rates or contours with large radii, define the chord error to be only one-third to one-fifth of tolerance **T** in Cycle **G62**. Additionally, define the maximum permissible point spacing to be between 0.25 mm and 0.5 mm. The geometry error or model error should also be specified to be very small (max. 1 µm).
- Even at higher machining feed rates, point spacings of greater than 2.5 mm are not recommended for curved contour areas
- For straight contour elements, one NC point at the beginning of a line and one NC point at the end suffice. Avoid the output of intermediate positions
- In programs with five axes moving simultaneously, avoid large changes in the ratio of path lengths in linear and rotational blocks. Otherwise large reductions in the feed rate could result at the tool reference point (TCP)
- The feed-rate limitation for compensating movements (e.g. via **M128 F...**) should be used only in exceptional cases. The feed-rate limitation for compensating movements can cause large reductions in the feed rate at the tool reference point (TCP).
- NC programs for 5-axis simultaneous machining with spherical cutters should preferably be output for the center of the sphere. The NC data are then generally more uniform. In Cycle **G62**, you can additionally set a higher rotary axis tolerance **TA** (e.g., between 1° and 3°) for an even more constant feed-rate curve at the tool center point (TCP).
- For NC programs for 5-axis simultaneous machining with toroid cutters or spherical cutters, where the NC output is for the south pole of the sphere, choose a lower rotary axis tolerance. 0.1° is a typical value. However, the maximum permissible contour damage is the decisive factor for the rotational axis tolerance. This contour damage depends on the possible tool tilting, tool radius and contact depth of the tool.
  With 5-axis gear hobbing with an end mill you can calculate the maximum possible contour damage T directly from the cutter contact length L and permissible contour tolerance TA:
  T ~ K x L x TA K = 0.0175 [1/°]
  Example: L = 10 mm, TA = 0.1°: T = 0.0175 mm

Possibilities for intervention on the control

Cycle **G62 TOLERANCE** is available for influencing the behavior of CAM programs directly on the control. Please note the information describing the functioning of Cycle **G62**. Also note the interactions with the chord error defined in the CAM system.

Further information: User's Manual for **Programming of Machining Cycles**

> Refer to your machine manual!
>
> Some machine tool builders provide an additional cycle for adapting the behavior of the machine to the respective machining operation (e.g., Cycle **G332** Tuning). Cycle **G332** can be used to modify filter settings, acceleration settings, and jerk settings.

Example

```
N340 G62 T0.05 P01 1 P02 3*
```

ADP motion control

> This function must be enabled and adapted by the machine tool builder.

An insufficient quality of data in NC programs created on CAM systems frequently causes inferior surface quality of the milled workpieces. The **ADP** (Advanced Dynamic Prediction) feature expands the conventional look-ahead of the permissible maximum feed rate profile and optimizes the motion control of the feed axes during milling. This enables clean surfaces with short machining times to be cut, even with a strongly fluctuating distribution of points in adjacent tool paths. This significantly reduces or eliminates the reworking complexity.

These are the most important benefits of ADP:

- Symmetrical feed-rate behavior on forward and backward paths with bidirectional milling
- Uniform feed rate curves with adjacent cutter paths
- Improved reaction to negative effects (e.g. short, step-like contours, coarse chord tolerances, heavily rounded block end-point coordinates) in NC programs generated by CAM systems
- Precise compliance to dynamic characteristics even in difficult conditions

12

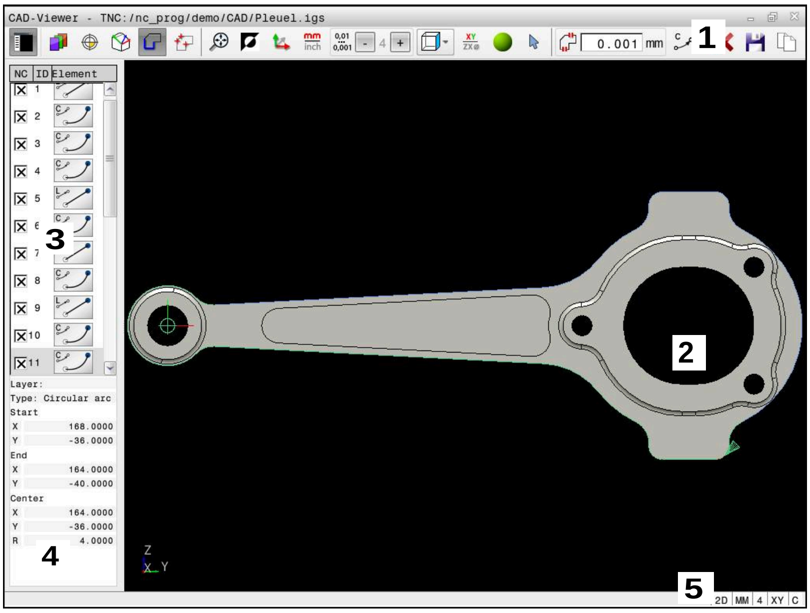
Data transfer from CAD files

12.1 Screen layout of the CAD viewer

Fundamentals of the CAD viewer

Screen display

When you open the **CAD-Viewer**, the following screen layout is displayed:



1 Menu bar
2 Graphics window
3 List View window
4 Element Information window
5 Status bar

File types

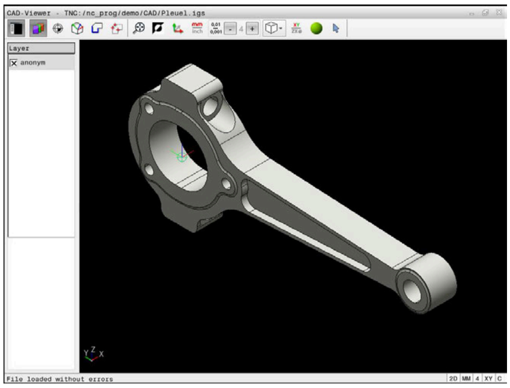
The **CAD-Viewer** enables you to open standardized CAD data formats directly on the control.

The control displays the following file types:

File	Type	Format
Step	.STP and .STEP	■ AP 203 ■ AP 214
IGES	.IGS and .IGES	■ Version 5.3
DXF	.DXF	■ R10 to 2015

12.2 CAD Import (option 42)

Application



> If the control is set to ISO, the extracted contours or machining positions are nevertheless output as Klartext programs in **.H** conversational format.

You can open CAD files directly on the control in order to extract contours and machining positions from it. You can then store them as Klartext programs or as point files. Klartext programs acquired in this manner can also be run on older HEIDENHAIN controls, since these contour programs contain only **L** and **CC**/**C** blocks.

> As an alternative to **CC** or **C** blocks, you can configure circular movements to be output as **CR** blocks.
>
> **Further information:** "Basic settings", Page 425

If you process files in **Programming** mode, then the control generates contour programs with the file extension **.H** and point files with the extension **.PNT** by default. You can select the file type in the save dialog.

To insert a selected contour or a selected machining position directly into an NC program, use the control's clipboard. Using the clipboard, you can even transfer the contents to the additional tools (e.g., **Leafpad** or **Gnumeric**).

> Operating notes:
>
> - Before loading the file into the control, ensure that the name of the file contains only permitted characters. **Further information:** "File names", Page 102
> - The control does not support binary DXF format. Save the DXF file in ASCII format in the CAD or drawing program.

Using the CAD viewer

> To use the **CAD-Viewer** without a touchscreen, you have to use a mouse or touchpad.

The **CAD-Viewer** runs as a separate application on the third desktop of the control. This enables you to use the screen switchover key to switch between the machine operating modes, the programming modes, and the **CAD-Viewer**. This is particularly useful if you want to add contours or machining positions to a Klartext program using the clipboard.

> If you are using a TNC 620 with touch control, you can replace some keystrokes with gestures.
>
> **Further information:** "Operating the touchscreen", Page 459

Opening the CAD file

- Press the **Programming** key

PGM MGT

- Press the **PGM MGT** key
- > The control opens the file manager.

SELECT TYPE

- Press the **SELECT TYPE** soft key
- > The control displays the selectable file formats.

SHOW CAD

- Press the **SHOW CAD** soft key
- Alternative: Press the **SHOW ALL** soft key

SELECT

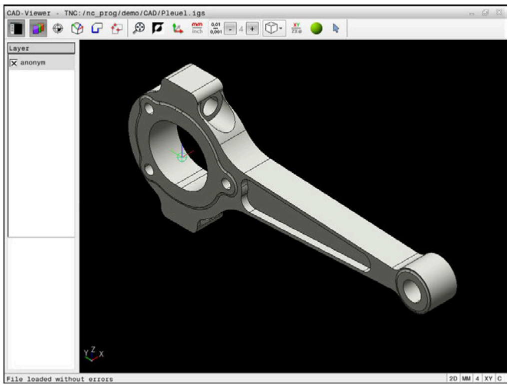
- Select the directory in which the CAD file is saved
- Select the desired CAD file

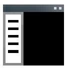
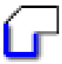
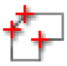
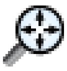
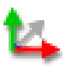
ENT

- Press the **ENT** key
- > The control starts the **CAD-Viewer** and shows the file contents on the screen. The control displays the layers in the List View window and the drawing in the Graphics window.

Basic settings

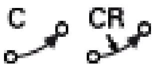
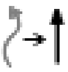
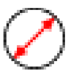
The basic settings specified below are selected using the icons in the header bar.



Icon	Setting
	Show or hide the List View window in order to expand the Graphics window
	Display of the various layers
	Set preset, with optional selection of the plane
	Set datum, with optional selection of the plane
	Select contour
	Select drilling positions
	Set the zoom to the largest possible rendering of the entire graphical representation
	Switch background color (black or white)
	Switch between 2-D and 3-D mode. The active mode is highlighted in color
mm inch	Set the unit of measure (**mm** or **inch**) for the file. The control then outputs the contour program and the machining positions in this unit of measure. The active unit of measure is highlighted in red
0,01 ... 0,001	Select the resolution. The resolution defines the number of decimal places and the number of positions for linearization. Default setting: 4 decimal places with **mm**, and 5 decimal places with **inch** as the unit of measure ℹ The **CAD-Viewer** linearizes all of the contours that are not in the XY plane. The finer the resolution, the more accurately the control will display the contours.
	Switch between various views of the model e.g. **Top**

Icon	Setting
	"Select, add, or remove contour elements" mode The icon shows the current mode. Clicking the icon activates the next mode.

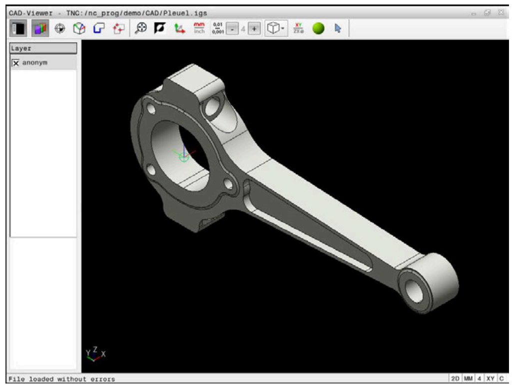
The control displays the following icons only in certain modes.

Icon	Setting
	The most recent step is undone.
	Contour transfer mode: The tolerance specifies how far apart neighboring contour elements may be from each other. You can use the tolerance to compensate for inaccuracies that occurred when the drawing was made. The default setting is 0.001 mm
	Arc mode: Arc mode defines whether circular arcs are output in C format or CR format (e.g., for cylinder surface interpolation) in the NC program.
	Point transfer mode: Specifies whether the control should display the tool path as a dashed line during the selection of machining positions
	Path optimization mode: The control optimizes the tool traverse movement so that there are shorter traverse movements between the machining positions. When the icon is pressed again, the optimization is reset
	Hole position mode: The control opens a pop-up window in which you can filter holes (full circles) based on their size

Operating notes:

- Set the correct unit of measure, because the CAD file does not contain this information.
- When creating NC programs for earlier control models, you must limit the resolution to three decimal places. In addition, you must remove the comments that the **CAD-Viewer** outputs into the contour program.
- The control displays the active basic settings in the status bar of the screen.

Setting layers



CAD files usually contain several layers. The designer uses these layers to create groups of various types of elements, e.g. the actual workpiece contour, dimensions, auxiliary and design lines, shadings, and texts.

Hiding unneeded layers makes the graphics easier to read and facilitates the extraction of the required information.

> Operating notes:
> - The CAD file to be processed must contain at least one layer. Elements not assigned to a layer are automatically moved by the control to the anonymous layer.
> - You can even select a contour if the designer has saved the lines on different layers.
> - If you double-click a layer, the control switches to Contour Transfer mode and selects the first contour element that was drawn. The control highlights the other selectable elements of this contour in green. Especially in case of contours with many short elements, this procedure spares you the effort of running a manual search for the beginning of a contour.

When you open a CAD file in the **CAD-Viewer**, all layers available are shown.

Hiding a layer

To hide a layer, proceed as follows:

- ▶ Select the **SET LAYER** function
- > In the List View window the control shows all layers contained in the active CAD file.
- ▶ Select the desired layer
- ▶ Select the check box to deactivate it
- ▶ Alternatively, use the space key
- > The control hides the selected layer.

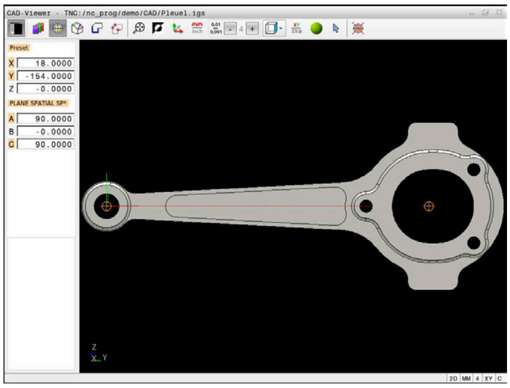
Showing a layer

To show a layer, proceed as follows:

- ▶ Select the **SET LAYER** function
- > In the List View window the control shows all layers contained in the active CAD file.
- ▶ Select the desired layer
- ▶ Select the check box to activate it
- ▶ Alternatively, use the space key
- > The control marks the selected layer in the List View with an ×.
- > The selected layer is shown.

Setting a preset

The datum of the drawing in the CAD file is not always located in a manner that lets you use it as a workpiece preset. Therefore, the control provides a function with which you can shift the workpiece preset to a suitable location by clicking an element. You can also define the orientation of the coordinate system.



You can position the preset at the following locations:

- By directly inputting numerical values into the List View window
- For straight lines:
  - Starting point
  - Center
  - End point
- For circular arcs:
  - Starting point
  - Center
  - End point
- For full circles:
  - At the quadrant transitions
  - At the center
- At the intersection between:
  - Two straight lines, even if the point of intersection is actually on the extension of one of the lines
  - Straight line and circular arc
  - Straight line and full circle
  - Two circles (regardless of whether a circular arc or a full circle)

> Operating note:
> You can change the preset even after you have selected the contour. The control does not calculate the actual contour data until you save the selected contour in a contour program.

NC syntax

The preset and optional orientation are inserted in the NC program as a comment starting with **origin**.

```
4 ;orgin = X... Y... Z...
5 ;orgin_plane_spatial = SPA... SPB... SPC...
```

Setting a preset on a single element

To set a preset on a single element, proceed as follows:

- ▶ Select the mode for setting a preset
- ▶ Place the mouse pointer on the desired element
- > The control indicates possible locations for the preset on the selected element with stars.
- ▶ Select the star symbol that matches the desired preset position
- ▶ If necessary, use the zoom function
- > The control sets the preset symbol at the selected location.
- ▶ In addition, align the coordinate system as needed
  Further information: "Adjusting the orientation of the coordinate system", Page 430

Setting a preset at the intersection between two elements

To set a preset at the intersection between two elements, proceed as follows:

- ▶ Select the mode for setting a preset
- ▶ Select the first element (straight line, full circle, or circular arc) using the left mouse button
- > The control highlights the element.
- ▶ Select the second element (straight line, circle, or circular arc) using the left mouse button
- > The control sets the preset symbol on the intersection.
- ▶ In addition, align the coordinate system as needed
  Further information: "Adjusting the orientation of the coordinate system", Page 430

Operating notes:

- If there are several possible intersections, the control selects the intersection nearest the mouse-click on the second element.
- If two elements do not intersect directly, the control automatically calculates the intersection of their extensions.
- If the control cannot calculate an intersection, it deselects the previously selected element.

Once a preset has been set, the control displays the preset icon with a yellow quadrant .

Use the following icon to delete a preset that has been set .

Adjusting the orientation of the coordinate system

The following conditions must be met in order to align the coordinate system:

- Preset has been defined
- There are elements next to the preset that can be used for the desired alignment

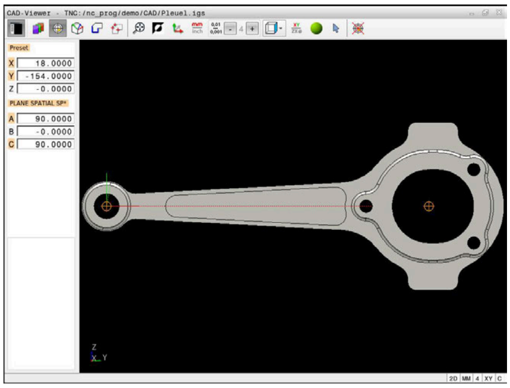
The position of the coordinate system is defined by the orientation of the axes.

To align the coordinate system, proceed as follows:

- ▶ Select an element located in the positive X direction using the left mouse button
- > The control aligns the X axis.
- > The control changes the angle in C.
- ▶ Select an element located in the positive Y direction using the left mouse button
- > The control aligns the Y and Z axes.
- > The control changes the angles in A and C.

> For angles not equal to 0, the control shows the List View in orange.

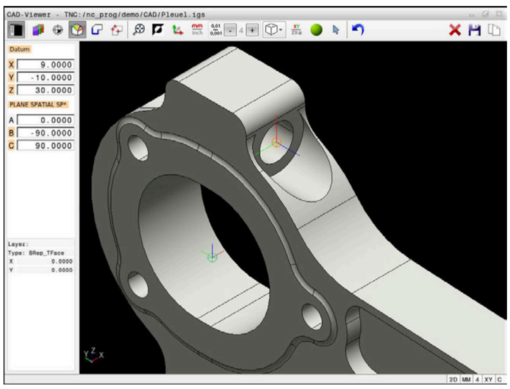
Element information



The control displays information about the element on the left of the window:

- Distance between the defined preset and the drawing datum
- Orientation of the coordinate system with respect to the drawing

Setting the datum



The workpiece preset is not always located in a manner that lets you machine the entire part. Therefore, the control has a function with which you can define a new datum and a tilting operation.

The datum with the orientation of the coordinate system can be set at the same positions as a preset.

Further information: "Setting a preset", Page 428

NC syntax

The datum and its optional orientation can be inserted as NC block or comments in the NC program by using the **TRANS DATUM AXIS** function for the datum and the **PLANE SPATIAL** function for the orientation.

If you define only one datum and its orientation, then the control inserts the functions in the NC program as an NC block.

```
4 TRANS DATUM AXIS X... Y... Z...
5 PLANE SPATIAL SPA... SPB... SPC... TURN MB MAX FMAX
```

If you additionally select contours or points, then the control inserts the functions in the NC program as comments.

```
4 ;TRANS DATUM AXIS X... Y... Z...
5 ;PLANE SPATIAL SPA... SPB... SPC... TURN MB MAX FMAX
```

Setting the datum on a single element

To set the datum on a single element, proceed as follows:

- ▶ Select the mode for specifying the datum
- ▶ Place the mouse pointer on the desired element
- > The control indicates possible locations for the datum on the selected element with stars.
- ▶ Select the star symbol that matches the desired datum position
- ▶ If necessary, use the zoom function
- > The control sets the datum icon at the selected location.
- ▶ In addition, align the coordinate system as needed
  Further information: "Adjusting the orientation of the coordinate system", Page 432

Setting a datum at the intersection between two elements

To set a datum at the intersection between two elements, proceed as follows:

- ▶ Select the mode for specifying the datum
- ▶ Select the first element (straight line, full circle, or circular arc) using the left mouse button
- > The control highlights the element.
- ▶ Select the second element (straight line, circle, or circular arc) using the left mouse button
- > The control sets the datum icon on the point of intersection.
- ▶ In addition, align the coordinate system as needed
  Further information: "Adjusting the orientation of the coordinate system", Page 432

> Operating notes:
> - If there are several possible intersections, the control selects the intersection nearest the mouse-click on the second element.
> - If two elements do not intersect directly, the control automatically calculates the intersection of their extensions.
> - If the control cannot calculate an intersection, it deselects the previously selected element.

Once a datum has been set, the control displays the datum icon with a yellow surface.

Use the following icon to delete a datum that has been set ✕.

Adjusting the orientation of the coordinate system

The following conditions must be met in order to align the coordinate system:

- The datum has been set
- There are elements next to the preset that can be used for the desired alignment

The position of the coordinate system is defined by the orientation of the axes.

To align the coordinate system, proceed as follows:

- ▶ Select an element located in the positive X direction using the left mouse button
- > The control aligns the X axis.
- > The control changes the angle in C.
- ▶ Select an element located in the positive Y direction using the left mouse button
- > The control aligns the Y and Z axes.
- > The control changes the angles in A and C.

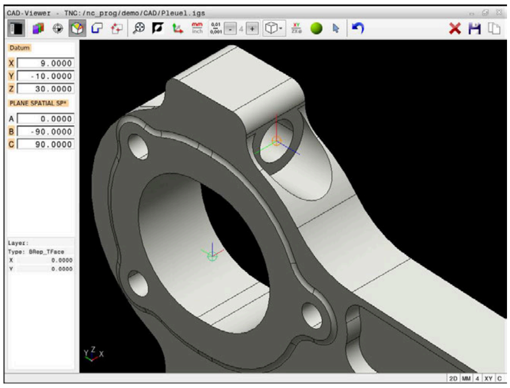
> For angles not equal to 0, the control shows the List View in orange.

Element information

In the Element Information window, the control displays how far away the datum you selected is from the workpiece preset.

The control displays information about the element on the left of the window:

- Distance between the datum that has been set and the workpiece preset
- Orientation of the coordinate system

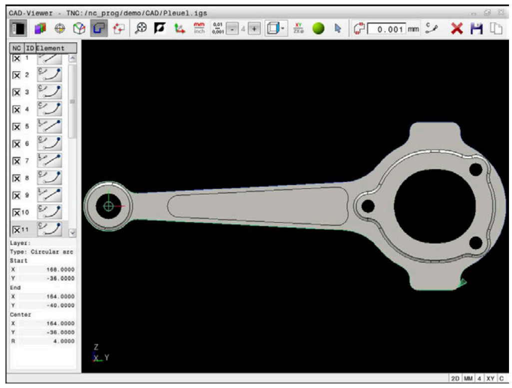


> You can further shift the datum manually after it has been set. To do so, enter the desired axis values into the coordinate field.

Selecting and saving a contour

Operating notes:

- This function is not available if option 42 is not enabled.
- Specify the direction of rotation during contour selection so that it matches the desired machining direction.
- Select the first contour element such that approach without collision is possible.
- If the contour elements are very close to one another, use the zoom function.



The following elements can be selected as a contour:

- Line segment
- Circle
- Circular arc
- Polyline
- Any curves (e.g., splines, ellipses)

Element information

In the Element Information window the control displays a range of information about the last contour element you selected in the List View window or in the Graphics window.

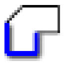
- **Layer**: specifies the active plane
- **Type**: specifies the type of element (e.g., line)
- **Coordinates**: specify the starting point and end point of an element, and the circle center and radius where appropriate

Ensure that the unit of measure used in the NC program matches with that used in the **CAD-Viewer**. Elements that have been copied from the **CAD-Viewer** to the clipboard do not contain any information about the unit of measure.

Select contour

> Operating note:
> If you double-click a layer in the list view window, the control switches to Contour Transfer mode and selects the first contour element that was drawn. The control highlights the other selectable elements of this contour in green. Especially in case of contours with many short elements, this procedure spares you the effort of running a manual search for the beginning of a contour.

To select a contour using available contour elements, proceed as follows:



- ▶ Select the contour selection mode
- ▶ Place the mouse pointer on the desired element
- > The control displays the suggested direction of rotation as a dashed line.
- ▶ If you need to change the direction of rotation, move the mouse pointer towards the opposite end point
- ▶ Select the element using the left mouse button
- > The selected contour element turns blue.
- > The control shows the other selectable elements in green.

> For branched contours, the control chooses the path with the smallest directional deviation. The control provides an additional mode that allows you to modify the suggested contour path.
> **Further information:** "Creating contour paths independent of available contour elements", Page 437

- ▶ Select the last green element of the desired contour using the left mouse button
- > The control changes the color of all selected elements to blue.
- > In the List View, all selected elements are given a check mark in the column **NC**.

Saving a contour

> Operating notes:
> - The control also transfers two workpiece-blank definitions (**BLK FORM**) to the contour program. The first definition contains the dimensions of the entire CAD file. The second one, which is the active one, contains only the selected contour elements, so that an optimized size of the workpiece blank results.
> - The control only saves elements that have been selected (blue elements), which means that they have been given a check mark in the List View window.

To save a selected contour, proceed as follows:

- ▶ Select the Save icon
- > The control prompts you to select the target directory, a file name, and the file type.
- ▶ Enter this information

ENT

- ▶ Confirm your input
- > The control saves the contour program.
- ▶ Alternative: Copy the selected contour elements to the clipboard

> Ensure that the unit of measure used in the NC program matches with that used in the **CAD-Viewer**. Elements that have been copied from the **CAD-Viewer** to the clipboard do not contain any information about the unit of measure.

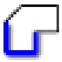
Deselecting the contour

To deselect the selected contour elements, proceed as follows:

- ▶ Select the Clear function to deselect all elements
- ▶ Alternative: Select individual elements by clicking them with the left mouse button while holding the **CTRL** key

Creating contour paths independent of available contour elements

To select any contours by using the end point, center, or transition points, proceed as follows:



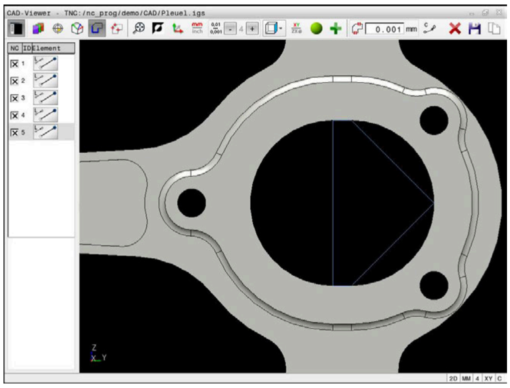
- ▶ Select the contour selection mode

- ▶ Activate the "Add contour elements" mode
- > The control displays the following icon:

- ▶ Place the mouse pointer on the contour element
- > The control displays selectable points.

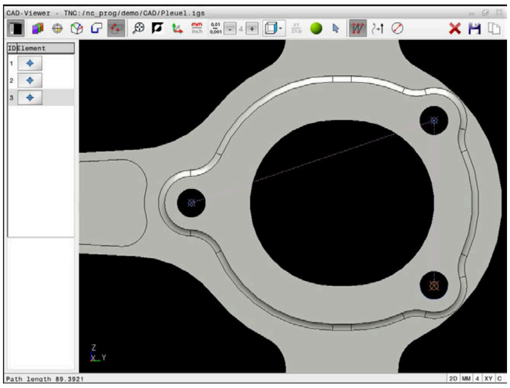
> Selectable points:
> - End point or midpoint of a line or curve
> - Quadrant transitions or center of a circle
> - Points of intersection between existing elements

- ▶ Select the starting point as needed
- ▶ Select the starting element
- ▶ Select the subsequent element
- ▶ Alternative: Select any selectable point
- > The control creates the desired contour path.



> Operating notes:
> - The contour paths available depend on the selectable contour elements that are shown in green. Without the green elements, the control will display all solutions available. To remove the proposed contour path, select the first green element by pressing the left mouse button while holding the **CTRL** key down. As an alternative, you can switch to the Remove mode:
>
> - If the contour element to be extended or shortened is a straight line, the control will extend or shorten the contour element along the same line. If the contour element to be extended or shortened is a circular arc, the control will extend or shorten the contour element along the same arc.

Selecting and saving machining positions



Operating notes:
- This function is not available if option 42 is not enabled.
- If the contour elements are very close to one another, use the zoom function.
- If required, configure the basic settings so that the control shows the tool paths. **Further information:** "Basic settings", Page 425

Three possibilities are available in the pattern generator for defining machining positions:
- Single selection: You select the desired machining positions by clicking them individually with the mouse
  Further information: "Single selection", Page 439
- Multiple selection by drag box: You select multiple machining positions by dragging a box around them with the mouse
  Further information: "Multiple selection by drag box", Page 439
- Multiple selection by search filter: You select all machining positions within a definable diameter range
  Further information: "Multiple selection by search filter", Page 440

Machining positions are deselected, deleted, or saved in the same manner as contour elements.

Selecting the file type

The following file types are available:
- Point table (**.PNT**)
- Klartext conversational language program (**.H**)

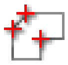
If you save the machining positions to a Klartext program, the control creates a separate linear block with a cycle call for every machining position (**L X... Y... Z... F MAX M99**).

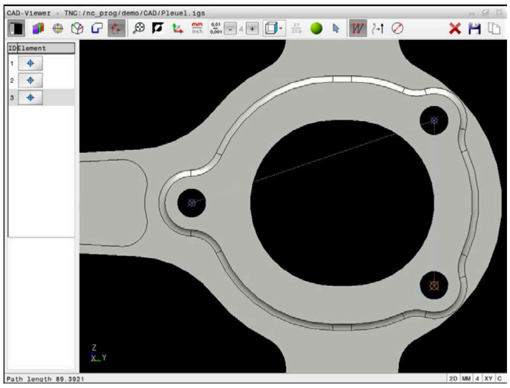
The NC syntax used allows you to export NC programs generated by CAD import to old HEIDENHAIN controls and run them there.

The point tables (.**PNT**) of the TNC 620 and iTNC 530 are not compatible. Transferring a point table to and running it on the other control model leads to problems and unpredictable behavior.

Single selection

To select individual machining positions, proceed as follows:

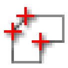


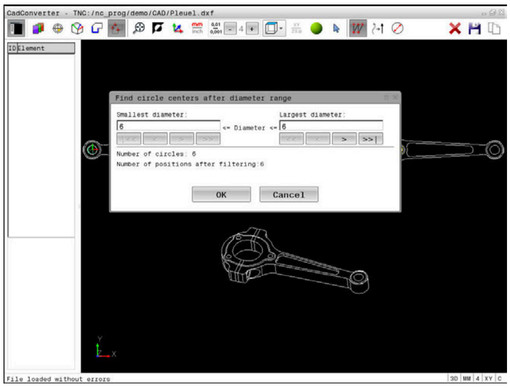


- ▶ Select the mode for choosing a machining position
- ▶ Place the mouse pointer on the desired element
- > The control displays the selectable element in orange.
- ▶ Select the circle center as machining position
- ▶ Alternative: Select the circle or a circle segment
- > The control loads the selected machining position into the List View window.

Multiple selection by drag box

To select multiple machining positions by dragging a box around them, proceed as follows:



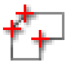


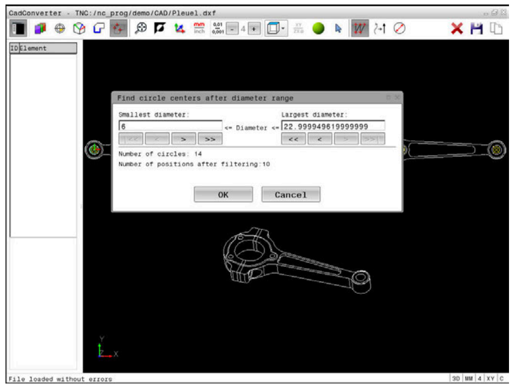
- ▶ Select the mode for choosing a machining position
- ▶ Activate the Add function
- > The control displays the following icon:

- ▶ Drag a box around the desired area while holding down the left mouse button
- > The control displays the minimum and maximum diameter in a pop-up window.
- ▶ Change the filter settings as needed
  Further information: "Filter settings", Page 440
- ▶ Confirm the diameter range with **OK**
- > The control loads all machining position within the selected diameter range into the List View window.

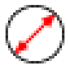
Multiple selection by search filter

To select multiple machining positions by search filter, proceed as follows:



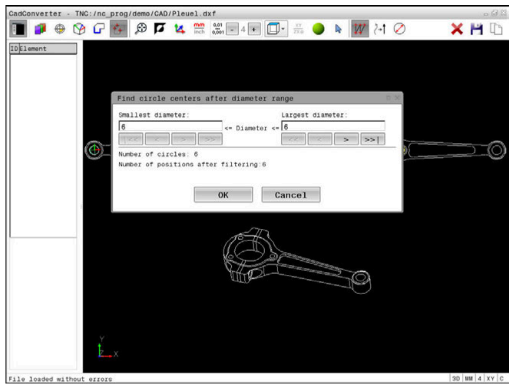


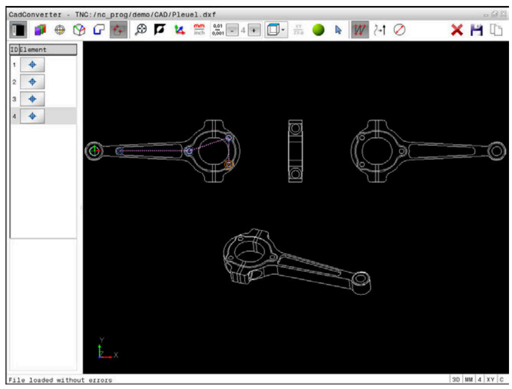
- Select the mode for choosing a machining position



- Activate the search filter
- > The control displays the minimum and maximum diameter in a pop-up window.
- Change the filter settings as needed **Further information:** "Filter settings", Page 440
- Confirm the diameter range with **OK**
- > The control loads all machining position within the selected diameter range into the List View window.

Filter settings





After you have used the quick selection function to mark hole positions, a pop-up window appears in which the smallest diameter found is to the left and the largest diameter to the right. With the buttons just below the diameter display you can adjust the diameter so that you can load the hole diameters that you want.

The following buttons are available:

Icon	Filter setting of smallest diameter
I<<	Display the smallest diameter found (default setting)
<	Display the next smaller diameter found
>	Display the next larger diameter found
>>	Display the largest diameter found. The control sets the filter for the smallest diameter to the value set for the largest diameter

Icon	Filter setting of largest diameter
<<	Display the smallest diameter found. The control sets the filter for the largest diameter to the value set for the smallest diameter
<	Display the next smaller diameter found
>	Display the next larger diameter found
>>I	Display the largest diameter found (default setting)

You can display the tool paths using the **SHOW TOOL PATH** icon.

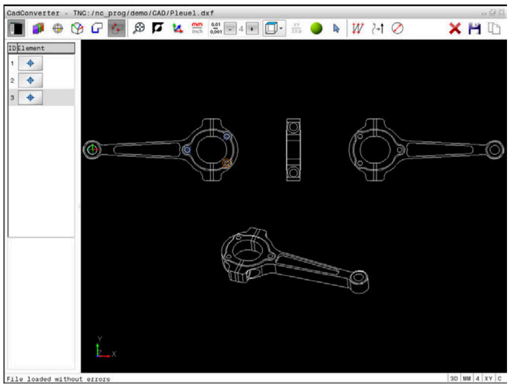
Further information: "Basic settings", Page 425

Element information

In the Element Information window, the control displays the coordinates of the last machining position selected.

You can also use the mouse to change the turning graphic. The following functions are available:

- To rotate the graphic move the mouse while holding down the right mouse button.
- To shift the displayed model, hold down the center mouse button or the mouse wheel (depending on your mouse model), and move the mouse.
- To zoom in on a certain area mark a zoom area by holding the left mouse button down
- To rapidly zoom in or out rotate the mouse wheel backwards or forwards
- To restore the standard view, double-click with the right mouse button



13

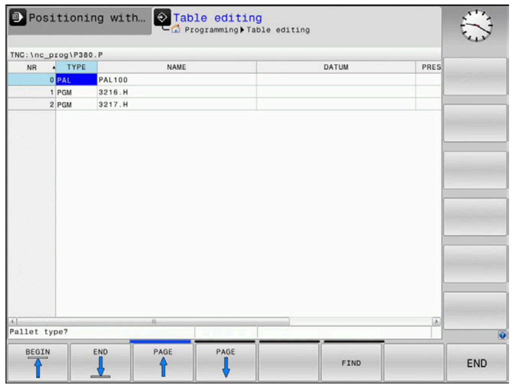
Pallets

13.1 Pallet management (option number 22)

Application

Refer to your machine manual!

Pallet table management is a machine-dependent function. The standard functional range is described below.



Pallet tables (**.p**) are mainly used in machining centers with pallet changers. The pallet tables call the different pallets (PAL), fixtures (FIX) optionally, and the associated NC programs (PGM). The pallet tables activate all defined presets and datum tables.

Without a pallet changer you can use pallet tables to process NC programs with different presets in sequence with just one press of **NC Start**.

The file name of a pallet table must always begin with a letter.

Columns of the pallet table

The machine tool builder defines a pallet table prototype that opens automatically when you create a pallet table.

The prototype can include the following columns:

Column	Meaning	Field type
NR	The control creates the entry automatically. The entry is required for the input field **Line number** of the **BLOCK SCAN** function.	Mandatory field
TYPE	The control differentiates between the following entries ■ **PAL** Pallet ■ **FIX** Fixture ■ **PGM** NC program Select the entries using the **ENT** key and the arrow keys or by soft key.	Mandatory field
NAME	File name The machine tool builder specifies the names for pallets and fixtures, if applicable, whereas you define program names. You must specify the complete path if the NC program is not saved in the directory of the pallet table.	Mandatory field
DATUM	Datum You must specify the complete path if the datum table is not saved in the folder of the pallet table. You activate datums from a datum table in the NC program using Cycle **G53**.	Optional field This entry is only required if a datum table is used.
PRESET	Workpiece preset Enter the preset number of the workpiece.	Optional field

Column	Meaning	Field type
LOCATION	Location of the pallet The entry **MA** indicates that there is a pallet or fixture in the working space of the machine and can be machined. Press the **ENT** key to enter **MA**. Press the **NO ENT** key to remove the entry and thus suppress machining.	Optional field If the column exists, the entry is mandatory.
LOCK	Line locked Using an * you can exclude the line of the pallet table from processing. Press the **ENT** key to identify the line with the entry *. Press the **NO ENT** key to cancel the lock. You can lock the execution for individual NC programs, fixtures or entire pallets. Unlocked lines (e.g. PGM) in a locked pallet are also not executed.	Optional field
PALPRES	Number of the pallet preset	Optional field This entry is only required if pallet presets are used.
W-STATUS	Execution status	Optional field This entry is only required for tool-oriented machining.
METHOD	Machining method	Optional field This entry is only required for tool-oriented machining.
CTID	ID for mid-program startup	Optional field This entry is only required for tool-oriented machining.
SP-X, SP-Y, SP-Z	Clearance height in the linear axes X, Y, and Z	Optional field
SP-A, SP-B, SP-C	Clearance height in the rotary axes A, B, and C	Optional field
SP-U, SP-V, SP-W	Clearance height in the parallel axes U, V, and W	Optional field
DOC	Comment	Optional field

You can remove the **LOCATION** column if you are only using pallet tables in which the control is to machine all lines.

Further information: "Inserting or deleting columns", Page 447

Editing a pallet table

When you create a new pallet table, it is empty at first. Using the soft keys, you can insert and edit lines.

Soft key	Editing function
BEGIN	Select the table start
END	Select the table end
PAGE	Select the previous page in the table
PAGE	Select the next page in the table
INSERT LINE	Insert as last line in the table
DELETE LINE	Delete the last line in the table
APPEND N LINES AT END	Add several lines at end of table
COPY FIELD	Copy the current value
PASTE FIELD	Insert the copied value
BEGIN LINE	Select beginning of line
END LINE	Select end of line
FIND	Find text or value
SORT/ HIDE COLUMNS	Sort or hide table columns
EDIT CURRENT FIELD	Edit the current field
SORT	Sort by column contents
MORE FUNCTIONS	Miscellaneous functions, e.g. saving
SELECT	Open file path selection

Selecting a pallet table

Proceed as follows to select a pallet table or create a new pallet table:

- Switch to the **Programming** operating mode or a program run operating mode
- Press the **PGM MGT** key

If no pallet tables are shown:

- Press the **SELECT TYPE** soft key
- Press the **SHOW ALL** soft key
- Select a pallet table with the arrow keys, or enter a name for a new pallet table (**.p**)
- Press the **ENT** key

> You can select either a list view or form view using the **Screen Layout** key.

Inserting or deleting columns

> This function is not enabled until the code number **555343** is entered.

Depending on the configuration, a newly created pallet table may not contain all columns. For tool-oriented machining, for example, you need columns that you have to insert first.

To insert a column in an empty pallet table, proceed as follows:

- Open the pallet table
- Press the **MORE FUNCTIONS** soft key
- Press the **EDIT FORMAT** soft key
- > The control opens a pop-up window displaying the available columns
- Using the arrow keys, select the desired column.
- Press the **INSERT COLUMN** soft key
- Press the **ENT** key

You can remove the column with the **DELETE COLUMN** soft key.

Fundamentals of tool-oriented machining

Application

Refer to your machine manual!

Tool-oriented machining is a machine-dependent function. The standard functional range is described below.

Tool-oriented machining allows you to machine several workpieces together even on a machine without pallet changer, which reduces tool-change times.

Limitation

NOTICE

Danger of collision!

Not all pallet tables and NC programs are suitable for tool-oriented machining. With tool-oriented machining, the control no longer executes the NC programs continuously, but divides them at the tool calls. The division of the NC programs allows functions that were not reset to be effective across programs (machine states). This leads to a danger of collision during machining!

- Consider the stated limitations
- Adapt pallet tables and NC programs to the tool-oriented machining
  - Reprogram the program information after each tool in every NC program (e.g. **M3** or **M4**).
  - Reset special functions and miscellaneous functions before each tool in every NC program (e. g., **Tilt the working plane** or **M138**)
- Carefully test the pallet table and associated NC programs in the **Program run, single block** operating mode

The following functions are not permitted:

- FUNCTION TCPM, M128
- M144
- M101
- M118
- Changing the pallet preset

The following functions require special attention, particularly for mid-program startup:

- Changing the machine statuses with a miscellaneous function (e.g. M13)
- Writing to the configuration (e.g. WRITE KINEMATICS)
- Traverse range switchover
- Cycle **G62**
- Tilting the working plane

Pallet table columns for tool-oriented machining

Unless the machine tool builder has made a different configuration, you need the following additional columns for tool-oriented machining:

Column	Meaning
W-STATUS	The machining status defines the machining progress. Enter BLANK for an unmachined (raw) workpiece. The control changes this entry automatically during machining. The control differentiates between the following entries ■ BLANK / no entry: Workpiece blank, requires machining ■ INCOMPLETE: Partly machined, requires further machining ■ ENDED: Machined completely, no further machining required ■ EMPTY: Empty space, no machining required ■ SKIP: Skip machining
METHOD	Indicates the machining method Tool-oriented machining is also possible with a combination of pallet fixtures, but not for multiple pallets. The control differentiates between the following entries ■ WPO: Workpiece oriented (standard) ■ TO: Tool oriented (first workpiece) ■ CTO: Tool oriented (further workpieces)
CTID	The control automatically generates the ID number for mid-program startup with block scan. If you delete or change the entry, mid-program startup is no longer possible.
SP-X, SP-Y, SP-Z, SP-A, SP-B, SP-C, SP-U, SP-V, SP-W	The entry for the clearance height in the existing axes is optional. You can enter safety positions for the axes. The control only approaches these positions if the machine tool builder processes them in the NC macros.

13.2 Batch Process Manager (option 154)

Application

Refer to your machine manual!

Your machine tool builder configures and enables the **Batch Process Manager** function.

The **Batch Process Manager** enables you to plan production orders on a machine tool.

You save the planned NC programs in a job list. You use the **Batch Process Manager** to open the job list.

The following information is displayed:

- Whether the NC program is free of errors
- Run time of the NC programs
- Availability of the tools
- Times at which manual interventions at the machine are necessary

The tool usage test function has to be enabled and switched on to ensure you get all information!

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Fundamentals

The **Batch Process Manager** is available in the following operating modes:

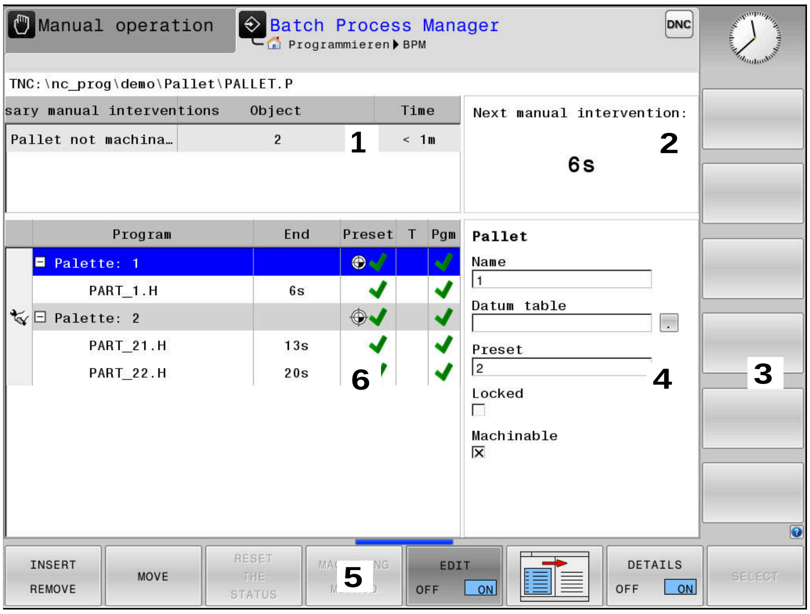
- **Programming**
- **Program run, single block**
- **Program run, full sequence**

In the **Programming** operating mode, you can create and edit the job list.

The job list is executed in the **Program run, single block** and **Program run, full sequence** operating modes. Changes are possible only to a limited extent.

Screen display

When you open the **Batch Process Manager** in the **Programming** operating mode, the following screen layout is displayed:



1 Displays all required manual interventions
2 Displays the next manual intervention
3 Shows any current soft keys provided by the machine tool builder
4 Shows the editable entries in the line highlighted in blue
5 Displays the current soft keys
6 Displays the job list

Columns in the job list

Column	Meaning
No column name	Status of the **Pallet**, **Clamping**, or **Program**
Program	Name or path of the **Pallet**, **Clamping**, or **Program**
Duration	Run time in seconds This column is only shown if you have a 19-inch screen.
End	End of the run time ■ Time in **Programming** mode ■ Actual time in **Program run, single block** and **Program run, full sequence** modes
Preset	Status of the workpiece preset
T	Status of the inserted tools
Pgm	Status of the NC program
Sts	Machining status

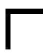
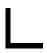
The status of the **Pallet**, **Clamping**, and **Program** is shown by means of icons in the first column.

The icons have the following meanings:

Icon	Meaning
	The **Pallet**, **Clamping**, or **Program** is locked
	The **Pallet** or **Clamping** is not enabled for machining
	This line is currently being executed in **Program run, single block** or **Program run, full sequence** mode and cannot be edited
	In this line, the program was interrupted manually

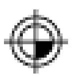
In the **Program** column, the machining method is indicated by means of icons.

The icons have the following meanings:

Icon	Meaning
No icon	Workpiece-oriented machining
 	Tool-oriented machining ■ Start ■ End

The status is shown by means of icons in the **Preset**, **T**, and **Pgm** columns.

The icons have the following meanings:

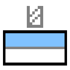
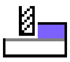
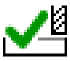
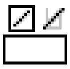
Icon	Meaning
	Test completed
	Test failed (e.g., because of expired tool life)
	Test not yet completed
	Incorrect program structure (e.g., pallet does not contain any subprograms)
	Workpiece preset is defined
	Check input You can assign a workpiece preset either to the pallet or to all NC subprograms.

Operating notes:

- In **Programming** operating mode, the **T** column is always empty because the control first checks the status in the **Program run, single block** and **Program run, full sequence** operating modes.
- If the tool usage test function is not enabled or is not switched on for your machine, then no icon is shown in the **Pgm** column

  Further information: User's Manual for **Setup, Testing and Running NC Programs**

In the **Sts** columns, the machining status is indicated by icons. The icons have the following meanings:

Icon	Meaning
	Workpiece blank, machining required
	Partially machined, requires further machining
	Completely machined, no further machining required
	Skip machining

Operating notes:

- The machining status is automatically adjusted during machining
- The **Sts** column is shown in the **Batch Process Manager** only if the pallet table contains the **W STATUS** column

  Further information: User's Manual for **Setup, Testing and Running NC Programs**

Opening the Batch Process Manager

Refer to your machine manual!

In machine parameter **standardEditor** (no. 102902), your machine tool builder specifies the standard editor used by the control.

Programming operating mode

If the control does not open the pallet table (.p) in the Batch Process Manager as a job list, proceed as follows:

- Select the desired job list
- Shift the soft-key row
- Press the **MORE FUNCTIONS** soft key
- Press the **SELECT EDITOR** soft key
- > The control opens the **Select editor** pop-up window.
- Select **BPM-EDITOR**
- Confirm with the **ENT** key
- Alternative: Press the **OK** soft key
- > The control opens the job list in the **Batch Process Manager**.

Program run, single block and Program run, full sequence operating modes

If the control does not open the pallet table (.p) in the Batch Process Manager as a job list, proceed as follows:

- Press the **Screen layout** key
- Press the **BPM** key
- > The control opens the job list in the **Batch Process Manager**.

Soft keys

The following soft keys are available:

Refer to your machine manual!

The machine tool builder can configure his own soft keys.

Soft key	Function
DETAILS OFF ON	Collapse or expand tree structure
EDIT OFF ON	Edit opened job list
INSERT REMOVE	Shows the soft keys **INSERT BEFORE**, **INSERT AFTER**, and **REMOVE**
MOVE	Move line
TAG	Select line

Soft key	Function
CANCEL THE MARKING	Cancel marking
INSERT BEFORE	Insert a new **Pallet**, **Clamping**, or **Program** before the cursor position
INSERT AFTER	Insert a new **Pallet**, **Clamping**, or **Program** after the cursor position
REMOVE	Delete line or block
	Switch active windows
SELECT	Select possible entries from a pop-up window
RESET THE STATUS	Reset the machining status to workpiece blank
MACHINING METHOD	Select workpiece-oriented or tool-oriented machining
ACCESSES OFF ON	Collapse or expand necessary manual interven-tions
TOOL MANAGEMENT	Open Extended Tool Management
INTERNAL STOP	Interrupt machining

Operating notes:

- The **TOOL MANAGEMENT**and **INTERNAL STOP** soft keys are available only in the **Program run, single block** and **Program run, full sequence** operating modes.
- If the pallet table contains the **W STATUS** column, the **RESET THE STATUS** soft key is available.
- If the pallet table contains the **W STATUS**, **METHOD**, and **CTID** columns, the **MACHINING METHOD** soft key is available.

Further information: User's Manual for **Setup, Testing and Running NC Programs**

Creating a job list

You can only create a new job list in the file manager.

> The file name of a job list must always begin with a letter.

- Press the **Programming** key
- Press the **PGM MGT** key
- > The control opens the file manager.
- Press the **NEW FILE** soft key
- Enter the file name with extension (.**p**)
- Confirm with the **ENT** key
- > The control opens an empty job list in the **Batch Process Manager**.
- Press the **INSERT REMOVE** soft key
- Press the **INSERT AFTER** soft key
- > The control displays the various types on the right-hand side.
- Select the desired type
  - **Pallet**
  - **Clamping**
  - **Program**
- > The control inserts an empty line in the job list.
- > The control shows the selected type on the right-hand side.
- Define the entries
  - **Name**: Enter the name directly or select one by means of the pop-up window, if there is one
  - **Datum table**: Enter the datum directly, where applicable, or select one by means of the pop-up window
  - **Preset**: Enter the workpiece preset directly, where applicable
  - **Locked**: The selected line is excluded from machining
  - **Machinable**: The selected line is enabled for machining
- Confirm your entries by pressing the **ENT** key.
- Repeat the steps if required
- Press the **EDIT** soft key

Editing a job list

You can edit a job list in the **Programming**, **Program run, single block**, and **Program run, full sequence** operating modes.

Operating notes:

- If a job list is selected in the **Program run, single block** or **Program run, full sequence** operating mode, it is not possible to edit the job list in the **Programming** operating mode.
- The possibilities of changing a job list during machining are limited, because the control defines a protected area.
- NC programs in the protected area are shown in light gray.

Proceed as follows to edit a line in the job list in the **Batch Process Manager**:

- Open the desired job list

- Press the **EDIT** soft key

- Place the cursor on the desired line (e.g., **Pallet**)
- > The control displays the selected line in blue.
- > The control displays the editable entries on the right-hand side.

- Press the **CHANGE WINDOW** soft key if required
- > The control switches the active window.
- The following entries can be changed:
  - **Name**
  - **Datum table**
  - **Preset**
  - **Locked**
  - **Machinable**

- Confirm the edited entries by pressing the **ENT** key.
- > The control adopts the changes.

- Press the **EDIT** soft key

Proceed as follows to move a line in the job list in the **Batch Process Manager**:

- Open the desired job list

- Press the **EDIT** soft key

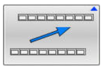
- Place the cursor on the desired line (e.g., **Program**)
- > The control displays the selected line in blue.

- Press the **MOVE** soft key

- Press the **TAG** soft key
- > The control highlights the line in which the cursor is positioned.

- Place the cursor on the desired position.
- > When the cursor is placed at a suitable position, the control shows the **INSERT BEFORE** and **INSERT AFTER** soft keys.

- Press the **INSERT BEFORE** soft key
- > The control inserts the line at the new position.



- Press the **GO BACK** soft key

- Press the **EDIT** soft key

14

Operating the touchscreen

14.1 Display unit and operation

Touchscreen

> Refer to your machine manual!
> This function must be enabled and adapted by the machine tool builder.

The touchscreen is distinguished by a black frame and the lack of soft-key selection keys.

The TNC 620 has its operating panel integrated in the 19″ screen.

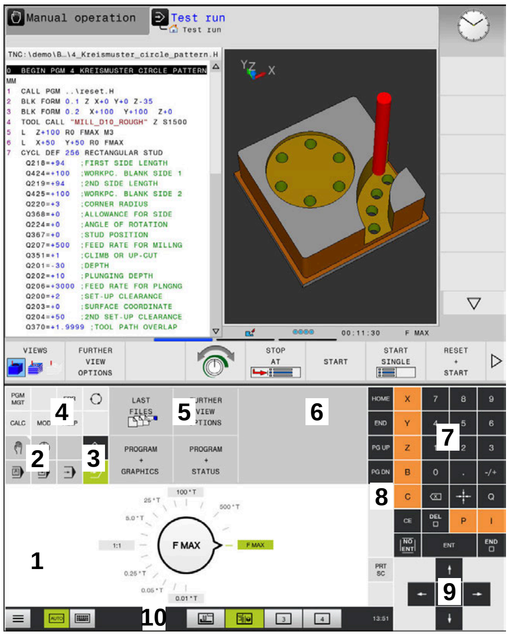
1 Header
When the control is on, the screen displays the selected operating modes in the header.
2 Soft-key row for the machine tool builder
3 Soft-key row
The control shows further functions in a soft-key row. The active soft-key row is shown as a blue bar.
4 Integrated operating panel
5 Setting the screen layout
6 Switchover between machine operating modes, programming modes, and a third desktop

> **Operability of touchscreens regarding electrostatic discharge**
> Touchscreens from HEIDENHAIN work based on a capacitive method of touch detection. This makes them sensitive to the user's electrostatic discharge.
> Users can discharge static electricity from their body by touching grounded metal objects. If problems with electrostatic discharge continue to occur, we recommend that users wear ESD shoes and ESD clothing.
> Please also refer to the information provided by your machine tool builder.

Operating panel

Integrated operating panel

The operating panel is integrated in the screen. The content of the operating panel changes depending on the current operating mode.



Operating panel of the Test Run mode

Operating panel in the Manual Operation mode

1 Area for showing the following:
- Alphabetic keyboard
- HEROS menu
- Potentiometer for the speed of simulation (only in the **Test Run** operating mode)

2 Machine operating modes

3 Programming modes

The control shows the active operating mode, to which the screen is switched, with a green background.

The control shows the operating mode in the background through a small white triangle.

4
- File management
- Calculator
- MOD function
- HELP function
- Show error messages

5 Rapid access menu

Depending on the operating mode, you'll find the most important functions here at a glance.

6 Initiating the programming dialogs (only in the **Programming** and **Positioning w/ Manual Data Input** operating modes)

7 Numerical input and axis selection

8 Navigation

9 Arrows and the jump statement **GOTO**

10 Task bar

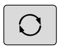
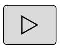
Further information: User's Manual for **Setup, Testing and Running NC Programs**

In addition, the machine tool builder supplies a machine operating panel.

> Refer to your machine manual!
>
> External keys, e.g.**NC START** or **NC STOP**, are described in your machine manual.

Basic operation

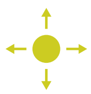
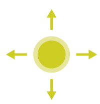
The following keys, for example, can easily be replaced by hand gestures:

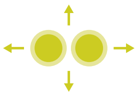
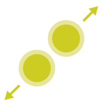
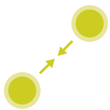
Key	Function	Gesture
	Switch between operating modes	Tap on the operating mode in the header
	Shift the soft-key row	Swipe horizontally over the soft-key row
	Soft-key selection keys	Tap on the function in the touchscreen

14.2 Gestures

Overview of possible gestures

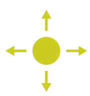
The screen of the control is multi-touch capable. That means that it can distinguish various gestures, including with two or more fingers at once.

Symbol	Gesture	Meaning
	Tap	A brief touch by a finger on the screen
	Double tap	Two brief touches on the screen
	Long press	Continuous contact of fingertip on the screen If you do not stop holding, the control will automatically cancel the holding gesture after approximately ten seconds. Permanent actuation is thus not possible.
	Swipe	Flowing motion over the screen
	Drag	A combination of long-press and then swipe, moving a finger over the screen when the starting point is clearly defined

Symbol	Gesture	Meaning
	Two-finger drag	A combination of long-press and then swipe, moving two fingers in parallel over the screen when the starting point is clearly defined
	Spread	Two fingers long-press and move away from each other
	Pinch	Two fingers move toward each other

Navigating in the table and NC programs

You can navigate in an NC program or a table as follows:

Symbol	Gesture	Function
	Tap	Mark the NC block or table line Stop scrolling
	Double tap	Activate the table line
	Swipe	Scroll through the NC program or table

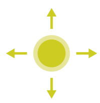
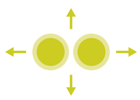
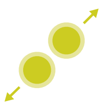
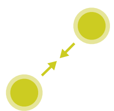
Operating the simulation

The control offers touch operation with the following graphics:

- Programming graphics in the **Programming** operating mode.
- 3-D view in the **Test Run** operating mode.
- 3-D view in the **Program Run Single Block** operating mode.
- 3-D view in the **Program Run Full Sequence** operating mode.
- Kinematics view

Rotating, zooming, or moving a graphic

The control supports the following gestures:

Symbol	Gesture	Function
	Double tap	Set the graphic to its original size
	Drag	Rotate the graphic (only 3-D graphics)
	Two-finger drag	Move graphics
	Spread	Magnify the graphic
	Pinch	Reduce the graphic

Measuring a graphic

If you have activated measurement in the **Test Run** operating mode, the following additional function is available:

Symbol	Gesture	Function
	Tap	Select the measuring point

Operating the CAD viewer

The control also supports touch operation for working with the **CAD-Viewer**. You have various gestures available depending on the operating mode.

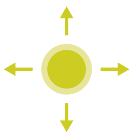
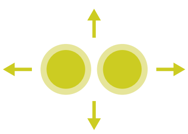
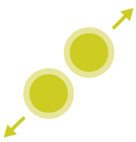
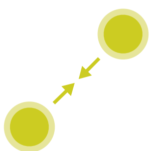
To be able to use all applications, first use the icon to select the desired function:

Icon	Function
	Default setting
	**Add** Works in the selection mode like a pressed **Shift** key
	Remove Works in the selection mode like a pressed **CTRL** key

Layer setting mode and specifying the workpiece preset

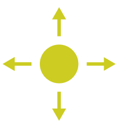
The control supports the following gestures:

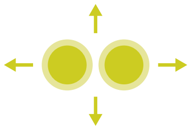
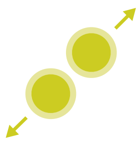
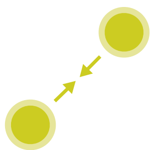
Symbol	Gesture	Function
	Tap on an element	Show element information Specify the workpiece preset
	Double-tap on the background	Set the graphic or 3-D model to its original size

Symbol	Gesture	Function
	Activate **Add** and double-tap on the background	Reset the graphic or 3-D model to its original size and angle
	Drag	Rotate the graphic or 3-D model (only in the Layer Setting mode)
	Two-finger drag	Move a graphic or 3-D model
	Spread	Enlarge a graphic or 3-D model
	Pinch	Reduce a graphic or 3-D model

Selecting a contour

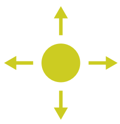
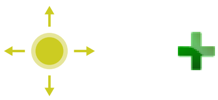
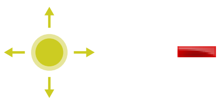
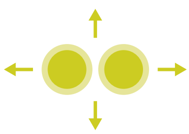
The control supports the following gestures:

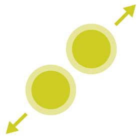
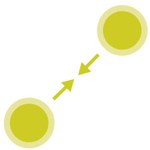
Symbol	Gesture	Function
	Tap on an element	Select element
	Tap on an element in the list-view window	Select or deselect an element
	Activate **Add** and tap on an element	Part, shorten, or lengthen an element
	Activate **Remove** and tap on an element	Deselect an element
	Double-tap on the background	Reset the graphic to its original size
	Swipe over an element	Show a preview of selected elements Show element information

Symbol	Gesture	Function
	Two-finger drag	Move graphics
	Spread	Magnify the graphic
	Pinch	Reduce the graphic

Selecting machining positions

The control supports the following gestures:

Symbol	Gesture	Function
	Tap on an element	Select element Select an intersection
	Double-tap on the background	Reset the graphic to its original size
	Swipe over an element	Show a preview of selected elements Show element information
	Activate **Add** and drag	Spread a fast selection area
	Activate **Remove** and drag	Spread an area for deselection of elements
	Two-finger drag	Move graphics

Symbol	Gesture	Function
	Spread	Magnify the graphic
	Pinch	Reduce the graphic

Saving elements and switching to the NC program

When you tap on the appropriate icons, the controls saves the selected elements.

You can switch back to the **Programming** operating mode in the following ways:

- Press the **Programming** key

  The control switches to the **Programming** mode of operation.
- Close the **CAD-Viewer**

  The control automatically switches to the **Programming** operating mode.
- Use the task bar to leave the **CAD-Viewer** open on the third desktop

  The third desktop stays active in the background

15

Tables and overviews

15.1 System data

List of D18 functions

With the **D18** function, you can read system data and save them to Q parameters. The selection of the system datum occurs via a group number (ID no.), a system data number, and, if necessary, an index.

> The read values of the function **D18** are always output by the control in **metric** units regardless of the NC program's unit of measure.

The following is a complete list of the **D18** function. Please be aware that not all functions are available depending on the model of your control.

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Program information				
	10	3	-	Number of the active machining cycle
		6	-	Number of the most recently executed touch probe cycle –1 = None
		7	-	Type of calling NC program: –1 = None 0 = Visible NC program 1 = Cycle/macro, main program is visible 2 = Cycle/macro, there is no visible main program
		103	Q parameter number	Relevant within NC cycles; for inquiry as to whether the Q parameter given under IDX was explicitly stated in the associated CYCLE DEF.
		110	QS parameter number	Is there a file with the name QS(IDX)? 0 = No, 1 = Yes This function eliminates relative file paths.
		111	QS parameter number	Is there a directory with the name QS(IDX)? 0 = no, 1 = Yes Only absolute directory paths are possible.

Group name	Group number ID...	System data number NO....	Index IDX...	Description
System jump addresses				
	13	1	-	Label number or label name (string or QS) jumped to during M2/M30 instead of ending the current NC program. Value = 0: M2/M30 have the normal effect
		2	-	Label number or label name (string or QS) jumped to in the event of FN14: ERROR with the NC CANCEL reaction instead of aborting the NC program with an error message. The error number programmed in the FN14 command can be read under ID992 NR14. Value = 0: FN14 has the normal effect.
		3	-	Label number or label name (string or QS) jumped to in the event of an internal server error (SQL, PLC, CFG) or with erroneous file operations (FUNCTION FILECOPY, FUNCTION FILEMOVE, or FUNCTION FILEDELETE) instead of aborting the NC program with an error message. Value = 0: Error has the normal effect.
Indexed access to Q parameters				
	15	10	Q parameter number	Reads Q(IDX)
		11	QL parameter no.	Reads QL(IDX)
		12	QR parameter no.	Reads QR(IDX)
Machine status				
	20	1	-	Active tool number
		2	-	Prepared tool number
		3	-	Active tool axis 0 = X 6 = U 1 = Y 7 = V 2 = Z 8 = W
		4	-	Programmed spindle speed
		5	-	Active spindle condition -1 = spindle condition not defined 0 = M3 active 1 = M4 active 2 = M5 active after M3 3 = M5 active after M4
		7	-	Active gear range
		8	-	Active coolant status 0 = off, 1 = on
		9	-	Active feed rate
		10	-	Index of prepared tool
		11	-	Index of active tool

Group name	Group number ID...	System data number NO....	Index IDX...	Description
		14	-	Number of active spindle
		20	-	Programmed cutting speed in turning operation
		21	-	Spindle mode in turning mode: 0 = constant speed 1 = constant cutting speed
		22	-	Coolant status M7: 0 = inactive, 1 = active
		23	-	Coolant status M8: 0 = inactive, 1 = active
Channel data				
	25	1	-	Channel number
Cycle parameters				
	30	1	-	Set-up clearance
		2	-	Hole depth / milling depth
		3	-	Plunging depth
		4	-	Feed rate for plunging
		5	-	First side length of pocket
		6	-	Second side length of pocket
		7	-	First side length of slot
		8	-	Second side length of slot
		9	-	Radius of circular pocket
		10	-	Feed rate for milling
		11	-	Rotational direction of the milling path
		12	-	Dwell time
		13	-	Thread pitch for Cycles 17 and 18
		14	-	Finishing allowance
		15	-	Roughing angle
		21	-	Probing angle
		22	-	Probing path
		23	-	Probing feed rate
		49	-	HSC mode (Cycle 32 Tolerance)
		50	-	Tolerance for rotary axes (Cycle 32 Tolerance)
		52	Q parameter number	Type of transfer parameter for user cycles: –1: Cycle parameter not programmed in CYCL DEF 0: Cycle parameter numerically programmed in CYCL DEF (Q parameter) 1: Cycle parameter programmed as string in CYCL DEF (Q parameter)
		60	-	Clearance height (touch probe cycles 30 to 33)

Group name	Group number ID...	System data number NO....	Index IDX...	Description
		61	-	Inspection (touch probe cycles 30 to 33)
		62	-	Cutting edge measurement (touch probe cycles 30 to 33)
		63	-	Q parameter number for the result (touch probe cycles 30 to 33)
		64	-	Q parameter type for the result (touch probe cycles 30 to 33) 1 = Q, 2 = QL, 3 = QR
		70	-	Multiplier for feed rate (cycles 17 and 18)
Modal status				
	35	1	-	Dimensions: 0 = absolute (G90) 1 = incremental (G91)
		2	-	Radius compensation: 0 = R0 1 = RR/RL 10 = Face milling 11 = Peripheral milling
Data for SQL tables				
	40	1	-	Result code for the last SQL command. If the last result code was 1 (=error), the error code is transferred as the return code.
Data from the tool table				
	50	1	Tool no.	Tool length L
		2	Tool no.	Tool radius R
		3	Tool no.	Tool radius R2
		4	Tool no.	Oversize for tool length DL
		5	Tool no.	Tool radius oversize DR
		6	Tool no.	Tool radius oversize DR2
		7	Tool no.	Tool locked TL 0 = not locked, 1 = locked
		8	Tool no.	Number of the replacement tool RT
		9	Tool no.	Maximum tool age TIME1
		10	Tool no.	Maximum tool age TIME2
		11	Tool no.	Current tool age CUR.TIME
		12	Tool no.	PLC status
		13	Tool no.	Maximum tooth length LCUTS
		14	Tool no.	Maximum plunge angle ANGLE
		15	Tool no.	TT: Number of tool teeth CUT
		16	Tool no.	TT: Wear tolerance for length, LTOL
		17	Tool no.	TT: Wear tolerance for radius, RTOL

Group name	Group number ID...	System data number NO....	Index IDX...	Description
		18	Tool no.	TT: Direction of rotation DIRECT 0 = positive, –1 = negative
		19	Tool no.	TT: Offset in plane R-OFFS R = 99999.9999
		20	Tool no.	TT: Offset in length L-OFFS
		21	Tool no.	TT: Breakage tolerance for length, LBREAK
		22	Tool no.	TT: Breakage tolerance for radius, RBREAK
		28	Tool no.	Maximum speed NMAX
		32	Tool no.	Point angle TANGLE
		34	Tool no.	LIFTOFF allowed (0 = No, 1 = Yes)
		35	Tool no.	Wear tolerance for radius R2TOL
		36	Tool no.	Tool type TYPE (miller = 0, grinder = 1, ... touch probe = 21)
		37	Tool no.	Corresponding line in the touch-probe table
		38	Tool no.	Timestamp of last use
		39	Tool no.	ACC
		40	Tool no.	Pitch for thread cycles
		44	Tool no.	Exceeding the tool life
		45	Tool no.	Front-face width of indexable insert (RCUTS)
		46	Tool no.	Usable length of the milling cutter
		47	Tool no.	Neck radius of the milling cutter (RN)

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Data from the pocket table				
	51	1	Pocket number	Tool number
		2	Pocket number	0 = no special tool 1 = special tool
		3	Pocket number	0 = no fixed pocket 1 = fixed pocket
		4	Pocket number	0 = pocket not locked 1 = pocket locked
		5	Pocket number	PLC status
Determine the tool pocket				
	52	1	Tool no.	Pocket number
		2	Tool no.	Tool magazine number
File information				
	56	1	-	Number of lines of the tool table
		2	-	Number of lines of the active datum table
		4	-	Number of lines in a freely definable table that has been opened with FN26: TABOPEN
Tool data for T and S strobes				
	57	1	T code	Tool number IDX0 = T0 strobe (store tool), IDX1 = T1 strobe (load tool), IDX2 = T2 strobe (prepare tool)
		2	T code	Tool index IDX0 = T0 strobe (store tool), IDX1 = T1 strobe (load tool), IDX2 = T2 strobe (prepare tool)
		5	-	Spindle speed IDX0 = T0 strobe (store tool), IDX1 = T1 strobe (load tool), IDX2 = T2 strobe (prepare tool)
Values programmed in TOOL CALL				
	60	1	-	Tool number T
		2	-	Active tool axis 0 = X 1 = Y 2 = Z 6 = U 7 = V 8 = W
		3	-	Spindle speed S
		4	-	Oversize for tool length DL
		5	-	Tool radius oversize DR
		6	-	Automatic TOOL CALL 0 = Yes, 1 = No
		7	-	Tool radius oversize DR2

Group name	Group number ID...	System data number NO....	Index IDX...	Description
		8	-	Tool index
		9	-	Active feed rate
		10	-	Cutting speed [mm/min]
Values programmed in TOOL DEF				
	61	0	Tool no.	Read the number of the tool change sequence: 0 = Tool already in spindle, 1 = Change between external tools, 2 = Change from internal to external tool, 3 = Change from special tool to external tool, 4 = Load external tool, 5 = Change from external to internal tool, 6 = Change from internal to internal tool, 7 = Change from special tool to internal tool, 8 = Load internal tool, 9 = Change from external tool to special tool, 10 = Change from special tool to internal tool, 11 = Change from special tool to special tool, 12 = Load special tool, 13 = Unload external tool, 14 = Unload internal tool, 15 = Unload special tool
		1	-	Tool number T
		2	-	Length
		3	-	Radius
		4	-	Index
		5	-	Tool data programmed in TOOL DEF 1 = Yes, 0 = No

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Values for LAC and VSC				
	71	0	0	Index of the NC axis for which the LAC weighing run will be performed or was last performed (X to W = 1 to 9)
			2	Total inertia determined by the LAC weighing run in [kgm²] (with A/B/C rotary axes) or total mass in [kg] (with X/Y/Z linear axes)
		1	0	Cycle 957 Retraction from thread
Freely available memory area for OEM cycles				
	72	0-39	0 to 30	Freely available memory area for OEM cycles. The values are only reset by the control during a control reboot (= 0). With “Cancel,” the values are not reset to the value that they had at the time of execution. Up to and including 597110-11: only NR 0-9 and IDX 0-9 Starting with 597110-12: NR 0-39 and IDX 0-30
Freely available memory area for user cycles				
	73	0-39	0 to 30	Freely available memory area for user cycles The values are only reset by the control during a control reboot (= 0). With “Cancel,” the values are not reset to the value that they had at the time of execution. Up to and including 597110-11: only NR 0-9 and IDX 0-9 Starting with 597110-12: NR 0-39 and IDX 0-30
Read minimum and maximum spindle speed				
	90	1	Spindle ID	Minimum spindle speed of the lowest gear range. If no gear stages are configured, CfgFeedLimits/minFeed of the first parameter set of the spindle is evaluated. Index 99 = active spindle
		2	Spindle ID	Maximum spindle speed from the highest gear stage. If no gear stages are configured, CfgFeedLimits/maxFeed of the first parameter set of the spindle is evaluated. Index 99 = active spindle
Tool compensation				
	200	1	1 = without oversize 2 = with oversize 3 = with	Active radius

Group name	Group number ID...	System data number NO....	Index IDX...	Description
			oversize and oversize from TOOL CALL	
		2	1 = without oversize 2 = with oversize 3 = with oversize and oversize from TOOL CALL	Active length
		3	1 = without oversize 2 = with oversize 3 = with oversize and oversize from TOOL CALL	Rounding radius R2
		6	Tool no.	Tool length Index 0= active tool
Coordinate transformations				
	210	1	-	Basic rotation (manual)
		2	-	Programmed rotation
		3	-	Active mirror axis. Bits 0 to 2 and 6 to 8: Axes X, Y, Z and U, V, W
		4	Axis	Active scaling factor Index: 1 - 9 (X, Y, Z, A, B, C, U, V, W)
		5	Rotary axis	3D-ROT Index: 1 - 3 (A, B, C)
		6	-	Tilt working plane in Program Run operating modes 0 = Not active –1 = Active
		7	-	Tilt working plane in Manual operating modes 0 = Not active –1 = Active
		8	QL parameter no.	Angle of misalignment between spindle and tilted coordinate system. Projects the angle specified in the QL parameter from the input coordinate system to the tool coordinate system. If IDX is omitted, the angle 0 is used for projection.
		10	-	Type of definition of the active tilt: 0 = no tilt—is returned if, both in **Manual Operation** and in the automatic modes, no tilt is active. 1 = axial 2 = spatial angle

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Active coordinate system				
	211	–	-	1 = input system (default) 2 = REF system 3 = tool change system
Special transformations in turning mode				
	215	1	-	Angle for the precession of the input system in the XY plane in turning mode. To reset the transformation the value 0 must be entered for the angle. This transformation is used in connection with Cycle 800 (parameter Q497).
		3	1-3	Reading out of the spatial angle written with NR2 Index: 1 - 3 (redA, redB, redC)
Current datum shift				
	220	2	Axis	Current datum shift in [mm] Index: 1 - 9 (X, Y, Z, A, B, C, U, V, W)
		3	Axis	Read the difference between reference point and preset. Index: 1 - 9 (X, Y, Z, A, B, C, U, V, W)
		4	Axis	Read values for OEM offset.. Index: 1 - 9 (X_OFFS, Y_OFFS, Z_OFFS,...)
Traverse range				
	230	2	Axis	Negative software limit switches Index: 1 - 9 (X, Y, Z, A, B, C, U, V, W)
		3	Axis	Positive software limit switches Index: 1 - 9 (X, Y, Z, A, B, C, U, V, W)
		5	-	Software limit switch on or off: 0 = on, 1 = off For modulo axes, either both the upper and lower limits or no limit at all must be set.
Read the nominal position in the REF system				
	240	1	Axis	Current nominal position in the REF system
Read the nominal position in the REF system, including offsets (handwheel, etc.)				
	241	1	Axis	Current nominal position in the REF system
Read the current position in the active coordinate system				
	270	1	Axis	Current nominal position in the input system When called while tool radius compensation is active, the function supplies the uncompensated positions for the principal axes X, Y, and Z. If the function is called for a rotary axis and tool radius compensation is active, an error message is issued. Index: 1 to 9 (X, Y, Z, A, B, C, U, V, W)
Read the current position in the active coordinate system, including offsets (handwheel, etc.)				
	271	1	Axis	Current nominal position in the input system

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Read information to M128				
	280	1	-	M128 active: –1 = Yes, 0 = No
		3	-	Condition of TCPM after Q No.: Q No. + 0: TCPM active, 0 = no, 1 = yes Q No. + 1: AXIS, 0 = POS, 1 = SPAT Q No. + 2: PATHCTRL, 0 = AXIS, 1 = VECTOR Q No. + 3: Feed rate, 0 = F TCP, 1 = F CONT
Machine kinematics				
	290	5	-	0: Temperature compensation not active 1: Temperature compensation active
		10	-	Index of the machine kinematics from Channels/ChannelSettings/CfgKinList/kinCompositeModels programmed in FUNCTION MODE MILL or FUNCTION MODE TURN –1 = Not programmed.
Read data of the machine kinematics				
	295	1	QS parameter no.	Read the axis names of the active 3-axis kinematics. The axis names are written according to QS(IDX), QS(IDX+1), and QS(IDX+2). 0 = Operation successful
		2	0	Is FACING HEAD POS function active? 1 = Yes, 0 = No
		4	Rotary axis	Read whether the defined rotary axis participates in the kinematic calculation. 1 = Yes, 0 = No (A rotary axis can be excluded from the kinematics calculating using M138.) Index: 4, 5, 6 (A, B, C)
		6	Axis	Angle head: Displacement vector in the basic coordinate system B-CS through angle head Index: 1, 2, 3 (X, Y, Z)
		7	Axis	Angle head: Direction vector of the tool in the basic coordinate system B-CS Index: 1, 2, 3 (X, Y, Z)
		10	Axis	Determine programmable axes. Determine the axis ID associated with the specified axis index (index from CfgAxis/axisList). Index: 1 - 9 (X, Y, Z, A, B, C, U, V, W)
		11	Axis ID	Determine programmable axes. Determine the index of the axis (X = 1, Y = 2, ...) for the specified axis ID Index: Axis ID (index from CfgAxis/axisList)

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Modify the geometrical behavior				
	310	20	Axis	Diameter programming: –1 = on, 0 = off
Current system time				
	320	1	0	System time in seconds that has elapsed since 01.01.1970, 00:00:00 (real time).
			1	System time in seconds that has elapsed since 01.01.1970, 00:00:00 (look-ahead calculation).
		3	-	Read the processing time of the current NC program.
Formatting of system time				
	321	0	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: DD.MM.YYYY hh:mm:ss
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: DD.MM.YYYY hh:mm:ss
		1	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: D.MM.YYYY h:mm:ss
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: D.MM.YYYY h:mm:ss
		2	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: D.MM.YYYY h:mm
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: D.MM.YYYY h:mm
		3	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: D.MM.YY h:mm
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: D.MM.YY h:mm
		4	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: YYYY-MM-DD hh:mm:ss

Group name	Group number ID...	System data number NO....	Index IDX...	Description
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: YYYY-MM-DD hh:mm:ss
		5	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: YYYY-MM-DD hh:mm
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: YYYY-MM-DD hh:mm
		6	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: YYYY-MM-DD h:mm
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: YYYY-MM-DD h:mm
		7	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: YY-MM-DD h:mm
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: YY-MM-DD h:mm
		8	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: DD.MM.YYYY
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: DD.MM.YYYY
		9	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: D.MM.YYYY
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: D.MM.YYYY
		10	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: D.MM.YY

Group name	Group number ID...	System data number NO....	Index IDX...	Description
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: D.MM.YY
		11	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: YYYY-MM-DD
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: YYYY-MM-DD
		12	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: YY-MM-DD
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: YY-MM-DD
		13	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: hh:mm:ss
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: hh:mm:ss
		14	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: h:mm:ss
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: h:mm:ss
		15	0	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (real time) Format: h:mm
			1	Formatting of: System time in seconds that have elapsed since 00:00:00 UTC on January 1, 1970 (look-ahead calculation) Format: h:mm

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Global Program Settings (GPS): Global activation status				
	330	0	-	0 = No GPS setting is active 1 = Any GPS setting is active
Global Program Settings (GPS): Individual activation status				
	331	0	-	0 = No GPS setting is active 1 = Any GPS setting is active
		1	-	GPS: Basic rotation 0 = Off, 1 = On
		3	Axis	GPS: Mirroring 0 = Off, 1 = On Index: 1 - 6 (X, Y, Z, A, B, C)
		4	-	GPS: Shift in the modified workpiece system 0 = Off, 1 = On
		5	-	GPS: Rotation in input system 0 = Off, 1 = On
		6	-	GPS: Feed rate factor 0 = Off, 1 = On
		8	-	GPS: Handwheel superimpositioning 0 = Off, 1 = On
		10	-	GPS: Virtual tool axis VT 0 = Off, 1 = On
		15	-	GPS: Selection of the handwheel coordinate system 0 = Machine coordinate system M-CS 1 = Workpiece coordinate system W-CS 2 = Modified workpiece coordinate system mW-CS 3 = Working plane coordinate system WPL-CS
		16	-	GPS: Shift in the workpiece system 0 = Off, 1 = On
		17	-	GPS: Axis offset 0 = Off, 1 = On

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Global Program Settings (GPS)				
	332	1	-	GPS: Angle of a basic rotation
		3	Axis	GPS: Mirroring 0 = Not mirrored, 1 = Mirrored Index: 1 - 6 (X, Y, Z, A, B, C)
		4	Axis	GPS: Shift in the modified workpiece coordinate system mW-CS Index: 1 - 6 (X, Y, Z, A, B, C)
		5	-	GPS: Angle of rotation in input coordinate system I-CS
		6	-	GPS: Feed rate factor
		8	Axis	GPS: Handwheel superimpositioning Maximum value Index: 1 - 10 (X, Y, Z, A, B, C, U, V, W, VT)
		9	Axis	GPS: Value for handwheel superimpositioning Index: 1 - 10 (X, Y, Z, A, B, C, U, V, W, VT)
		16	Axis	GPS: Shift in the workpiece coordinate system W-CS Index: 1 - 3 (X, Y, Z)
		17	Axis	GPS: Axis offset Index: 4 - 6 (A, B, C)
TS touch trigger probe				
	350	50	1	Touch probe type: 0: TS120, 1: TS220, 2: TS440, 3: TS630, 4: TS632, 5: TS640, 6: TS444, 7: TS740
			2	Line in the touch-probe table
		51	-	Effective length
		52	1	Effective radius of the stylus tip
			2	Rounding radius
		53	1	Center offset (reference axis)
			2	Center offset (minor axis)
		54	-	Spindle-orientation angle in degrees (center offset)
		55	1	Rapid traverse
			2	Measuring feed rate
			3	Feed rate for pre-positioning: FMAX_PROBE or FMAX_MACHINE
		56	1	Maximum measuring range
			2	Set-up clearance
		57	1	Spindle orientation possible 0=No, 1=Yes
			2	Angle of spindle orientation in degrees

Group name	Group number ID...	System data number NO....	Index IDX...	Description
TT tool touch probe for tool measurement				
	350	70	1	TT: Touch probe type
			2	TT: Line in the tool touch probe table
		71	1/2/3	TT: Touch probe center (REF system)
		72	-	TT: Touch probe radius
		75	1	TT: Rapid traverse
			2	TT: Measuring feed rate with stationary spindle
			3	TT: Measuring feed rate with rotating spindle
		76	1	TT: Maximum probing path
			2	TT: Safety clearance for linear measurement
			3	TT: Safety clearance for radius measurement
			4	TT: Distance from the lower edge of the cutter to the upper edge of the stylus
		77	-	TT: Spindle speed
		78	-	TT: Probing direction
		79	-	TT: Activate radio transmission
		80	-	TT: Stop probing movement upon stylus deflection
Preset from touch probe cycle (probing results)				
	360	1	Coordinate	Last preset of a manual touch probe cycle, or last touch point from Cycle 0 (input coordinate system). Compensations: length, radius, and center offset
		2	Axis	Last preset of a manual touch probe cycle, or last touch point from Cycle 0 (machine coordinate system, only axes from the active 3-D kinematics are allowed as index). Compensation: only center offset
		3	Coordinate	Result of measurement in the input system of touch probe Cycles 0 and 1. The measurement result is read out in the form of coordinates. Compensation: only center offset
		4	Coordinate	Last preset of a manual touch probe cycle, or last touch point from Cycle 0 (workpiece coordinate system) The measurement result is read in the form of coordinates. Compensation: only center offset
		5	Axis	Axis values, not compensated
		6	Coordinate / axis	Readout of the measurement results in the form of coordinates / axis values in the input system from probing operations. Compensation: only length
		10	-	Oriented spindle stop

Group name	Group number ID...	System data number NO....	Index IDX...	Description
		11	-	Error status of probing: 0: Probing was successful –1: Touch point not reached –2: Touch probe already deflected at the start of the probing process
Read values from or write values to the active datum table				
	500	Row number	Column	Read values
Read values from or write values to the preset table (basic transformation)				
	507	Row number	1-6	Read values
Read axis offsets from or write axis offsets to the preset table				
	508	Row number	1-9	Read values
Data for pallet machining				
	510	1	-	Active line
		2	-	Current pallet number. Read value of the NAME column of the last PAL-type entry. If the column is empty or does not contain a numerical value, a value of –1 is returned.
		3	-	Active row of the pallet table.
		4	-	Last line of the NC program for the current pallet.
		5	Axis	Tool-oriented editing: Clearance height is programmed: 0 = No, 1 = Yes Index: 1 - 9 (X, Y, Z, A, B, C, U, V, W)
		6	Axis	Tool-oriented editing: Clearance height The value is invalid if ID510 NR5 returns the value 0 with the corresponding IDX. Index: 1 - 9 (X, Y, Z, A, B, C, U, V, W)
		10	-	Row number up to which the pallet table is to be searched during block scan.
		20	-	Type of pallet editing? 0 = Workpiece-oriented 1 = Tool oriented
		21	-	Automatic continuation after NC error: 0 = Locked 1 = Active 10 = Abort continuation 11 = Continuation with the rows in the pallet table that would have been executed next if not for the NC error 12 = Continuation with the row in the pallet table in which the NC error arose 13 = Continuation with the next pallet

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Read data from the point table				
	520	Row number	10	Read value from active point table.
			11	Read value from active point table.
			1-3 X/Y/Z	Read value from active point table.
Read or write the active preset				
	530	1	-	Number of the active preset in the active preset table.
Active pallet preset				
	540	1	-	Number of the active pallet preset. Returns the number of the active preset. If no pallet preset is active, the function returns the value –1.
		2	-	Number of the active pallet preset. As with NR1.
Values for the basic transformation of the pallet preset				
	547	row number	Axis	Read values of the basic transformation from the pallet preset table.. Index: 1 to 6 (X, Y, Z, SPA, SPB, SPC)
Axis offsets from the pallet preset table				
	548	Row number	Offset	Read values of the axis offsets from the pallet preset table.. Index: 1 - 9 (X_OFFS, Y_OFFS, Z_OFFS,...)
OEM offset				
	558	Row number	Offset	Read values for OEM offset.. Index: 1 - 9 (X_OFFS, Y_OFFS, Z_OFFS,...)
Read and write the machine status				
	590	2	1-30	Freely available; not deleted during program selection.
		3	1-30	Freely available; not deleted during a power failure (persistent storage).
Read/write look-ahead parameter of a single axis (at machine level)				
	610	1	-	Minimum feed rate (**MP_minPathFeed**) in mm/min
		2	-	Minimum feed rate at corners (**MP_minCornerFeed**) in mm/min
		3	-	Feed-rate limit for high speeds (**MP_maxG1Feed**) in mm/min
		4	-	Max. jerk at low speeds (**MP_maxPathJerk**) in m/s³
		5	-	Max. jerk at high speeds (**MP_maxPathJerkHi**) in m/s³
		6	-	Tolerance at low speeds (**MP_pathTolerance**) in mm

Group name	Group number ID...	System data number NO....	Index IDX...	Description
		7	-	Tolerance at high speeds (**MP_pathToleranceHi**) in mm
		8	-	Max. derivative of jerk (**MP_maxPathYank**) in m/s^4
		9	-	Tolerance factor for curve machining (**MP_curveTolFactor**)
		10	-	Factor for max. permissible jerk at curvature changes (**MP_curveJerkFactor**)
		11	-	Maximum jerk with probing movements (**MP_pathMeasJerk**)
		12	-	Angle tolerance for machining feed rate (**MP_angleTolerance**)
		13	-	Angle tolerance for rapid traverse (**MP_angleToleranceHi**)
		14	-	Max. corner angle for polygons (**MP_maxPolyAngle**)
		18	-	Radial acceleration with machining feed rate (**MP_maxTransAcc**)
		19	-	Radial acceleration with rapid traverse (**MP_maxTransAccHi**)
		20	Index of physical axis	Max. feed rate (**MP_maxFeed**) in mm/min
		21	Index of physical axis	Max. acceleration (**MP_maxAcceleration**) in m/s^2
		22	Index of physical axis	Maximum transition jerk of the axis in rapid traverse (**MP_axTransJerkHi**) in m/s^2
		23	Index of physical axis	Maximum transition jerk of the axis during machining free rate (**MP_axTransJerk**) in m/s^3
		24	Index of physical axis	Acceleration feedforward control (**MP_compAcc**)
		25	Index of physical axis	Axis-specific jerk at low speeds (**MP_axPathJerk**) in m/s^3
		26	Index of physical axis	Axis-specific jerk at high speeds (**MP_axPathJerkHi**) in m/s^3
		27	Index of physical axis	More precise tolerance examination in corners (**MP_reduceCornerFeed**) 0 = deactivated, 1 = activated
		28	Index of physical axis	DCM: Maximum tolerance for linear axes in mm (**MP_maxLinearTolerance**)
		29	Index of physical axis	DCM: Maximum angle tolerance in [°] (**MP_maxAngleTolerance**)
		30	Index of physical axis	Tolerance monitoring for successive threads (**MP_threadTolerance**)

Group name	Group number ID...	System data number NO....	Index IDX...	Description
		31	Index of physical axis	Form (**MP_shape**) of the **axisCutterLoc** filter 0: Off 1: Average 2: Triangle 3: HSC 4: Advanced HSC
		32	Index of physical axis	Frequency **MP_frequency**) of the **axisCutterLoc** filter in Hz
		33	Index of physical axis	Form (**MP_shape**) of the **axisPosition** filter 0: Off 1: Average 2: Triangle 3: HSC 4: Advanced HSC
		34	Index of physical axis	Frequency (**MP_frequency**) of the **axisPosition** filter in Hz
		35	Index of physical axis	Order of the filter for **Manual** operating mode (**MP_manualFilterOrder**)
		36	Index of physical axis	HSC mode (**MP_hscMode**) of the **axisCutterLoc** filter
		37	Index of physical axis	HSC mode (**MP_hscMode**) of the **axisPosition** filter
		38	Index of physical axis	Axis-specific jerk for probing movements (**MP_axMeasJerk**)
		39	Index of physical axis	Weighting of the filter error for calculating filter deviation (**MP_axFilterErrWeight**)
		40	Index of physical axis	Maximum filter length of position filter (**MP_maxHscOrder**)
		41	Index of physical axis	Maximum filter length of CLP filter (**MP_maxHscOrder**)
		42	-	Maximum feed rate of the axis at machining feed rate (**MP_maxWorkFeed**)
		43	-	Maximum path acceleration at machining feed rate (**MP_maxPathAcc**)
		44	-	Maximum path acceleration at rapid traverse (**MP_maxPathAccHi**)
		51	Index of physical axis	Compensation of following error in the jerk phase (**MP_IpcJerkFact**)
		52	Index of physical axis	kv factor of the position controller in 1/s (**MP_kvFactor**)

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Measure the maximum utilization of an axis				
	621	0	Index of physical axis	Conclude measurement of the dynamic load and save the result in the specified Q parameter.
Read SIK contents				
	630	0	Option no.	You can explicitly determine whether the SIK option given under **IDX** has been set or not. 1 = option is enabled 0 = option is not enabled
		1	-	You can determine whether a Feature Content Level (for upgrade functions) is set, and which one. –1 = No FCL is set <No.> = FCL that is set
		2	-	Read serial number of the SIK -1 = No valid SIK in the system
		10	-	Define the type of control: 0 = iTNC 530 1 = NCK-based control (TNC 640, TNC 620, TNC 320, TNC 128, PNC 610, ...)
Read Functional Safety (FS) information				
	820	1	-	FS limitations: 0 = No Functional Safety (FS) 1 = Guard door open (SOM1) 2 = Guard door open (SOM2) 3 = Guard door open (SOM3) 4 = Guard door open (SOM4) 5 = All guard doors closed
Counter				
	920	1	-	Planned workpieces. In **Test Run** operating mode the counter generally generates the value 0.
		2	-	Already machined workpieces. In **Test Run** operating mode the counter generally generates the value 0.
		12	-	Workpieces still to be machined. In **Test Run** operating mode the counter generally generates the value 0.
Read and write data of current tool				
	950	1	-	Tool length L
		2	-	Tool radius R
		3	-	Tool radius R2
		4	-	Oversize for tool length DL
		5	-	Tool radius oversize DR
		6	-	Tool radius oversize DR2

Group name	Group number ID...	System data number NO....	Index IDX...	Description
		7	-	Tool locked TL 0 = not locked, 1 = locked
		8	-	Number of the replacement tool RT
		9	-	Maximum tool age TIME1
		10	-	Maximum tool age TIME2 at TOOL CALL
		11	-	Current tool age CUR.TIME
		12	-	PLC status
		13	-	Tooth length in the tool axis LCUTS
		14	-	Maximum plunge angle ANGLE
		15	-	TT: Number of tool teeth CUT
		16	-	TT: Wear tolerance for length LTOL
		17	-	TT: Wear tolerance for radius RTOL
		18	-	TT: Direction of rotation DIRECT 0 = positive, –1 = negative
		19	-	TT: Offset in plane R-OFFS R = 99999.9999
		20	-	TT: Offset in length L-OFFS
		21	-	TT: Break tolerance for length LBREAK
		22	-	TT: Break tolerance for radius RBREAK
		28	-	Maximum spindle speed [rpm] NMAX
		32	-	Point angle TANGLE
		34	-	LIFTOFF allowed (0 = No, 1 = Yes)
		35	-	Wear tolerance for radius R2TOL
		36	-	Tool type TYPE (miller = 0, grinder = 1, ... touch probe = 21)
		37	-	Corresponding line in the touch-probe table
		38	-	Timestamp of last use
		39	-	ACC
		40	-	Pitch for thread cycles
		44	-	Exceeding the tool life
		45	-	Front-face width of indexable insert (RCUTS)
		46	-	Usable length of the milling cutter
		47	-	Neck radius of the milling cutter (RN)

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Freely available memory area for tool management				
	956	0-9	-	Freely available data area for tool management. The data is not reset when the program is aborted.
Tool usage and tooling				
	975	1	-	Tool usage test for the current NC program: Result –2: Test not possible, function disabled in the configuration Result –1: Test not possible, tool usage file missing Result 0: Test OK, all tools available Result 1: Test not OK
		2	Line	Check availability of the tools required in the pallet from line IDX in the current pallet table. –3 = No pallet is defined in row IDX, or function was called outside of pallet editing –2 / –1 / 0 / 1 see NR1
Lift off the tool at NC stop				
	980	3	-	(This function is obsolete—HEIDENHAIN recommends not to use it any longer. ID980 NR3 = 1 is equivalent to ID980 NR1 = –1, ID980 NR3 = 0 has the same effect as ID980 NR1 = 0. Other values are not permissible.) Enable lift-off to the value defined in CfgLiftOff: 0 = Lock lift-off function 1 = Enable lift-off function
Touch probe cycles and coordinate transformations				
	990	1	-	Approach behavior: 0 = Standard behavior 1 = Approach probing position without compensation. Effective radius, set-up clearance is zero
		2	16	Automatic / Manual machine operating modes
		4	-	0 = Stylus not deflected 1 = Stylus deflected
		6	-	TT tool touch probe active? 1 = Yes 0 = No
		8	-	Momentary spindle angle in [°]
		10	QS parameter no.	Determine the tool number from the tool name. The return value depends on the rules configured for the search of the replacement tool. If there are multiple tools with the same name, the first tool from the tool table will be selected.

Group name	Group number ID...	System data number NO....	Index IDX...	Description
				If the tool selected by these rules is locked, a replacement tool will be returned. –1: No tool with the specified name found in the tool table or all qualifying tools are locked.
		16	0	0 = Transfer control over the channel spindle to the PLC, 1 = Assume control over the channel spindle
			1	0 = Pass tool spindle control to the PLC, 1 = Take control of the tool spindle
		19	-	Suppress touch prove movement in cycles: 0 = Movement will be suppressed (CfgMachineSimul/simMode parameter not equal to FullOperation or **Test Run** operating mode is active) 1 = Movement will be performed (CfgMachineSimul/simMode parameter = FullOperation, can be programmed for testing purposes)
Status of execution				
	992	10	-	Block scan active 1 = yes, 0 = no
		11	-	Block scan—information on block scan: 0 = NC program started without block scan 1 = Iniprog system cycle is run before block scan 2 = Block scan is running 3 = Functions are being updated –1 = Iniprog cycle was canceled before block scan –2 = Cancellation during block scan –3 = Cancellation of the block scan after the search phase, before or during the update of functions –99 = Implicit cancellation
		12	-	Type of canceling for interrogation within the OEM_CANCEL macro: 0 = No cancellation 1 = Cancellation due to error or emergency stop 2 = Explicit cancellation with internal stop after stop in the middle of the block 3 = Explicit cancellation with internal stop after stop at the end of a block
		14	-	Number of the last FN14 error
		16	-	Real execution active? 1 = execution, 0 = simulation
		17	-	2-D graphics during programming active? 1 = yes 0 = no

Group name	Group number ID...	System data number NO....	Index IDX...	Description
		18	-	Live programming graphics (**AUTO DRAW** soft key) active? 1 = Yes 0 = No
		20	-	Information on combined milling/turning mode of operation: 0 = Milling (after **FUNCTION MODE MILL**) 1 = Turning (after **FUNCTION MODE TURN**) 10 = Execute the operations for the turning-to-milling transition 11 = Execute the operations for the milling-to-turning transition
		30	-	Interpolation of multiple axes permitted? 0 = No (e.g. for straight cut control) 1 = yes
		31	-	R+/R– possible/permitted in MDI mode? 0 = No 1 = Yes
		32	0	Cycle call possible/permitted? 0 = No 1 = Yes
			Cycle number	Single cycle enabled: 0 = No 1 = Yes
		40	-	Copy tables in **Test Run** operating mode? Value 1 will be set when a program is selected and when the **RESET+START** soft key is pressed. The **iniprog.h** system cycle will then copy the tables and reset the system datum. 0 = no 1 = yes
		101	-	M101 active (visible condition)? 0 = no 1 = yes
		136	-	M136 active? 0 = no 1 = yes

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Activate machine parameter subfile				
	1020	13	QS parameter no.	Has a machine parameter subfile with path from QS number (IDX) been loaded? 1 = Yes 0 = No
Configuration settings for cycles				
	1030	1	-	Display **spindle does not rotate** error message? **(CfgGeoCycle/displaySpindleErr)** 0 = no, 1 = yes
			-	Check **the algebraic sign for depth error message!** display? **(CfgGeoCycle/displayDepthErr)** 0 = no, 1 = yes
Data transfer between HEIDENHAIN cycles and OEM macros				
	1031	1	0	Component monitoring: counter of the measurement. Cycle 238 Measure machine data automatically increments this counter.
			1	Component monitoring: Type of measurement –1 = No measurement. Writing of the value with FN17 concludes Cycle 238. 0 = Circular test 1 = Waterfall diagram 2 = Frequency response 3 = Envelope curve spectrum
			2	Component Monitoring: Index of the axis from **CfgAxes\MP_axisList**
			3 – 9	Component monitoring: further arguments depend on the measurement **Further information:** "Arguments for the circular interpolation test", Page **Further information:** "Arguments for the waterfall chart test", Page **Further information:** "Arguments for frequency response test", Page **Further information:** "Arguments for the envelope curve spectrum test", Page
		100	-	Component monitoring: optional names of the monitoring tasks, as specified in **System\Monitoring\CfgMonComponent**. After completion of the measurement, the monitoring tasks stated here are executed consecutively. When assigning the input parameters, remember to separate the listed monitoring tasks by commas.
User settings for the user interface				
	1070	1	-	Feed rate limit of soft key FMAX; 0 = FMAX is inactive

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Bit test				
	2300	Number	Bit number	This function checks whether a bit has been set in a number. The number to be checked is transferred as NR, the bit to be searched for as IDX, with IDX0 designating the least significant bit. To call this function for great numbers, make sure to transfer NR as a Q parameter. 0 = Bit not set 1 = Bit set
Read program information (system string)				
	10010	1	-	Path of the current main program or pallet program.
		2	-	Path of the NC program shown in the block display.
		3	-	Path of the cycle selected with **SEL CYCLE** or **CYCLE DEF 12 PGM CALL**, or path of the currently active cycle
		10	-	Path of the NC program selected with **SEL PGM "..."**.
Indexed access to QS parameters				
	10015	20	QS parameter no.	Reads QS(IDX)
		30	QS parameter no.	Returns the string that you obtain if you replace anything except for letters and digits in QS(IDX) by '_'.
Read channel data (system string)				
	10025	1	-	Name of machining channel (key)
Read data for SQL tables (system string)				
	10040	1	-	Symbolic name of the preset table.
		2	-	Symbolic name of the datum table.
		3	-	Symbolic name of the pallet preset table.
		10	-	Symbolic name of the tool table.
		11	-	Symbolic name of the pocket table.
		12	-	Symbolic name of the turning tool table

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Values programmed in the tool call (system string)				
	10060	1	-	Tool name
Read machine kinematics (system strings)				
	10290	10	-	Symbolic name of the machine kinematics from Channels/ChannelSettings/CfgKinList/kinCompositeModels programmed in **FUNCTION MODE MILL** or **FUNCTION MODE TURN**.
Traverse range switchover (system string)				
	10300	1	-	Key name of the last active range of traverse
Read current system time (system string)				
	10321	1 - 16	-	1: DD.MM.YYYY hh:mm:ss 2 and 16: DD.MM.YYYY hh:mm 3: DD.MM.YY hh:mm 4: YYYY-MM-DD hh:mm:ss 5 and 6: YYYY-MM-DD hh:mm 7: YY-MM-DD hh:mm 8 and 9: DD.MM.YYYY 10: DD.MM.YY 11: YYYY-MM-DD 12: YY-MM-DD 13 and 14: hh:mm:ss 15: hh:mm As an alternative, you can use **DAT** in **SYSSTR(...)** to specify a system time in seconds that is to be used for formatting.
Read data of touch probes (TS, TT) (system string)				
	10350	50	-	TS probe type from TYPE column of the touch probe table (**tchprobe.tp**)
		70	-	Type of TT tool touch probe from CfgTT/type.
		73	-	Key name of the active tool touch probe TT from **CfgProbes/activeTT**.
Read and write data of touch probes (TS, TT) (system string)				
	10350	74	-	Serial number of the active tool touch probe TT from **CfgProbes/activeTT**.
Read the data for pallet machining (system string)				
	10510	1	-	Pallet name
		2	-	Path of the selected pallet table.
Read version ID of the NC software (system string)				
	10630	10	-	The string corresponds to the format of the version ID shown, e.g. **340590 09** or **817601 05 SP1**.
Read information on unbalance cycle (system string)				
	10855	1	-	Path of the unbalance calibration table belonging to the active kinematics

Group name	Group number ID...	System data number NO....	Index IDX...	Description
Read data of the current tool (system string)				
	10950	1	-	Current tool name
		2	-	Entry from the DOC column of the active tool
		3	-	AFC control setting
		4	-	Tool-carrier kinematics
		5	-	Entry from the DR2TABLE column – file name of the compensation value table for 3D-ToolComp

Comparison: D18 functions

The following table lists the D18 functions from previous controls, which were not implemented in this manner in the TNC 620.

In most cases, this function has been replaced by another function.

No.	IDX	Contents	Replacement function
ID 10 Program information			
1	-	mm/inch condition	Q113
2	-	Overlap factor for pocket milling	CfgRead
4	-	Number of the active fixed cycle	ID 10 no. 3
ID 20 Machine status			
15	Log. axis	Assignment between logic and geometric axes	
16	-	Feed rate for transition arcs	
17	-	Currently selected range of traverse	SYSTRING 10300
19	-	Maximum spindle speed for current gear stage and spindle	Maximum gear range: ID 90 No. 2
ID 50 Data from the tool table			
23	Tool no.	PLC value	1)
24	Tool no.	Probe center offset in reference axis (CAL-OF1)	ID 350 NR 53 IDX 1
25	Tool no.	Probe center offset in minor axis (CALOF-2)	ID 350 NR 53 IDX 2
26	Tool no.	Spindle angle during calibration (CAL-ANG)	ID 350 NR 54
27	Tool no.	Tool type for pocket table (PTYP)	2)
29	Tool no.	Position P1	1)
30	Tool no.	Position P2	1)
31	Tool no.	Position P3	1)
33	Tool no.	Thread pitch (Pitch)	ID 50 NR 40
ID 51 Data from the pocket table			
6	Pocket no.	Tool type	2)
7	Pocket no.	P1	2)
8	Pocket no.	P2	2)

No.	IDX	Contents	Replacement function
9	Pocket no.	P3	2)
10	Pocket no.	P4	2)
11	Pocket no.	P5	2)
12	Pocket no.	Pocket reserved 0 = No, 1 = Yes	2)
13	Pocket no.	Box magazine: Pocket above occupied: 0 = No, 1 = Yes	2)
14	Pocket no.	Box magazine: Pocket below occupied: 0 = No, 1 = Yes	2)
15	Pocket no.	Box magazine: Pocket to the left occupied: 0 = No, 1 = Yes	2)
16	Pocket number	Box magazine: Pocket to the right occupied: 0 = No, 1 = Yes	2)
ID 56 File information			
1	-	Number of lines of the tool table	
2	-	Number of lines of the active datum table	
3	Q parameters	Number of active axes that are programmed in the active datum table	
4	-	Number of lines in a freely definable table that has been opened with D26	
ID 214 Current contour data			
1	-	Contour transition mode	
2	-	Max. linearization error	
3	-	Mode for M112	
4	-	Character mode	
5	-	Mode for M124	1)
6	-	Specification for contour pocket machining	
7	-	Filter for control loop	
8	-	Tolerance programmed with Cycle G62	ID 30 no. 48
ID 240 Nominal positions in the REF system			
8	-	ACTUAL position in the REF system	
ID 280 Information on M128			
2	-	Feed rate that was programmed with M128	ID 280 NR 3
ID 290 Switch the kinematics			
1	-	Line of the active kinematics table	SYSSTRING 10290
2	Bit no.	Interrogate the bits in MP7500	Cfgread
3	-	Status of collision monitoring (old)	Can be activated and deactivated in the NC program
4	-	Status of collision monitoring (new)	Can be activated and deactivated in the NC program
ID 310 Modifications of geometrical behavior			

No.	IDX	Contents	Replacement function
116	-	M116: –1 = On, 0 = Off	
126	-	M126: –1 = On, 0 = Off	
ID 350 Touch-probe data			
10	-	TS: Touch-probe axis	ID 20 NR 3
11	-	TS: Effective ball radius	ID 350 NR 52
12	-	TS: Effective length	ID 350 NR 51
13	-	TS: Ring gauge radius	
14	1/2	TS: Center offset in reference/minor axis	ID 350 NR 53
15	-	TS: Direction of center offset relative to 0° position	ID 350 NR 54
20	1/2/3	TT: Center point X/Y/Z	ID 350 NR 71
21	-	TT: Plate radius	ID 350 NR 72
22	1/2/3	TT: 1st probing position X/Y/Z	Cfgread
23	1/2/3	TT: 2nd probing position X/Y/Z	Cfgread
24	1/2/3	TT: 3rd probing position X/Y/Z	Cfgread
25	1/2/3	TT: 4th probing position X/Y/Z	Cfgread
ID 370 Touch probe cycle settings			
1	-	Do not move to set-up clearance in Cycle 0.0 (as with ID990 NR1)	ID 990 NR 1
2	-	MP 6150 Rapid traverse for measurement	ID 350 NR 55 IDX 1
3	-	MP 6151 Machine rapid traverse as rapid traverse for measurement	ID 350 NR 55 IDX 3
4	-	MP 6120 Feed rate for measurement	ID 350 NR 55 IDX 2
5	-	MP 6165 Angle tracking on/off	ID 350 NR 57
ID 501 Datum table (REF system)			
Line	Column	Value in datum table	Preset table
ID 502 Preset table			
Line	Column	Read the value from preset table, taking into account the active machining system	
ID 503 Preset table			
Line	Column	Read the value directly from the preset table	ID 507
ID 504 Preset table			
Line	Column	Read the basic rotation from the preset table	ID 507 IDX 4-6
ID 505 Datum table			
1	-	0 = No datum table selected 1 = Datum table selected	
ID 510 Data for pallet machining			
7	-	Test the insertion of a fixture from the PAL line	

No.	IDX	Contents	Replacement function
ID 530 Active preset			
2	Line	Write-protect the line in the active preset table: 0 = No, 1 = Yes	D26 and D28: read out the Locked column
ID 990 Approach behavior			
2	10	0 = No execution in block scan 1 = Execution in block scan	ID 992 NR 10 / NR 11
3	Q parameters	Number of axes that are programmed in the selected datum table	
ID 1000 Machine parameter			
MP number	MP index	Value of the machine parameter	CfgRead
ID 1010 Machine parameter is defined			
MP number	MP index	0 = Machine parameter does not exist 1 = Machine parameter exists	CfgRead

[1] Function or table column no longer exists

[2] Use D26 and D28 to read out the table cell

15.2 Overview tables

Miscellaneous functions

M	Effect	Effective at block		Page
		Start	End	
M0	Program STOP/Spindle STOP/Coolant OFF		■	217
M1	Optional program run STOP/Spindle STOP/Coolant OFF		■	217
M2	Stop program/Spindle STOP/Coolant OFF/ CLEAR status display (depending on machine parameter)/Return jump to block 1		■	217
M3 M4 M5	Spindle ON clockwise Spindle ON counterclockwise Spindle STOP	■ ■ 	 ■	217
M6	Tool change/STOP program run (depending on machine parameter)/Spindle STOP		■	217
M8 M9	Coolant ON Coolant OFF	■ 	 ■	217
M13 M14	Spindle ON clockwise/Coolant ON Spindle ON counterclockwise/Coolant on	■ ■		217
M30	Same function as M2		■	217
M89	Vacant miscellaneous function **or** cycle call, modally effective (depending on machine parameter)	■ 	 ■	Cycles Manual
M91	Within the positioning block: Coordinates are referenced to machine datum	■		218
M92	Within the positioning block: Coordinates are referenced to a position defined by machine manufacturer, e.g. tool change position	■		218
M94	Reduce the rotary axis display to a value below 360°	■		402
M97	Machine small contour steps		■	221
M98	Machine open contours completely		■	222
M99	Blockwise cycle call		■	Cycles Manual
M101 M102	Automatic tool change with replacement tool if maximum tool life has expired Reset M101		■ ■	125
M103	Feed rate factor for plunging movements	■		223
M107 M108	Suppress error message for replacement tools with oversize Reset M107		■ ■	125
M109 **M110** M111	Constant contouring speed at cutting edge (feed rate increase and reduction) Constant contouring speed at cutting edge (only feed rate reduction) Reset M109/M110	■ ■ 	 ■	224
M116 M117	Feed rate in mm/min on rotary axes Reset M116	■ 	 ■	400
M118	Superimpose handwheel positioning during program run	■		228
M120	Pre-calculate the radius-compensated contour (LOOK AHEAD)	■		226
M126 M127	Shorter-path traverse of rotary axes Reset M126	■ 	 ■	401

M	Effect	Effective at block Start	End	Page
M128	Maintaining the position of the tool tip when positioning with tilted axes (TCPM)	■		403
M129	Reset M128		■	
M130	Within the positioning block: Points are referenced to the untilted coordinate system	■		220
M136	Feed rate F in millimeters per spindle revolution	■		224
M137	Reset M136			
M138	Selection of tilted axes	■		405
M140	Retraction from the contour in the tool-axis direction	■		229
M141	Suppress touch probe monitoring	■		231
M143	Delete basic rotation	■		231
M144	Compensating the machine’s kinematic configuration for ACTUAL/NOMINAL positions at end of block	■		406
M145	Reset M144		■	
M148	Automatically retract tool from the contour at an NC stop	■		232
M149	Reset M148		■	
M197	Corner rounding	■	■	233

User functions

User functions		
Short description	■	Basic version: 3 axes plus closed-loop spindle
	□	Additional axis for 4 axes plus closed-loop spindle
	□	Additional axis for 5 axes plus closed-loop spindle
Program entry	In HEIDENHAIN conversational format and ISO (G codes)	
Position entry	■	Nominal positions for lines and arcs in Cartesian coordinates or polar coordinates
	■	Incremental or absolute dimensions
	■	Display and entry in mm or inches
Tool compensation	■	Tool radius in the working plane and tool length
	x	Radius compensated contour look ahead for up to 99 blocks (M120)
Tool tables	Multiple tool tables with any number of tools	
Constant contour speed	■	With respect to the path of the tool center
	■	With respect to the cutting edge
Parallel operation	Creating an NC program with graphical support while another NC program is being run	
Cutting data	Automatic calculation of spindle speed, cutting speed, feed per tooth, and feed per revolution	
3-D machining (Advanced Function Set 2)	**2**	Motion control with minimum jerk
	2	3-D tool compensation via surface-normal vectors
	2	Using the electronic handwheel to change the angle of the swivel head during program run without affecting the position of the tool center point (tool tip or center of sphere) (TCPM = **T**ool **C**enter **P**oint **M**anagement)
	2	Keeping the tool normal to the contour
	2	Tool radius compensation perpendicular to traversing and tool direction
Rotary table machining (Advanced Function Set 1)	**1**	Programming of cylindrical contours as if in two axes
	1	Feed rate in distance per minute
Contour elements	■	Straight line
	■	Chamfer
	■	Circular path
	■	Circle center
	■	Circle radius
	■	Tangentially connected arc
	■	Rounded corners

User functions		
Approaching and departing the contour	■	Via straight line: tangential or perpendicular
	■	Via circular arc
Free contour programming (FK)	**x**	FK free contour programming in HEIDENHAIN Klartext format with graphic support for workpiece drawings not dimensioned for NC
Program jumps	■	Subprograms
	■	Program section repeats
	■	External NC programs
Machining cycles	■	Cycles for drilling, and conventional and rigid tapping
	x	Cycles for pecking, reaming, boring, and counterboring
	x	Cycles for milling internal and external threads
	■	Roughing and finishing rectangular and circular pockets
	x	Roughing and finishing rectangular and circular studs
	x	Cycles for clearing level and inclined surfaces
	x	Cycles for milling linear and circular slots
	x	Cartesian and polar point patterns
	x	Contour pocket
	x	Contour train
	x	OEM cycles (special cycles developed by the machine manufacturer) can also be integrated
Coordinate transformation	■	Datum shift, rotation, mirroring
	■	Scaling factor (axis-specific)
	1	Tilting of the working plane (Advanced Function Set 1)
Q parameters Programming with variables	■	Mathematical functions =, +, –, *, /, roots
	■	Logical operations (=, ≠, <, >)
	■	Calculating with parentheses
	■	sin α, cos α, tan α , arc sin, arc cos, arc tan, a^n, e^n, In, log, absolute value of a number, constant π, negation, truncation of digits before or after the decimal point
	■	Functions for calculation of circles
	■	String parameters

User functions		
Programming aids	■	Calculator
	■	Color highlighting of syntax elements
	■	Complete list of all current error messages
	■	Context-sensitive help function
	■	Graphic support for the programming of cycles
	■	Comment and structure blocks in the NC program
Teach-In	■	Actual positions can be transferred directly to the NC program
Test graphics	x	Graphic simulation before a program run, even while another NC program is being run
Display modes	x	Plan view / projection in 3 planes / 3-D view / 3-D line graphics
	x	Detail enlargement
Programming graphics	■	In the **Programming** operating mode, the contours of the NC blocks are drawn on screen while they are being entered (2-D pencil-trace graphics), even while another NC program is being run
Program-run graphics Display modes	x	Graphic simulation of real-time machining in plan view / projection in 3 planes / 3-D view
Machining time	■	Calculation of machining time in the **Test Run** operating mode
	■	Display of the current machining time in the **Program Run, Single Block** and **Program Run, Full Sequence** operating modes
Preset management	■	For saving any datums
Returning to the contour	■	Block scan in any NC block in the NC program, returning the tool to the calculated nominal position to continue machining
	■	NC program interruption, contour departure and return
Datum tables	■	Multiple datum tables for storing workpiece-specific datums
Touch probe cycles	x	Calibrating the touch probe
	x	Compensation of workpiece misalignment, manual or automatic
	x	Manual and automatic presetting
	x	Automatic workpiece measurement
	x	Tools can be measured automatically

15.3 Differences between the TNC 620 and the iTNC 530

Comparison: PC software

Function	TNC 620	iTNC 530
ConfigDesign for the configuration of machine parameters	Available	Not available
TNCanalyzer for the analysis and evaluation of service files	Available	Not available

Comparison: User functions

Function	TNC 620	iTNC 530
Program entry		
▪ smarT.NC	▪ –	▪ X
▪ ASCII editor	▪ X, directly editable	▪ X, editable after conversion
Position entry		
▪ Set the last tool position as pole (empty CC block)	▪ X (error message if pole transfer is ambiguous)	▪ X
▪ Spline sets (**SPL**)	▪ –	▪ X, with option 9
Tool table		
▪ Flexible management of tool types	▪ X	▪ –
▪ Filtered display of selectable tools	▪ X	▪ –
▪ Sorting function	▪ X	▪ –
▪ Column names	▪ Sometimes with _	▪ Sometimes with **-**
▪ Form view	▪ Switchover with Screen Layout key	▪ Switchover by soft key
▪ Exchange of tool table between TNC 620 and iTNC 530	▪ X	▪ Not possible
Touch probe table for managing different 3-D touch probes	X	–
Cutting data calculator: Automatic calculation of spindle speed and feed rate	▪ Simple cutting data calculator without stored table ▪ Cutting data calculator with stored technology tables	Using stored technology tables

Function	TNC 620	iTNC 530
Define any tables	■ Freely definable tables (.TAB files) ■ Reading and writing with D26 to D28 ■ Definable via config. data ■ The names of tables and table columns must start with a letter, and no arithmetic operators are permitted	■ Freely definable tables (.TAB files) ■ Reading and writing with D26 to D28
Traverse in tool-axis direction		
■ Manual operation (3-D ROT menu)	■ X	■ X, FCL2 function
■ With handwheel superimpositioning	■ X	■ X, option 44
Entry of feed rates:		
■ **FU** (feed per revolution mm/1)	■ –	■ X
■ **FZ** (tooth feed rate)	■ –	■ X
■ **FT** (time in seconds for path)	■ –	■ X
■ **FMAXT** (only for active rapid traverse potentiometer: time in seconds for path)	■ –	■ X
FK free contour programming		
■ Programming for workpiece drawings not dimensioned for NC programming	■ X, option 19	■ X
■ Conversion of FK program to Klartext conversational language	■ –	■ X
■ FK blocks in combination with **M89**	■ –	■ X
Program jumps:		
■ Maximum number of labels	■ 65535	■ 1000
■ Subprograms	■ X	■ X
■ Nesting depth for subprograms	■ 20	■ 6

Function	TNC 620	iTNC 530
Q parameter programming:		
■ D15: PRINT	■ –	■ X
■ D25: PRESET	■ –	■ X
■ D29: PLC LIST	■ X	■ –
■ D31: RANGE SELECT	■ –	■ X
■ D32: PLC PRESET	■ –	■ X
■ D37: EXPORT	■ X	■ –
■ **D16**	■ X	■ –
■ Writing to LOG files	■ X	■ –
■ Configurable behavior for undefined or empty QS parameters		
Graphic support		
■ 2-D programming graphics	■ X	■ X
■ REDRAW function (**REDRAW**)	■ –	■ X
■ Show grid lines as the background	■ X	■ –
■ Program run graphics (plan view, projection in 3 planes, 3-D view)	■ X, with option 20	■ X
■ High-resolution view	■ X	■ X
■ Test graphics (plan view, projection on 3 planes, 3-D view)	■ X, with option 20	■ X
■ Tool display	■ X, with option 20	■ X
■ Adjusting the simulation speed	■ X, with option 20	■ X
■ Coordinates of line intersection for projection in 3 planes	■ –	■ X
■ Expanded zoom functions (mouse operation)	■ X, with option 20	■ X
■ Displaying frame for workpiece blank	■ X, with option 20	■ X
■ Displaying the depth value in plan view during mouse-over	■ X, with option 20	■ X
■ Deliberately stop test run (**STOP AT**)	■ X, with option 20	■ X
■ Factor in tool change macro	■ X (differing to actual execution)	■ X

Function	TNC 620	iTNC 530
Preset table		
■ Line 0 of the preset table can be edited manually	■ X	■ –
Pallet management		
■ Support of pallet files	■ X, option 22	■ X
■ Tool-oriented machining	■ X, option 22	■ X
■ Management of presets for a pallet in a table	■ X, option 22	■ X
Programming aids:		
■ Color highlighting of syntax elements	■ X	■ –
■ Calculator	■ X (scientific)	■ X (standard)
■ Convert NC blocks to comments	■ X	■ –
■ Structure blocks in NC program	■ X	■ X
■ Structure view in test run	■ –	■ X
Dynamic Collision Monitoring (DCM):		
■ Collision monitoring in Automatic operation	■ –	■ X, option 40
■ Collision monitoring in Manual operation	■ –	■ X, option 40
■ Graphic depiction of the defined collision objects	■ –	■ X, option 40
■ Collision checking in test run	■ –	■ X, option 40
■ Fixture monitoring	■ –	■ X, option 40
■ Tool carrier management	■ X	■ X, option 40
CAM support:		
■ Load contours from Step data and Iges data	■ X, option 42	■ –
■ Load machining positions from Step data and Iges data	■ X, option 42	■ –
■ Offline filter for CAM files	■ –	■ X
■ Stretch filter	■ X	■ –
MOD functions:		
■ User parameters	■ Config data	■ Numerical structure
■ OEM help files with service functions	■ –	■ X
■ Data medium inspection	■ –	■ X
■ Load service packs	■ –	■ X
■ Specify the axes for actual position capture	■ –	■ X
■ Configure counter	■ X	■ –

Function	TNC 620	iTNC 530
Special functions:		
■ Create reverse program	■ –	■ X
■ Adaptive Feed Control AFC	■ –	■ X, option 45
■ Define the counter with **FUNCTION COUNT**	■ X	■ –
■ Define the dwell time with **FUNCTION FEED**	■ X	■ –
■ Define the dwell time with **FUNCTION DWELL**	■ X	■ –
■ Determine the integration of the programmed coordinates with **FUNCTION PROG PATH**	■ X	■ –
Functions for large molds and dies:		
■ Global program settings (GS)	■ –	■ X, option 44
Status displays:		
■ Dynamic display of Q-parameter contents, definable number ranges	■ X	■ –
■ Graphic display of residual run time	■ –	■ X
Individual color settings of user interface	–	X

Comparison: Miscellaneous functions

M	Effect	TNC 620	iTNC 530
M00	Program STOP/Spindle STOP/Coolant OFF	X	X
M01	Optional program STOP	X	X
M02	Stop program/Spindle STOP/Coolant OFF/ Clear status display (depending on machine parameter)/Return jump to block 1	X	X
M03 M04 M05	Spindle ON clockwise Spindle ON counterclockwise Spindle STOP	X	X
M06	Tool change/Program run STOP (machine-specific function)/ Spindle STOP	X	X
M08 M09	Coolant ON Coolant OFF	X	X
M13 M14	Spindle ON clockwise/Coolant ON Spindle ON counterclockwise/Coolant on	X	X
M30	Same function as M02	X	X
M89	Free miscellaneous function **or** cycle call, modally effective (machine-specific function)	X	X
M90	Constant contouring speed at corners (not required at TNC 620)	–	X
M91	Within the positioning block: Coordinates are referenced to machine datum	X	X
M92	Within the positioning block: Coordinates are referenced to a position defined by machine manufacturer, e.g. tool change position	X	X
M94	Reduce the rotary axis display to a value below 360°	X	X
M97	Machine small contour steps	X	X
M98	Machine open contours completely	X	X
M99	Blockwise cycle call	X	X
M101 M102	Automatic tool change with replacement tool if maximum tool life has expired Reset M101	X	X
M103	Reduce feed rate during plunging to factor F (percentage)	X	X
M104	Reactivate most recently set preset	– (recommended: Cycle 247)	X
M105 M106	Machining with second k_v factor Machining with first k_v factor	–	X
M107 M108	Suppress error message for replacement tools with oversize Reset M107	X	X
M109	Constant contouring speed at cutting edge (feed rate increase and reduction)	X	X
M110	Constant contouring speed at cutting edge (only feed rate reduction)	X	X
M111	Reset M109/M110	X	X
	Functionality for **APPR** and **DEP**	X	

M	Effect	TNC 620	iTNC 530
M112 M113	Enter contour transitions between any two contour transitions Reset M112	– (recommended: Cycle 32)	X
M114 M115	Automatic compensation of machine geometry when working with tilted axes Reset M114	– (recommended: M128, TCPM)	X, option 8
M116 M117	Feed rate on rotary tables in mm/min Reset M116	X, option 8	X, option 8
M118	Superimpose handwheel positioning during program run	X, option 21	X
M120	Pre-calculate the radius-compensated contour (LOOK AHEAD)	X, option 21	X
M124	Contour filter	– (possible via user parameters)	X
M126 M127	Shorter-path traverse of rotary axes Reset M126	X	X
M128 M129	Maintaining the position of the tool tip when positioning tilted axes (TCPM) Reset M128	X, option 9	X, option 9
M130	Within the positioning block: Points are referenced to the untilted coordinate system	X	X
M134 M135	Precision stop at non-tangential contour transitions when positioning with rotary axes Reset M134	X (depends on the machine tool builder)	X
M136 M137	Feed rate F in millimeters per spindle revolution Reset M136	X	X
M138	Selection of tilted axes	X	X
M140	Retraction from the contour in the tool-axis direction	X	X
M141	Suppress touch probe monitoring	X	X
M142	Delete modal program information	–	X
M143	Delete basic rotation	X	X
M144 M145	Compensating the machine's kinematic configuration for ACTUAL/NOMINAL positions at end of block Reset M144	X, option 9	X, option 9
M148 M149	Automatically retract tool from the contour at an NC stop Reset M148	X	X
M150	Suppress limit switch message	–	X
M197	Rounding the corners	X	–
M200 - M204	Laser cutting functions	–	X

Comparison: Touch probe cycles in the Manual operation and Electronic handwheel operating modes

Cycle	TNC 620	iTNC 530
Touch-probe table for managing 3-D touch probes	X	–
Calibrating the effective length	X, option 17	X
Calibrating the effective radius	X, option 17	X
Measuring a basic rotation using a line	X, option 17	X
Setting the preset on any axis	X, option 17	X
Setting a corner as preset	X, option 17	X
Setting a circle center as preset	X, option 17	X
Setting a center line as preset	X, option 17	X
Measuring a basic rotation using two holes/cylindrical studs	X, option 17	X
Setting the preset using four holes/cylindrical studs	X, option 17	X
Setting the circle center using three holes/cylindrical studs	X, option 17	X
Determine and offset misalignment of a plane	X, option 17	–
Support of mechanical touch probes by manually capturing the current position	By soft key or hard key	By hard key
Write measurement values to the preset table	X, option 17	X
Write measurement values to the datum table	X, option 17	X

Comparison: Differences in programming

Function	TNC 620	iTNC 530
File management:		
■ Entry of name	■ Opens the **Select file** pop-up window.	■ Synchronizes the cursor
■ Support of key combinations	■ Not available	■ Available
■ Favorites Management	■ Not available	■ Available
■ Configuration of column structure	■ Not available	■ Available
Selecting a tool from the table	Selection via split-screen menu	Selection in a pop-up window
Programming special functions with the **SPEC FCT** key	Pressing the key opens a soft-key row as a submenu. To exit the submenu, press the **SPEC FCT** key again; then the control shows the last active soft-key row	Pressing the key adds the soft-key row as the last row. To exit the menu, press the **SPEC FCT** key again; then the control shows the last active soft-key row
Programming approach and departure motions with the **APPR DEP** key	Pressing the key opens a soft-key row as a submenu. To exit the submenu, press the **APPR DEP** key again; then the control shows the last active soft-key row	Pressing the key adds the soft-key row as the last row. To exit the menu, press the **APPR DEP** key again; then the control shows the last active soft-key row
Pressing the hard key **END** with active **CYCLE DEF** and **TOUCH PROBE** menus	Terminates the editing process and calls the file manager	Exits the respective menu
Calling the file manager if **CYCLE DEF** and **TOUCH PROBE** menus are active	Terminates the editing process and calls the file manager. The respective soft-key row remains selected when the file manager is exited	**Key non-functional** error message.
Calling the file manager if **CYCL CALL**, **SPEC FCT**, **PGM CALL** and **APPR DEP** menus are open	Terminates the editing process and calls the file manager. The respective soft-key row remains selected when the file manager is exited	Terminates the editing process and calls the file manager. The basic soft-key row is selected when the file manager is exited

Function	TNC 620	iTNC 530
Datum table:		
■ Sorting function by values within an axis	■ Available	■ Not available
■ Resetting the table	■ Available	■ Not available
■ Switching the list/form view	■ Switch via the screen layout key	■ Switchover by toggle soft key
■ Inserting individual line	■ Allowed everywhere, renumbering possible after request. Empty line is inserted, must be filled with zeros manually	■ Only allowed at the end of the table. Line with value 0 in all columns is inserted
■ Transfer of actual position values on individual axis to the datum table using the keys	■ Available in the **Program Run Single Block** and **Program Run, Full Sequence** operating modes	■ Available
■ Transfer of actual position values on all active axes to the datum table using the keys	■ Not available	■ Available
■ Capturing the last positions measured by TS using the keys	■ Not available	■ Available
FK free contour programming:		
■ Programming of parallel axes	■ With X/Y coordinates, independent of machine type; switchover with **FUNCTION PARAXMODE**	■ Machine-dependent with the existing parallel axes
■ Automatic correction of relative references	■ Relative references in contour subprograms are not corrected automatically	■ All relative references are corrected automatically
■ Specify the working plane during programming	■ BLK form ■ **Plane XY ZX YZ** soft key if the working plane differs	■ BLK form

Function	TNC 620	iTNC 530
Q-parameter programming:		
- Q-parameter formula with SGN	**Q12 = SGN Q50** - If **Q50 = 0** then **Q12 = 0** - If **Q50 > 0** then **Q12 = 1** - If **Q50 < 0** then **Q12 -1**	**Q12 = SGN Q50** - If **Q50 >= 0** then **Q12 = 1** - If **Q50 < 0** then **Q12 -1**
- Access to machine parameters	- With the **CFGREAD** function	- Via **D18** functions
- Creating interactive cycles with **CYCLE QUERY**, e.g. touch probe cycles in Manual Operation	- Available	- Not available
Handling of error messages:		
- Help with error messages	- Call via **ERR** key	- Call via **HELP** key
- Switching the operating mode while help menu is active	- Help menu is closed when the operating mode is switched	- Operating mode switchover is not allowed (key is non-functional)
- Selecting the background operating mode while help menu is active	- Help menu is closed when F12 is used for switching	- Help menu remains open when F12 is used for switching
- Identical error messages	- Are collected in a list	- Are displayed only once
- Acknowledgment of error messages	- Every error message (even if it is displayed more than once) must be acknowledged, the **DELETE ALL** function is available	- Error message to be acknowledged only once
- Access to protocol functions	- Log and powerful filter functions (errors, keystrokes) are available	- Complete log without filter functions available
- Saving service files	- Available. No service file is generated upon a system crash - Error number selectable for which a service file will be generated automatically	- Available. A service file is generated automatically upon a system crash

Function	TNC 620	iTNC 530
Find function:		
■ List of words recently searched for	■ Not available	■ Available
■ Show elements of active block	■ Not available	■ Available
■ Show list of all available NC blocks	■ Not available	■ Available
Starting the search function with the up/down arrow keys when highlighted	Works up to max. 50000 NC blocks, can be set via configuration datum	No limitation regarding program length
Programming graphics:		
■ True-to-scale display of grid	■ Available	■ Not available
■ Editing contour subprograms in SLII cycles with **AUTO DRAW ON**	■ With error messages, in the main program the cursor is positioned on the **CYCL CALL** NC block	■ With error messages, the cursor is positioned on the NC block in the contour subprogram that caused the error
■ Moving the zoom window	■ Repeat function not available	■ Repeat function available
Programming minor axes:		
■ Syntax **FUNCTION PARAXCOMP**: Define the behavior of the display and the paths of traverse	■ Available	■ Not available
■ Syntax **FUNCTION PARAXMODE**: Define the assignment of the parallel axes to be traversed	■ Available	■ Not available

Comparison: Differences in Test Run, functionality

Function	TNC 620	iTNC 530
Entering a program with the **GOTO** key	Function only possible if the **START SINGLE** soft key was not pressed	Function also possible after **START SINGLE**
Calculation of machining time	Each time the simulation is repeated by pressing the START soft key, the machining time is totaled	Each time the simulation is repeated by pressing the START soft key, time calculation starts at 0
Single block	With point pattern cycles and **CYCL CALL PAT**, the control stops after each point	Point pattern cycles and **CYCL CALL PAT** are handled by the control as a single NC block

Comparison: Differences in Test Run, operation

Function	TNC 620	iTNC 530
Zoom function	Each sectional plane can be selected by individual soft keys	Sectional plane can be selected via three toggle soft keys
Machine-specific miscellaneous functions M	Lead to error messages if they are not integrated in the PLC	Are ignored during Test Run
Displaying/editing the tool table	Function available via soft key	Function not available
Tool depiction	■ Turquoise: Tool length ■ Red: Length of cutting edge and tool is engaged ■ Blue: Length of cutting edge and tool is not engaged	■ - ■ Red: Tool is engaged ■ Green: Tool is not engaged
View options of 3-D view	Available	Function not available
Adjustable model quality	Available	Function not available

Comparison: Differences in programming station

Function	TNC 620	iTNC 530
Demo version	NC programs with more than 100 NC blocks cannot be selected; an error message is issued	NC programs can be selected, max. 100 NC blocks are displayed, further NC blocks are truncated in the display
Demo version	If nesting with **%** results in more than 100 NC blocks, there is no test graphic display; an error message is not issued	Nested NC programs can be simulated
Demo version	You can transfer up to 10 elements from the CAD viewer to an NC program.	You can transfer up to 31 lines from the DXF converter to an NC program.
Copying NC programs	Copying to and from the directory **TNC:** is possible with Windows Explorer	**TNCremo** or file manager of programming station must be used for copying
Shifting the horizontal soft-key row	Clicking the soft-key bar shifts one soft-key row to the right or left	Clicking any soft-key bar activates the respective soft-key row

15.4 DIN/ISO function overview TNC 620

G codes

Tool movements	
G00	**Cartesian line in rapid traverse**
G01	**Cartesian line at feed rate**
G02	**Cartesian circle clockwise**
G03	**Cartesian circle CCW**
G05	**Cartesian circle**
G06	**Cartesian circle, tang. transit.**
G07	**Cartesian line, paraxial**
G10	**Polar line in rapid traverse**
G11	**Polar line at feed rate**
G12	**Polar circle clockwise**
G13	**Polar circle counterclockwise**
G15	**Polar circle**
G16	**Polar circle, tang. transition**

Approach or depart from chamfer/rounding/contour	
G24	**Chamfer with length R** with chamfer length R
G25	**Corner rounding with radius R** with radius R
G26	**Tangential approach** of a contour with radius R
G27	**Tangential departure** from a contour with radius R

Tool definition	
G99	**Tool definition** with tool number T, length L, and radius R

Tool radius compensation	
G40	**Path of tool center** without tool radius compensation
G41	**Radius compensation left of path**
G42	**Radius compens. right of path**
G43	**Radius compensation: extend path** for G07
G44	**Radius compens.: shorten path** for G07

Blank form definition for graphics	
G30	**Workpiece blank def.: MIN point** (G17/G18/G19)
G31	**Workpiece blank def.: MAX point** (G90/G91)

Cycles for drilling, tapping and thread milling	
G200	**DRILLING**
G201	**REAMING**
G202	**BORING**

Cycles for drilling, tapping and thread milling	
G203	**UNIVERSAL DRILLING**
G204	**BACK BORING**
G205	**UNIVERSAL PECKING**
G206	**TAPPING** with floating tap holder
G207	**RIGID TAPPING** without floating tap holder
G208	**BORE MILLING**
G209	**TAPPING W/ CHIP BRKG**
G240	**CENTERING**
G241	**SINGLE-LIP D.H.DRLNG**
G262	**THREAD MILLING**
G263	**THREAD MLLNG/CNTSNKG**
G265	**HEL. THREAD DRLG/MLG**
G267	**OUTSIDE THREAD MLLNG**

Cycles for milling pockets, studs, and slots	
G233	**FACE MILLING**
G251	**RECTANGULAR POCKET**
G252	**CIRCULAR POCKET**
G253	**SLOT MILLING**
G254	**CIRCULAR SLOT**
G256	**RECTANGULAR STUD**
G257	**CIRCULAR STUD**
G258	**POLYGON STUD**

Coordinate transformation	
G28	**MIRRORING**
G53	**DATUM SHIFT**
G54	**DATUM SHIFT**
G72	**SCALING FACTOR**
G73	**ROTATION**
G80	**WORKING PLANE**
G247	**PRESETTING**

SL cycles	
G37	**CONTOUR**
G120	**CONTOUR DATA**
G121	**PILOT DRILLING**
G122	**ROUGH-OUT**
G123	**FLOOR FINISHING**
G124	**SIDE FINISHING**

SL cycles	
G125	**CONTOUR TRAIN**
G127	**CYLINDER SURFACE**
G128	**CYLINDER SURFACE**
G129	**CYL SURFACE RIDGE**
G139	**CYL. SURFACE CONTOUR**
G270	**CONTOUR TRAIN DATA**
G271	**OCM CONTOUR DATA**
G272	**OCM ROUGHING**
G273	**OCM FINISHING FLOOR**
G274	**OCM FINISHING SIDE**
G275	**TROCHOIDAL SLOT**
G276	**THREE-D CONT. TRAIN**

Cycles for creating point patterns	
G220	**POLAR PATTERN**
G221	**CARTESIAN PATTERN**
G224	**DATAMATRIX CODE PATTERN**

Cycles for turning	
G37	**CONTOUR**
G800	**ADJUST XZ SYSTEM**
G801	**RESET ROTARY COORDINATE SYSTEM**
G810	**TURN CONTOUR LONG.**
G811	**SHOULDER, LONGITDNL.**
G812	**SHOULDER, LONG. EXT.**
G813	**TURN PLUNGE CONTOUR LONGITUDINAL**
G814	**TURN PLUNGE LONGITUDINAL EXT.**
G815	**CONTOUR-PAR. TURNING**
G820	**TURN CONTOUR TRANSV.**
G821	**SHOULDER, FACE**
G822	**SHOULDER, FACE. EXT.**
G823	**TURN TRANSVERSE PLUNGE**
G824	**TURN PLUNGE TRANSVERSE EXT.**
G830	**THREAD CONTOUR-PARALLEL**
G831	**THREAD LONGITUDINAL**
G832	**THREAD EXTENDED**
G840	**RECESS TURNG, RADIAL**
G841	**SIMPLE REC. TURNG., RADIAL DIR.**
G842	**ENH.REC.TURNNG, RAD.**

Cycles for turning	
G850	**RECESS TURNG, AXIAL**
G851	**SIMPLE REC TURNG, AX**
G852	**ENH.REC.TURNING, AX.**
G860	**CONT. RECESS, RADIAL**
G861	**SIMPLE RECESS, RADL.**
G862	**EXPND. RECESS, RADL.**
G870	**CONT. RECESS, AXIAL**
G871	**SIMPLE RECESS, AXIAL**
G872	**EXPND. RECESS, AXIAL**
G880	**GEAR HOBBING**
G883	**TURNING SIMULTANEOUS FINISHING**
G892	**CHECK UNBALANCE**

Special cycles	
G4	**DWELL TIME**
G36	**ORIENTATION**
G39	**PGM CALL**
G62	**TOLERANCE**
G86	**THREAD CUTTING**
G225	**ENGRAVING**
G232	**FACE MILLING**
G238	**MEASURE MACHINE STATUS**
G239	**ASCERTAIN THE LOAD**
G285	**DEFINE GEAR**
G286	**GEAR HOBBING**
G287	**GEAR SKIVING**
G291	**COUPLG.TURNG.INTERP.**
G292	**CONTOUR.TURNG.INTRP.**

Cycles for grinding	
G1000	**DEFINE RECIP. STROKE**
G1001	**START RECIP. STROKE**
G1002	**STOP RECIP. STROKE**
G1010	**DRESSING DIAMETER**
G1015	**PROFILE DRESSING**
G1030	**ACTIVATE WHEEL EDGE**
G1032	**GRINDING WHL LENGTH COMPENSATION**
G1033	**GRINDING WHL RADIUS COMPENSATION**

Touch probe cycles for measuring workpiece misalignment	
G400	BASIC ROTATION
G401	ROT OF 2 HOLES
G402	ROT OF 2 STUDS
G403	ROT IN ROTARY AXIS
G404	SET BASIC ROTATION
G405	ROT IN C AXIS
G1410	PROBING ON EDGE
G1411	PROBING TWO CIRCLES
G1420	PROBING IN PLANE

Touch probe system cycles for setting datum	
G408	SLOT CENTER PRESET
G409	RIDGE CENTER PRESET
G410	PRESET INSIDE RECTAN
G411	PRESET OUTS. RECTAN
G412	PRESET INSIDE CIRCLE
G413	PRESET OUTS. CIRCLE
G414	PRESET OUTS. CORNER
G415	PRESET INSIDE CORNER
G416	PRESET CIRCLE CENTER
G417	PRESET IN TS AXIS
G418	PRESET FROM 4 HOLES
G419	PRESET IN ONE AXIS

Touch probe cycles for workpiece measurement	
G55	REF. PLANE
G420	MEASURE ANGLE
G421	MEASURE HOLE
G422	MEAS. CIRCLE OUTSIDE
G423	MEAS. RECTAN. INSIDE
G424	MEAS. RECTAN. OUTS.
G425	MEASURE INSIDE WIDTH
G426	MEASURE RIDGE WIDTH
G427	MEASURE COORDINATE
G430	MEAS. BOLT HOLE CIRC
G431	MEASURE PLANE

Special cycles	
G441	FAST PROBING
G444	PROBING IN 3-D

Special cycles	
G600	**GLOBAL WORKING SPACE**
G601	**LOCAL WORKING SPACE**

Touch probe cycles for touch probe calibration	
G460	**TS CALIBRATION OF TOOL LENGTH**
G461	**CALIBRATION OF A TS IN A RING**
G462	**TS CALIBRATION ON STUD**
G463	**CALIBRATION OF TS ON A SPHERE**

Touch probe cycles for kinematics measurement	
G450	**SAVE KINEMATICS**
G451	**MEASURE KINEMATICS**
G452	**PRESET COMPENSATION**
G453	**KINEMATICS GRID**

Touch probe cycles for tool measurement	
G480	**CALIBRATE TT**
G481	**CAL. TOOL LENGTH**
G482	**CAL. TOOL RADIUS**
G483	**MEASURE TOOL**
G484	**CALIBRATE IR TT**

Define the working plane	
G17	**Spindle axis Z - plane XY**
G18	**Spindle axis Y - plane ZX**
G19	**Spindle axis X - plane YZ**

Dimensions	
G70	Unit of measure: Inch
G71	Unit of measure: mm
G90	**Absolute dimension**
G91	Incremental dimension

Other G codes	
G29	**Load current position**
G38	**Stop program run**
G51	**Prepare tool changer**
G79	Cycle call
G98	**Set label**

Addresses

Addresses	
%	■ Program start ■ Program call
#	Datum number with G53
A	Rotation about X axis
B	Rotation about Y axis
C	Rotation about Z axis
D	Q parameter definitions
DL	Wear compensation for length with T
DR	Wear compensation for radius with T
E	Tolerance ■ M112 ■ M124
F	■ Feed rate ■ Dwell time with G04 ■ Scaling factor with G72 ■ Factor for feed-rate reduction F with M103
G	G codes
H	■ Polar coordinate angle ■ Rotation angle with G73 ■ Max. permissible angle with M112
I	X coordinate of the circle center/pole
Y	Y coordinate of the circle center/pole
K	Z coordinate of the circle center/pole
L	■ Set a label number with G98 ■ Jump to a label number ■ Tool length with G99
M	M functions
N	Block number
P	■ Cycle parameters in machining cycles ■ Value or Q parameter in Q parameter definition
Q	Q parameter
R	■ Polar coordinate radius ■ Radius with G02/G03/G05 ■ Rounding radius with G25/G26/G27 ■ Tool radius with G99
S	■ Spindle speed ■ Spindle orientation with G36
T	■ Tool definition with G99 ■ Tool call ■ Next tool with G51

Addresses	
U	Axis parallel to X axis
V	Axis parallel to Y axis
W	Axis parallel to Z axis
X	X axis
Y	Y axis
Z	Z axis
*	End of block

Contour cycles

Program structure with machining with multiple tools	
List of contour programs	G37 P01 ...
Defining **contour data**	G120 Q1 ...
Drill define/call Contour cycle: Pilot drilling Cycle call	G121 Q10 ...
Roughing mill define/call Contour cycle: Rough-out Cycle call	G122 Q10 ...
Finishing mill define/call Contour cycle: Floor finishing Cycle call	G123 Q11 ...
Finishing mill define/call Contour cycle: Side finishing Cycle call	G124 Q11 ...
End of main program, return	**M02**
Contour subprograms	G98 ... G98 L0

Radius compensation of the contour subprograms

Contour	Programming sequence of the contour elements	Radius Compensation
Inside (pocket)	clockwise (CW) counterclockwise (CCW)	G42 (RR) G41 (RL)
Outside (island)	clockwise (CW) counterclockwise (CCW)	G41 (RL) G42 (RR)

Coordinate transformations

Coordinate transformation	Activate	Cancel
Datum shift	G54 X+20 Y+30 Z+10	G54 X0 Y0 Z0
Mirroring	G28 X	G28
Rotation	G73 H+45	G73 H+0
Scaling factor	G72 F 0.8	G72 F1 ...
Machining plane	G80 A+10 B+10 C+15	G80
Machining plane	PLANE ...	PLANE RESET

Q parameter definitions

D	Function
00	Assignment
01	Addition
02	Subtraction
03	Multiplication
04	Division
05	Square root
06	Sine
07	Cosine
08	Root of sum of squares $c = \sqrt{(a^2+b^2)}$
09	If equal, go to label number
10	If not equal, go to label number
11	If greater than, go to label number
12	If less than, go to label number
13	Angle with ARCTAN
14	Output error messages
15	External output
16	Formatted output of texts or Q parameter values
18	Read system data
19	Send values to the PLC
20	NC and PLC synchronization
26	Opening a freely definable table
27	Write to a freely definable table
28	Read from a freely definable table
29	Transfer up to eight values to the PLC
37	Export local Q parameters or QS parameters into a calling NC program
38	Send information from the NC program

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R

S

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V

W

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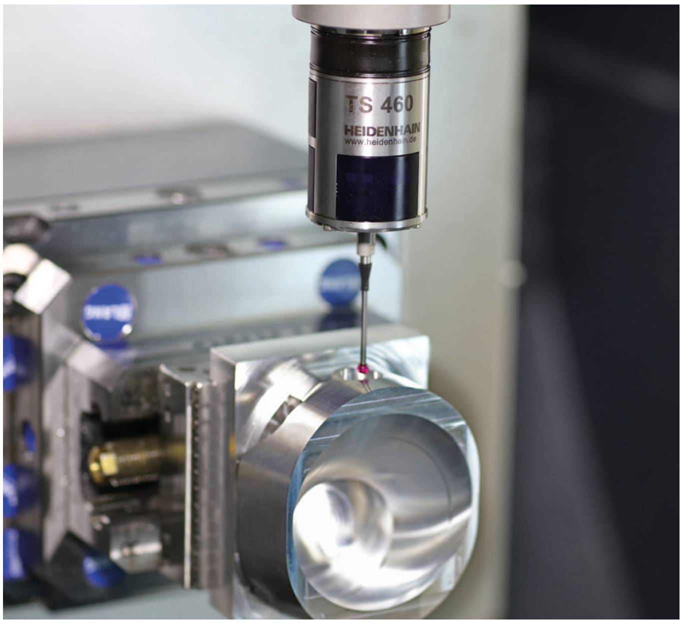
Touch probes from HEIDENHAIN

help you reduce non-productive time and improve the dimensional accuracy of the finished workpieces.

Workpiece touch probes

TS 248, TS 260	Signal transmission by cable
TS 460	Radio or infrared transmission
TS 640, TS 740	Infrared transmission

- Workpiece alignment
- Preset setting
- Workpiece measurement



Tool touch probes

TT 160	Signal transmission by cable
TT 460	Infrared transmission

- Tool measurement
- Wear monitoring
- Tool breakage detection

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