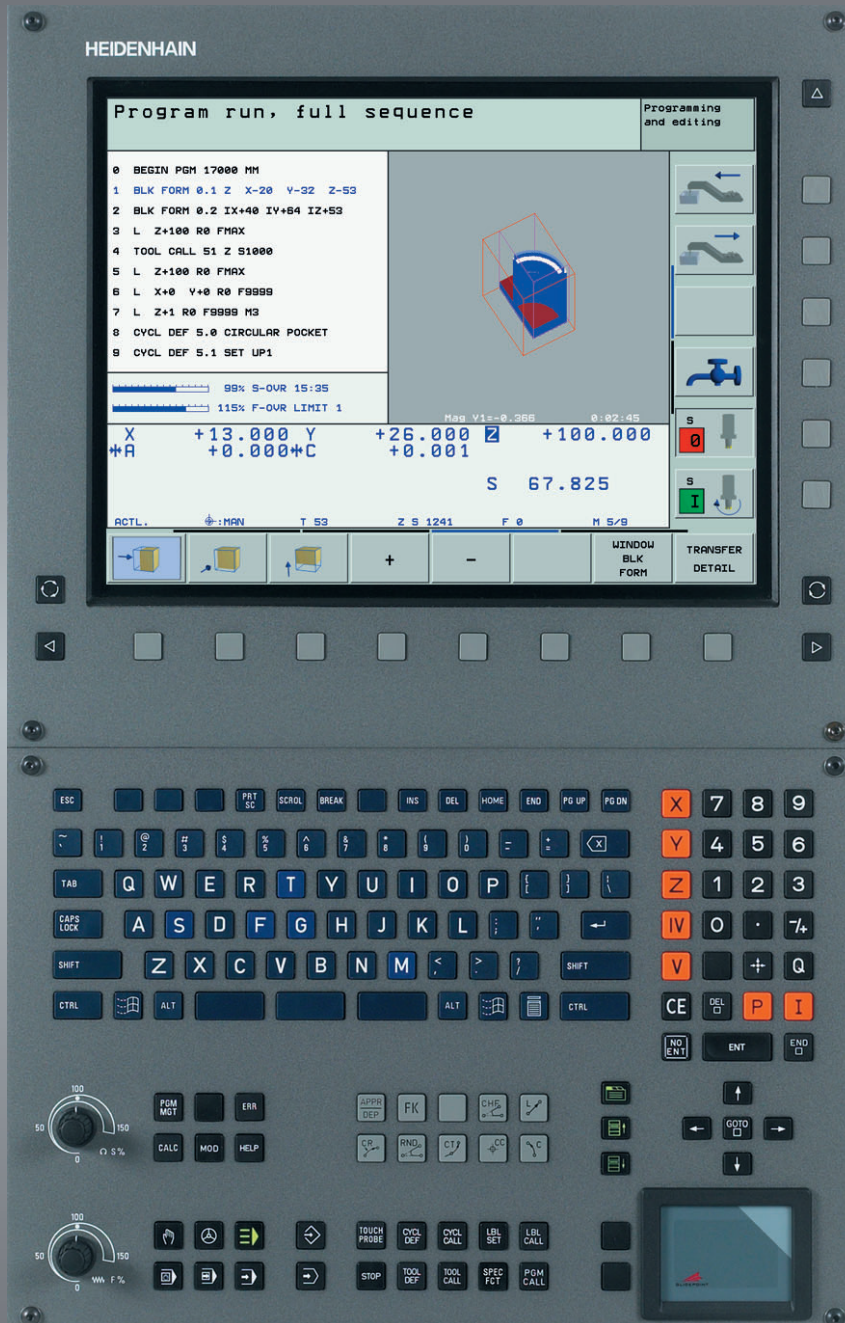




HEIDENHAIN



## User's Manual HEIDENHAIN Conversational Programming

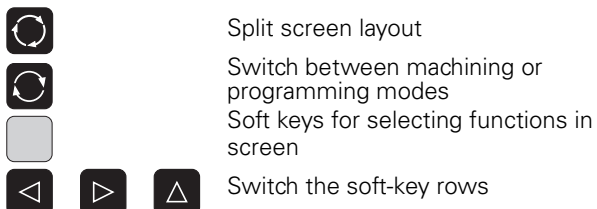
# iTNC 530

NC Software  
340 490-xx  
340 491-xx  
340 492-xx  
340 493-xx  
340 494-xx

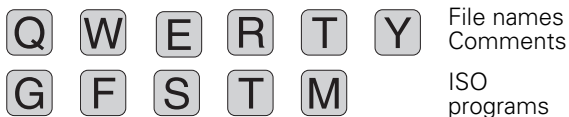
English (en)  
1/2005



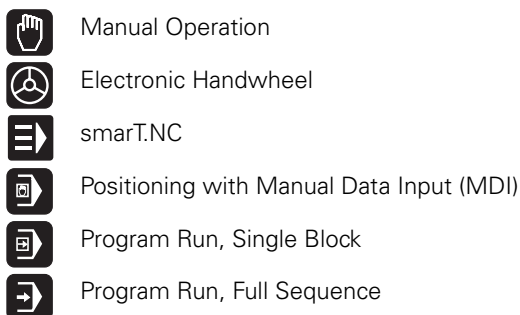
## Controls on the visual display unit



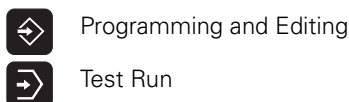
## Typewriter keyboard for entering letters and symbols



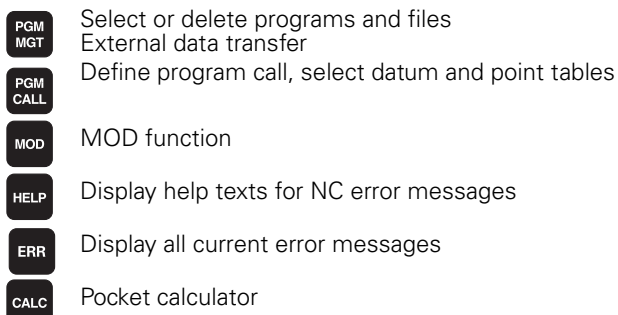
## Machine operating modes



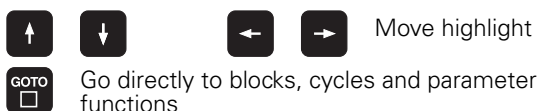
## Programming modes



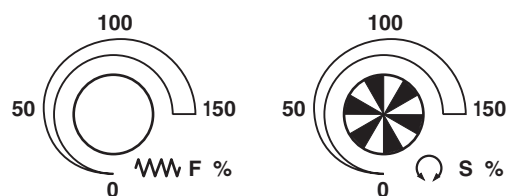
## Program/file management, TNC functions



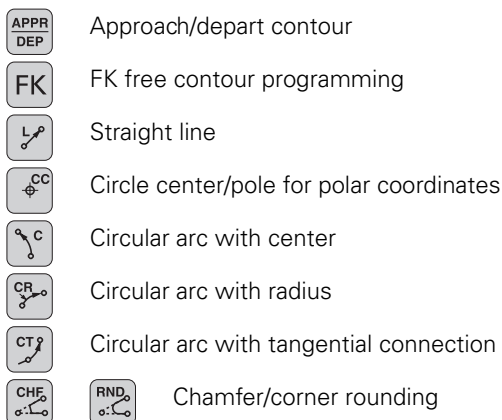
## Moving the highlight, going directly to blocks, cycles and parameter functions



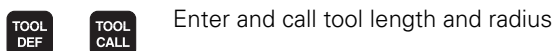
## Override control knobs for feed rate/spindle speed



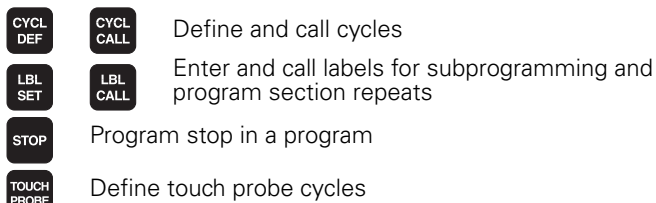
## Programming path movements



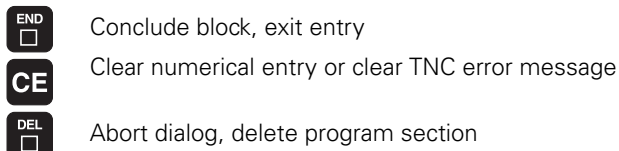
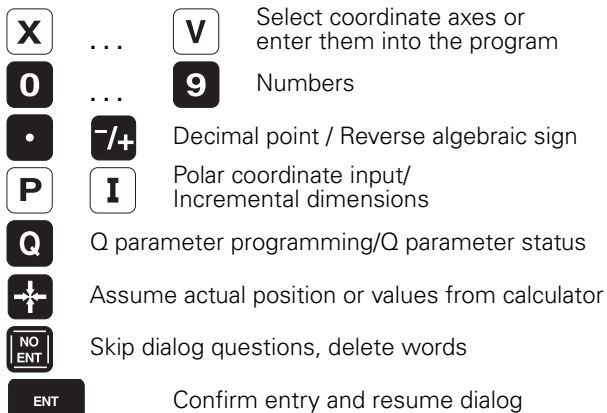
## Tool functions



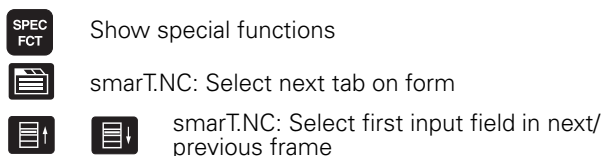
## Cycles, subprograms and program section repeats



## Coordinate axes and numbers: Entering and editing



## Special functions / smarT.NC

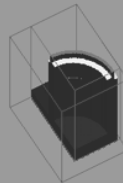


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Program run, full sequence

Programming  
and editing

```
0 BEGIN PGM 17000 MM
1 BLK FORM 0.1 Z X-20 Y-32 Z-53
2 BLK FORM 0.2 IX+40 IY+54 IZ+53
3 L Z+100 R0 FMAX
4 TOOL CALL S1 Z S1000
5 L Z+100 R0 FMAX
6 L X+0 Y+0 R0 F9999
7 L Z+1 R0 F9999 M3
8 CYCL DEF 5.0 CIRCULAR POCKET
9 CYCL DEF 5.1 SET UP1
```



99% S-OVR 15:35  
115% F-OVR LIMIT 1

Mag V1=-0.366 0:02:45

X +13.000 Y +26.000 Z +100.000  
+A +0.000+C +0.001

S 67.825

ACTL. MAN T 53 Z S 1241 F 0 M 5/9

WINDOW BLK FORM TRANSFER DETAIL

ESC PRT SC SCROL BREAK INS DEL HOME END PG UP PG DN  
~ 1 2 3 4 5 6 7 8 9 0 = + <X>  
TAB Q W E R T Y U I O P { } ; ' < > <X>  
CAPS LOCK A S D F G H J K L ; ' < > <X>  
SHIFT Z X C V B N M , . / ? < > <X> SHIFT  
CTRL ALT CTRL NO ENT ENT END



PGM MGT ERR  
CALC MOD HELP

APPR DEP FK CHG L  
CR RND CT CC C



↑  
← GOTO →  
↓



PGM MGT ERR  
CALC MOD HELP

TOUCH PROBE CYCL DEF CYCL CALL LBL SET LBL CALL  
STOP TOOL DEF TOOL CALL SPEC FCT PGM CALL







# TNC Model, Software and Features

This manual describes functions and features provided by TNCs as of the following NC software numbers.

TNC model	NC software number
iTNC 530	340 490-xx
iTNC 530 E	340 491-xx
iTNC 530, dual-processor version	340 491-xx
iTNC 530 E, dual-processor version	340 493-xx
iTNC 530 programming station	340 494-xx

The suffix E indicates the export version of the TNC. The export version of the TNC has the following limitations:

- Linear movement is possible in no more than 4 axes simultaneously.

The machine tool builder adapts the usable features of the TNC to his machine by setting machine parameters. Some of the functions described in this manual may not be among the features provided by your machine tool.

Some TNC functions have to be implemented by the machine tool builder and are therefore not universally available on all machines. These functions include:

- Probing function for the 3-D touch probe
- Tool measurement with the TT 130
- Rigid tapping
- Returning to the contour after an interruption



In addition, the iTNC 530 also has two software option packets that can be enabled by you or your machine tool builder. Each packet is to be enabled separately and contains the following respective functions:

**Software option 1**


Cylinder surface interpolation (Cycles 27, 28, 29 and 39)
Feed rate in mm/min on rotary axes: M116
Tilting the machining plane (Cycle 19 and 3D-ROT soft key in the manual operating mode)
Circle in 3 axes (with tilted working plane)

**Software option 2**

Block processing time 0.5 ms instead of 3.6 ms
5 axis interpolation
Spline interpolation
3-D machining: <ul style="list-style-type: none"><li>■ <b>M114:</b> Automatic compensation of machine geometry when working with tilted axes</li><li>■ <b>M128:</b> Maintaining the position of the tool tip when positioning with tilted axes (TCPM)</li><li>■ <b>FUNCTION TCPM:</b> Maintaining the position of the tool tip when positioning with tilted axes (TCPM) in selectable modes.</li><li>■ <b>M144:</b> Compensating the machine's kinematic configuration for ACTUAL/NOMINAL positions at end of block</li><li>■ Additional parameters <b>finishing/roughing</b> and <b>tolerance for rotary axes</b> in Cycle 32 (G62)</li><li>■ <b>LN</b> blocks (3-D compensation)</li></ul>

Please contact your machine tool builder to become familiar with the features of your machine.

Many machine manufacturers, as well as HEIDENHAIN, offer programming courses for the TNCs. We recommend these courses as an effective way of improving your programming skill and sharing information and ideas with other TNC users.



**Touch Probe Cycles User's Manual:**

All of the touch probe functions are described in a separate manual. Please contact HEIDENHAIN if you require a copy of this User's Manual. ID number: 375 319-xx.

**Location of use**

The TNC 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.



## Functions new since the predecessor versions 340 422-xx and 340 423-xx

- The form-based smarT.NC operating mode, for which separate user documentation is available, was introduced. In connection with this the TNC operating panel was enhanced. There are some new keys available for quicker navigation within smarT.NC (see "Operating panel" on page 39).
- The single-processor versions supports pointing devices (mice) via the USB 2.0 interface.
- The tooth feed  $f_z$  and feed per revolution  $f_u$  can now be defined as alternate feed entries (see "Functions for setting the feed rate" on page 105).
- New **CENTERING** cycle (see "CENTERING (Cycle 240)" on page 275)
- New M function M150 for suppressing limit switch messages (see "Suppress limit switch message: M150" on page 249)
- M128 is now also permitted for mid-program startup (see "Mid-program startup (block scan)" on page 565).
- The number of available Q parameters was expanded to 2000 (see "Principle and Overview" on page 502).
- The number of available label numbers was expanded to 1000. Now label names can be assigned as well (see "Labeling Subprograms and Program Section Repeats" on page 486).
- In the Q parameter functions FN9 to FN12 you can now also assign label names as jump targets (see "If-Then Decisions with Q Parameters" on page 510).
- Selectively machine points from a point table (see "Hiding single points from the machining process" on page 269).
- The current time is also shown in the additional status display window (see "General program information" on page 44).
- Several columns were added to the tool table (see "Tool table: Standard tool data" on page 146).
- The Test Run can now also be stopped and continued within machining cycles (see "Running a program test" on page 559).



## Functions changed since the predecessor versions 340 422-xx and 340 423-xx

- The layouts of the status display and additional status display were redesigned (see “Status Displays” on page 43).
- Software 340 490 no longer supports the small resolution in combination with the BC 120 screen (see “Visual display unit” on page 37).
- New key layout of the TE 530 B keyboard unit (see “Operating panel” on page 39)
- The entry range for the EULPR precession angle in the PLANE EULER function was expanded (see “Defining the Machining Plane with Euler Angles: EULER PLANE” on page 460).
- The plane vector in the PLANE EULER function no longer has to be entered in standardized form (see “Defining the Machining Plane with Two Vectors: VECTOR PLANE” on page 462).
- Positioning behavior of the CYCL CALL PAT function modified (see “Calling a cycle in connection with point tables” on page 271)
- The tool types available for selection in the tool table were increased in preparation for future functions.



## New/changed descriptions in this manual

- New key layout of the TE 530 B keyboard unit (see “Operating panel” on page 39)
- The “Standard File Management” (file management without directory structure) chapter was removed from the manual.





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# 1

## Introduction



## 1.1 The iTNC 530

HEIDENHAIN TNC controls are workshop-oriented contouring controls that enable you to program conventional machining operations right at the machine in an easy-to-use conversational programming language. They are designed for milling, drilling and boring machines, as well as for machining centers. The iTNC 530 can control up to 12 axes. You can also change the angular position of the spindle under program control.

An integrated hard disk provides storage for as many programs as you like, even if they were created off-line. For quick calculations you can call up the on-screen pocket calculator at any time.

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

### Programming: HEIDENHAIN conversational, smarT.NC and ISO formats

HEIDENHAIN conversational programming is an especially easy method of writing programs. Interactive graphics illustrate the individual machining steps for programming the contour. If a production drawing is not dimensioned for NC, the HEIDENHAIN FK free contour programming does the necessary calculations automatically. Workpiece machining can be graphically simulated either during or before actual machining.

The smarT.NC operating mode offers TNC beginners an especially simple possibility to quickly and without much training create structured conversational dialog programs. Separate user documentation is available for smarT.NC.

It is also possible to program in ISO format or DNC mode.

You can also enter and test one program while the control is running another (does not apply to smarT.NC).

### Compatibility

The TNC can run all part programs that were written on HEIDENHAIN controls TNC 150 B and later. In as much as old TNC programs contain OEM cycles, the iTNC 530 must be adapted to them with the PC software CycleDesign. For more information, contact your machine tool builder or HEIDENHAIN.





## 1.2 Visual Display Unit and Operating Panel

### Visual display unit

The TNC is delivered with the BF 150 (TFT) color flat-panel display (see figure at top right).

#### 1 Header

When the TNC is on, the selected operating modes are shown in the screen header: the machining mode at the left and the programming mode at right. The currently active mode is displayed in the larger box, where the dialog prompts and TNC messages also appear (unless the TNC is showing only graphics).

#### 2 Soft keys

In the footer the TNC indicates additional functions in a soft-key row. You can select these functions by pressing the keys immediately below them. The lines immediately above the soft-key row indicate the number of soft-key rows that can be called with the black arrow keys to the right and left. The line representing the active soft-key row is highlighted.

#### 3 Soft-key selection keys

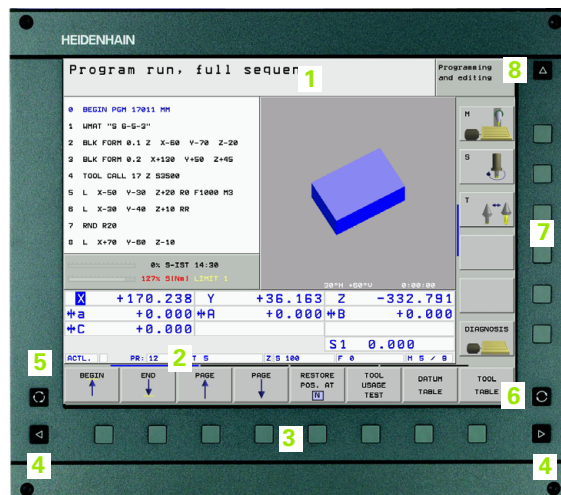
#### 4 Switches the soft-key rows

#### 5 Sets the screen layout

#### 6 Shift key for switchover between machining and programming modes

#### 7 Soft-key selection keys for machine tool builders

#### 8 Switches soft-key rows for machine tool builders



Screen layout

You select the screen layout yourself: In the PROGRAMMING AND EDITING mode of operation, for example, you can have the TNC show 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 program blocks in one large window. The available screen windows depend on the selected operating mode.

To change the screen layout:



Press the SPLIT SCREEN key: The soft-key row shows the available layout options (see “Modes of Operation” on page 40).



Select the desired screen layout.



## Operating panel

The TNC is delivered with the TE 530 operating panel. The figure at right shows the controls and displays of the TE 530 keyboard unit.

- 1 Alphabetic keyboard for entering texts and file names, and for ISO programming.

Dual-processor version: Additional keys for Windows operation

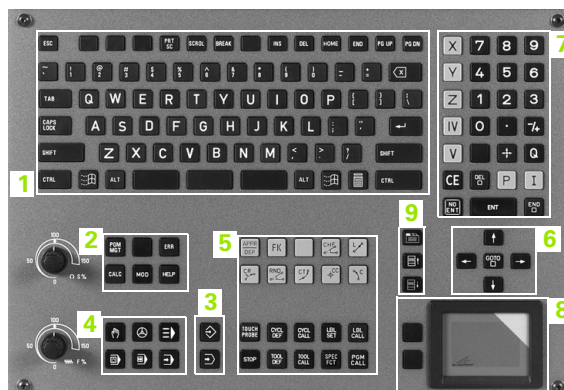
- 2 ■ File Management
- Calculator
- MOD function
- HELP function
- 3 Programming modes
- 4 Machine operating modes
- 5 Initiation of programming dialog
- 6 Arrow keys and GOTO jump command
- 7 Numerical input and axis selection
- 8 Touchpad: Only for operating the dual-processor version, soft keys and smarT.NC
- 9 smarT.NC navigation keys

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



Some machine manufacturers do not use the standard operating panel from HEIDENHAIN. Please refer to your machine manual in these cases.

Machine panel buttons, e.g. NC START or NC STOP, are also described in the manual for your machine tool.



# 1.3 Modes of Operation

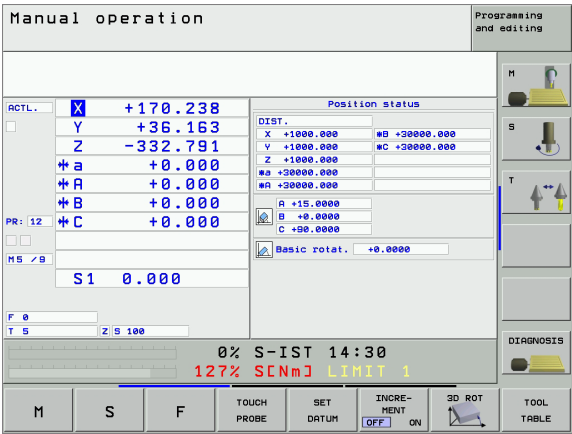
## Manual operation and electronic handwheel

The Manual Operation mode is required for setting up the machine tool. In this operating mode you can position the machine axes manually or by increments, set the datums, and tilt the working plane.

The Electronic Handwheel mode of operation allows you to move the machine axes manually with the HR electronic handwheel.

**Soft keys for selecting the screen layout** (select as described previously)

Screen windows	Soft key
Positions	POSITION
Left: positions—Right: status display	POSITION + STATUS

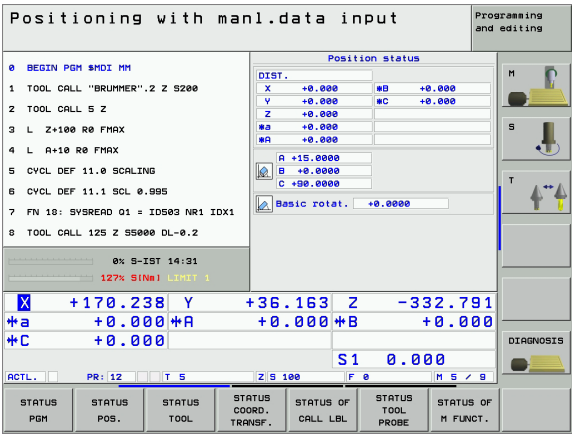


## Positioning with Manual Data Input (MDI)

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**

Screen windows	Soft key
Program	PGM
Left: program blocks—Right: status display	PGM + STATUS

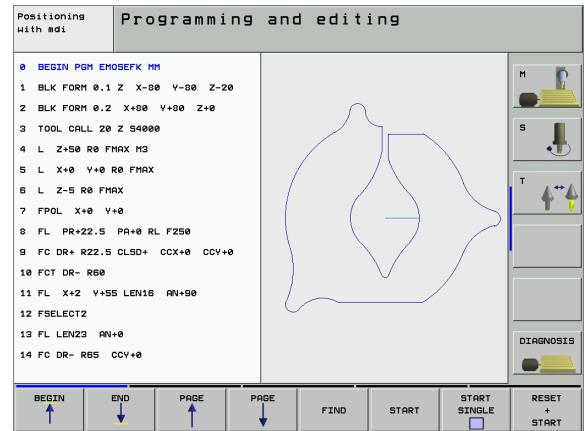


## Programming and editing

In this mode of operation you can write your part 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 individual steps.

### Soft keys for selecting the screen layout

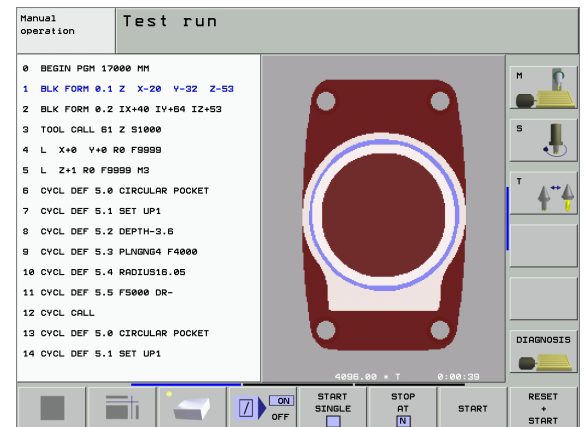
Screen windows	Soft key
Program	PGM
Left: program blocks, right: program structure	PGM + SECTS
Left: program, right: programming graphics	PGM + GRAPHICS



## Test run

In the Test Run mode of operation, the TNC checks programs and program sections for errors, such as geometrical incompatibilities, missing or incorrect data within the program or violations of the work space. This simulation is supported graphically in different display modes.

Soft keys for selecting the screen layout: see "Program Run, Full Sequence and Program Run, Single Block" on page 42.



Program Run, Full Sequence and Program Run, Single Block

In the Program Run, Full Sequence mode of operation the TNC executes a part program continuously to its end or to a manual or programmed stop. You can resume program run after an interruption.

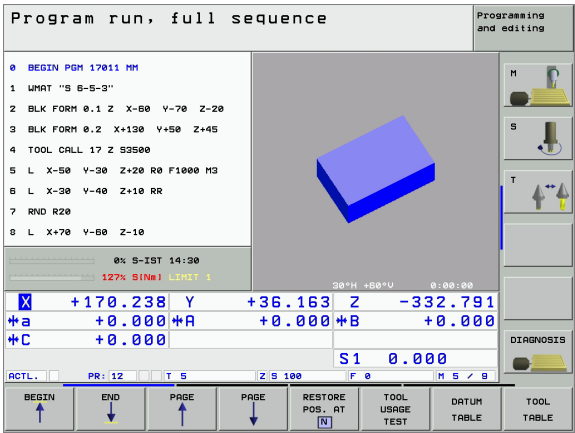
In the Program Run, Single Block mode of operation you execute each block separately by pressing the machine START button.

Soft keys for selecting the screen layout

Screen windows	Soft key
Program	PGM
Left: program blocks, right: program structure	PGM + SECTS
Left: program, right: status	PGM + STATUS
Left: program, right: graphics	PGM + GRAPHICS
Graphics	GRAPHICS

Soft keys for selecting the screen layout for pallet tables

Screen windows	Soft key
Pallet table	PALLET
Left: program, right: pallet table	PGM + PALLET
Left: pallet table, right: status	PALLET + STATUS
Left: pallet table, right: graphics	PALLET + GRAPHICS



# 1.4 Status Displays





## “General” status display

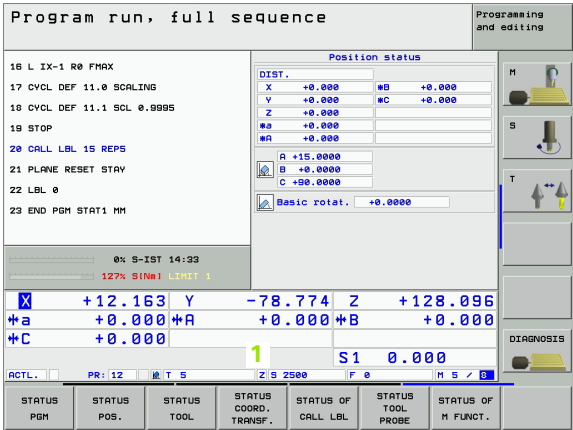
The status display **1** informs you of the current state of the machine tool. It is displayed automatically in the following modes of operation:

- Program Run, Single Block and Program Run, Full Sequence, except if the screen layout is set to display graphics only, and
- Positioning with Manual Data Input (MDI).

In the Manual mode and Electronic Handwheel mode the status display appears in the large window.

### Information in the status display

Symbol	Meaning
<b>ACTL.</b>	Actual or nominal coordinates of the current position.
<b>XYZ</b>	Machine axes; the TNC displays auxiliary axes in lower-case letters. The sequence and quantity of displayed axes is determined by the machine tool builder. Refer to your machine manual for more information
<b>FSM</b>	The displayed feed rate in inches corresponds to one tenth of the effective value. Spindle speed S, feed rate F and active M functions
*	Program run started
	Axis locked.
	Axis can be moved with the handwheel.
	Axes are moving in a tilted working plane.
	Axes are moving under a basic rotation.
<b>PR</b>	Number of the active datum from the preset table. If the datum was set manually, the TNC displays the text <b>MAN</b> behind the symbol.



## Additional status displays

The additional status displays contain detailed information on the program run. They can be called in all operating modes except for the Programming and Editing mode of operation.

### To switch on the additional status display:



Call the soft-key row for screen layout.



Select the layout option for the additional status display.

### To select an additional status display:



Shift the soft-key rows until the STATUS soft keys appear.



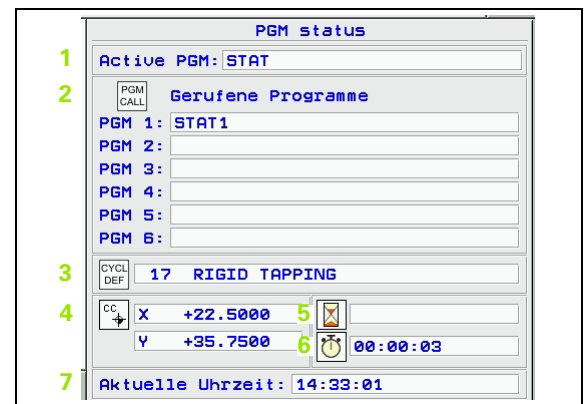
Select the desired additional status display, e.g. general program information.

You can choose between several additional status displays with the following soft keys:



### General program information

- 1 Name of the active main program
- 2 Active programs
- 3 Active machining cycle
- 4 Circle center CC (pole)
- 5 Operating time
- 6 Dwell time counter
- 7 Current time





STATUS  
POS.

## Positions and coordinates

- 1 Position display
- 2 Type of position display, e.g. actual position
- 3 Tilt angle of the working plane
- 4 Angle of a basic rotation

**Position status**

DIST.			
X	+0.000	#B	+0.000
Y	+0.000	#C	+0.000
Z	+0.000		
#a	+0.000		
#A	+0.000		
A +15.0000			
B +0.0000			
C +90.0000			
Basic rotat. +0.0000			

STATUS  
TOOL

## Information on tools

- 1 T: Tool number and name
- RT: Number and name of a replacement tool
- 2 Tool axis
- 3 Tool lengths and radii
- 4 Oversizes (delta values) from TOOL CALL (PGM) and the tool table (TAB)
- 5 Tool life, maximum tool life (TIME 1) and maximum tool life for TOOL CALL (TIME 2)
- 6 Display of the active tool and the (next) replacement tool

**Tool status**

T: T5			
L	+48.6900		
R	+5.0000		
R2	+5.0000		
DL DR DR2			
TAB	+0.1500		
PGM	+0.2500	+0.1000	+0.0500
CUR.TIME TIME1 TIME2			
	00:00		
TOOL CALL 5			
RT			

STATUS  
COORD.  
TRANSF.

## Coordinate transformations

- 1 Name of the active datum table
- 2 Active datum number (#), comment from the active line of the active datum number (DOC) from Cycle 7
- 3 Active datum shift (Cycle 7); The TNC displays an active datum shift in up to 8 axes
- 4 Mirrored axes (Cycle 8)
- 5 Active rotation angle (Cycle 10)
- 6 Active scaling factor/factors (Cycles 11 / 26); The TNC displays an active scaling factor in up to 6 axes
- 7 Scaling datum

See "Coordinate Transformation Cycles" on page 426.

**Coordinate-transformation status**

Datum table: TNC:\...\NULLTAB.D			
# 1	DOC:		
X	+25.0000		
Y	+37.5000		
Mirroring			
X Y			
Scaling (CC)		Scal. factor	
X	+0.0000		0.999500
Y	+0.0000		0.999500
Z	+0.0000		0.999500



### Program section repeats/subprograms

- 1 Active program section repeats with block number, label number, and number of programmed repeats/repeats yet to be run
- 2 Active subprogram numbers with block number in which the subprogram was called and the label number that was called

Status of CALL LBL		
Program section repeats		
Block no.	LBL no.	REP

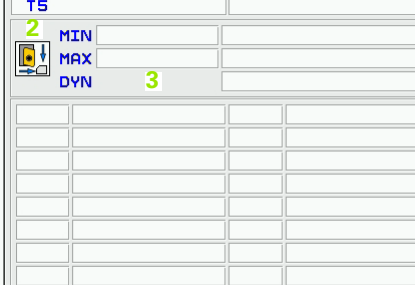
  

Subprograms:	Block no.	LBL no.
	2	99

STATUS  
TOOL  
PROBE

### Tool measurement

- 1 Number of the tool to be measured
- 2 Display whether the tool radius or the tool length is being measured
- 3 MIN and MAX values of the individual cutting edges and the result of measuring the rotating tool (DYN = dynamic measurement)
- 4 Cutting edge number with the corresponding measured value. If the measured value is followed by an asterisk, the allowable tolerance in the tool table was exceeded

STATUS OF  
M FUNCT.

## Active miscellaneous functions M

- 1 List of the active M functions with fixed meaning
- 2 List of the active M functions with function assigned by machine manufacturer.

[illegible]

## 1.5 Accessories: HEIDENHAIN 3-D Touch Probes and Electronic Handwheels

### 3-D touch probes

With the various HEIDENHAIN 3-D touch probe systems you can:

- Automatically align workpieces
- Quickly and precisely set datums
- Measure the workpiece during program run
- Measure and inspect tools



All of the touch probe functions are described in a separate manual. Please contact HEIDENHAIN if you require a copy of this User's Manual. Id. Nr.: 329 203-xx.

#### TS 220 and TS 640 touch trigger probes

These touch probes are particularly effective for automatic workpiece alignment, datum setting and workpiece measurement. The TS 220 transmits the triggering signals to the TNC via cable and is a cost-effective alternative for applications where digitizing is not frequently required.

The TS 640 touch probe features infrared transmission of the triggering signal to the control. This makes it highly convenient for use on machines with automatic tool changers.

Principle of operation: HEIDENHAIN triggering touch probes feature a wear resisting optical switch that generates an electrical signal as soon as the stylus is deflected. This signal is transmitted to the TNC, which stores the current position of the stylus as an actual value.



**TT 130 tool touch probe for tool measurement**

The TT 130 is a triggering 3-D touch probe for tool measurement and inspection. Your TNC provides three cycles for this touch probe with which you can measure the tool length and radius automatically either with the spindle rotating or stopped. The TT 130 features a particularly rugged design and a high degree of protection, which make it insensitive to coolants and swarf. The triggering signal is generated by a wear-resistant and highly reliable optical switch.

**HR electronic handwheels**

Electronic handwheels facilitate moving the axis slides precisely by hand. A wide range of traverses per handwheel revolution is available. Apart from the HR 130 and HR 150 integral handwheels, HEIDENHAIN also offers the HR 410 portable handwheel (see figure at center right) and HR 420 (lower right). You will find a detailed description of HR 420 in Chapter 2 of this manual (see “HR 420 electronic handwheel” on page 55).





# 2

**Manual Operation and Setup**



## 2.1 Switch-On, Switch-Off

### Switch-on



Switch-on and Traversing the Reference Points can vary depending on the machine tool. Refer to your machine manual.

Switch on the power supply for control and machine. The TNC then displays the following dialog:

#### MEMORY TEST

The TNC memory is automatically checked.

#### POWER INTERRUPTED



TNC message that the power was interrupted—clear the message.

#### TRANSLATE PLC PROGRAM

The PLC program of the TNC is automatically compiled.

#### RELAY EXT. DC VOLTAGE MISSING



Switch on external dc voltage. The TNC checks the functioning of the EMERGENCY STOP circuit.

#### MANUAL OPERATION TRAVERSE REFERENCE POINTS



Cross the reference points manually in the displayed sequence: For each axis press the machine START button, or



Cross the reference points in any sequence: Press and hold the machine axis direction button for each axis until the reference point has been traversed.



If your machine is equipped with absolute encoders, you can leave out traversing the reference mark. In such a case, the TNC is ready for operation immediately after the machine control voltage is switched on.



The TNC is now ready for operation in the Manual Operation mode.



The reference points need only be traversed if the machine axes are to be moved. If you intend only to write, edit or test programs, you can select the Programming and Editing or Test Run modes of operation immediately after switching on the control voltage.

You can traverse the reference points later by pressing the PASS OVER REFERENCE soft key in the Manual Operation mode.

## Traversing the reference point in a tilted working plane

The reference point of a tilted coordinate system can be traversed by pressing the machine axis direction buttons. The "tilting the working plane" function must be active in the Manual Operation mode (see "Activating manual tilting" on page 74). The TNC then interpolates the corresponding axes.

The NC START button has no function. Pressing this button may result in an error message.



Make sure that the angle values entered in the menu for tilting the working plane match the actual angles of the tilted axis.

## Switch-off



iTNC 530 with Windows 2000: See "Switching Off the iTNC 530," page 638.

To prevent data being lost at switch-off, you need to shut down the operating system as follows:

- Select the Manual operating mode



- Select the function for shutting down, confirm again with the YES soft key.
- When the TNC displays the message **Now you can switch off the TNC** in a superimposed window, you may cut off the power supply to the TNC.



Inappropriate switch-off of the TNC can lead to data loss.



## 2.2 Moving the Machine Axes

**Note**



Traversing with the machine axis direction buttons can vary depending on the machine tool. The machine tool manual provides further information.

**To traverse with the machine axis direction buttons:**



Select the Manual Operation mode



Press the machine axis direction button and hold it as long as you wish the axis to move, or



and



Move the axis continuously: Press and hold the machine axis direction button, then press the machine START button.



To stop the axis, press the machine STOP button.

You can move several axes at a time with these two methods. You can change the feed rate at which the axes are traversed with the F soft key (see "Spindle Speed S, Feed Rate F and Miscellaneous Functions M" on page 61).





## Incremental jog positioning

With incremental jog positioning you can move a machine axis by a preset distance.



Select the Manual or Electronic Handwheel mode of operation.



Select incremental jog positioning: Switch the INCREMENT soft key to ON

**JOG INCREMENT =**

**8**

**ENT**

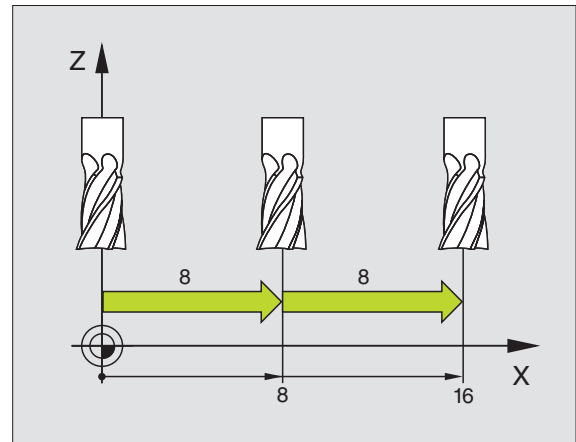
Enter the jog increment in millimeters, i.e. 8 mm.



Press the machine axis direction button as often as desired.



The maximum permissible value for infeed is 10 mm.



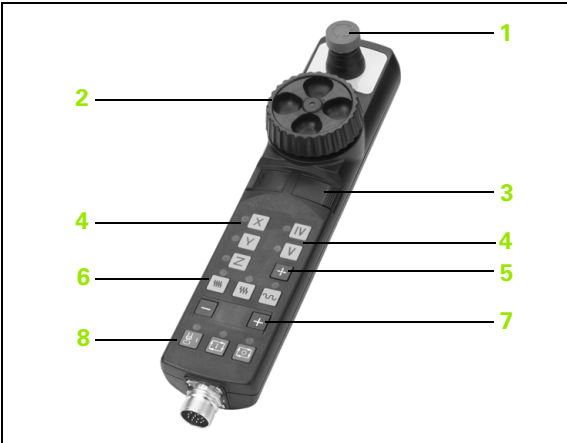
Traversing with the HR 410 electronic handwheel

The portable HR 410 handwheel is equipped with two permissive buttons. The permissive buttons are located below the star grip.

You can only move the machine axes when a permissive button is depressed (machine-dependent function).

The HR 410 handwheel features the following operating elements:

- 1 EMERGENCY OFF button
- 2 Handwheel
- 3 Permissive buttons
- 4 Axis address keys
- 5 Actual-position-capture key
- 6 Keys for defining the feed rate (slow, medium, fast; the feed rates are set by the machine tool builder)
- 7 Direction in which the TNC moves the selected axis
- 8 Machine function (set by the machine tool builder)



The red indicator lights show the axis and feed rate you have selected.

It is also possible to move the machine axes with the handwheel during a program run if **M118** is active.

Procedure:



Select the Electronic Handwheel operating mode.



Press and hold a permissive button.



Select the axis.



Select the feed rate.



or



Move the active axis in the positive or negative direction.



## HR 420 electronic handwheel

Unlike the HR 410, the HR 420 portable handwheel is equipped with a display. In addition, you can run important setup functions through the handwheel soft keys, e.g. setting datums or entering and running M functions.

As soon as you press the handwheel activation key, it activates the handwheel and deactivates the control panel. This is indicated by a pop-up window on the TNC screen.

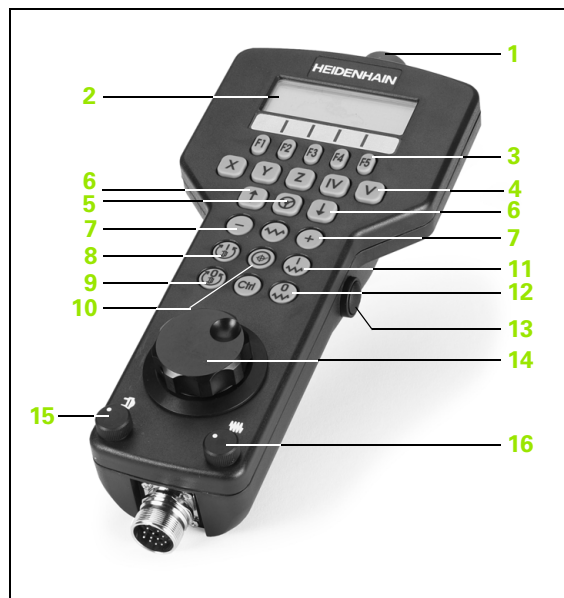
The HR 420 handwheel features the following operating elements:

- 1 EMERGENCY OFF button
- 2 Handwheel display for status display and function selection
- 3 Soft keys
- 4 Axis address keys
- 5 Handwheel activation key
- 6 Arrow keys for definition of handwheel sensitivity
- 7 Direction key by which the TNC moves the selected axis
- 8 Switch on the spindle (machine-specific M function)
- 9 Switch off the spindle (machine-specific M function)
- 10 NC-block creation key
- 11 NC start
- 12 NC stop
- 13 Permissive button
- 14 Handwheel
- 15 Spindle speed potentiometer. Effective as soon as the handwheel is active. The spindle speed potentiometer on the control panel is then inactive
- 16 Feed rate potentiometer. Effective as soon as the handwheel is active. The feed rate potentiometer on the control panel is then inactive

If **M118** is active, it is even possible to move the machine axes with the handwheel during the program run.



Your machine manufacturer can make additional functions of the HR 420 available. Please refer to your machine manual.



### Display

The handwheel display has four lines (see screen at upper right). The TNC shows there the following information:

- 1 **NOML X+1.563**: Type of position display and position of the selected axis
- 2 \*: STIB (control is in operation)
- 3 **S1800**: Current spindle speed
- 4 **F500**: Feed rate at which the selected axis is moving
- 5 **E**: There is an error
- 6 **3D**: Tilted-working-plane function is active
- 7 **2D**: Basic rotation function is active
- 8 **RES 5.0**: Active handwheel resolution. Distance in mm/rev (°/rev for rotary axes) that the selected axis moves for one handwheel revolution
- 9 **STEP ON** or **OFF**: Incremental jog active or inactive. If the function is active, the TNC also displays the active jog increment
- 10 Soft key row: Selection of various functions, described in the following sections

### Select the axis to be moved

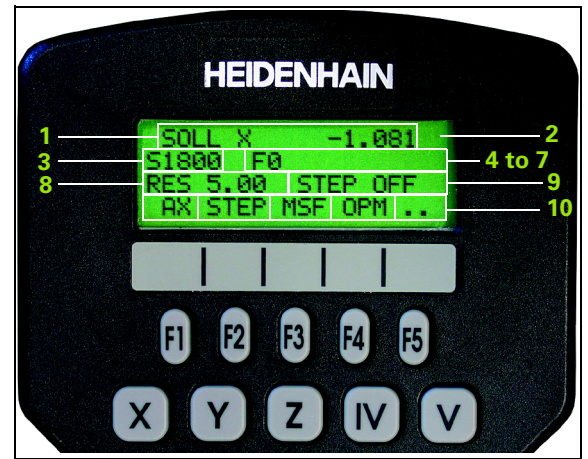
You can activate directly through the axis address keys the principal axes X, Y, Z and two other axes defined by the machine tool builder. If you machine has more axes, proceed as follows.

- Press the handwheel soft key F1 (**AX**): The TNC displays all active axes on the handwheel display. The active axis blinks
- Select the desired axis with the handwheel soft key F1 (→) or F2 (←) and confirm your selection with F3 (**OK**).

### Set the handwheel sensitivity

The handwheel sensitivity sets the distance the axis moves per handwheel revolution. The sensitivity settings are preset and can be selected directly through the handwheel arrow keys (only if incremental jog is not active).

Selectable sensitivity levels: 0.01/0.02/0.05/0.1/0.2/0.5/1/2/5/10/20 [mm/revolution or degrees/revolution]



## Moving the axes



Select the Electronic Handwheel operating mode.



Activate the handwheel: Press the handwheel key on the HR 420. Now the TNC is operable only through the HR 420. A pop-up window stating such appears on the TNC screen.



If required, press and hold the permissive button



Use the handwheel to select the axis to be moved.  
Select the additional axes via soft key



or



Move the active axis in the positive or negative direction.



Deactivate the handwheel: Press the handwheel key on the HR 420. Now the TNC can be operated through the control panel



### Incremental jog positioning

With incremental jog positioning the TNC moves the currently active handwheel axis by a preset distance defined by you.

- ▶ Press the handwheel soft key F2 (**STEP**)
- ▶ Activate incremental jog positioning: Press handwheel soft key 3 (**ON**)
- ▶ Select the desired jog increment by pressing the F1 or F2 key. If you press and hold the respective key, each time it reaches a decimal value 0 the TNC increases the counting increment by a factor of 10. If in addition you press the Ctrl key, the counting increment increases to 1. The smallest possible jog increment is 0.0001 mm. The largest possible is 10 mm
- ▶ Confirm the selected jog increment with soft key 4 (**OK**)
- ▶ With the + or – handwheel key, move the active handwheel axis in the corresponding direction

### Entering miscellaneous functions M

- ▶ Press the handwheel soft key F3 (**MSF**)
- ▶ Press the handwheel soft key F1 (**M**)
- ▶ Select the desired M function number by pressing the F1 or F2 key
- ▶ Execute the M function with the NC start key

### Entering the spindle speed S

- ▶ Press the handwheel soft key F3 (**MSF**)
- ▶ Press the handwheel soft key F2 (**S**)
- ▶ Select the desired speed by pressing the F1 or F2 key. If you press and hold the respective key, each time it reaches a decimal value 0 the TNC increases the counting increment by a factor of 10. If in addition you press the Ctrl key, the counting increment increases to 1000
- ▶ Activate the new speed S with the NC start key

### Enter the feed rate F

- ▶ Press the handwheel soft key F3 (**MSF**)
- ▶ Press the handwheel soft key F3 (**S**)
- ▶ Select the desired feed rate by pressing the F1 or F2 key. If you press and hold the respective key, each time it reaches a decimal value 0 the TNC increases the counting increment by a factor of 10. If in addition you press the Ctrl key, the counting increment increases to 1000
- ▶ Confirm the new feed rate F with the handwheel soft key F3 (**OK**)

### Datum setting

- ▶ Press the handwheel soft key F3 (**MSF**)
- ▶ Press the handwheel soft key F4 (**PRS**)
- ▶ If required, select the axis in which the datum is to be set
- ▶ Reset the axis with the handwheel soft key F3 (**OK**), or with F1 and F2 set the desired value and then confirm with F3 (**OK**). By also pressing the Ctrl key, you can increase the counting increment to 10

### Changing modes of operation

With the handwheel soft key F4 (**OPM**), you can use the handwheel to switch the mode of operation, provided that the current status of the control allows a mode change.

- ▶ Press the handwheel soft key F4 (**OPM**)
- ▶ Select the desired operating mode by handwheel soft key
  - MAN: Manual Operation
  - MDI: Positioning with Manual Data Input
  - SGL: Program Run, Single Block
  - RUN: Program Run, Full Sequence

### Generating a complete L Block



Use the MOD function to define the axis values to be taken into an NC block (see "Selecting the Axes for Generating L Blocks" on page 597).

If no axes are selected, the TNC displays the error message **No axes selected**

- ▶ Select the **Positioning with MDI** operating mode
- ▶ If required, use the arrow keys on the TNC keyboard to select the NC block after which the new L block is to be inserted.
- ▶ Actuate handwheel
- ▶ Press the Generate-NC-block handwheel key: The TNC inserts a complete L block containing all axis positions selected through the MOD function



### Features in the program run modes of operation

You can use the following functions in the Program Run modes of operation:

- NC start (handwheel NC-start key)
- NC stop (handwheel NC-stop key)
- After the NC-stop key has been pressed: Internal stop (handwheel soft keys **MOP** and then **STOP**)
- After the NC-stop key has been pressed: Manual axis traverse (handwheel soft keys **MOP** and then **MAN**)
- Returning to the contour, after the axes were moved manually during a program interruption (handwheel soft keys **MOP** and then **REPO**). Operation is by handwheel soft key, which function similarly to the control-screen soft keys (see “Returning to the contour” on page 567)
- On/off switch for the Tilted Working Plane function (handwheel soft keys **MOP** and then **3D**)





## 2.3 Spindle Speed S, Feed Rate F and Miscellaneous Functions M

### Function

In the Manual Operation and Electronic Handwheel operating modes, you can enter the spindle speed S, feed rate F and the miscellaneous functions M with soft keys. The miscellaneous functions are described in Chapter 7 "Programming: Miscellaneous Functions."



The machine tool builder determines which miscellaneous functions M are available on your control and what effects they have.

### Entering values

#### Spindle speed S, miscellaneous function M

S

To enter the spindle speed, press the S soft key.

SPINDLE SPEED S =

1000

Enter the desired spindle speed and confirm your entry with the machine START button.

I

The spindle speed S with the entered rpm is started with a miscellaneous function M. Proceed in the same way to enter a miscellaneous function M.

#### Feed rate F

After entering a feed rate F, you must confirm your entry with the ENT key instead of the machine START button.

The following is valid for feed rate F:

- If you enter F=0, then the lowest feed rate from MP1020 is effective
- F is not lost during a power interruption

### Changing the spindle speed and feed rate

With the override knobs you can vary the spindle speed S and feed rate F from 0% to 150% of the set value.



The override dial for spindle speed is only functional on machines with infinitely variable spindle drive.



### 2.4 Datum Setting (Without a 3-D Touch Probe)

#### Note



For datum setting with a 3-D touch probe, refer to the Touch Probe Cycles Manual.

You fix a datum by setting the TNC position display to the coordinates of a known position on the workpiece.

#### Preparation

- ▶ Clamp and align the workpiece.
- ▶ Insert the zero tool with known radius into the spindle.
- ▶ Ensure that the TNC is showing the actual position values.

## Datum setting with axis keys



### Fragile workpiece?

If the workpiece surface must not be scratched, you can lay a metal shim of known thickness  $d$  on it. Then enter a tool axis datum value that is larger than the desired datum by the value  $d$ .



Select the **Manual Operation** mode



Move the tool slowly until it touches (scratches) the workpiece surface

Select an axis (all axes can also be selected via the ASCII keyboard)

**DATUM SET Z=**

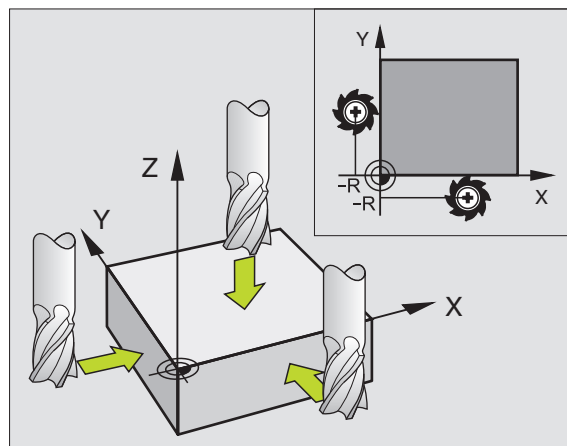
**0**

ENT

Zero tool in spindle axis: Set the display to a known workpiece position (here, 0) or enter the thickness  $d$  of the shim. In the tool axis, offset the tool radius.

Repeat the process for the remaining axes.

If you are using a preset tool, set the display of the tool axis to the length  $L$  of the tool or enter the sum  $Z=L+d$ .



Datum management with the preset table



You should definitely use the preset table if:

- Your machine is equipped with rotary axes (tilting table or swivel head) and you work with the tilted working plan function
- Your machine is equipped with a spindle-head changing system
- Up to now you have been working with older TNC controls with REF-based datum tables
- You wish to machine identical workpieces that are differently aligned

Preset table can contain any number of lines (datums). To optimize the file size and the processing speed, you should use only as many lines as you need for datum management.

For safety reasons, new lines can be inserted only at the end of the preset table.

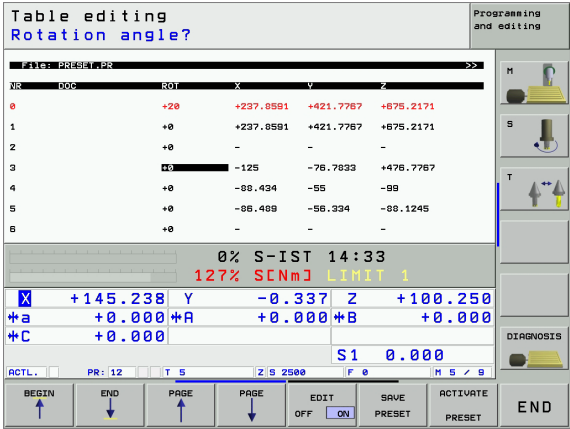
Saving the datums in the preset table

The preset table has the name PRESET.PR, and is saved in the directory TNC:\. PRESET.PR is editable only in the **Manual** and **E1** **Handwheel** modes. In the Programming and Editing mode you can only read the table, not edit it.

It is permitted to copy the preset table into another directory (for data backup). Lines that were written by your machine tool builder are also always write-protected in the copied tables. You therefore cannot edit them.

Never change the number of lines in the copied tables! That could cause problems when you want to reactivate the table.

To activate the preset table copied to another directory you have to copy it back to the directory TNC:\.



There are several methods for saving datums and/or basic rotations in the preset table:

- Through probing cycles in the **Manual** or **E1. Handwheel** modes (see User's Manual, Touch Probe Cycles, Chapter 2)
- Through the probing cycles 400 to 402 and 410 to 419 in automatic mode (see User's Manual, Touch Probe Cycles, Chapter 3)
- By adopting the current datum, which you set manually with the axis keys



Manual entry of values in the preset table is allowed only if there are no tilting devices on your machine. An exception to this rule is the entry of basic rotations in the **ROT** column. The reason is that the TNC compensates the geometry of the tilting device when it saves values in the preset table.

Basic rotations from the preset table rotate the coordinate system about the preset, which is shown in the same line as the basic rotation.

When setting a datum, the TNC checks whether the position of the tilting axes match the corresponding values of the 3D ROT menu (depending on Machine Parameter 7500 bit 5). Therefore:

- If the "Tilt working plane" function is not active, the position displays for the rotary axes must = 0° (zero the rotary axes if necessary).
- If the "Tilt working plane" function is active, the position displays for the rotary axes must match the angles entered in the 3D ROT menu.

The machine manufacturer can lock any lines in the preset table in order to place fixed datums there (e.g. a center point for a rotary table). Such lines in the preset table are shown in a different color (default: red).

The line 0 in the preset table is write protected. In line 0, the TNC always saved the datum that you most recently set manually.

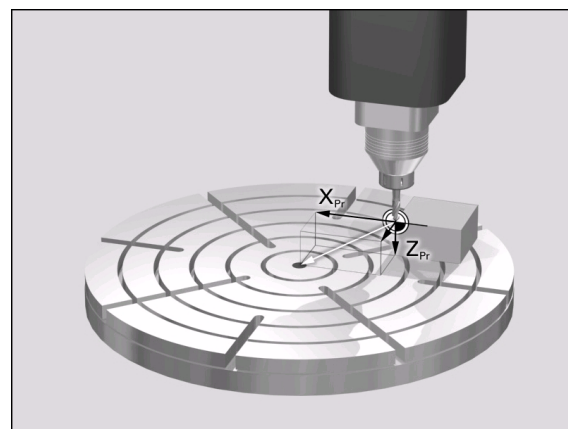
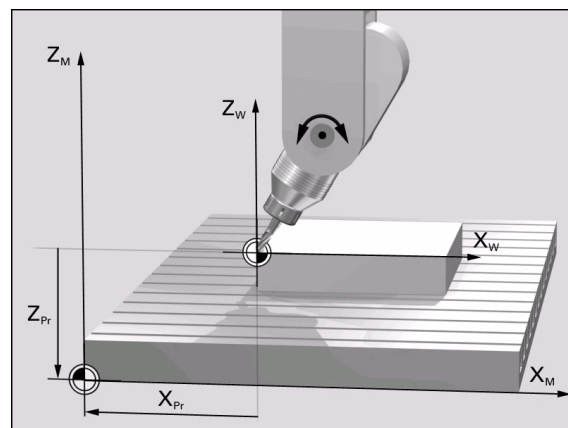
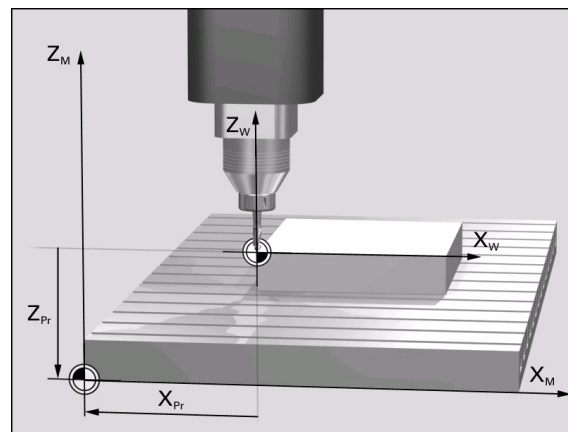


### Explanation of values saved in the preset table















- Simple machine with three axes without tilting device  
The TNC saves in the preset table the distance from the workpiece datum to the reference point (including algebraic sign, see figure at upper right)
- Machine with swivel head  
The TNC saves in the preset table the distance from the workpiece datum to the reference point (including algebraic sign, see figure at center right)
- Machine with rotary table  
The TNC saves in the preset table the distance from the workpiece datum to the center of the rotary table (including algebraic sign, see figure at lower right)
- Machine with rotary table and swivel head  
The TNC saves in the preset table the distance from the workpiece datum to the center of the rotary table.



Keep in mind that moving an indexing feature on your machine table (realized by changing the kinematic description) requires you to redefine any workpiece-based presets.



# Editing the preset table

Editing function in table mode	Soft key
Select beginning of table	
Select end of table	
Select previous page in table	
Select next page in table	
Release/lock preset table for editing	 
In the selected line of the preset table, save the datum that is active in the Manual operating mode	
Activate the datum of the selected line of the preset table	
Add the entered number of lines to the end of the table (2nd soft-key row)	
Copy the highlighted field (2nd soft-key row)	
Insert the copied field (2nd soft-key row)	
Reset the selected line: The TNC enters – in all columns (2nd soft-key row)	
Insert a single line at the end of the table (2nd soft-key row)	
Delete a single line at the end of the table (2nd soft-key row)	



Activating the datum from the preset table in the Manual operating mode



When activating a datum from the preset table, the TNC resets all coordinate transformations that were activated with the following cycles:

- Cycle 7, Datum Shift
- Cycle 8, Mirroring
- Cycle 10, Rotation
- Cycle 11, Scaling
- Cycle 26, Axis-Specific Scaling

However, the coordinate transformation from Cycle 19, Tilted Working Plane, remains active.



Select the **Manual Operation** mode



Call the function for setting the datum

DATUM SET X=



Call preset table



Release the preset table for editing: Set the EDIT OFF/ON soft key to ON.



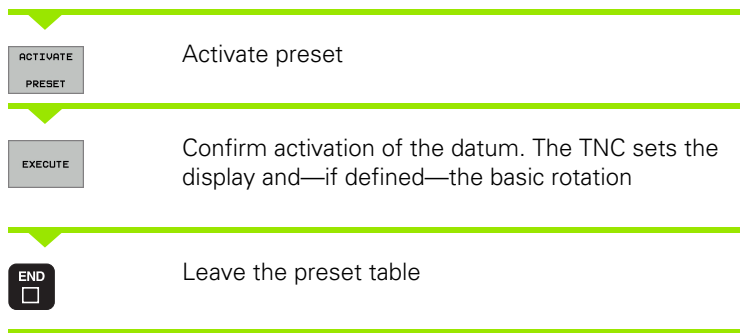
With the arrow keys, select the datum number that you want to activate, or



With the GOTO key, select the datum number that you want to activate. Confirm with the ENT key.







### Activating the datum from the preset table in an NC program

To activate datums from the preset table during program run, use Cycle 247. In Cycle 247 you define the number of the datum that you want to activate (see "DATUM SETTING (Cycle 247)" on page 432).



## 2.5 Tilting the Working Plane (Software Option 1)

### Application, function



The functions for tilting the working plane are interfaced to the TNC and the machine tool by the machine tool builder. With some swivel heads and tilting tables, the machine tool builder determines whether the entered angles are interpreted as coordinates of the rotary axes or as angular components of a tilted plane. Refer to your machine manual.

The TNC supports the tilting functions on machine tools with swivel heads and/or tilting tables. Typical applications are, for example, oblique holes or contours in an oblique plane. The working plane is always tilted around the active datum. The program is written as usual in a main plane, such as the X/Y plane, but is executed in a plane that is tilted relative to the main plane.

There are three functions available for tilting the working plane:

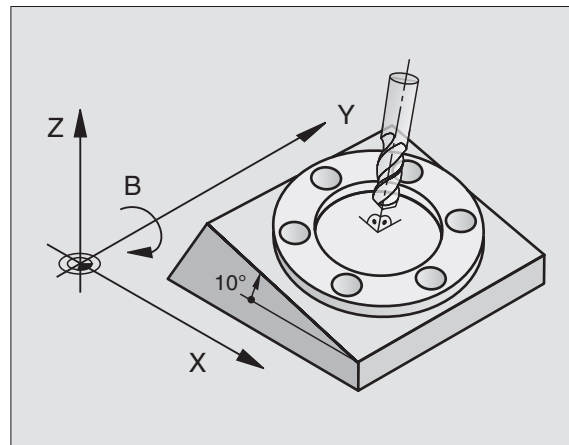
- 3-D ROT soft key in the Manual mode and Electronic Handwheel mode, see “Activating manual tilting” on page 74.
- Tilting under program control, Cycle 19 **WORKING PLANE**, in the part program (see “WORKING PLANE (Cycle 19, software option 1)” on page 438).
- Tilting under program control, **PLANE** function in the part program (see “The PLANE Function: Tilting the Working Plane (Software Option 1)” on page 452).

The TNC functions for “tilting the working plane” are coordinate transformations in which the working plane is always perpendicular to the direction of the tool axis.

When tilting the working plane, the TNC differentiates between two machine types:

#### ■ Machine with tilting tables

- You must tilt the workpiece into the desired position for machining by positioning the tilting table, for example with an L block
- The position of the transformed tool axis **does not change** in relation to the machine-based coordinate system. Thus if you rotate the table—and therefore the workpiece—by 90° for example, the coordinate system **does not rotate**. If you press the Z+ axis direction button in the Manual Operation mode, the tool moves in Z+ direction.
- In calculating the transformed coordinate system, the TNC considers only the mechanically influenced offsets of the particular tilting table (the so-called “translational” components).



### ■ Machine with swivel head

- You must bring the tool into the desired position for machining by positioning the swivel head, for example with an L block.
- The position of the transformed tool axis changes in relation to the machine-based coordinate system. Thus if you rotate the swivel head of your machine—and therefore the tool—in the B axis by 90° for example, the coordinate system rotates also. If you press the Z+ axis direction button in the Manual Operation mode, the tool moves in X+ direction of the machine-based coordinate system.
- In calculating the transformed coordinate system, the TNC considers both the mechanically influenced offsets of the particular swivel head (the so-called “translational” components) and offsets caused by tilting of the tool (3-D tool length compensation).

## Traversing the reference points in tilted axes

With tilted axes, you use the machine axis direction buttons to cross over the reference points. The TNC interpolates the corresponding axes. Be sure that the function for tilting the working plane is active in the Manual Operation mode and that the actual angle of the tilted axis was entered in the menu field.



## Setting the datum in a tilted coordinate system

After you have positioned the rotary axes, set the datum in the same manner as for a non-tilted system. The behavior of the TNC during datum setting depends on machine parameter 7500:

### ■ MP 7500, bit 5=0

With an active tilted working plane, the TNC checks during datum setting in the X, Y and Z axes whether the current coordinates of the rotary axes agree with the tilt angles that you defined (3D-ROT menu). If the tilted working plane function is not active, the TNC checks whether the rotary axes are at 0° (actual positions). If the positions do not agree, the TNC will display an error message.

### ■ MP 7500, bit 5=1

The TNC does not check whether the current coordinates of the rotary axes (actual positions) agree with the tilt angles that you defined.



Always set a reference point in all three reference axes.

If your machine tool is not equipped with axis control, you must enter the actual position of the rotary axis in the menu for manual tilting: The actual positions of one or several rotary axes must match the entry. Otherwise the TNC will calculate an incorrect datum.

## Datum setting on machines with rotary tables

If you use a rotary table to align the workpiece, for example with probing cycle 403, you must set the table position value to zero after alignment and before setting the datum in the linear axes X, Y and Z. The TNC will otherwise display an error message. Cycle 403 provides you with an input parameter for this purpose (see User's Manual for Touch Probe Cycles, "Basic Rotation Compensation via Rotary Axis").

## Datum setting on machines with spindle-head changing systems

If your machine is equipped with a spindle head changer, you should use the preset table to manage your datums. Datums saved in preset tables account for the active machine kinematics (head geometry). If you exchange heads, the TNC accounts for the new head dimensions so that the active datum is retained.

## Position display in a tilted system

The positions displayed in the status window (**ACTL.** and **NOML.**) are referenced to the tilted coordinate system.

## Limitations on working with the tilting function

- The probing function for basic rotation is not available if you have activated the working plane function in the Manual operating mode.
- PLC positioning (determined by the machine tool builder) is not possible.



Activating manual tilting



To select manual tilting, press the 3-D ROT soft key. You can now select the desired menu items with the arrow keys.


Enter the tilt angle.

To set the desired operating mode in menu option “Tilt working plane” to Active, select the menu option and switch with the ENT key.

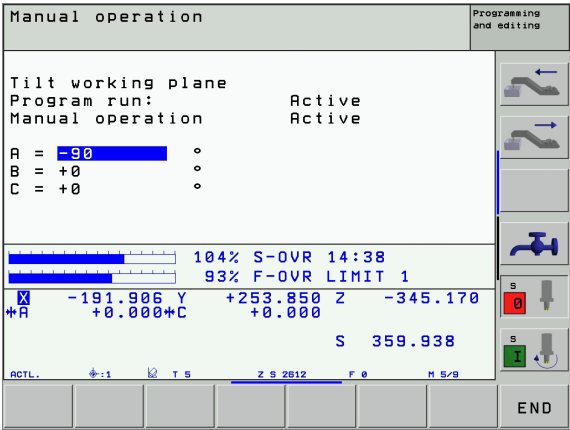


To conclude entry, press the END key.

To reset the tilting function, set the desired operating modes in the menu “Tilt working plane” to Inactive.

If the tilted working plane function is active and the TNC moves the machine axes in accordance with the tilted axes, the status display shows the symbol .

If you activate the “Tilt working plane” function for the Program Run operating mode, the tilt angle entered in the menu becomes active in the first block of the part program. If you are using Cycle 19 **WORKING PLANE** in the part program, the angular values defined in the cycle (starting at the cycle definition) are effective. Angle values entered in the menu will be overwritten.





# 3

**Positioning with Manual Data  
Input (MDI)**



### 3.1 Programming and Executing Simple Machining Operations

The Positioning with Manual Data Input mode of operation is particularly convenient for simple machining operations or pre-positioning of the tool. It enables you to write a short program in HEIDENHAIN conversational programming or in ISO format, and execute it immediately. You can also call TNC cycles. The program is stored in the file \$MDI. In the Positioning with MDI operating mode, the additional status displays can also be activated.

#### Positioning with Manual Data Input (MDI)



Select the Positioning with MDI mode of operation.  
Program the file \$MDI as you wish.



To start program run, press the machine START key.



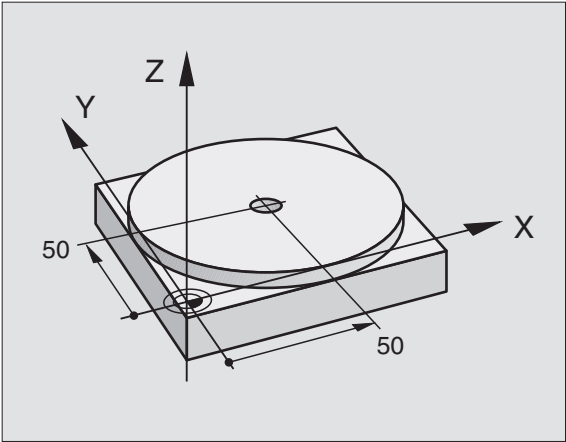
#### Limitation

FK free contour programming, programming graphics and program run graphics cannot be used. The \$MDI file must not contain a program call (**PGM CALL**).

#### Example 1

A hole with a depth of 20 mm is to be drilled into a single workpiece. After clamping and aligning the workpiece and setting the datum, you can program and execute the drilling operation in a few lines.

First you pre-position the tool in L blocks (straight-line blocks) to the hole center coordinates at a setup clearance of 5 mm above the workpiece surface. Then drill the hole with Cycle 1 **1 PECKING**.



0 BEGIN PGM \$MDI MM	
1 TOOL DEF 1 L+0 R+5	Define tool: zero tool, radius 5
2 TOOL CALL 1 Z S2000	Call tool: tool axis Z spindle speed 2000 rpm
3 L Z+200 R0 FMAX	Retract tool (F MAX = rapid traverse)
4 L X+50 Y+50 R0 FMAX M3	Move the tool at F MAX to a position above the hole, spindle on
6 CYCL DEF 200 DRILLING	Define DRILLING cycle
Q200=5 ;SET-UP CLEARANCE	Set-up clearance of the tool above the hole
Q201=-15 ;DEPTH	Total hole depth (Algebraic sign=working direction)






Q206=250	;FEED RATE FOR PLNGNG	Feed rate for pecking
Q202=5	;INFEED DEPTH	Depth of each infeed before retraction
Q210=0	;DWELL TIME AT TOP	Dwell time after every retraction in seconds
Q203=-10	;SURFACE COORDINATE	Coordinate of the workpiece surface
Q204=20	;2ND SET-UP CLEARANCE	Set-up clearance of the tool above the hole
Q211=0.2	;DWELL TIME AT DEPTH	Dwell time in seconds at the hole bottom
7 CYCL CALL		Call DRILLING cycle
8 L Z+200 R0 FMAX M2		Retract the tool
9 END PGM \$MDI MM		End of program

Straight line function L (see “Straight Line L” on page 191), DRILLING cycle(see “DRILLING (Cycle 200)” on page 277).


### Example 2: Correcting workpiece misalignment on machines with rotary tables

Use the 3-D touch probe to rotate the coordinate system. See “Touch Probe Cycles in the Manual and Electronic Handwheel Operating Modes,” section “Compensating workpiece misalignment,” in the Touch Probe Cycles User’s Manual.

Write down the rotation angle and cancel the Basic Rotation.




Select operating mode: Positioning with MDI.




IV

Select the axis of the rotary table, enter the rotation angle you wrote down previously and set the feed rate. For example: **L C+2.561 F50**



Conclude entry.



Press the machine START button: The rotation of the table corrects the misalignment.



Protecting and Erasing Programs in \$MDI

The \$MDI file is generally intended for short programs that are only needed temporarily. Nevertheless, you can store a program, if necessary, by proceeding as described below:



Select the Programming and Editing mode of operation.



To call the file manager, press the PGM MGT key (program management).



Move the highlight to the \$MDI file.



To select the file copying function, press the COPY soft key.

TARGET FILE =

BOREHOLE

Enter the name under which you want to save the current contents of the \$MDI file.



Copy the file.



To close the file manager, press the END soft key.

Erasing the contents of the \$MDI file is done in a similar way: Instead of copying the contents, however, you erase them with the DELETE soft key. The next time you select the operating mode Positioning with MDI, the TNC will display an empty \$MDI file.



- If you wish to delete \$MDI, then
- you must not have selected the Positioning with MDI mode (not even in the background).
  - you must not have selected the \$MDI file in the Programming and Editing mode.

For further information, see “Copying a single file” on page 92.





# 4

**Fundamentals of NC,  
File Management,  
Programming Aids, Pallet  
Management**



## 4.1 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 TNC 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 association, incremental position encoders are provided with reference marks. The scales of the position encoders contain one or more reference marks that transmit a signal to the TNC when they are crossed over. From the signal the TNC can re-establish the assignment of displayed positions to machine positions. 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°.

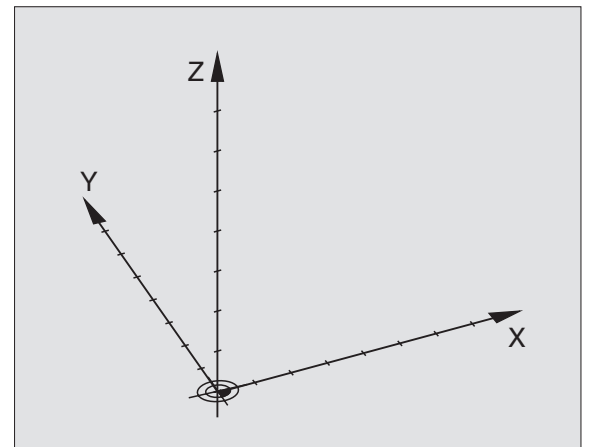
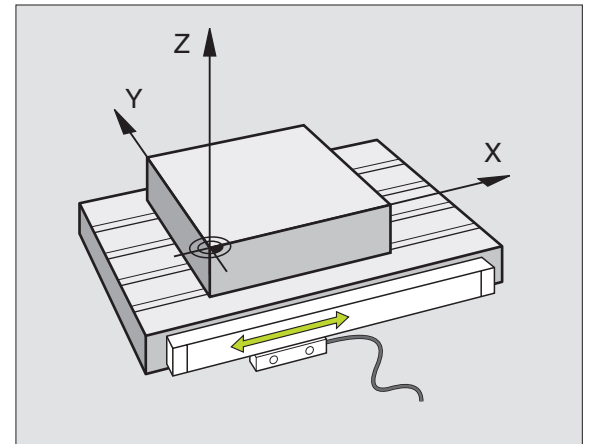
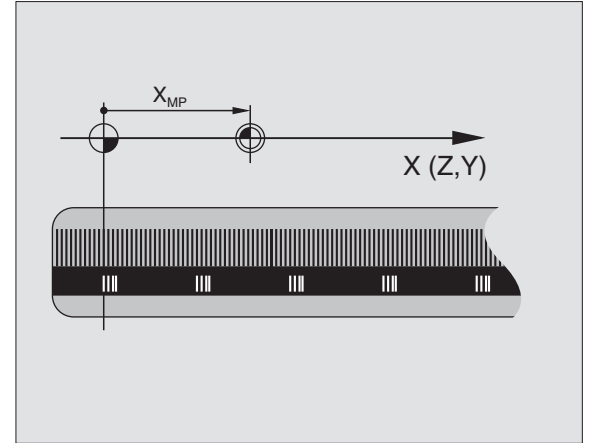
With absolute encoders, an absolute position value is transmitted to the control immediately upon switch-on. In this way the assignment of the actual position to the machine slide position is re-established directly after switch-on.

### Reference system

A reference system is required to define positions in a plane or in space. The position data are always referenced to a predetermined point and are described through coordinates.

The Cartesian coordinate system (a rectangular coordinate system) is based on the three coordinate axes X, Y and Z. The axes are mutually perpendicular and intersect at one point called the datum. A coordinate identifies the distance from the datum in one of these directions. A position in a plane is thus described through two coordinates, and a position in space through three coordinates.

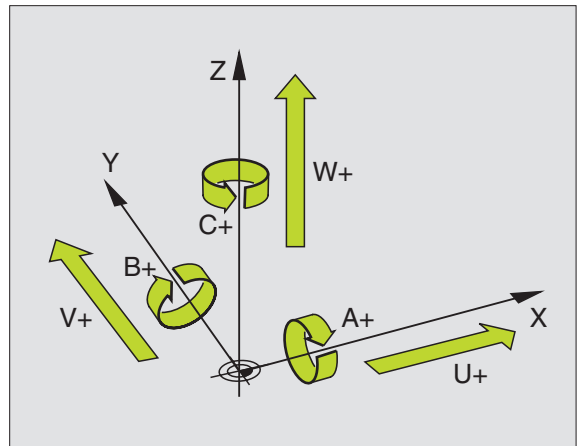
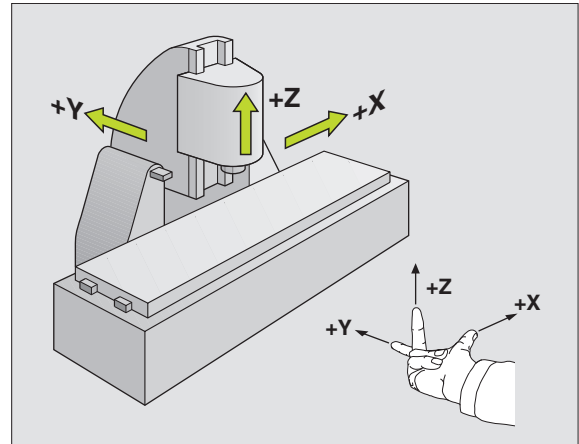
Coordinates that are referenced to the datum are referred to as absolute coordinates. Relative coordinates are referenced to any other known position (reference point) you define within the coordinate system. Relative coordinate values are also referred to as incremental coordinate values.



## Reference system on milling machines

When using a milling machine, you orient tool movements to the Cartesian coordinate system. The illustration at right shows how the Cartesian coordinate system describes the machine axes. The “right-hand rule” is illustrated for remembering the three axis directions: the middle finger points in the positive direction of the tool axis from the workpiece toward the tool (the Z axis), the thumb points in the positive X direction, and the index finger in the positive Y direction.

The iTNC 530 can control up to 9 axes. The axes U, V and W are secondary linear axes parallel to the main axes X, Y and Z, respectively. Rotary axes are designated as A, B and C. The illustration at lower right shows the assignment of secondary axes and rotary axes to the main axes.



Polar coordinates

If the production drawing is dimensioned in Cartesian coordinates, you also write the part 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:

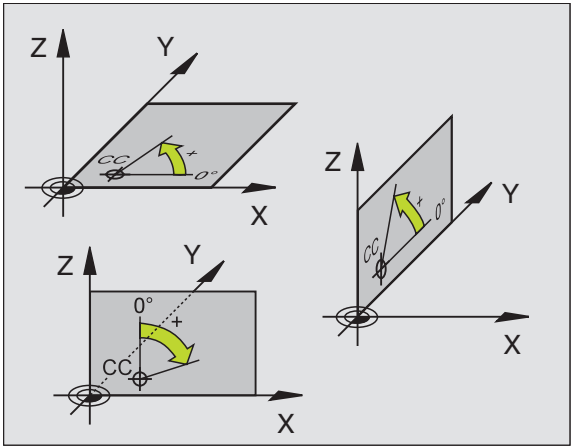
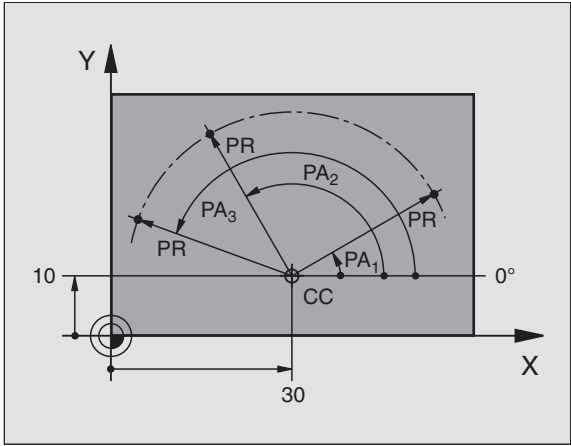
- Polar Radius, the distance from the circle center CC to the position, and the
- Polar Angle, the size of the angle between the reference axis and the line that connects the circle center CC with the position.

See figure at upper right.

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 PA.

Coordinates of the pole (plane)	Reference axis of the angle
X/Y	+X
Y/Z	+Y
Z/X	+Z



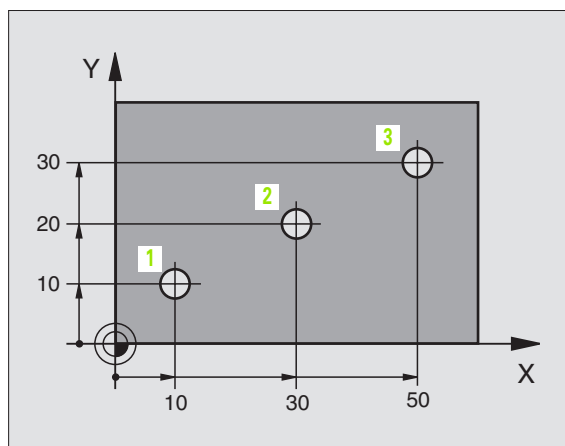
## Absolute and incremental workpiece positions

### 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 uniquely 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 a part program in incremental coordinates, you thus program the tool to move by the distance between the previous and the subsequent nominal positions. Incremental coordinates are therefore also referred to as chain dimensions.

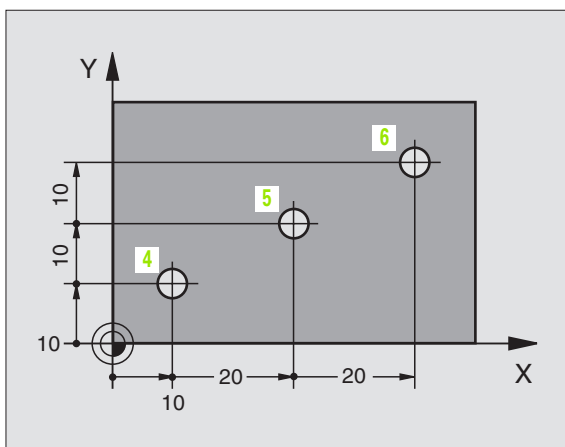
To program a position in incremental coordinates, enter the prefix "I" before the axis.

Example 2: Holes dimensioned in incremental coordinates

Absolute coordinates of hole 4

X = 10 mm  
Y = 10 mm

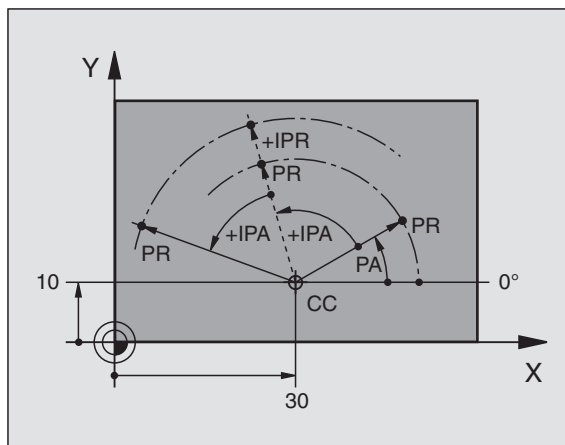
Hole 5, referenced to 4	Hole 6, referenced to 5
X = 20 mm	X = 20 mm
Y = 10 mm	Y = 10 mm



### Absolute and incremental polar coordinates

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

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



## Setting the datum

A production drawing identifies a certain form element of the workpiece, usually a corner, as the absolute datum. Before setting the datum, you align the workpiece with the machine axes and move the tool in each axis to a known position relative to the workpiece. You then set the TNC display to either zero or a predetermined position value. This establishes the reference system for the workpiece, which will be used for the TNC display and your part program.

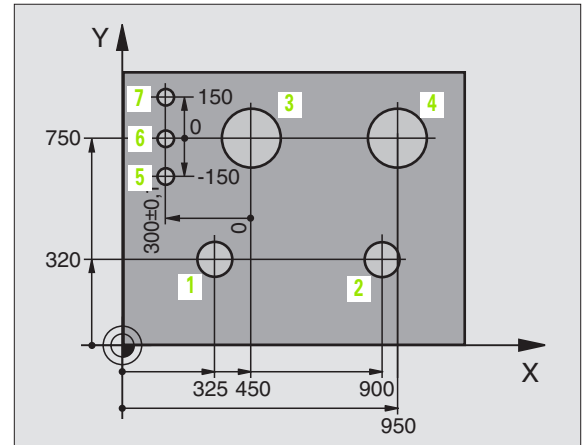
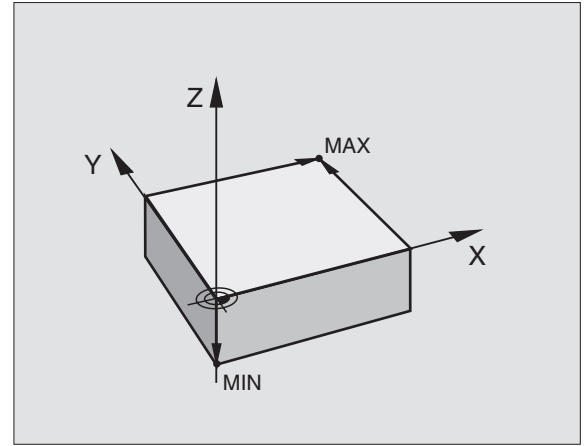
If the production drawing is dimensioned in relative coordinates, simply use the coordinate transformation cycles (see "Coordinate Transformation Cycles" on page 426).

If the production drawing is not dimensioned for NC, set the datum at a position or corner on the workpiece which is suitable for deducing the dimensions of the remaining workpiece positions.

The fastest, easiest and most accurate way of setting the datum is by using a 3-D touch probe from HEIDENHAIN. See "Setting the Datum with a 3-D Touch Probe" in the Touch Probe Cycles User's Manual.

### Example

The workpiece drawing at right shows holes (1 to 4) whose dimensions are shown with respect to an absolute datum with the coordinates  $X=0, Y=0$ . The holes (5 to 7) are dimensioned with respect to a relative datum with the absolute coordinates  $X=450, Y=750$ . With the **DATUM SHIFT** cycle you can temporarily set the datum to the position  $X=450, Y=750$ , to be able to program the holes (5 to 7) without further calculations.





## 4.2 File Management: Fundamentals

### Files

Files in the TNC	Type
<b>Programs</b>	
In HEIDENHAIN format	.H
In ISO format	.I
<b>smarT.NC files</b>	
Structured unit program	.HU
Contour descriptions	.HC
Point tables for machining positions	.PNT
<b>Tables for</b>	
Tools	.T
Tool changers	.TCH
Pallets	.P
Datums	.D
Presets	.PR
Cutting data	.CDT
Cutting materials, workpiece materials	.TAB
Dependent data (such as structure items)	.DEP
<b>Texts as</b>	
ASCII files	.A

When you write a part program on the TNC, you must first enter a file name. The TNC saves the program to the hard disk as a file with the same name. The TNC can also save texts and tables as files.

The TNC 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.

You can manage an almost unlimited number of files with the TNC, at least **36 GB**.

#### File names

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

PROG20	.H
File name	File type



### Data backup

We recommend saving newly written programs and files on a PC at regular intervals.

You can do this with the free backup program TNCBACK.EXE from HEIDENHAIN. Your machine tool builder can provide you with a copy of TNCBACK.EXE.

In addition, you need a floppy disk on which all machine-specific data, such as PLC program, machine parameters, etc., are stored. Please contact your machine tool builder for more information on both the backup program and the floppy disk.



Saving the contents of the entire hard disk (> 2 GB) can take up to several hours. In this case, it is a good idea to save the data outside of working hours, (e.g. overnight), or to use the PARALLEL EXECUTE function to copy in the background while you work.



Depending on operating conditions (e.g., vibration load), hard disks generally have a higher failure rate after three to five years of service. HEIDENHAIN therefore recommends having the hard disk inspected after three to five years.

## 4.3 Working with the File Manager

### Directories

To ensure that you can easily find your files, we recommend that you organize your hard disk into directories. You can divide a directory into further directories, which are called subdirectories. With the `-/+` key or `ENT` you can show or hide the subdirectories.



The TNC can manage up to 6 directory levels!

If you save more than 512 files in one directory, the TNC no longer sorts them alphabetically!

### Directory names

The name of a directory can contain up to 16 characters and does not have an extension. If you enter more than 16 characters for the directory name, the TNC will display an error message.

### Paths

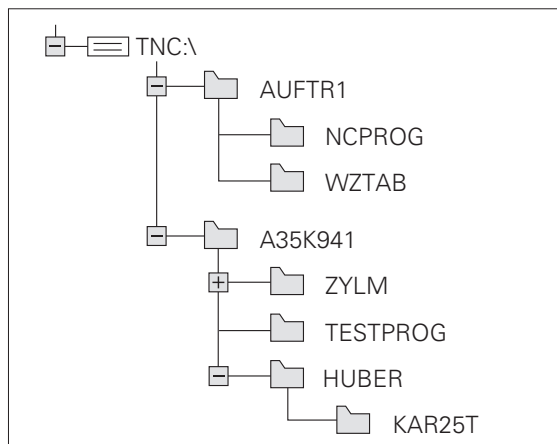
A path indicates the drive and all directories and subdirectories under which a file is saved. The individual names are separated by a backslash "`\`".

### Example














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

**TNC:\AUFTR1\NCPROG\PROG1.H**

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



Overview: Functions of the File Manager

Function	Soft key
Copy (and convert) individual files	
Select target directory	
Display a specific file type	
Display the last 10 files that were selected	
Erase a file or directory	
Tag a file	
Renaming a file	
Protect a file against editing and erasure	
Cancel file protection	
Manage network drives	
Copying a directory	
Display all the directories of a particular drive	
Delete directory with all its subdirectories	



## Calling the File Manager

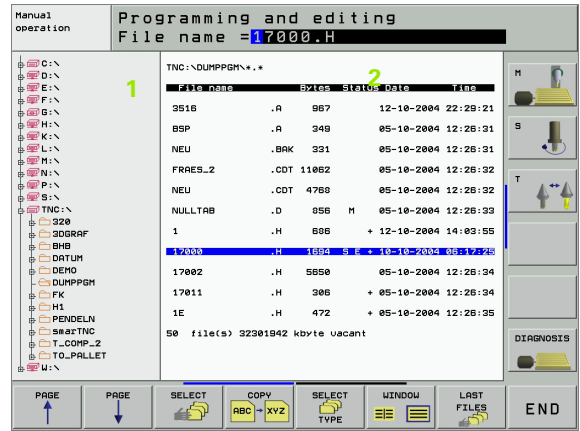


Press the PGM MGT key: The TNC displays the file management window (see figure at top right for default setting. If the TNC displays a different screen layout, press the WINDOW soft key.)

The narrow window on the left **1** shows the available drives and directories. Drives designate devices with which data are stored or transferred. One drive is the hard disk of the TNC. Other drives are the interfaces (RS232, RS422, Ethernet), which can be used, for example, to connect a personal computer. A directory is always identified by a folder symbol to the left and the directory name to the right. The control displays a subdirectory to the right of and below its parent directory. A box with the + symbol in front of the folder symbol indicates that there are further subdirectories, which can be shown with the +/- key or ENT.

The wide window on the right **2** 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
<b>FILE NAME</b>	Name with up to 16 characters and file type
<b>BYTE</b>	File size in bytes
<b>STATUS</b>	File properties:
E	Program is selected in the Programming and Editing mode of operation.
S	Program is selected in the Test Run mode of operation.
M	Program is selected in a program run mode of operation.
P	File is protected against editing and erasure.
<b>DATE</b>	Date the file was last changed
<b>TIME</b>	Time the file was last changed



Selecting drives, directories and files



Call the File Manager.

With the arrow keys or the soft keys, you can move the highlight to the desired position on the screen:



Moves the highlight from the left to the right window, and vice versa.



Moves the highlight up and down within a window.



Moves the highlight one page up or down within a window.

Step 1: Select drive

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



or



Select a drive: Press the SELECT soft key or the ENT key.

Step 2: Select a directory

Move the highlight to the desired directory in the left-hand 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 soft key for the desired file type, or



Press the SHOW ALL soft key to display all files, or

4\* .H



Use wild card characters, e.g. to show all files of the file type .H that begin with 4.

Move the highlight to the desired file in the right window



or

The selected file is opened in the operating mode from which you have called the File Manager: Press the SELECT soft key or the ENT key.



### Creating a new directory (only possible on the drive TNC:\)

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

NEW



Enter the new file name, and confirm with ENT.

CREATE \NEW DIRECTORY?



Press the YES soft key to confirm, or



Abort with the NO soft key.



## Copying a single file

- Move the highlight to the file you wish to copy.



- Press the COPY soft key to select the copy function. The TNC displays a soft-key row with soft keys for different functions.



- Press the "Select target directory" soft key to select the desired directory in a pop-up window. After the target directory has been selected, the corresponding path is indicated in the header. Use the Backspace key to position the cursor directly at the end of the path name and enter the name of the destination file.



- Enter the name of the destination file and confirm your entry with the ENT key or EXECUTE soft key: The TNC copies the file into the active directory or into the selected destination directory. The original file is retained, or



- Press the PARALLEL EXECUTE soft key to copy the file in the background. Copying in the background permits you to continue working while the TNC is copying. This can be useful if you are copying very large files that take a long time. While the TNC is copying in the background you can press the INFO PARALLEL EXECUTE soft key (under MORE FUNCTIONS, second soft-key row) to check the progress of copying.



When the copying process has been started with the EXECUTE soft key, the TNC displays a pop-up window with a progress indicator.



### Copying a table

If you are copying tables, you can overwrite individual lines or columns in the target table with the REPLACE FIELDS soft key. Prerequisites:

- The target table must exist.
- The file to be copied must only contain the columns or lines you want to replace.



The **REPLACE FIELDS** soft key does not appear when you want to overwrite the table in the TNC with an external data transfer software, such as TNCremoNT. Copy the externally created file into a different directory, and then copy the desired fields with the TNC file management.

#### Example

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

- Tool number (column **T**)
- Tool length (column **L**)
- Tool radius (column **R**)

Copy this file to a directory other than the one containing the previous TOOL.T. If you wish to copy this file over the existing table using the TNC file management, the TNC asks if you wish to overwrite the existing TOOL.T tool table:


- ▶ If you press the YES soft key, the TNC will completely overwrite the current TOOL.T tool table. After this copying process the new TOOL.T table consists of 10 lines. The only remaining columns in the table are tool number, tool length and tool radius.
- ▶ Or, if you press the REPLACE FIELDS soft key, the TNC merely overwrites the first 10 lines of the columns number, length and radius in the TOOL.T file. The data of the other lines and columns is not changed.
- ▶ Or, if you press the REPLACE EMPTY LINES soft key, the TNC merely overwrites the lines in the TOOL.T file that do not contain any data. The data of the other lines and columns is not changed.

### Copying a directory


Move the highlight in the left window onto the directory you want to copy. Instead of the COPY soft key, press the COPY DIR soft key. Subdirectories are also copied at the same time.



### Choosing one of the last 10 files selected





Call the File Manager.




Display the last 10 files selected: Press the LAST FILES soft key.

Use the arrow keys to move the highlight to the file you wish to select:





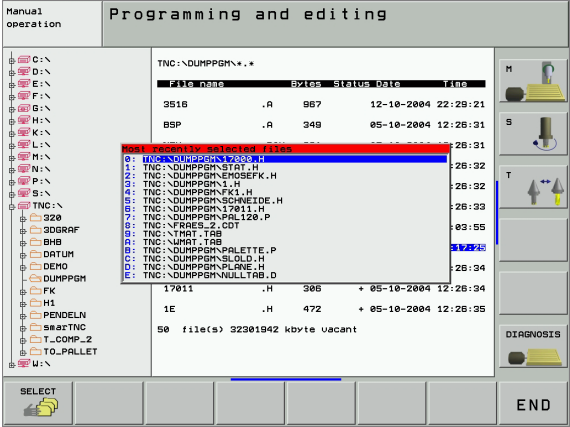
Moves the highlight up and down within a window.



Select a drive: Press the SELECT soft key or the ENT key.


or






### Deleting a file

- ▶ Move the highlight to the file you want to delete.
 


  - ▶ To select the erasing function, press the DELETE soft key. The TNC inquires whether you really intend to erase the file.
  - ▶ To confirm, press the JA soft key;
  - ▶ To abort erasure, press the NO soft key.






### Deleting a directory

- ▶ Delete all files and subdirectories stored in the directory that you wish to erase.
- ▶ Move the highlight to the directory you want to delete.
 


  - ▶ To select the erasing function, press the DELETE soft key. The TNC inquires whether you really intend to erase the directory.
  - ▶ To confirm, press the JA soft key;
  - ▶ To abort erasure, press the NO soft key.




Tagging files


Tagging functions	Soft key
Tag a single file	
Tag all files in the directory	
Untag a single file	
Untag all files	
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 highlight to the first file.




To display the tagging functions, press the TAG soft key.




Tag a file by pressing the TAG FILE soft key.



Move the highlight to the next file you wish to tag:



To mark more files, press the TAG FILE soft key.



To copy the tagged files, press the COPY TAG soft key, or



Delete the tagged files by pressing END to end the marking function, and then the DELETE soft key to delete the tagged files.



## Renaming a file

- ▶ Move the highlight to the file you want to rename.



- ▶ Select the renaming function.
- ▶ Enter the new file name; the file type cannot be changed.
- ▶ To execute renaming, press the ENT key.

## Additional functions

### Protecting a file / Canceling file protection

- ▶ Move the highlight to the file you want to protect.



- ▶ To select the additional functions, press the MORE FUNCTIONS soft key.
- ▶ To enable file protection, press the PROTECT soft key. The file now has status P.
- ▶ To cancel file protection, proceed in the same way using the UNPROTECT soft key.

### Erasing a directory together with all its subdirectories and files

- ▶ Move the highlight in the left window onto the directory you want to erase.



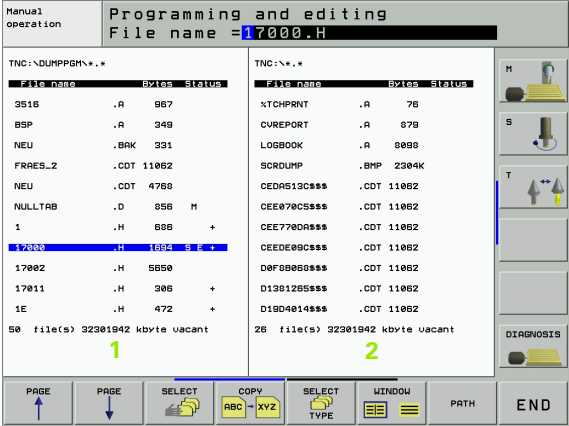
- ▶ To select the additional functions, press the MORE FUNCTIONS soft key.
- ▶ Press DELETE ALL to erase the directory together with its subdirectories.
- ▶ To confirm, press the YES soft key. To abort erasure, press the NO soft key.

# Data transfer to or from an external data medium

Before you can transfer data to an external data medium, you must set up the data interface (see "Setting the Data Interfaces" on page 577).

**PGM MGT** Call the File Manager.

**WINDOW** Select the screen layout for data transfer: press the WINDOW soft key. In the left half of the screen (1) the TNC shows all files saved on its hard disk. In the right half of the screen (2) it shows all files saved on the external data medium.



Use the arrow keys to highlight the file(s) that you want to transfer:

**↑ ↓** Moves the highlight up and down within a window.  
**← →** Moves the highlight from the left to the right window, and vice versa.

If you wish to copy from the TNC to the external data medium, move the highlight in the left window to the file to be transferred.

If you wish to copy from the external data medium to the TNC, move the highlight in the right window to the file to be transferred.

**COPY ABC → XYZ** To transfer a single file: Press the COPY soft key, or

**TAG** Transfer several files: Press the TAG soft key (in the second soft-key row, see "Tagging files" on page 95), or

**COPY TNC → EXT** Transfer all files: Press the TNC => EXT soft key.



Confirm with the EXECUTE soft key or with the ENT key. A status window appears on the TNC, informing about the copying progress, or

If you wish to transfer more than one file or longer files, press the PARALLEL EXECUTE soft key. The TNC then copies the file in the background.



To end data transfer, move the highlight into the left window and then press the WINDOW soft key. The standard file manager window is displayed again.



To select another directory in the split-screen display, press the PATH soft key. Select the desired directory in the pop-up window by using the arrow keys and the ENT key.

## Copying files into another directory

- ▶ Select the screen layout with the two equally sized windows.
- ▶ To display directories in both windows, press the PATH soft key.

In the right window

- ▶ Move the highlight 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

- ▶ Select the directory with the files that you wish to copy and press ENT to display them.



- ▶ Display the file tagging functions.



- ▶ Move the highlight to the file you want to copy and tag it. You can tag several files in this way, if desired.



- ▶ Copy the tagged files into the target directory.

Additional tagging functions: see "Tagging files" on page 95.

If you have marked files in the left and right windows, the TNC copies from the directory in which the highlight is located.

### Overwriting files

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

- ▶ To overwrite all files, press the YES soft key, or
- ▶ To overwrite no files, press the NO soft key, or
- ▶ To confirm each file separately before overwriting it, press the CONFIRM soft key.

If you wish to overwrite a protected file, this must also be confirmed or aborted separately.



The TNC in a network



- To connect the Ethernet card to your network, see “Ethernet Interface” on page 581.
- To connect the iTNC with Windows 2000 to your network, see “Network Settings” on page 641.
- The TNC logs error messages during network operation (see “Ethernet Interface” on page 581).

If the TNC is connected to a network, the directory window 1 displays up to 7 drives (see figure at right). All the functions described above (selecting a drive, copying files, etc.) also apply to network drives, provided that you have been given the corresponding rights.

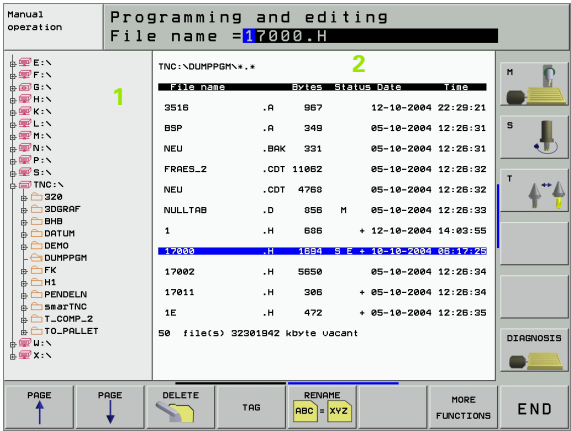
Connecting and disconnecting a network drive



- To select the program management: Press the PGM MGT key. If necessary, press the WINDOW soft key to set up the screen as it is shown at the upper right.



- To manage the network drives: Press the NETWORK soft key (second soft-key row). In the right-hand window 2 the TNC shows the network drives available for access. With the soft keys described below you can define the connection for each drive.



Function	Soft key
Establish network connection. If the connection is active, the TNC shows an <b>M</b> in the <b>Mnt</b> column. You can connect up to 7 additional drives with the TNC.	MOUNT DEVICE
Delete network connection.	UNMOUNT DEVICE
Automatically establish network connection whenever the TNC is switched on. The TNC shows an <b>A</b> in the <b>Auto</b> column if the connection is established automatically.	AUTO MOUNT
Do not establish network connection automatically when the TNC is switched on.	NO AUTO MOUNT

It may take some time to mount a network device. At the upper right of the screen the TNC displays **[READ DIR]** to indicate that a connection is being established. The maximum transmission speed is 2 to 5 MB/s, depending on the type of file being transferred and how busy the network is.





## 4.4 Creating and Writing Programs

### Organization of an NC program in HEIDENHAIN conversational format

A part program consists of a series of program blocks. The figure at right illustrates the elements of a block.

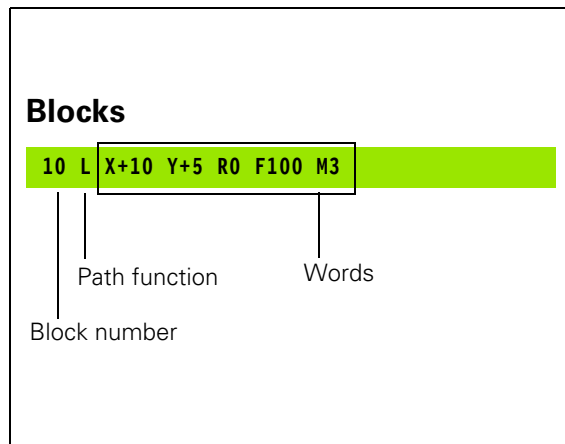
The TNC numbers the blocks in ascending sequence.

The first block of a program is identified by **BEGIN PGM**, the program name and the active unit of measure.

The subsequent blocks contain information on:

- The workpiece blank
- Tool definitions, tool calls
- Feed rates and spindle speeds, as well as
- Path contours, cycles and other functions

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



### Defining the blank form – BLK FORM

Immediately after initiating a new program, you define a cuboid workpiece blank. If you wish to define the blank at a later stage, press the SPEC FCT key and then the BLK FORM soft key. This definition is needed for the TNC's graphic simulation feature. The sides of the workpiece blank lie parallel to the X, Y and Z axes and can be up to 100 000 mm long. The blank form is defined by two of its corner points:


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




You only need to define the blank form if you wish to run a graphic test for the program!

Creating a new part program


You always enter a part program in the **Programming and Editing** mode of operation. An example of program initiation:


 Select the **Programming and Editing** mode of operation.

 To call the File Manager, press the PGM MGT key.

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

FILE NAME = OLD.H




 Enter the new program name and confirm your entry with the ENT key.

 To select the unit of measure, press the MM or INCH soft key. The TNC switches the screen layout and initiates the dialog for defining the **BLK FORM** (workpiece blank).




WORKING SPINDLE AXIS X/Y/Z ?

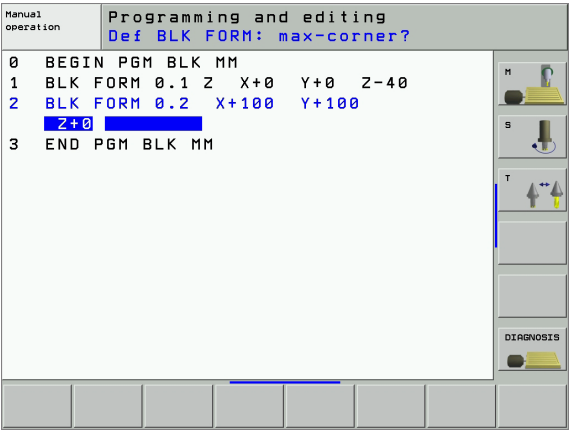
Enter the spindle axis.

DEF BLK FORM: MIN-CORNER ?

0  Enter in sequence the X, Y and Z coordinates of the MIN point.  
0   
-40 

DEF BLK FORM: MAX-CORNER ?

100  Enter in sequence the X, Y and Z coordinates of the MAX point.  
100   
0 



### Example: Display the BLK form in the NC program

0 BEGIN PGM NEW MM	Program begin, name, unit of measure
1 BLK FORM 0.1 Z X+0 Y+0 Z-40	Spindle axis, MIN point coordinates
2 BLK FORM 0.2 X+100 Y+100 Z+0	MAX point coordinates
3 END PGM NEW MM	Program end, name, unit of measure

The TNC automatically generates the block numbers as well as the **BEGIN** and **END** blocks.



If you do not wish to define a blank form, cancel the dialog at **Working spindle axis X/Y/Z** by pressing the DEL key!

The TNC can display the graphics only if the shortest side is at least 50 µm long and the longest side is no longer than 99 999.999 mm.



Programming tool movements in conversational format

To program a block, initiate the dialog by pressing a function key. In the screen headline, the TNC then asks you for all the information necessary to program the desired function.

Example of a dialog



Dialog initiation

COORDINATES?



10

Enter the target coordinate for the X axis.



20

ENT

Enter the target coordinate for the Y axis, and go to the next question with ENT.

RADIUS COMP. RL/RR/NO COMP. ?



Enter "No radius compensation" and go to the next question with ENT.

FEED RATE F=? / F MAX = ENT

100

ENT

Enter a feed rate of 100 mm/min for this path contour; go to the next question with ENT.

MISCELLANEOUS FUNCTION M?

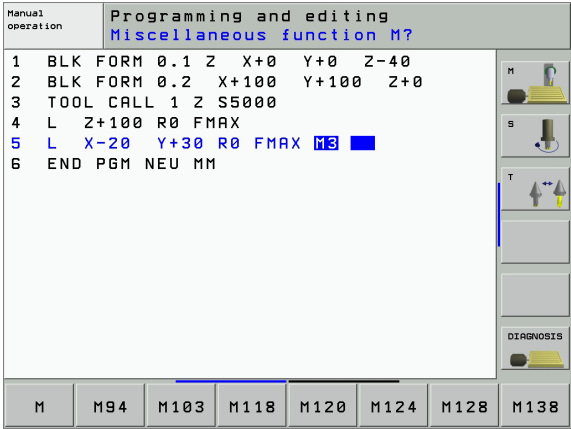
3











ENT

Enter the miscellaneous function **M3** "spindle ON"; pressing the ENT key terminates this dialog.

The program-block window displays the following line:

3 L X+10 Y+5 R0 F100 M3



Functions for setting the feed rate	Soft key
Rapid traverse	
Traverse feed rate automatically calculated in <b>TOOL CALL</b>	
Move at the programmed feed rate (unit of measure is mm/min)	
With <b>FT</b> , instead of a speed you define a time in seconds (input range 0.001 to 999.999 seconds), in which the programmed path is to be traversed. <b>FT</b> is effective only blockwise	
With <b>FMAXT</b> , instead of a speed you define a time in seconds (input range 0.001 to 999.999 seconds), in which the programmed path is to be traversed. <b>FMAXT</b> is effective only for keyboards with a rapid traverse potentiometer. <b>FMAXT</b> is effective only blockwise	
Define the feed per revolution (units in mm/rev or inch/rev)	
Define the tooth feed (units in mm/tooth or inch/tooth). The number of teeth must be defined in the tool table in the <b>CUT.</b> column.	
Functions for conversational guidance	Key
Ignore the dialog question	
End the dialog immediately	
Abort the dialog and erase the block	



## Actual position capture

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

- Positioning-block programming.
- Cycle programming.
- Define the tools with **TOOL DEF**.

To transfer the correct position values, proceed as follows:

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



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



- Select the axis: The TNC writes the current position of the selected axis into the active input box.














In the working plane the TNC always captures the coordinates of the tool center, even though tool radius compensation is active.








In the tool axis the TNC always captures the coordinates of the tool tip and thus always takes the active tool length compensation into account.

# Editing a program

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

Function	Soft key/key
Go to previous page	
Go to next page	
Go to beginning of program	
Go to end of program	
Change the position of the current block on the screen: Press this soft key to display additional program blocks that are programmed before the current block.	
Change the position of the current block on the screen: Press this soft key to display additional program blocks that are programmed after the current block.	
Move from one block to the next	 
Select individual words in a block	 
To select a certain block, press the GOTO key, enter the desired block number, and confirm with the ENT key. Or: Enter the block number step and press the N LINES soft key to jump over the entered number of lines upward or downward.	



Function	Soft key/key
Set the selected word to zero	
Erase an incorrect number	
Clear a (non-blinking) error message	
Delete the selected word	
Delete the selected block	
Erase cycles and program sections	
Insert the block that was last edited or deleted.	

**Inserting blocks at any desired location**

- ▶ Select the block after which you want to insert a new block and initiate the dialog.

**Editing and inserting words**

- ▶ Select a word in a block and overwrite it with the new one. The plain-language 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 blocks

For this function, set the AUTO DRAW soft key to OFF.



To select a word in a block, press the arrow keys repeatedly until the highlight is on the desired word.



Select a block with the arrow keys.

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



If you have started a search in a very long program, the TNC shows a progress display window. You then have the option of canceling the search via soft key.

In the tool axis the TNC always captures the coordinates of the tool tip and thus always takes the active tool length compensation into account.

### Finding any text

- ▶ To select the search function, press the FIND soft key. The TNC displays the dialog prompt **Find text**:
- ▶ Enter the text that you wish to find.
- ▶ To find the text, press the EXECUTE soft key.



Marking, copying, deleting and inserting program sections

The TNC provides certain functions for copying program sections within an NC program or into another NC program—see the table below.

To copy a program section, proceed as follows:

- ▶ Select the soft-key row containing the marking functions.
- ▶ Select the first (last) block of the section you wish to copy.
- ▶ To mark the first (last) block, press the SELECT BLOCK soft key. The TNC then highlights the first character of the block and superimposes the soft key CANCEL SELECTION.
- ▶ Move the highlight to the last (first) block of the program section you wish to copy or delete. The TNC shows the marked blocks in a different color. You can end the marking function at any time by pressing the CANCEL SELECTION soft key.
- ▶ To copy the selected program section, press the COPY BLOCK soft key. To delete the selected section, press the DELETE BLOCK soft key. The TNC stores the selected block.
- ▶ Using the arrow keys, select the block after which you wish to insert the copied (deleted) program section.



To insert the section into another program, select the corresponding program using the File Manager and then mark the block after which you wish to insert the copied block.

- ▶ To insert the block, press the INSERT BLOCK soft key.
- ▶ To end the marking function, press the CANCEL SELECTION soft key.

Function	Soft key
Switch marking function on	<div>SELECT BLOCK</div>
Switch marking function off	<div>CANCEL SELECTION</div>
Delete marked block	<div>DELETE BLOCK</div>
Insert block that is stored in the buffer memory	<div>INSERT BLOCK</div>
Copy marked block	<div>COPY BLOCK</div>



The TNC search function

With the search function of the TNC, you can search for any text within a program and replace it by a new text, if required.

Searching for texts

- ▶ If required, select the block containing the word you wish to find.
- FIND

▶ Select the search function: The TNC superimposes the search window and displays the available search functions in the soft-key row (see table of search functions).
- X +40

▶ Enter the text to be searched for. Please note that the search is case-sensitive.
- CONTINUE

▶ Start the search process: The TNC displays the available search options in the soft-key row (see the table of search options on the next page).
- WHOLE WORD  
OFF ON

▶ If required, change the search options.
- EXECUTE

▶ Start the search process: The TNC moves to the next block containing the text you are searching for.
- EXECUTE

▶ Repeat the search process: The TNC moves to the next block containing the text you are searching for.
- END


▶ End the search function.

Search functions	Soft key
Show the superimposed window containing the last search items. Use the arrow keys to select a search item and confirm with the ENT key.	LAST SEARCH ELEMENTS
Show the superimposed window containing possible search items of the current block. Use the arrow keys to select a search item and confirm with the ENT key.	CURRENT BLOCK ELEMENTS
Show the superimposed window containing a selection of the most important NC functions. Use the arrow keys to select a search item and confirm with the ENT key.	NC BLOCKS
Activate the Find/Replace function.	SEARCH + REPLACE



Search options	Soft key
Define the search direction.	<div>UPWARD DOWNWARD</div> <div>UPWARD DOWNWARD</div>
Define the end of the search: With COMPLETE, the search starts at the current block and is continued until the current block is reached again.	<div>COMPLETE BEGIN/END</div> <div>COMPLETE BEGIN/END</div>
Start a new search.	<div>NEW SEARCH</div>

Find/Replace any text



The find/replace function is not possible if

- a program is protected
- the program is currently being run by the TNC

When using the REPLACE ALL function, ensure that you do not accidentally replace text that you do not want to change. Once replaced, such text cannot be restored.

- ▶ If required, select the block containing the word you wish to find.

FIND

SEARCH  
+  
REPLACE

X

Z

CONTINUE

WHOLE  
WORD  
OFF ON

EXECUTE

EXECUTE

END
- ▶ Select the Search function: The TNC superimposes the search window and displays the available search functions in the soft-key row.
- ▶ Activate the Replace function: The TNC superimposes a window for entering the text to be inserted.
- ▶ Enter the text to be searched for. Please note that the search is case-sensitive. Then confirm with the ENT key.
- ▶ Enter the text to be inserted. Please note that the entry is case-sensitive.
- ▶ Start the search process: The TNC displays the available search options in the soft-key row (see the table of search options).
- ▶ If required, change the search options.
- ▶ Start the search process: The TNC moves to the next occurrence of the text you are searching for.
- ▶ To replace the text and then move to the next occurrence of the text, press the REPLACE soft key. To replace all text occurrences, press the REPLACE soft key. To skip the text and move to its next occurrence press the DO NOT REPLACE soft key.
- ▶ End the search function.



## 4.5 Interactive Programming Graphics

### To generate/not generate graphics during programming:

While you are writing the part program, you can have the TNC generate a 2-D pencil-trace graphic of the programmed contour.

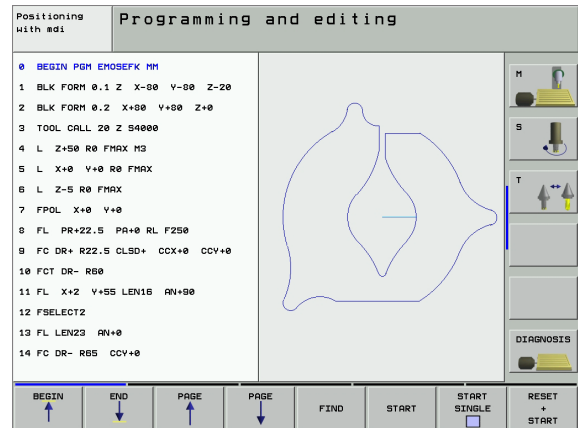
- ▶ To switch the screen layout to displaying program blocks to the left and graphics to the right, press the SPLIT SCREEN key and PGM + GRAPHICS soft key.



- ▶ Set the AUTO DRAW soft key to ON. While you are entering the program lines, the TNC generates each path contour you program in the graphics window in the right screen half.

If you do not wish to have graphics generated during programming, set the AUTO DRAW soft key to OFF.

Even when AUTO DRAW ON is active, graphics are not generated for program section repeats.



### Generating a graphic for an existing program

- ▶ Use the arrow keys to select the block up to which you want the graphic to be generated, or press GOTO and enter the desired block number.



- ▶ To generate graphics, press the RESET + START soft key.

Additional functions:

Function	Soft key
Generate a complete graphic	
Generate interactive graphic blockwise	
Generate a complete graphic or complete it after RESET + START	
Stop the programming graphics. This soft key only appears while the TNC is generating the interactive graphics	



Block number display ON/OFF



- ▶ Shift the soft-key row (see figure at upper right).
- ▶ To show block numbers: Set the SHOW OMIT BLOCK NR. soft key to SHOW.
- ▶ To omit block numbers: Set the SHOW OMIT BLOCK NR. soft key to OMIT.

Erase the graphic









- ▶ Shift the soft-key row (see figure at upper right).
- ▶ Delete graphic: Press CLEAR GRAPHIC soft key.

Magnifying or reducing a detail

You can select the graphics display by selecting a detail with the frame overlay. You can now magnify or reduce the selected detail.

- ▶ Select the soft-key row for detail magnification/reduction (second row, see figure at center right).

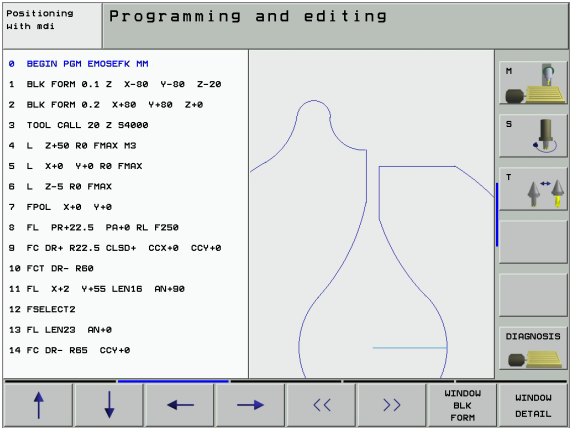
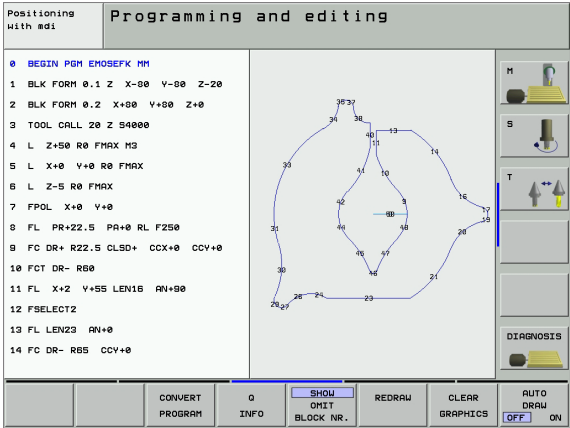
The following functions are available:

Function	Soft key
Show and move the frame overlay. Press and hold the desired soft key to move the frame overlay.	   
Reduce the frame overlay—press and hold the soft key to reduce the detail.	
Enlarge the frame overlay—press and hold the soft key to magnify the detail.	



- ▶ Confirm the selected area with the WINDOW DETAIL soft key.

With the WINDOW BLK FORM soft key, you can restore the original section.



## 4.6 Structuring Programs

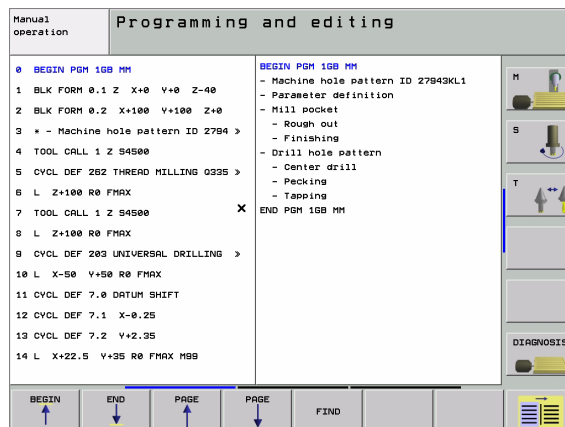
### Definition and applications

This TNC function enables you to comment part programs in structuring blocks. Structuring blocks are short texts with up to 37 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 programs in a clear and comprehensible way.

This function is particularly convenient if you want to change the program later. Structuring blocks can be inserted into the part program at any point. They can also be displayed in a separate window, and edited or added to, as desired.

The inserted structure items are managed by the TNC in a separate file (extension: .SEC.DEF). This speeds navigation in the program structure window.



### Displaying the program structure window / Changing the active window



- ▶ To display the program structure window, select the screen display PGM+SECTS.



- ▶ To change the active window, press the "Change window" soft key.

### Inserting a structuring block in the (left) program window

- ▶ Select the block after which the structuring block is to be inserted.



- ▶ Press the INSERT STRUCTURE soft key or the \* key on the ASCII keyboard.

- ▶ Enter the structuring text with the alphabetic keyboard.



- ▶ If necessary, change the structure depth with the soft key.

### Selecting blocks in the program structure window

If you are scrolling through the program structure window block by block, the TNC at the same time automatically moves the corresponding NC blocks in the program window. This way you can quickly skip large program sections.



## 4.7 Adding Comments

### Function

You can add comments to any desired block in the part program to explain program steps or make general notes. There are three possibilities for adding comments:

### Entering comments during programming

- ▶ Enter the data for a program block, then press the semicolon key “;” on the alphabetic keyboard—the TNC displays the dialog prompt **COMMENT ?**
- ▶ Enter your comment and conclude the block by pressing the END key.






### Inserting comments after program entry

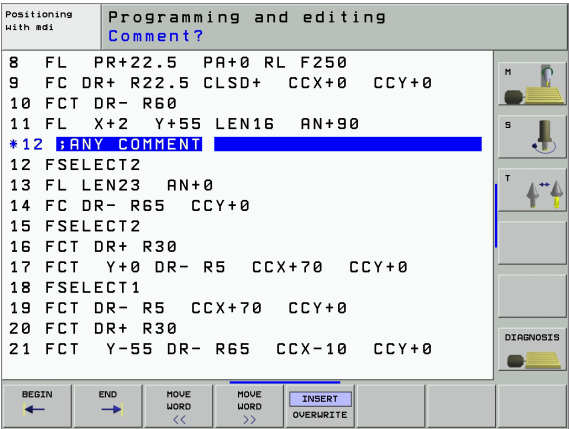
- ▶ Select the block to which a comment is to be added.
- ▶ Select the last word in the block with the right arrow key: A semicolon appears at the end of the block and the TNC displays the dialog prompt **COMMENT ?**
- ▶ Enter your comment and conclude the block by pressing the END key.

### Entering a comment in a separate block

- ▶ Select the block after which the comment is to be inserted.
- ▶ Initiate the programming dialog with the semicolon key (;) on the alphabetic keyboard.
- ▶ Enter your comment and conclude the block by pressing the END key.

### Functions for editing the comment

Function	Soft key
Jump to beginning of comment	
Jump to end of comment	
Jump to the beginning of a word. Words must be separated by a space.	
Jump to the end of a word. Words must be separated by a space.	
Switch between insert mode and overwrite mode	





# 4.8 Creating Text Files

## Function

You can use the TNC's text editor to write and edit texts. Typical applications:

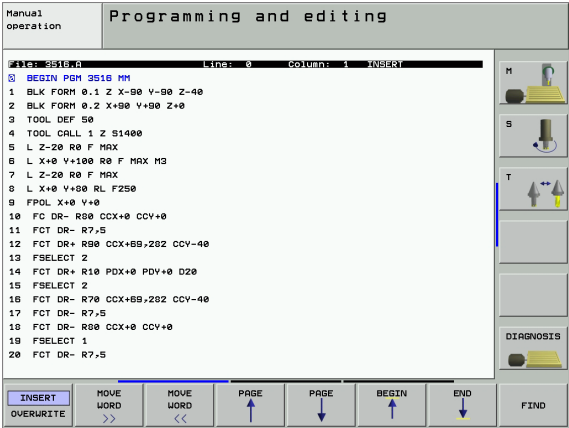
- Recording test results
- Documenting working procedures
- Creating formularies

Text files are type .A files (ASCII files). If you want to edit other types of files, you must first convert them into type .A files.

## Opening and exiting text files






- Select the Programming and Editing mode of operation.
- To call the File Manager, press the PGM MGT key.
- To display type .A files, press the SELECT TYPE and then the SHOW .A soft keys.
- Select a file and open it with the SELECT soft key or ENT key, or create 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 a part program.



Cursor movements	Soft key
Move one word to the right	
Move one word to the left	
Go to next screen page	
Go to previous screen page	
Go to beginning of file	
Go to end of file	



Editing functions	Key
Begin a new line	
Erase the character to the left of the cursor	
Insert a blank space	
Switch between upper and lower case letters	 

Editing texts

The first line of the text editor is an information headline displaying the file name, and the location and writing mode of the cursor:

- File:** Name of the text file
- Line:** Line in which the cursor is presently located
- Column:** Column in which the cursor is presently located
- INSERT:** Insert new text, pushing the existing text to the right
- OVERWRITE:** Write over the existing text, erasing it by replacing it with new text

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.

The line in which the cursor is presently located is depicted in a different color. A line can have up to 77 characters. To start a new line, press the RET key or the ENT key.



## Deleting and 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 placed in the buffer memory.
- Move the cursor to the location where you wish to insert the text, and press the RESTORE LINE/WORD soft key.

Function	Soft key
Delete and temporarily store a line	DELETE LINE
Delete and temporarily store a word	DELETE WORD
Delete and temporarily store a character	DELETE CHAR
Insert a line or word from temporary storage	INSERT LINE / WORD

## Editing text blocks

You can copy and erase text blocks of any size, and insert them at other locations. Before carrying out any of these editing functions, you must first select the desired text block:

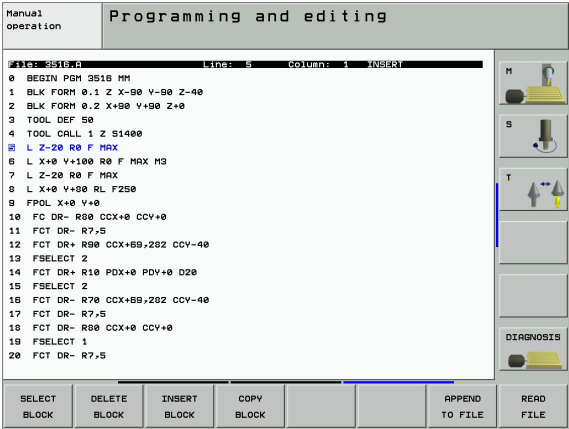
- To select a text block, move the cursor to the first character of the text you wish to select.

SELECT  
BLOCK

- Press the MARK 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:

Function	Soft key
Delete the selected text and store temporarily	DELETE BLOCK
Store marked block temporarily without erasing (copy)	INSERT BLOCK



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.
- ▶ Press the INSERT BLOCK soft key for the text block to be inserted.

You can insert the temporarily stored text block as often as desired.

## To transfer the selected text to a different file,

- ▶ Select the text block as described previously.
- ▶ Press the APPEND TO FILE soft key. The TNC displays the dialog prompt **Destination file =**
- ▶ Enter the path and name of the target file. The TNC appends the selected text to the end of the specified file. If no target file with the specified name is found, the TNC creates a new file with the selected text.

## To insert another file at the cursor position,

- ▶ Move the cursor to the location in the text where you wish to insert another file.
- ▶ Press the READ FILE soft key. The TNC displays the dialog prompt **File name =**
- ▶ 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. Two functions are available:

### 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.
- ▶ To select the search function, press the FIND soft key.
- ▶ Press the FIND CURRENT WORD soft key.
- ▶ To leave the search function, press the END soft key.

### Finding any text

- ▶ To select the search function, press the FIND soft key. The TNC displays the dialog prompt **Find text:**
- ▶ Enter the text that you wish to find.
- ▶ To find the text, press the EXECUTE soft key.
- ▶ To leave the search function, press the END soft key.



## 4.9 Integrated Pocket Calculator

### Operation

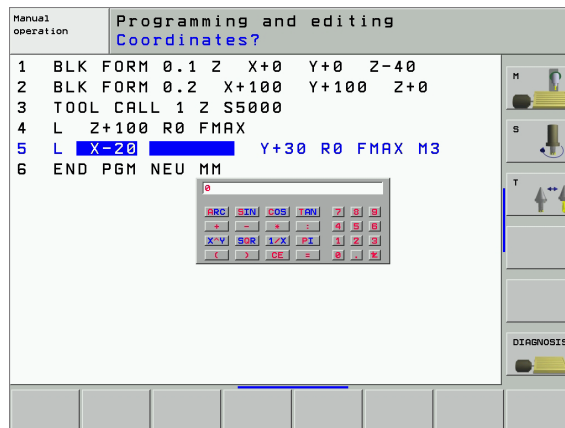
The TNC features an integrated pocket calculator with the basic mathematical functions.

- ▶ Use the CALC key to show and hide the on-line pocket calculator.
- ▶ The calculator is operated with short commands through the alphabetic keyboard. The commands are shown in a special color in the calculator window:

Mathematical function	Command (key)
Addition	+
Subtraction	−
Multiplication	*
Division	:
Sine	S
Cosine	C
Tangent	T
Arc sine	AS
Arc cosine	AC
Arc tangent	AT
Powers	^
Square root	Q
Inversion	/
Parenthetic calculations	( )
p (3.14159265359)	P
Display result	=

#### To transfer the calculated value into the program,

- ▶ Select the word into which the calculated value is to be transferred by using the arrow keys.
- ▶ Superimpose the on-line calculator by using the CALC key and perform the desired calculation.
- ▶ Press the actual position capture key for the TNC to superimpose a soft-key row.
- ▶ Press the CALC soft key for the TNC to transfer the value into the active input box and to close the calculator.



## 4.10 Immediate Help for NC Error Messages

### Displaying error messages

The TNC automatically generates error messages when it detects problems such as

- Incorrect data input
- Logical errors in the program
- Contour elements that are impossible to machine
- Incorrect use of the touch probe system

An error message that contains a program block number was caused by an error in the indicated block or in the preceding block. The TNC error messages can be canceled with the CE key, after the cause of the error has been removed.

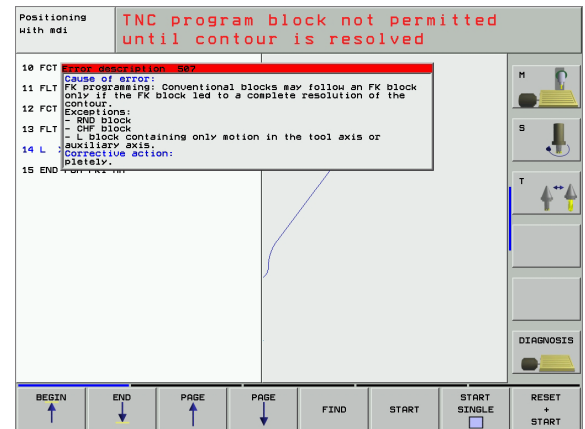
If you require more information on a particular error message, press the HELP key. A window is then superimposed where the cause of the error is explained and suggestions are made for correcting the error.

### Display HELP

HELP

- ▶ To display Help, press the HELP key.
- ▶ Read the description of the error and the possibilities for correcting it. The TNC may show additional information that can be helpful to trained HEIDENHAIN personnel during troubleshooting. Close the Help window with the CE key, thus canceling the error message.
- ▶ Remove the cause of the error as described in the Help window.

The TNC displays the Help text automatically if the error message is blinking. The TNC needs to be restarted after blinking error messages. To restart the TNC, press and hold the END key for two seconds.



## 4.11 List of all Current Error Messages

### Function

With this function you can show a popup window in which the TNC shows all current error messages. The TNC shows errors both from the NC as well as those from the machine tool builder.

### Show error list

You can call the list as soon as at least one error message is present:



- ▶ To display the list, press the ERR key.
- ▶ You can select one of the current error messages with the arrow keys.
- ▶ With the CE key or the DEL key you can delete the error message from the popup window momentarily selected. When you delete the last error message, the popup window closes as well.
- ▶ To close the popup window, press the ERR key again. Current error messages are retained.



Parallel to the error list you can also view the respective help text in a separate window: Press the HELP key.



Window contents


Column	Meaning
Number	Error number (–1: no error number defined), issued by HEIDENHAIN or your machine tool builder
Class	<p>Error class. Defines how the TNC processes this error.</p> <ul style="list-style-type: none"><li>■ <b>ERROR</b> Program run is interrupted by the TNC (INTERNAL STOP)</li><li>■ <b>FEED HOLD</b> The feed-rate release is deleted</li><li>■ <b>PGM HOLD</b> The program run is interrupted (the control-in-operation symbol blinks)</li><li>■ <b>PGM ABORT</b> The program run is interrupted (INTERNAL STOP)</li><li>■ <b>EMERG. STOP</b> EMERGENCY STOP is set off</li><li>■ <b>RESET</b> TNC executes a system restart</li><li>■ <b>WARNING</b> Warning message, the program run resumes.</li><li>■ <b>INFO</b> Info message, the program run resumes.</li></ul>
Group	<p>Group. Specifies from which section of the operating system software the error message was generated:</p> <ul style="list-style-type: none"><li>■ <b>OPERATING</b></li><li>■ <b>PROGRAMMING</b></li><li>■ <b>PLC</b></li><li>■ <b>GENERAL</b></li></ul>
Error message	Respective error text displayed by the TNC





# 4.12 Pallet Management

## Function



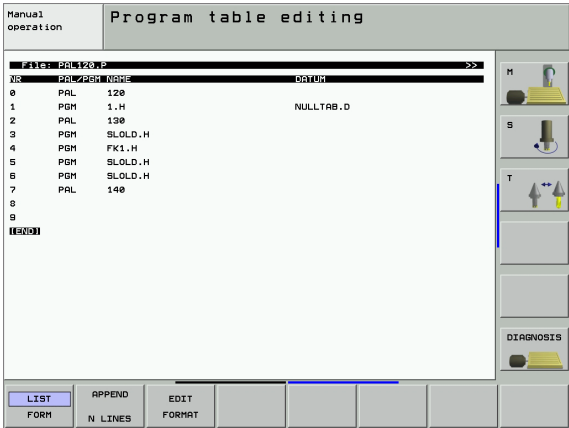
Pallet table management is a machine-dependent function. The standard functional range will be described below. Refer to your machine manual for more information.

Pallet tables are used for machining centers with pallet changers: The pallet table calls the part programs that are required for the different pallets, and activates datum shifts or datum tables.

You can also use pallet tables to run in succession several programs that have different datums.

Pallet tables contain the following information:

- **PAL/PGM** (entry obligatory):  
Identification for pallet or NC program (select with ENT or NO ENT)
- **NAME** (entry obligatory):  
Pallet or program name. The machine tool builder determines the pallet name (see Machine Manual). The program name must be stored in the same directory as the pallet table. Otherwise you must enter the full path name for the program.
- **PRESET** (entry optional):  
Preset number from the preset table. The preset number defined here is interpreted by the TNC either as a pallet datum **PAL** in the **PAL/PGM** column or as a workpiece datum (**PGM** entry in the **PAL/PGM**) line.
- **DATUM** (entry optional):  
Name of the datum table. The datum table must be stored in the same directory as the pallet table. Otherwise you must enter the full path name for the datum table. Datums from the datum table can be activated in the NC program with Cycle 7 **DATUM SHIFT**.



- **X, Y, Z** (entry optional, other axes also possible):  
For pallet names, the programmed coordinates are referenced to the machine datum. For NC programs, the programmed coordinates are referenced to the pallet datum. These entries overwrite the datum that you last set in the Manual mode of operation. With the miscellaneous function M104 you can reactivate the datum that was last set. With the actual-position-capture key, the TNC opens a window that enables you to have the TNC enter various points as datums (see table below):

Position	Meaning
Actual values	Enter the coordinates of the current tool position referenced to the active coordinate system.
Reference values	Enter the coordinates of the current tool position referenced to the machine datum.
<b>ACTUAL</b> measured values	Enter the coordinates referenced to the active coordinate system of the datum last probed in the Manual operating mode.
<b>REF</b> measured values	Enter the coordinates referenced to the machine datum of the datum last probed in the Manual operating mode.





With the arrow keys and ENT, select the position that you wish to confirm. Then press the ALL VALUES soft key so that the TNC saves the respective coordinates of all active axes in the pallet table. With the PRESENT VALUE soft key, the TNC saves the coordinates of the axis on which the highlight in the pallet table is presently located.



If you have not defined a pallet before an NC program, the programmed coordinates are then referenced to the machine datum. If you do not define an entry, the datum that was set manually remains active.

Editing function	Soft key
Select beginning of table	
Select end of table	
Select previous page in table	
Select next page in table	
Insert as last line in the table	
Delete the last line in the table	



Editing function	Soft key
Go to beginning of next line	
Add the entered number of lines at the end of the table	
Copy the highlighted field (2nd soft-key row)	
Insert the copied field (2nd soft-key row)	

## Selecting a pallet table

- ▶ Call the file manager in the Programming and Editing or Program Run mode: Press the PGM MGT key.
- ▶ To display all type .P files, press the soft keys SELECT TYPE and SHOW .P.
- ▶ Select a pallet table with the arrow keys, or enter a new file name to create a new table.
- ▶ Confirm your entry with the ENT key.

## Leaving the pallet file

- ▶ To call the file manager, press the PGM MGT soft key.
- ▶ To select a different type of file, press the SELECT TYPE soft key and the soft key for the desired file type, for example SHOW.H.
- ▶ Select the desired file.



## Executing the pallet file



Programs executed over the pallet file must not contain M30 (M02).

MP7683 defines whether the pallet table is to be executed blockwise or continuously .

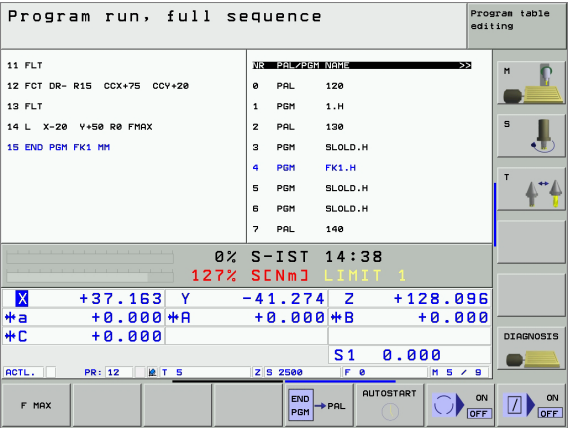
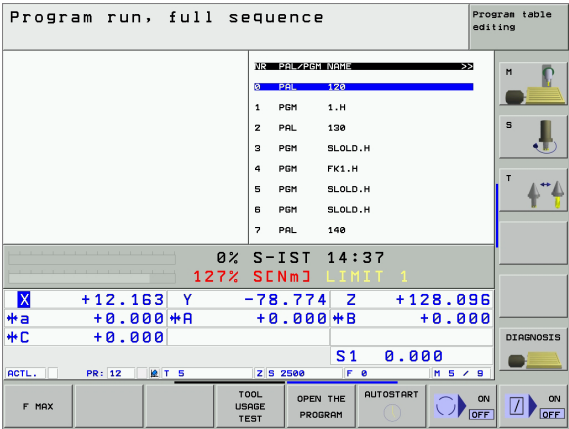
Provided that machine parameter 7246 is set so that the tool usage test is active, you can monitor the tool service life for all tools used in a pallet (see "Tool usage test" on page 590).

- ▶ Select the file manager in the Program Run, Full Sequence or Program Run, Single Block operating modes: Press the PGM MGT key.
- ▶ To display all type .P files, press the soft keys SELECT TYPE and SHOW .P.
- ▶ Select the pallet table with the arrow keys and confirm with ENT.
- ▶ To execute the pallet table: Press the NC Start button. The TNC executes the pallets as set in MP7683.

### Screen layout for executing pallet tables

You can have the TNC display the program contents and pallet file contents on the screen together by selecting the screen layout PGM + PALLET. During execution, the TNC then shows program blocks to the left and the pallet to the right. To check the program contents before execution, proceed as follows:

- ▶ Select a pallet table.
- ▶ With the arrow keys, choose the program you would like to check.
- ▶ Press the OPEN PGM soft key: The TNC displays the selected program on the screen. You can now page through the program with the arrow keys.
- ▶ To return to the pallet table, press the END PGM soft key.



## 4.13 Pallet Operation with Tool-Oriented Machining

### Function



Pallet management in combination with tool-oriented machining is a machine-dependent function. The standard functional range will be described below. Refer to your machine manual for more information.

Pallet tables are used for machining centers with pallet changers: The pallet table calls the part programs that are required for the different pallets, and activates datum shifts or datum tables.

You can also use pallet tables to run in succession several programs that have different datums.

Pallet tables contain the following information:

- **PAL/PGM** (entry obligatory):  
The entry **PAL** identifies the pallet, **FIX** marks the fixture level and **PGM** is used to enter the workpiece.
- **W-STATE:**  
Current machining status. The machining status is used to determine the current stage of machining. Enter **BLANK** for an unmachined (raw) workpiece. During machining, the TNC changes this entry to **INCOMPLETE**, and after machining has finished, to **ENDED**. The entry **EMPTY** is used to identify a space at which no workpiece is to be clamped or where no machining is to take place.
- **METHOD** (entry obligatory):  
Entry that determines the method of program optimization. Machining is workpiece-oriented if **WPO** is entered. Machining of the piece is tool-oriented if **TO** is entered. In order to include subsequent workpieces in the tool-oriented machining, you must enter **CTO** (continued tool oriented). Tool-oriented machining is also possible with pallet fixtures, but not for multiple pallets.
- **NAME** (entry obligatory):  
Pallet or program name. The machine tool builder determines the pallet name (see Machine Manual). Programs must be stored in the same directory as the pallet table. Otherwise you must enter the full path and name for the program.
- **PRESET** (entry optional):  
Preset number from the preset table. The preset number defined here is interpreted by the TNC either as a pallet datum **PAL** in the **PAL/PGM** column or as a workpiece datum (**PGM** entry in the **PAL/PGM**) line.
- **DATUM** (entry optional):  
Name of the datum table. The datum table must be stored in the same directory as the pallet table. Otherwise you must enter the full path name for the datum table. Datums from the datum table can be activated in the NC program with Cycle 7 **DATUM SHIFT**.

Program run full sequence

Program table editing  
Pallet=PAL / Program=PGM

NO	PAL/PGM	W-STATE	METHOD	NAME
0	FIX			PAL4-208-4
1	FIX			
2	PGM	BLANK	WPO	TNC:\DUMPPGM\FK1.H
3	PGM	BLANK	WPO	TNC:\DUMPPGM\FK1.H
4	PGM	BLANK	WPO	TNC:\DUMPPGM\FK1.H
5	PGM	BLANK	WPO	TNC:\DUMPPGM\FK1.H
6	FIX			
7	PGM	BLANK	CTO	SLOLD.H
8	FIX			
9	PGM	BLANK	WPO	SLOLD.H
10	PGM	BLANK	TO	SLOLD.H
11	FIX			
12	PGM	BLANK	CTO	SLOLD.H
13	PGM	BLANK	TO	SLOLD.H
14	PGM	BLANK	CTO	SLOLD.H
15	PGM	BLANK	CTO	SLOLD.H
16	PGM	BLANK	WPO	SLOLD.H
17	PGM	BLANK	TO	SLOLD.H
18	PAL			PAL4-208-11
19	PGM	BLANK	TO	TNC:\DUMPPGM\FK1.H

BEGIN END PAGE PAGE INSERT LINE DELETE LINE NEXT LINE



■ **X, Y, Z** (entry optional, other axes also possible):  
For pallets and fixtures, the programmed coordinates are referenced to the machine datum. For NC programs, the programmed coordinates are referenced to the pallet or fixture datum. These entries overwrite the datum that you last set in the Manual mode of operation. With the miscellaneous function M104 you can reactivate the datum that was last set. With the actual-position-capture key, the TNC opens a window that enables you to have the TNC enter various points as datums (see table below):

Position	Meaning
Actual values	Enter the coordinates of the current tool position referenced to the active coordinate system.
Reference values	Enter the coordinates of the current tool position referenced to the machine datum.
<b>ACTUAL</b> measured values	Enter the coordinates referenced to the active coordinate system of the datum last probed in the Manual operating mode.
<b>REF</b> measured values	Enter the coordinates referenced to the machine datum of the datum last probed in the Manual operating mode.










With the arrow keys and ENT, select the position that you wish to confirm. Then press the ALL VALUES soft key so that the TNC saves the respective coordinates of all active axes in the pallet table. With the PRESENT VALUE soft key, the TNC saves the coordinates of the axis on which the highlight in the pallet table is presently located.








If you have not defined a pallet before an NC program, the programmed coordinates are then referenced to the machine datum. If you do not define an entry, the datum that was set manually remains active.






















- **SP-X, SP-Y, SP-Z** (entry optional, other axes also possible):  
Safety positions can be entered for the axes. These positions can be read with SYSREAD FN18 ID510 NR 6 from NC macros. SYSREAD FN18 ID510 NR 5 can be used to determine if a value was programmed in the column. The positions entered are only approached if these values are read and correspondingly programmed in the NC macros.
- **CTID** (entered by the TNC):  
The context ID number is assigned by the TNC and contains instructions about the machining progress. Machining cannot be resumed if the entry is deleted or changed.




Editing function in table mode	Soft key
Select beginning of table	
Select end of table	
Select previous page in table	
Select next page in table	
Insert as last line in the table	
Delete the last line in the table	
Go to beginning of next line	
Add the entered number of lines at the end of the table	
Edit the table format	

Editing function in entry-form mode	Soft key
Select previous pallet	
Select next pallet	
Select previous fixture	
Select next fixture	
Select previous workpiece	



Editing function in entry-form mode	Soft key
Select next workpiece	
Switch to pallet plane	
Switch to fixture plane	
Switch to workpiece plane	
Select standard pallet view	
Select detailed pallet view	
Select standard fixture view	
Select detailed fixture view	
Select standard workpiece view	
Select detailed workpiece view	
Insert pallet	
Insert fixture	
Insert workpiece	
Delete pallet	
Delete fixture	
Delete workpiece	
Delete clipboard contents	
Tool-optimized machining	
Workpiece-optimized machining	



Editing function in entry-form mode	Soft key
Connect or separate the types of machining	
Mark plane as being empty	
Mark plane as being unmachined	

## Selecting a pallet file

- ▶ Call the file manager in the Programming and Editing or Program Run mode: Press the PGM MGT key.
- ▶ To display all type .P files, press the soft keys SELECT TYPE and SHOW .P.
- ▶ Select a pallet table with the arrow keys, or enter a new file name to create a new table.
- ▶ Confirm your entry with the ENT key.



Setting up the pallet file with the entry form

Pallet operation with tool- or workpiece-oriented machining is divided into three levels:

- Pallet level **PAL**
- Fixture level **FIX**
- Workpiece level **PGM**

You can switch to a detail view in each level. Set the machining method and the statuses for the pallet, fixture and workpiece in the standard view. If you are editing an existing pallet file, the updated entries are displayed. Use the detail view for setting up the pallet file.

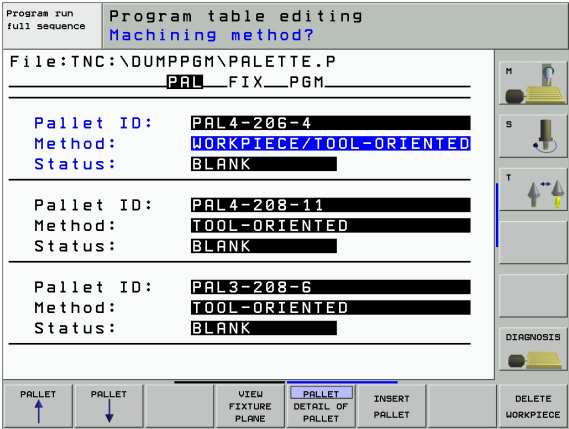


Set up the pallet file according to the machine configuration. If you only have one fixture with multiple workpieces, then defining one fixture **FIX** with the workpieces **PGM** is sufficient. However, if one pallet contains several fixtures, or if a fixture is machined from more than one side, you must define the pallet **PAL** with the corresponding fixture levels **FIX**.

Use the screen layout button to switch between table view and form view.

Graphic support for form entry is not yet available.

The various levels of the entry form can be reached with the appropriate soft keys. The current level is highlighted in the status line of the entry form. When you switch to table view with the screen layout button, the cursor is placed in the same level as it was in the form view.



### Setting up the pallet plane

- **Pallet ID:** The pallet name is displayed
- **Method:** You can choose between the WORKPIECE ORIENTED and TOOL ORIENTED machining methods. The selected method is assumed for the workpiece level and overwrites any existing entries. In tabular view, WORKPIECE ORIENTED appears as **WPO**, and TOOL ORIENTED appears as **TO**.



The TO-WP-ORIENTED entry cannot be made via soft key. It only appears when different machining methods were chosen for the workpieces in the workpiece or machining level.

If the machining method was determined in the fixture level, the entries are transferred to the workpiece level, where they overwrite any existing entries.

- **Status:** The soft key **BLANK** identifies the pallet and the corresponding fixtures and workpieces as not yet having been machined, and enters **BLANK** in the Status field. Use the soft key **EMPTY POSITION** if you want to skip the pallet during machining. **EMPTY** appears in the Status field.

### Setting up details in the pallet level

- **Pallet ID:** Enter the pallet name.
- **Datum:** Enter the pallet datum.
- **Datum table:** Enter the name and path of the datum table of the workpiece. The data is transferred to the fixture and workpiece levels.
- **Safe height:** (optional): Safe position for the individual axes referenced to the pallet. The positions entered are only approached if these values were read and correspondingly programmed in the NC macros.

Program run full sequence | Program table editing  
Machining method?

File: TNC:\DUMPPGM\PALETTE.P  
PAL FIX PGM

Pallet ID: PAL4-206-4  
Method: WORKPIECE/TOOL-ORIENTED  
Status: BLANK

Pallet ID: PAL4-208-11  
Method: TOOL-ORIENTED  
Status: BLANK

Pallet ID: PAL3-208-6  
Method: TOOL-ORIENTED  
Status: BLANK

PALLET | PALLET | VIEW FIXTURE PLANE | PALLET DETAIL OF PALLET | INSERT PALLET | DELETE WORKPIECE

Program run full sequence | Program table editing  
Pallet / NC program?

File: TNC:\DUMPPGM\PALETTE.P  
PAL FIX PGM

Pallet ID: PAL4-206-4  
Datum: X120.238 Y202.94 Z20.326

Datum table: TNC:\RK\TEST\TABLE01.D

Cl. height: X Y Z100

PALLET | PALLET | VIEW FIXTURE PLANE | PALLET DETAIL OF PALLET | INSERT PALLET | DELETE WORKPIECE



Setting up the fixture level

- **Fixture:** The number of the fixture is displayed. The number of fixtures within this level is shown after the slash.
- **Method:** You can choose between the WORKPIECE ORIENTED and TOOL ORIENTED machining methods. The selected method is assumed for the workpiece level and overwrites any existing entries. In tabular view, WORKPIECE ORIENTED appears as **WPO**, and TOOL ORIENTED appears as **TO**. Use the **CONNECT/SEPARATE** soft key to mark fixtures that are to be included for calculating the machining process for tool-oriented machining. Connected fixtures are marked with a dashed line, whereas separated fixtures are connected with a solid line. Connected workpieces are marked in tabular view with the entry **CTO** in the METHOD column.



The TO-WP-ORIENTED entry cannot be made via soft key. It only appears when different machining methods were chosen for the workpieces in the workpiece level.

If the machining method was determined in the fixture level, the entries are transferred to the workpiece level, where they overwrite any existing entries.

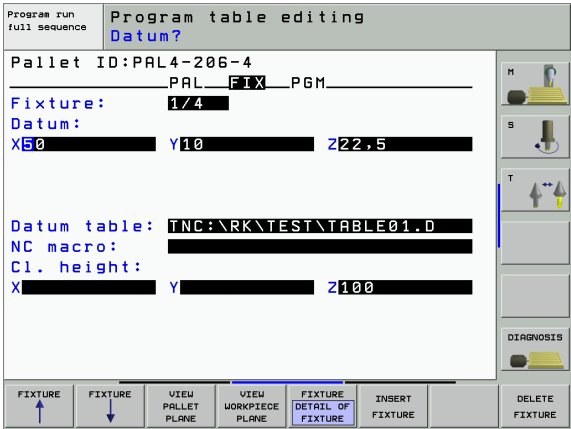
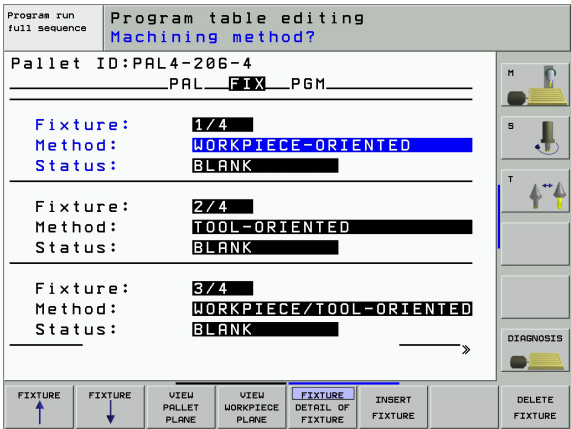
- **Status:** The soft key **BLANK** identifies the fixture and the corresponding workpieces as not yet having been machined, and enters **BLANK** in the Status field. Use the soft key **EMPTY POSITION** if you want to skip the fixture during machining. **EMPTY** appears in the Status field.

Setting up details in the fixture level

- **Fixture:** The number of the fixture is displayed. The number of fixtures within this level is shown after the slash.
- **Datum:** Enter the fixture datum.
- **Datum table:** Enter the name and path of the datum table valid for machining the workpiece. The data is transferred to the workpiece level.
- **NC macro:** In tool-oriented machining, the macro TCTOOLMODE is carried out instead of the normal tool-change macro.
- **Safe height:** (optional): Safe position for the individual axes referenced to the fixture.



Safety positions can be entered for the axes. These positions can be read with SYSREAD FN18 ID510 NR 6 from NC macros. SYSREAD FN18 ID510 NR 5 can be used to determine if a value was programmed in the column. The positions entered are only approached if these values are read and correspondingly programmed in the NC macros.



### Setting up the workpiece level

- **Workpiece:** The number of the workpiece is displayed. The number of workpieces within this fixture level is shown after the slash.
- **Method:** You can choose between the WORKPIECE ORIENTED and TOOL ORIENTED machining methods. In tabular view, WORKPIECE ORIENTED appears as **WPO**, and TOOL ORIENTED appears as **T0**.  
Use the **CONNECT/SEPARATE** soft key to mark workpieces that are to be included for calculating the machining process for tool-oriented machining. Connected workpieces are marked with a dashed line, whereas separated workpieces are connected with a solid line. Connected workpieces are marked in tabular view with the entry **CT0** in the METHOD column.
- **Status:** The soft key **BLANK** identifies the workpiece as not yet having been machined, and enters BLANK in the Status field. Use the soft key **EMPTY POSITION** if you want to skip the workpiece during machining. EMPTY appears in the Status field.



Enter the method and status in the pallet or fixture level. Then the entry will be assumed for all corresponding workpieces.

For several workpiece variants within one level, the workpieces of one variant should be entered together. This way, the workpieces of each variant can be marked with the CONNECT/SEPARATE soft key, and can be machined in groups.

Program run full sequence		Program table editing	
Machining method?			
Pallet ID: PAL4-206-4	Fixture: 1		
PAL FIX PGM			
Workpiece: 1/4	Method: WORKPIECE-ORIENTED		
Status: BLANK			
Workpiece: 2/4	Method: WORKPIECE-ORIENTED		
Status: BLANK			
Workpiece: 3/4	Method: WORKPIECE-ORIENTED		
Status: BLANK			
		DIAGNOSIS	
WORKPIECE	WORKPIECE	VIEW FIXTURE PLANE	WORKPIECE DETAIL OF WORKPIECE
↑	↓		INSERT WORKPIECE DELETE WORKPIECE

### Setting up details in the workpiece level

- **Workpiece:** The number of the workpiece is displayed. The number of workpieces within this fixture or pallet level is shown after the slash.
- **Datum:** Enter the workpiece datum.
- **Datum table:** Enter the name and path of the datum table valid for machining the workpiece. If you use the same datum table for all workpieces, enter the name and path in the pallet or fixture levels. The data is automatically transferred to the workpiece level.
- **NC program:** Enter the path of the NC program that is necessary for machining the workpiece.
- **Safe height:** (optional): Safe position for the individual axes referenced to the workpiece. The positions entered are only approached if these values were read and correspondingly programmed in the NC macros.

Program run full sequence		Program table editing	
Datum?			
Pallet ID: PAL4-206-4	Fixture: 1		
PAL FIX PGM			
Workpiece: 1/4	Datum: X84.502 Y20.957 Z36.5362		
Datum table: TNC:\RK\TEST\TABLE01.D	NC program: TNC:\DUMPPGM\FK1.H		
Cl. height: X Y Z100			
		DIAGNOSIS	
WORKPIECE	WORKPIECE	VIEW FIXTURE PLANE	WORKPIECE DETAIL OF WORKPIECE
↑	↓		INSERT WORKPIECE DELETE WORKPIECE



## Sequence of tool-oriented machining



The TNC only carries out tool-oriented machining if the TOOL ORIENTED method was selected, and TO or CTO is entered in the table.

- The entry TO or CTO in the Method field tells the TNC that the oriented machining is valid beyond these lines.
- The pallet management starts the NC program given in the line with the entry TO.
- The first workpiece is machined until the next tool call is pending. Departure from the workpiece is coordinated by a special tool-change macro.
- The entry in the column W-STATE is changed from BLANK to INCOMPLETE, and the TNC enters a hexadecimal value in the field CTID.



The value entered in the field CTID is a unique identifier of the machining progress for the TNC. If this value is deleted or changed, machining cannot be continued, nor is mid-program startup or resumption of machining possible.

- All lines in the pallet file that contain the entry CTO in the Method field are machined in the same manner as the first workpiece. Workpieces in several fixtures can be machined.
- The TNC uses the next tool for the following machining steps again from the line with the entry TO if one of the following situations applies:
  - If the entry PAL is in the PAL/PGM field in the next line.
  - If the entry TO or WPO is in the Method field in the next line.
  - If in the lines already machined there are entries under Method which do not have the status EMPTY or ENDED.
- The NC program is continued at the stored location based on the value entered in the CTID field. Usually the tool is changed for the first piece, but the TNC suppresses the tool change for the following workpieces.
- The entry in the CTID field is updated after every machining step. If an END PGM or M02 is executed in an NC program, then an existing entry is deleted and ENDED is entered in the Machining Status field.

- If the entries TO or CTO for all workpieces within a group contain the status ENDED, the next lines in the pallet file are run.



In mid-program startup, only one tool-oriented machining operation is possible. Subsequent pieces are machined according to the method entered.

The value entered in the CTID field is stored for a maximum of 2 weeks. Within this time the machining process can be continued at the stored location. After this time the value is deleted, in order to prevent large amounts of unnecessary data on the hard disk.

The operating mode can be changed after executing a group of entries with TO or CTO.

The following functions are not permitted:

- Switching the traverse range
- PLC datum shift
- M118

## Leaving the pallet file

- ▶ To call the file manager, press the PGM MGT soft key.
- ▶ To select a different type of file, press the SELECT TYPE soft key and the soft key for the desired file type, for example SHOW.H.
- ▶ Select the desired file.

## Executing the pallet file



In MP7683, set whether the pallet table is to be executed blockwise or continuously (see "General User Parameters" on page 606).

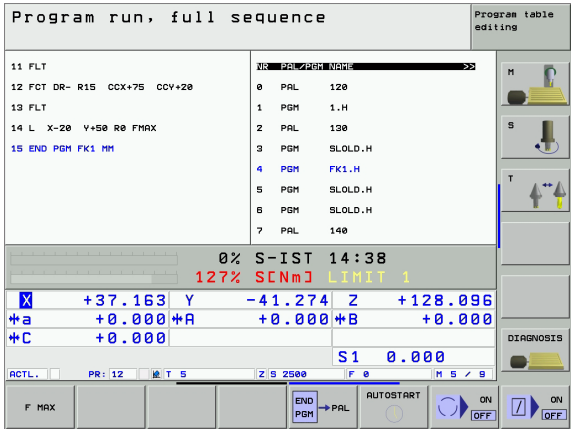
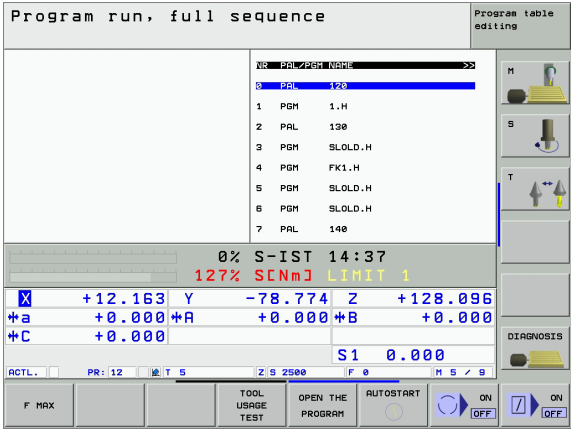
- ▶ Select the file manager in the Program Run, Full Sequence or Program Run, Single Block operating modes: Press the PGM MGT key.
- ▶ To display all type .P files, press the soft keys SELECT TYPE and SHOW .P.
- ▶ Select the pallet table with the arrow keys and confirm with ENT.
- ▶ To execute the pallet table: Press the NC Start button. The TNC executes the pallets as set in MP7683.



Screen layout for executing pallet tables

You can have the TNC display the program contents and pallet file contents on the screen together by selecting the screen layout PGM + PALLET. During execution, the TNC then shows program blocks to the left and the pallet to the right. To check the program contents before execution, proceed as follows:

- ▶ Select a pallet table.
- ▶ With the arrow keys, choose the program you would like to check.
- ▶ Press the OPEN PGM soft key: The TNC displays the selected program on the screen. You can now page through the program with the arrow keys.
- ▶ To return to the pallet table, press the END PGM soft key.







# 5

**Programming: Tools**



## 5.1 Entering Tool-Related Data

### Feed rate F

The feed rate **F** is the speed (in millimeters per minute or inches per minute) at which the tool center moves. The maximum feed rates can be different for each machine axis, and are set in machine parameters.

#### Input

You can enter the feed rate in the **TOOL CALL** block and in every positioning block (see “Creating the program blocks with the path function keys” on page 181).

#### Rapid traverse

If you wish to program rapid traverse, enter **F MAX**. To enter **F MAX**, press the ENT key or the F MAX soft key when the dialog question **FEED RATE F = ?** appears on the TNC screen.



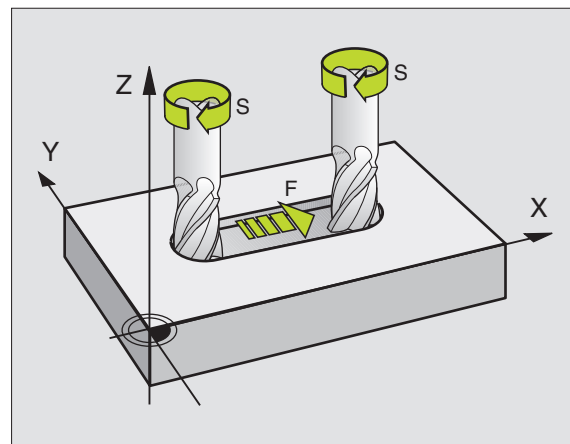
To move your machine at rapid traverse, you can also program the corresponding numerical value, e.g. **F30000**. Unlike **FMAX**, this rapid traverse remains in effect not only in the individual block but in all blocks until you program a new feed rate.

#### Duration of effect

A feed rate entered as a numerical value remains in effect until a block with a different feed rate is reached. **F MAX** is only effective in the block in which it is programmed. After the block with **F MAX** 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 program run with the feed-rate override knob F.



## Spindle speed S

The spindle speed S is entered in revolutions per minute (rpm) in a **TOOL CALL** block.

### Programmed change

In the part program, you can change the spindle speed in a TOOL CALL block by entering the spindle speed only:



- ▶ To program a tool call, press the TOOL CALL key.
- ▶ Ignore the dialog question for **Tool number ?** with the NO ENT key.
- ▶ Ignore the dialog question for **Working spindle axis X/Y/Z ?** with the NO ENT key.
- ▶ Enter the new spindle speed for the dialog question **Spindle speed S= ?**, and confirm with END.

### Changing during program run

You can adjust the spindle speed during program run with the spindle-speed override knob S.



## 5.2 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 TNC 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.

Tool data can be entered either directly in the part program with TOOL DEF or separately in a tool table. In a tool table, you can also enter additional data for the specific tool. The TNC will consider all the data entered for the tool when executing the part program.

### Tool numbers and tool names

Each tool is identified by a number between 0 and 254. If you are working with tool tables, you can use higher numbers and you can also enter a tool name for each tool. Tool names can have up to 32 characters.

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

There are two ways to determine the tool length  $L$ :

#### Determining the difference between the length of the tool and that of a zero tool $L_0$

For the algebraic sign:

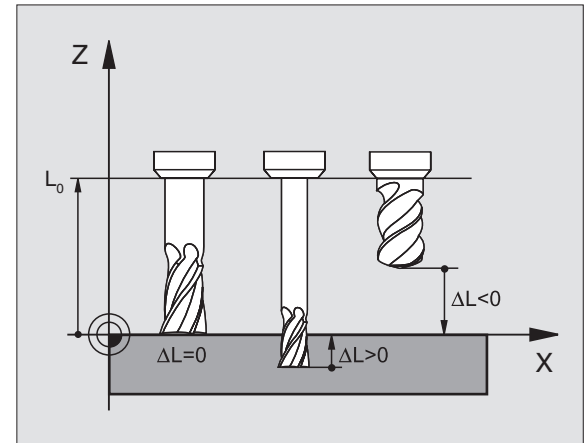
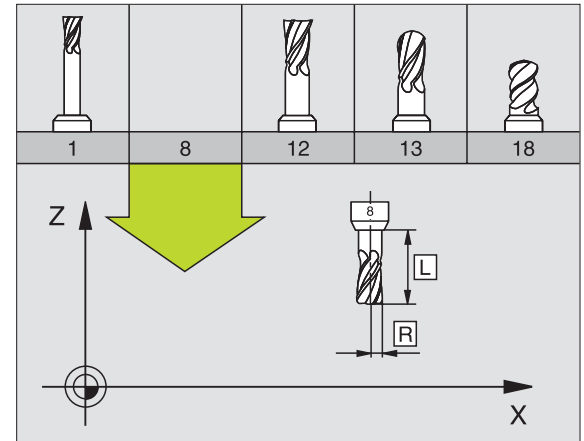
- $L > L_0$ : The tool is longer than the zero tool
- $L < L_0$ : The tool is shorter than the zero tool

To determine the length:

- Move the zero tool to the reference position in the tool axis (e.g. workpiece surface with  $Z=0$ ).
- Set the datum in the tool axis to 0 (datum setting).
- Insert the desired tool.
- Move the tool to the same reference position as the zero tool.
- The TNC displays the difference between the current tool and the zero tool.
- Enter the value in the TOOL DEF block or in the tool table by pressing the actual-position-capture key.

#### Determining the length $L$ with a tool presetter

Enter the determined value directly in the TOOL DEF tool definition block or in the tool table without further calculations.



## 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 describes a tool oversize (**DL**, **DR**, **DR2**>0). If you are programming the machining data with an allowance, enter the oversize value in the **TOOL CALL** block of the part program.

A negative delta value describes a tool undersize (**DL**, **DR**, **DR2**<0). An undersize is entered in the tool table for wear.

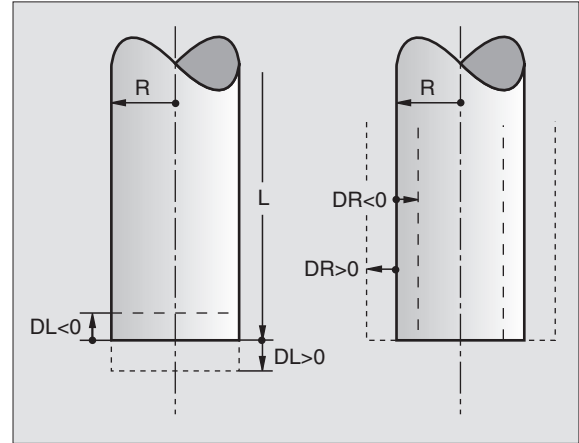
Delta values are usually entered as numerical values. In a **TOOL CALL** block, you can also assign the values to Q parameters.

Input range: You can enter a delta value with up to  $\pm 99.999$  mm.



Delta values from the tool table influence the graphical representation of the **tool**. The representation of the **workpiece** remains the same in the simulation.

Delta values from the **TOOL CALL** block change the represented size of the **workpiece** during the simulation. The simulated **tool size** remains the same.



## Entering tool data into the program

The number, length and radius of a specific tool is defined in the **TOOL DEF** block of the part program.

► To select tool definition, press the **TOOL DEF** key.



- **Tool number:** Each tool is uniquely identified by its tool number.
- **Tool length:** Compensation value for the tool length
- **Tool radius** Compensation value for the tool radius



In the programming dialog, you can transfer the value for tool length and tool radius directly into the input line by pressing the desired axis soft key.

### Example

```
4 TOOL DEF 5 L+10 R+5
```

Entering tool data in tables

You can define and store up to 30000 tools and their tool data in a tool table. In Machine Parameter 7260, you can define how many tools are to be stored by the TNC when a new table is set up. Also see the Editing Functions later in this Chapter. In order to be able to assign various compensation data to a tool (indexing the tool number), MP7262 must not be equal to 0.

You must use tool tables if

- you wish to use indexed tools such as stepped drills with more than one length compensation value (page 151),
- your machine tool has an automatic tool changer,
- you want to measure tools automatically with the TT 130 touch probe (see the Touch Probe Cycles User’s Manual, Chapter 4),
- you want to rough-mill the contour with Cycle 22 (see “ROUGH-OUT (Cycle 22)” on page 377),
- you want to rough-mill the contour with Cycle 22 (see “RECTANGULAR POCKET (Cycle 251)” on page 325)
- you want to work with automatic cutting data calculations.

Tool table: Standard tool data

Abbr.	Input	Dialog
T	Number by which the tool is called in the program (e.g. 5, indexed: 5.2)	–
NAME	Name by which the tool is called in the program	Tool name?
L	Value for tool length compensation L	Tool length?
R	Compensation value for the tool radius R	Tool radius R?
R2	Tool radius R2 for toroid cutters (only for 3-D radius compensation or graphical representation of a machining operation with spherical or toroid cutters)	Tool radius R2?
DL	Delta value for tool length L	Tool length oversize?
DR	Delta value for tool radius R	Tool radius oversize?
DR2	Delta value for tool radius R2	Tool radius oversize R2?
LCUTS	Tooth length of the tool for Cycle 22	Tooth length in the tool axis?
ANGLE	Maximum plunge angle of the tool for reciprocating plunge-cut in Cycles 22 and 208	Maximum plunge angle?
TL	Set tool lock (TL: Tool Locked)	Tool locked? Yes = ENT / No = NO ENT
RT	Number of a replacement tool, if available (see also TIME2)	Replacement tool?
TIME1	Maximum tool life in minutes. This function can vary depending on the individual machine tool. Your machine manual provides more information on TIME1.	Maximum tool age?



Abbr.	Input	Dialog
<b>TIME2</b>	Maximum tool life in minutes during <b>TOOL CALL</b> : If the current tool age exceeds this value, the TNC changes the tool during the next <b>TOOL CALL</b> (see also <b>CUR.TIME</b> ).	<b>Maximum tool age for TOOL CALL?</b>
<b>CUR.TIME</b>	Current age of the tool in minutes: The TNC automatically counts the current tool life ( <b>CUR.TIME</b> ). A starting value can be entered for used tools.	<b>Current tool life?</b>
<b>DOC</b>	Comment on tool (up to 16 characters)	<b>Tool description?</b>
<b>PLC</b>	Information on this tool that is to be sent to the PLC	<b>PLC status?</b>
<b>PLC VAL</b>	Value of this tool that is to be sent to the PLC	<b>PLC value?</b>
<b>PTYP</b>	Tool type for evaluation in the pocket table	<b>Tool type for pocket table?</b>
<b>NMAX</b>	Limits the spindle speed for this tool. The programmed value is monitored (error message) as well as a shaft speed increase via the potentiometer. Function inactive: Enter –	<b>Maximum speed [rpm]?</b>
<b>LIFTOFF</b>	Definition of whether the TNC should retract the tool in the direction of the positive tool axis at an NC stop in order to avoid leaving dwell marks on the contour. If <b>Y</b> is defined, the TNC retracts the tool from the contour by 0.1 mm, provided that this function was activated in the NC program with M148 (see “Automatically retract tool from the contour at an NC stop: M148” on page 248).	<b>Retract tool Y/N ?</b>
<b>P1 ... P3</b>	Machine-dependent function: Transfer of a value to the PLC. Please refer to your machine manual.	<b>Value?</b>
<b>KINEMATIC</b>	Machine-dependent function: Kinematics description for vertical milling heads, which the TNC adds to the active machine kinematics.	<b>Additional kinematic description?</b>
<b>T-ANGLE</b>	Point angle of the tool. Is used by the Centering cycle (Cycle 240) in order to calculate the centering depth from the diameter entry.	<b>Point angle (Type DRILL+CSINK)?</b>
<b>PITCH</b>	Thread pitch of the tool (currently still without function)	<b>Thread pitch (only type TAP)?</b>



**Tool table: Tool data required for automatic tool measurement**



For a description of the cycles governing automatic tool measurement, see the Touch Probe Cycles Manual, Chapter 4.

Abbr.	Input	Dialog
CUT	Number of teeth (20 teeth maximum)	Number of teeth?
LTOL	Permissible deviation from tool length L for wear detection. If the entered value is exceeded, the TNC locks the tool (statusL). Input range: 0 to 0.9999 mm	Wear tolerance: length?
RTOL	Permissible deviation from tool radius R for wear detection. If the entered value is exceeded, the TNC locks the tool (statusL). Input range: 0 to 0.9999 mm	Wear tolerance: radius?
DIRECT.	Cutting direction of the tool for measuring the tool during rotation	Cutting direction (M3 = -)?
TT:R-OFFS	For tool length measurement: Tool offset between stylus center and tool center. Preset value: Tool radius R (NO ENT means R).	Tool offset: radius?
TT:L-OFFS	Tool radius measurement: Tool offset in addition to MP6530 between upper surface of stylus and lower surface of tool. Default: 0	Tool offset: length?
LBREAK	Permissible deviation from tool length L for breakage detection. If the entered value is exceeded, the TNC locks the tool (statusL). Input range: 0 to 0.9999 mm	Breakage tolerance: length?
RBREAK	Permissible deviation from tool radius R for breakage detection. If the entered value is exceeded, the TNC locks the tool (status L). Input range: 0 to 0.9999 mm	Breakage tolerance: radius?

**Tool table: Tool data for automatic speed/feed rate calculation.**

Abbr.	Input	Dialog
TYPE	Tool type: Press the SELECT TYPE (3rd soft-key row); the TNC superimposes a window where you can select the type of tool you want. Functions are currently only assigned to the DRILL and MILL tool types.	Tool type?
TMAT	Tool material: Press the SELECT MATERIAL soft key (3rd soft-key row): The TNC superimposes a window where you can select the type of material you want.	Tool material?
CDT	Cutting data table: Press the SELECT CDT soft key (3rd soft-key row): The TNC superimposes a window where you can select a cutting data table.	Name of cutting data table?





**Tool table: Tool data for 3-D touch trigger probe (only when bit 1 is set in MP7411 = 1, also see the Touch Probe Cycles Manual)**

Abbr.	Input	Dialog
CAL-OF1	During calibration, the TNC stores in this column the center misalignment in the reference axis of the 3-D probe, if a tool number is indicated in the calibration menu.	Center misalignmt. in ref. axis?
CAL-OF2	During calibration, the TNC stores in this column the center misalignment in the minor axis of the 3-D probe, if a tool number is indicated in the calibration menu.	Center misalignment minor axis?
CAL-ANG	During calibration, the TNC stores in this column the spindle angle at which the 3-D probe was calibrated, if a tool number is indicated in the calibration menu.	Spindle angle for calibration?



Editing tool tables

The tool table that is active during execution of the part program is designated as TOOL.T. TOOL.T must be saved in the directory TNC:\ and can only be edited in one of the machine operating modes. Other tool tables that are used for archiving or test runs are given different file names with the extension ".T".

To open the tool table TOOL.T:

- ▶ Select any machine operating mode.
  - ▶ To select the tool table, press the TOOL TABLE soft key.
- ▶ Set the EDIT soft key to ON.



To open any other tool table

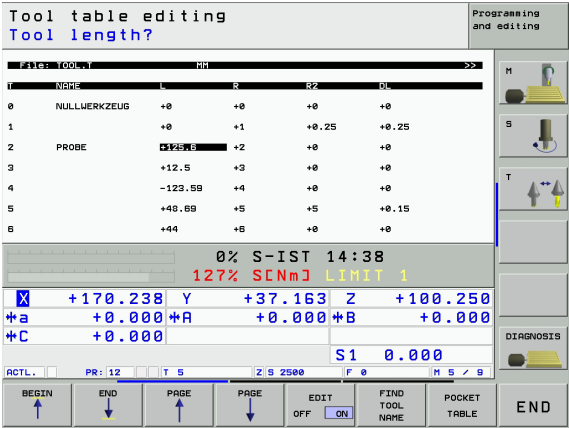
- ▶ Select the Programming and Editing mode of operation.
  - ▶ Call the File Manager.
  - ▶ To select the file type, press the SELECT TYPE soft key.
  - ▶ To show type .T files, press the SHOW .T soft key.
  - ▶ Select a file or enter a new file name. Conclude your entry with the ENT key or the SELECT soft key.












When you have opened the tool table, you can edit the tool data by moving the cursor to the desired position in the table with the arrow keys or the soft keys. You can overwrite the stored values, or enter new values at any position. The available editing functions are illustrated in the table below.

If the TNC cannot show all positions in the tool table in one screen page, the highlight bar at the top of the table will display the symbol ">>" or "<<".

Editing functions for tool tables	Soft key
Select beginning of table	
Select end of table	
Select previous page in table	
Select next page in table	
Look for the tool name in the table	
Show tool information in columns or show all information on one tool on one screen page	




Editing functions for tool tables	Soft key
Move to beginning of line	
Move to end of line	
Copy highlighted field	
Insert copied field	
Add the entered number of lines (tools) at the end of the table.	
Insert a line for the indexed tool number after the active line. The function is only active if you are permitted to store multiple compensation data for a tool (MP7262 not equal to 0). The TNC inserts a copy of the tool data after the last available index and increases the index by 1. Application: e.g. stepped drill with more than one length compensation value.	
Delete current line (tool).	
Display / Do not display pocket numbers.	
Display all tools / only those tools that are stored in the pocket table.	

Leaving the tool table

- Call the file manager and select a file of a different type, such as a part program.

Additional notes on tool tables

MP7266.x defines which data can be entered in the tool table and in which sequence the data is displayed.



You can overwrite individual columns or lines of a tool table with the contents of another file. Prerequisites:

- The target file must exist.
- The file to be copied must contain only the columns (or lines) you want to replace.

To copy individual columns or lines, press the REPLACE FIELDS soft key (see “Copying a single file” on page 92).



Using an external PC to overwrite individual tool data

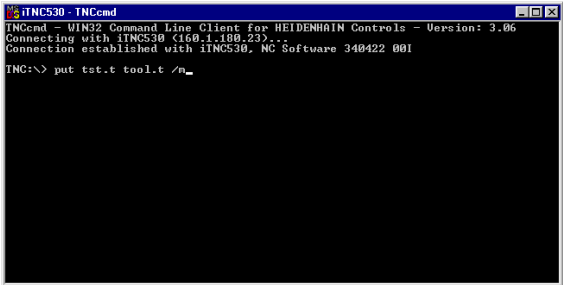
The HEIDENHAIN data transfer software TNCremoNT provides an especially convenient way to use an external PC to overwrite tool data (see “Software for data transfer” on page 579). This applies when you measure tool data on an external tool presetter and then want to transfer the data to the TNC. Follow this procedure:

- ▶ Copy the tool table TOOL.T to the TNC, for example to TST.T
- ▶ Start the data transfer software TNCremoNT on the PC
- ▶ Establish a connection with the TNC
- ▶ Transfer the copied tool table TST.T to the PC
- ▶ Use any text editor to reduce TST.T to the lines and columns to be changed (see figure at upper right). Make sure that the header is not changed and the data is always flush in the column. The tool numbers (column T) need not be consecutive
- ▶ In TNCremoNT, select the menu item <Extras> and <TNCcmd>: This starts TNCcmd
- ▶ To transfer TST.T to the TNC, enter the following command and confirm with the return key (see figure at center right):  
put tst.t tool.t /m



During transfer, only the tool data defined in the subfile (e.g. TST.T) is overwritten. All other tool data of the table TOOL.T remains unchanged.

BEGIN TST .T MM			
T	NAME	L	R
1		+12.5	+9
3		+23.15	+3.5
[END]			



## Pocket table for tool changer



The machine tool builder adapts the functional range of the pocket table to the requirements of your machine. The machine tool manual provides further information.

For automatic tool changing you need the pocket table TOOL\_P.TCH. The TNC can manage several pocket tables with any file names. To activate a specific pocket table for program run you must select it in the file management of a Program Run mode of operation (status M). In order to be able to manage various magazines in a tool-pocket table (indexing the pocket number), Machine Parameters 7261.0 to 7261.3 must not be equal to 0.

### Editing a pocket table in a Program Run operating mode



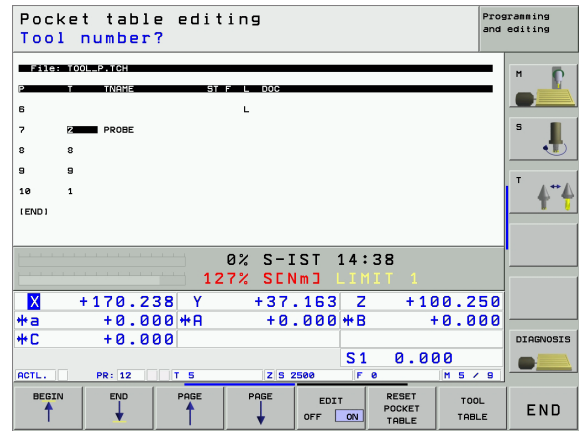
- To select the tool table, press the TOOL TABLE soft key.



- To select the pocket table, press the POCKET TABLE soft key.



- Set the EDIT soft key to ON.










### Selecting a pocket table in the Programming and Editing operating mode



- ▶ Call the File Manager.
- ▶ To select the file type, press the SELECT TYPE soft key.
- ▶ To show files of the type .TCH, press the soft key TCH FILES (second soft-key row).
- ▶ Select a file or enter a new file name. Conclude your entry with the ENT key or the SELECT soft key.

Abbr.	Input	Dialog
P	Pocket number of the tool in the tool magazine	–
T	Tool number	<b>Tool number?</b>
ST	Special tool with a large radius requiring several pockets in the tool magazine. If your special tool takes up pockets in front of and behind its actual pocket, these additional pockets need to be locked in column L (status L).	<b>Special tool?</b>
F	Fixed tool number. The tool is always returned to the same pocket in the tool magazine	<b>Fixed pocket?</b> Yes = ENT / No = NO ENT
L	Locked pocket (see also column ST)	<b>Pocket locked</b> Yes = ENT / No = NO ENT
PLC	Information on this tool pocket that is to be sent to the PLC	<b>PLC status?</b>
TNAME	Display of the tool name from TOOL.T	–
DOC	Display of the comment to the tool from TOOL.T	–
PTYP	Tool type. Function is defined by the machine tool builder. The machine tool documentation provides further information.	<b>Tool type for pocket table?</b>
P1 ... P5	Function is defined by the machine tool builder. The machine tool documentation provides further information.	<b>Value?</b>
RSV	Pocket reservation for box magazines	<b>Pocket reserv.:</b> Yes = ENT / No = NOENT
LOCKED_ABOVE	Box magazine: Lock the pocket above	<b>Lock the pocket above?</b>
LOCKED_BELOW	Box magazine: Lock the pocket below	<b>Lock the pocket below?</b>
LOCKED_LEFT	Box magazine: Lock the pocket at left	<b>Lock the pocket at left?</b>
LOCKED_RIGHT	Box magazine: Lock the pocket at right	<b>Lock the pocket at right?</b>

Editing functions for pocket tables	Soft key
Select beginning of table	
Select end of table	
Select previous page in table	
Select next page in table	
Reset pocket table	
Go to beginning of next line	
Reset tool number column T	



## Calling tool data

A TOOL CALL block in the part program is defined with the following data:

- Select the tool call function with the TOOL CALL key.



- **Tool number:** Enter the number or name of the tool. The tool must already be defined in a **TOOL DEF** block or in the tool table. The TNC automatically places the tool name in quotation marks. The tool name always refers to the entry in the active tool table TOOL.T. If you wish to call a tool with other compensation values, also enter the index you defined in the tool table after the decimal point.
- **Working spindle axis X/Y/Z:** Enter the tool axis.
- **Spindle speed S:** Enter the spindle speed directly or allow the TNC to calculate the spindle speed if you are working with cutting data tables. Press the S CALCULATE AUTOMAT. soft key. The TNC limits the spindle speed to the maximum value set in MP3515.
- **Feed rate F:** Enter the feed rate directly or allow the TNC to calculate the feed rate if you are working with cutting data tables. Press the F CALCULATE AUTOMAT. soft key. The TNC limits the feed rate to the maximum feed rate of the slowest axis (set in MP1010). F is effective until you program a new feed rate in a positioning or TOOL CALL 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.

### Example: 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 is to be programmed with an oversize of 0.2 mm, the tool radius 2 with an oversize of 0.05 mm, and the tool radius with an undersize of 1 mm.

```
20 TOOL CALL 5.2 Z S2500 F350 DL+0.2 DR-1 DR2+0.05
```

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

### Tool preselection with tool tables

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



## Tool change



The tool change function can vary depending on the individual machine tool. The machine tool manual provides further information.

### Tool change position

The tool change position must be approachable without collision. With the miscellaneous functions **M91** and **M92**, you can enter machine-referenced (rather than workpiece-referenced) coordinates for the tool change position. If **TOOL CALL 0** is programmed before the first tool call, the TNC moves the tool spindle in the tool axis to a position that is independent of the tool length.

### Manual tool change

To change the tool manually, stop the spindle and move the tool to the tool change position:

- ▶ Move to the tool change position under program control.
- ▶ Interrupt program run (see “Interrupting machining” on page 562).
- ▶ Change the tool.
- ▶ Resume program run (see “Resuming program run after an interruption” on page 564).



### Automatic tool change

If your machine tool has automatic tool changing capability, the program run is not interrupted. When the TNC reaches a **TOOL CALL**, it replaces the inserted tool by another from the tool magazine.

### Automatic tool change if the tool life expires: M101



The function of **M101** can vary depending on the individual machine tool. The machine tool manual provides further information.

The TNC automatically changes the tool if the tool life **TIME2** expires during program run. To use this miscellaneous function, activate **M101** at the beginning of the program. **M101** is reset with **M102**.

The tool is changed automatically

- after the net NC block after expiration of the tool life, or
- at latest one minute after tool life expires (calculation is for a potentiometer setting of 100%)



If the tool life ends during an active M120 (look ahead), the TNC waits to change the tool until after the block in which you canceled the radius compensation with an R0 block.

The TNC automatically changes the tool even if a fixed cycle is being run.

The TNC does not automatically change the tool as long as a tool change program is running.

### Prerequisites for standard NC blocks with radius compensation R0, RR, RL

The radius of the replacement tool must be the same as that of the original tool. If the radii are not equal, the TNC displays an error message and does not replace the tool.

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

See "Three-Dimensional Tool Compensation (Software Option 2)," page 163. The radius of the replacement tool can differ from the radius of the original tool. The tool radius is not included in program blocks transmitted from CAD systems. You can enter the delta value (**DR**) either in the tool table or in the **TOOL CALL** block.

If **DR** is greater than zero, the TNC displays an error message and does not replace the tool. You can suppress this message with the M function **M107**, and reactivate it with **M108**.

## 5.3 Tool Compensation

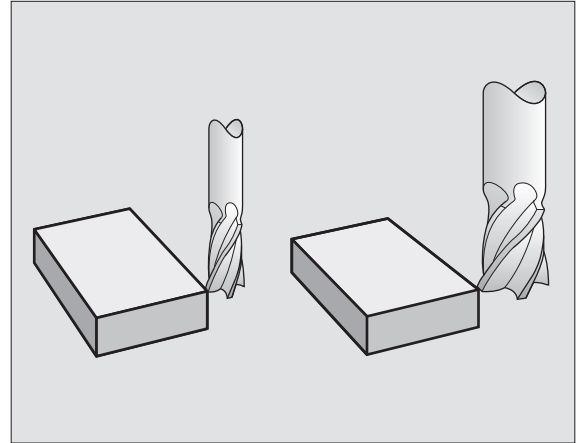
### Introduction

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

If you are writing the part program directly on the TNC, the tool radius compensation is effective only in the working plane. The TNC accounts for the compensation value in up to five axes including the rotary axes.



If a part program generated by a CAD system contains surface-normal vectors, the TNC can perform three-dimensional tool compensation (see "Three-Dimensional Tool Compensation (Software Option 2)" on page 163).



### Tool length compensation

Length compensation becomes effective automatically as soon as a tool is called and the tool axis moves. To cancel length compensation, call a tool with the length  $L=0$ .



If you cancel a positive length compensation with **TOOL CALL 0**, the distance between tool and workpiece will be reduced.

After **TOOL CALL**, the path of the tool in the tool axis, as entered in the part program, is adjusted by the difference between the length of the previous tool and that of the new one.

For tool length compensation, the TNC takes the delta values from both the **TOOL CALL** block and the tool table into account:

Compensation value =  $L + DL_{\text{TOOL CALL}} + DL_{\text{TAB}}$  where

- L:** is the tool length **L** from the **TOOL DEF** block or tool table.
- $DL_{\text{TOOL CALL}}$**  is the oversize for length **DL** in the **TOOL CALL** block (not taken into account by the position display).
- $DL_{\text{TAB}}$**  is the oversize for length **DL** in the tool table.



## Tool radius compensation

The NC block for programming a tool movement contains:

- **RL** or **RR** for radius compensation.
- **R+** or **R-** for radius compensation in single-axis movements.
- **R0** if there is no radius compensation.

Radius compensation becomes effective as soon as a tool is called and is moved with a straight line block in the working plane with RL or RR.



The TNC automatically cancels radius compensation if you:

- program a straight line block with **R0**
- depart the contour with the **DEP** function
- program a **PGM CALL**
- select a new program with PGM MGT.

For tool radius compensation, the TNC takes the delta values from both the **TOOL CALL** block and the tool table into account:

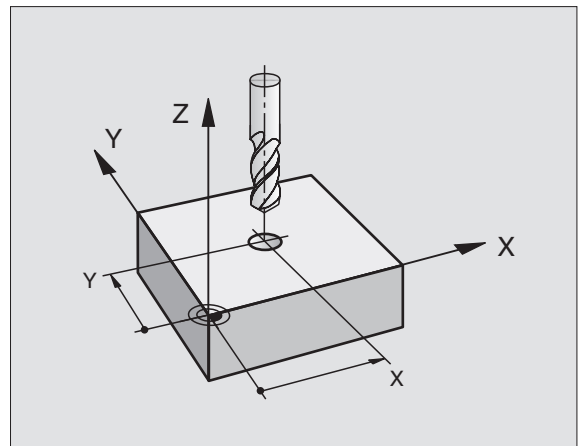
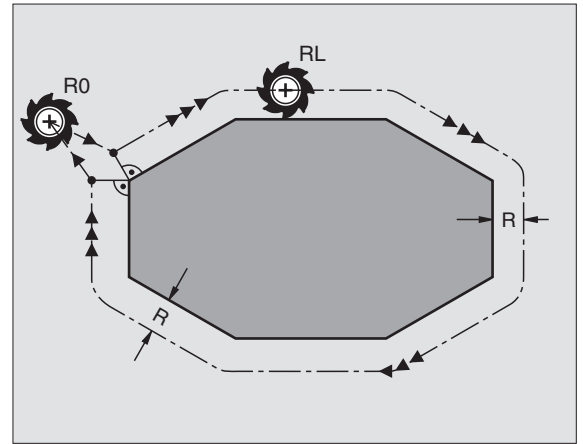
Compensation value =  $R + DR_{\text{TOOL CALL}} + DR_{\text{TAB}}$  where

- R** is the tool radius **R** from the **TOOL DEF** block or tool table.
- DR<sub>TOOL CALL</sub>** is the oversize for radius **DR** in the **TOOL CALL** block (not taken into account by the position display).
- DR<sub>TAB</sub>** is the oversize for radius **DR** in the tool table.

### Contouring without radius compensation: R0

The tool center moves in the working plane along the programmed path or to the programmed coordinates.

Applications: Drilling and boring, pre-positioning.



## Tool movements with radius compensation: RR and RL

**RR** The tool moves to the right of the programmed contour

**RL** 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. See figures at right.

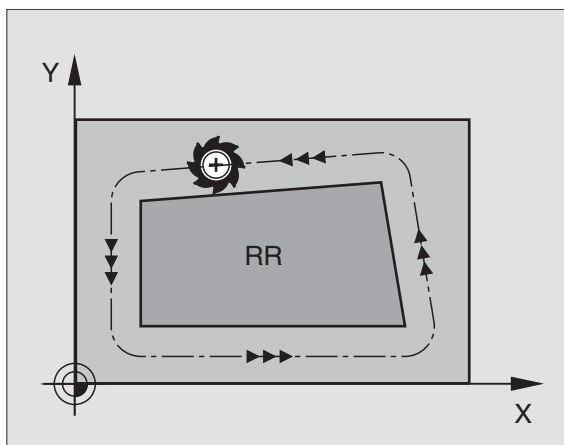
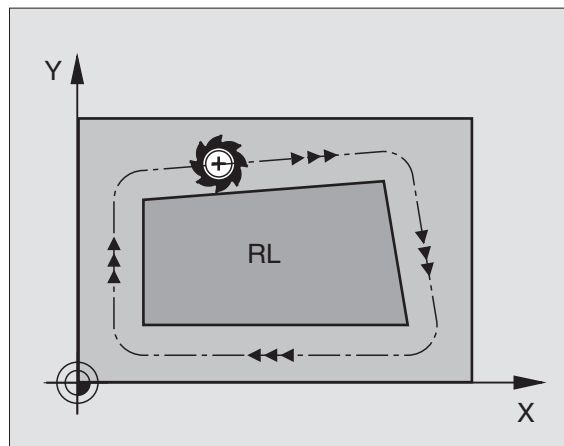


Between two program blocks with different radius compensations (**RR** and **RL**) you must program at least one traversing block in the working plane without radius compensation (that is, with **RO**).

Radius compensation does not take effect until the end of the block in which it is first programmed.

You can also activate the radius compensation for secondary axes in the working plane. Program the secondary axes too in each following block, since otherwise the TNC will execute the radius compensation in the principal axis again.

Whenever radius compensation is activated with **RR/RL** or canceled with **RO**, the TNC positions the tool perpendicular to the programmed starting or end position. Position the tool at a sufficient distance from the first or last contour point to prevent the possibility of damaging the contour.



### Entering radius compensation

Program any desired path function, enter the coordinates of the target point and confirm your entry with ENT.

**RADIUS COMP.: RL/RR/NO COMP.?**

RL

To select tool movement to the left of the contour, press the RL soft key, or

RR

To select tool movement to the right of the contour, press the RR soft key, or

ENT

To select tool movement without radius compensation or to cancel radius compensation, press the ENT key.

END



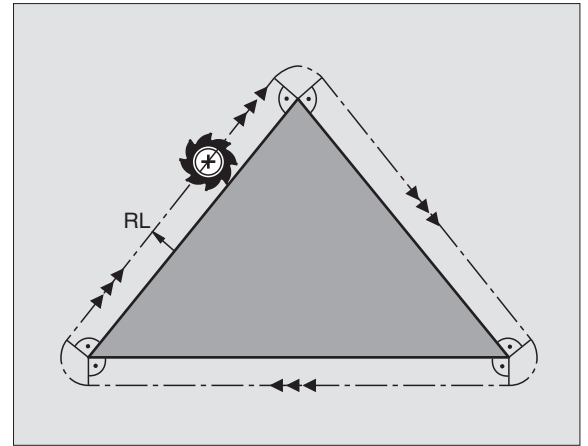
To terminate the block, press the END key.

### Radius compensation: Machining corners

- Outside corners  
If you program radius compensation, the TNC moves the tool around outside corners either on a transitional arc or on a spline (selectable via MP7680). If necessary, the TNC reduces the feed rate at outside corners to reduce machine stress, for example at very great changes of direction.
- Inside corners  
The TNC 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. The permissible tool radius, therefore, is limited by the geometry of the programmed contour.

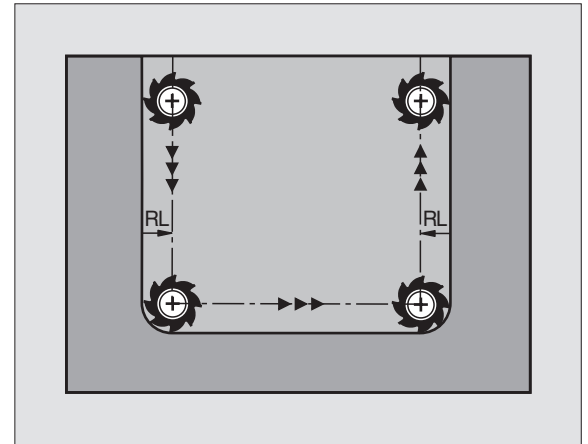


To prevent the tool from damaging the contour, be careful not to program the starting or end position for machining inside corners at a corner of the contour.



### Machining corners without radius compensation

If you program the tool movement without radius compensation, you can change the tool path and feed rate at workpiece corners with the miscellaneous function **M90**. See "Smoothing corners: M90," page 235.



## 5.4 Three-Dimensional Tool Compensation (Software Option 2)

### Introduction

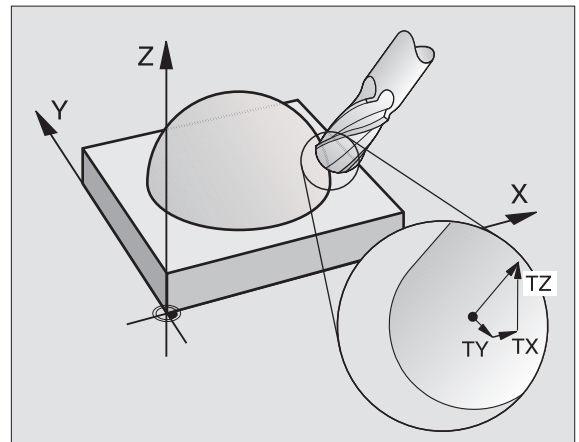
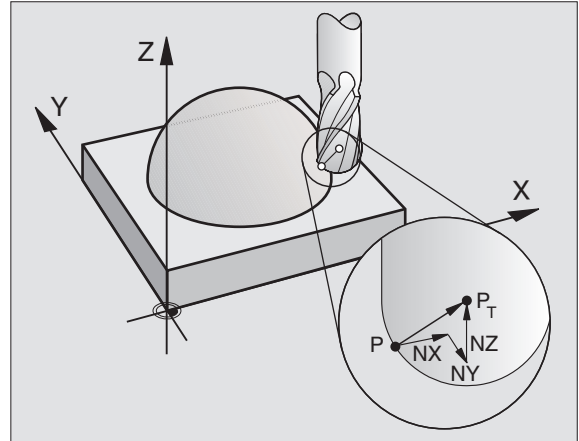
The TNC can carry out a three-dimensional tool compensation (3-D compensation) for straight-line blocks. Apart from the X, Y and Z coordinates of the straight-line end point, these blocks must also contain the components NX, NY and NZ of the surface-normal vector (see figure above right and explanation further down on this page).

If, in addition, you want to carry out a tool orientation or a three-dimensional radius compensation, these blocks also need a normalized vector with the components TX, TY and TZ, which determines the tool orientation (see figure at center right).

The straight-line end point, the components for the surface-normal vector as well as those for the tool orientation must be calculated by a CAD system.

### Application possibilities

- Use of tools with dimensions that do not correspond with the dimensions calculated by the CAD system (3-D compensation without definition of the tool orientation)
- Face milling: compensation of the milling machine geometry in the direction of the surface-normal vector (3-D compensation with and without definition of the tool orientation). Cutting is usually with the end face of the tool
- Peripheral milling: compensation of the mill radius perpendicular to the direction of movement and perpendicular to the tool direction (3-D radius compensation with definition of the tool orientation). Cutting is usually with the lateral surface of the tool



## Definition of a normalized vector

A normalized vector is a mathematical quantity with a value of 1 and a direction. The TNC requires up to two normalized vectors for LN blocks, one to determine the direction of the surface-normal vector, and another (optional) to determine the tool orientation direction. The direction of a surface-normal vector is determined by the components  $NX$ ,  $NY$  and  $NZ$ . With an end mill and a radius mill, this direction is perpendicular from the workpiece surface to be machined to the tool datum  $P_T$ , and with a toroid cutter through  $P_T'$  or  $P_T$  (see figure at upper right). The direction of the tool orientation is determined by the components  $TX$ ,  $TY$  and  $TZ$ .



The coordinates for the X, Y, Z positions and the surface-normal components  $NX$ ,  $NY$ ,  $NZ$ , as well as  $TX$ ,  $TY$ ,  $TZ$  must be in the same sequence in the NC block.

Always indicate all of the coordinates and all of the surface-normal vectors in an LN block, even if the values have not changed from the previous block.

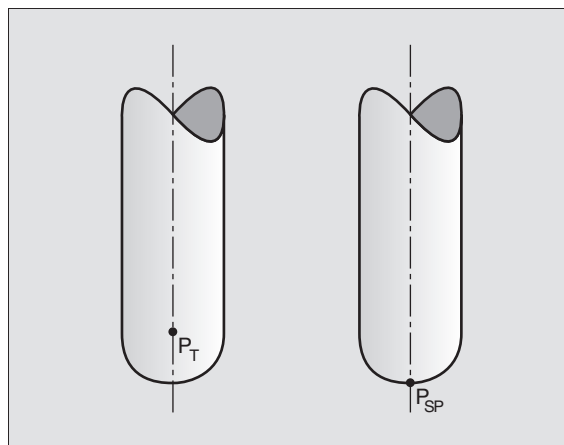
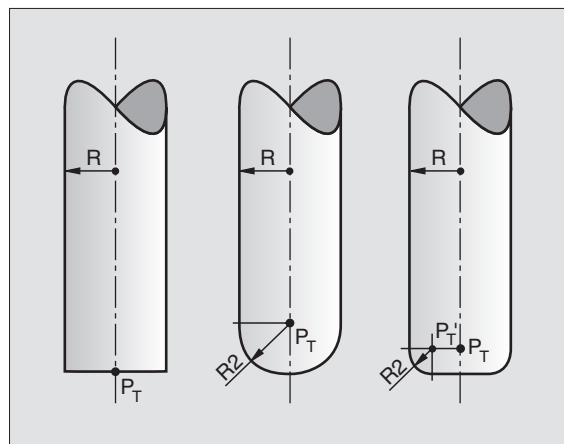
$TX$ ,  $TY$  and  $TZ$  must always be defined with numerical values. You cannot use Q parameters.

3-D compensation with surface-normal vectors is only effective for coordinates in the main axes X, Y, Z.

If you insert a tool with oversize (positive delta value), the TNC outputs an error message. You can suppress the error message with the M function **M107** (see "Prerequisites for NC blocks with surface-normal vectors and 3-D compensation" on page 158).

The TNC will not display an error message if an entered tool oversize would cause damage to the contour.

MP 7680 defines whether the CAD system has calculated the tool length compensation from the center of sphere  $P_T$  or the south pole of the sphere  $P_{SP}$  (see figure at right).



## Permissible tool forms

You can describe the permissible tool shapes in the tool table via tool radius  $R$  and  $R2$  (see figure at upper right):

- Tool radius  $R$ : Distance from the tool center to the tool circumference.
- Tool radius 2  $R2$ : Radius of the curvature between tool tip and tool circumference.

The ratio of  $R$  to  $R2$  determines the shape of the tool:

- $R2 = 0$ : End mill
- $R2 = R$ : Ball-nose cutter
- $0 < R2 < R$ : Toroid cutter

These data also specify the coordinates of the tool datum  $P_T$ .



## Using other tools: Delta values

If you want to use tools that have different dimensions than the ones you originally programmed, you can enter the difference between the tool lengths and radii as delta values in the tool table or **TOOL CALL**:

- Positive delta value **DL**, **DR**, **DR2**: The tool is larger than the original tool (oversize).
- Negative delta value **DL**, **DR**, **DR2**: The tool is smaller than the original tool (undersize).

The TNC then compensates the tool position by the sum of the delta values from the tool table and the tool call.

## 3-D compensation without tool orientation

The TNC displaces the tool in the direction of the surface-normal vectors by the sum of the delta values (tool table and **TOOL CALL**).

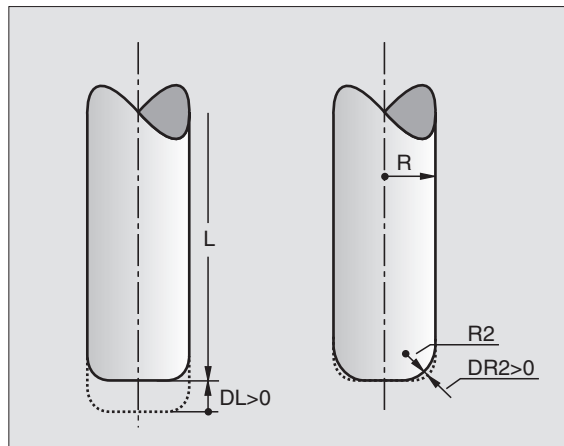
### Example: Block format with surface-normal vectors

```
1 LN X+31.737 Y+21.954 Z+33.165
  NX+0.2637581 NY+0.0078922 NZ-0.8764339 F1000 M3
```

- LN:** Straight line with 3-D compensation  
**X, Y, Z:** Compensated coordinates of the straight-line end point  
**NX, NY, NZ:** Components of the surface-normal vector  
**F:** Feed rate  
**M:** Miscellaneous function

The feed rate F and miscellaneous function M can be entered and changed in the Programming and Editing mode of operation.

The coordinates of the straight-line end point and the components of the surface-normal vectors are to be defined by the CAD system.



## Face Milling: 3-D compensation with and without tool orientation

The TNC displaces the tool in the direction of the surface-normal vectors by the sum of the delta values (tool table and **TOOL CALL**).

If **M128** (see “Maintaining the position of the tool tip when positioning with tilted axes (TCPM): M128 (software option 2)” on page 254) is active, the TNC maintains the tool perpendicular to the workpiece contour if no tool orientation is programmed in the LN block.

If there is a tool orientation defined in the LN block, then the TNC will position the rotary axes automatically so that the tool can reach the defined orientation.



This function is possible only on machines for which you can define spatial angles for the tilting axis configuration. Refer to your machine manual.

The TNC is not able to automatically position the rotary axes on all machines. Refer to your machine manual.



### Danger of collision!

On machines whose rotary axes only allow limited traverse, sometimes automatic positioning can require the table to be rotated by 180°. In this case, make sure that the tool head does not collide with the workpiece or the clamps.

### Example: Block format with surface-normal vectors without tool orientation

```
LN X+31.737 Y+21.954 Z+33.165
   NX+0.2637581 NY+0.0078922 NZ-0.8764339 F1000 M128
```

**Example: Block format with surface-normal vectors and tool orientation**

```

LN X+31.737 Y+21.954 Z+33.165
  NX+0.2637581 NY+0.0078922 NZ0.8764339
  TX+0.0078922 TY-0.8764339 TZ+0.2590319 F1000 M128

```

**LN:** Straight line with 3-D compensation  
**X, Y, Z:** Compensated coordinates of the straight-line end point  
**NX, NY, NZ:** Components of the surface-normal vector  
**TX, TY, TZ:** Components of the normalized vector for workpiece orientation  
**F:** Feed rate  
**M:** Miscellaneous function

The feed rate **F** and miscellaneous function **M** can be entered and changed in the Programming and Editing mode of operation.

The coordinates of the straight-line end point and the components of the surface-normal vectors are to be defined by the CAD system.



Peripheral Milling: 3-D radius compensation with workpiece orientation

The TNC displaces the tool perpendicular to the direction of movement and perpendicular to the tool direction by the sum of the delta values **DR** (tool table and **TOOL CALL**) . Determine the compensation direction with radius compensation **RL/RR** (see figure at upper right, traverse direction Y+). For the TNC to be able to reach the set tool orientation, you need to activate the function **M128** (see “Maintaining the position of the tool tip when positioning with tilted axes (TCPM): M128 (software option 2)” on page 254). The TNC then positions the rotary axes automatically so that the tool can reach the defined orientation with the active compensation.



This function is possible only on machines for which you can define spatial angles for the tilting axis configuration. Refer to your machine manual.

The TNC is not able to automatically position the rotary axes on all machines. Refer to your machine manual.



Danger of collision!

On machines whose rotary axes only allow limited traverse, sometimes automatic positioning can require the table to be rotated by 180°. In this case, make sure that the tool head does not collide with the workpiece or the clamps.

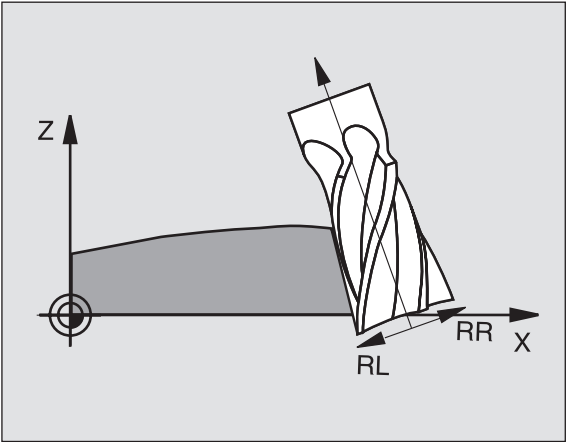
There are two ways to define the tool orientation:

- In an LN block with the components TX, TY and TZ
- In an L block by indicating the coordinates of the rotary axes

Example: Block format with tool orientation

```
1 LN X+31.737 Y+21.954 Z+33.165
   TX+0.0078922 TY0.8764339 TZ+0.2590319 F1000 M128
```

- LN: Straight line with 3-D compensation
- X, Y, Z: Compensated coordinates of the straight-line end point
- TX, TY, TZ: Components of the normalized vector for workpiece orientation
- F: Feed rate
- M: Miscellaneous function



**Example: Block format with rotary axes**

```
1 L X+31.737 Y+21.954 Z+33.165  
  RL B+12.357 C+5.896 F1000 M128
```

<b>L:</b>	Straight line
<b>X, Y, Z:</b>	Compensated coordinates of the straight-line end point
<b>L:</b>	Straight line
<b>B, C:</b>	Coordinates of the rotary axes for tool orientation
<b>RL:</b>	Radius compensation
<b>M:</b>	Miscellaneous function



# 5.5 Working with Cutting Data Tables

## Note



The TNC must be specially prepared by the machine tool builder for the use of cutting data tables.

Some functions or additional functions described here may not be provided on your machine tool. Refer to your machine manual.

## Applications

In cutting data tables containing various workpiece and cutting material combinations, the TNC can use the cutting speed  $V_C$  and the tooth feed  $f_Z$  to calculate the spindle speed  $S$  and the feed rate  $F$ . This calculation is only possible if you defined the workpiece material in the program and various tool-specific features in the tool table.



Before you let the TNC automatically calculate the cutting data, the tool table from which the TNC is to take the tool-specific data must be first be activated in the Test Run mode (status S).

Editing function for cutting data tables	Soft key
Insert line	INSERT LINE
Delete line	DELETE LINE
Go to beginning of next line	NEXT LINE
Sort the table	SORT BLOCK NUMBERS
Copy the highlighted field (2nd soft-key row)	COPY FIELD
Insert the copied field (2nd soft-key row)	PASTE FIELD
Edit the table format (2nd soft-key row)	EDIT FORMAT

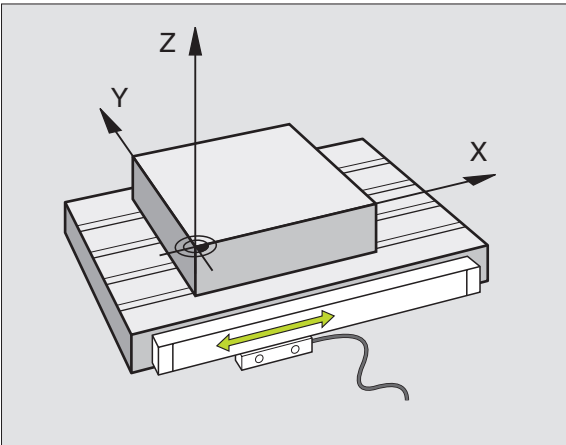
DATE:	TOOL.T	MM	CDT		
T	R	CUT.	TYP	TMAT	
0	...	...	...	...	...
1	...	...	...	...	...
2	+5	4	MILL	HSS	PRO1
3	...	...	...	...	...
4	...	...	...	...	...

DATE:	PRO1.CDT	Vc1	F1
NR	WMAT	TMAT	
0	...	...	...
1	...	...	...
2	ST65	HSS	40 0.06
3	...	...	...
4	...	...	...

```
0 BEGIN PGM xxx.H MM
1 BLK FORM 0.1 Z X+0 Y+0 Z-20
2 BLK FORM 0.2 Z X+100 Y+100 Z+0
3 WMAT "ST65"
4 ...
5 TOOL CALL 2 Z S1273 F305
```



## Table for workpiece materials

Workpiece materials are defined in the table WMAT.TAB (see figure at upper right). WMAT.TAB is stored in the TNC:\ directory and can contain as many materials as you want. The name of the material type can have up to 32 characters (including spaces). The TNC displays the contents of the NAME column when you are defining the workpiece material in the program (see the following section).



If you change the standard workpiece material table, you must copy it into a new directory. Otherwise your changes will be overwritten during a software update by the HEIDENHAIN standard data. Define the path in the TNC.SYS file with the code word WMAT= (see "Configuration file TNC.SYS" on page 176).

To avoid losing data, save the WMAT.TAB file at regular intervals.

Manual operation

Program table editing

NAME ?

NO	NAME	DOC
0	Werkz.-Stahl 1.2519	
1	14 NiCr 14 Einsatz-Stahl 1.5752	
2	142 W 12 Werkz.-Stahl 1.2562	
3	15 CrNi 6 Einsatz-Stahl 1.5919	
4	16 CrMo 4 Baustahl 1.7337	
5	16 MnCr 5 Einsatz-Stahl 1.7131	
6	17 MoV 8 4 Baustahl 1.5406	
7	19 CrNi 8 Einsatz-Stahl 1.5928	
8	19 Mn 5 Baustahl 1.0402	
9	21 MnCr 5 Werkz.-Stahl 1.2162	
10	26 CrMo 4 Baustahl 1.7219	
11	28 NiCrMo 4 Baustahl 1.6513	
12	30 CrMoV 8 Verg.-Stahl 1.7707	
13	30 CrNiMo 8 Verg.-Stahl 1.8598	
14	31 CrMo 12 Nitrier-Stahl 1.8515	
15	31 CrMoV 8 Nitrier-Stahl 1.8519	
16	32 CrMo 12 Verg.-Stahl 1.7261	
17	34 CrAl 8 Nitrier-Stahl 1.8594	
18	34 CrAlMo 5 Nitrier-Stahl 1.8507	
19	34 CrAlNi 7 Nitrier-Stahl 1.8558	

BEGIN END PAGE PAGE INSERT DELETE NEXT ORDER  
LINE LINE LINE LINE

### Defining the workpiece material in the NC program

In the NC program select the workpiece material from the WMAT.TAB table using the WMAT soft key:

SPEC  
FCT

► Show the soft-key row with special functions

WMAT

► Program the workpiece material: In the Programming and Editing operating mode, press the WMAT soft key.

SELECTION  
WINDOW

► The WMAT.TAB table is superimposed: Press the SELECTION WINDOW soft key, and in a second window the TNC displays the list of materials that are stored in the WMAT.TAB table.

► Select your workpiece material by using the arrow keys to move the highlight onto the material you wish to select and confirming with the ENT key. The TNC transfers the selected material to the WMAT block.

► To terminate the dialog, press the END key.



If you change the WMAT block in a program, the TNC outputs a warning. Check whether the cutting data stored in the TOOL CALL block are still valid.



Table for tool cutting materials

Tool cutting materials are defined in the TMAT.TAB table. TMAT.TAB is stored in the TNC:\ directory and can contain as many material names as you want (see figure at upper right). The name of the cutting material type can have up to 16 characters (including spaces). The TNC displays the NAME column when you are defining the tool cutting material in the TOOL.T tool table.



If you change the standard tool cutting material table, you must copy it into a new directory. Otherwise your changes will be overwritten during a software update by the HEIDENHAIN standard data. Define the path in the TNC.SYS file with the code word TMAT= (see "Configuration file TNC.SYS" on page 176).

To avoid losing data, save the TMAT.TAB file at regular intervals.

Manual operation

Program table editing  
Cutting material?

NR	NAME	UNIT
0	HM	HM beschichtet
1	HC-P25	HM beschichtet
2	HC-P25	HM beschichtet
3	HSS	
4	HSSE-Co5	HSS + Kobalt
5	HSSE-Co8	HSS + Kobalt
6	HSSE-Co8-TiN	HSS + Kobalt
7	HSSE/TiON	TiON-beschichtet
8	HSSE/TiN	TiN-beschichtet
9	HT-P15	Cermet
10	HT-M15	Cermet
11	HU-K15	HM unbeschichtet
12	HU-K25	HM unbeschichtet
13	HU-P25	HM unbeschichtet
14	HU-P35	HM unbeschichtet
15	Hartmetall	Vollhartmetall

END

BEGIN END PAGE PAGE INSERT LINE DELETE LINE NEXT LINE ORDER

Table for cutting data

Define the workpiece material / cutting material combinations with the corresponding cutting data in a file table with the file name extension .CDT; see figure at center right. You can freely configure the entries in the cutting data table. Besides the obligatory columns NR, WMAT and TMAT, the TNC can also manage up to four cutting speed ( $V_C$ ) / feed rate (F) combinations.

The standard cutting data table FRAES\_2.CDT is stored in the directory TNC:\. You can edit FRAES\_2.CDT, or add as many new cutting-data tables as you wish.



If you change the standard cutting data table, you must copy it into a new directory. Otherwise your changes will be overwritten during a software update by the HEIDENHAIN standard data (see "Configuration file TNC.SYS" on page 176).

All of the cutting data tables must be stored in the same directory. If the directory is not the standard directory TNC:\, then behind the code word PCDT= you must enter the path in which your cutting data is stored.

To avoid losing data, save your cutting data tables at regular intervals.

Manual operation

Program table editing  
Workpiece material?

NR	WMAT	TMAT	VC1	F1	VC2	F2
0	ST 33-1	HSSE/TiN	40	0.015	55	0.020
1	ST 33-1	HSSE/TiON	40	0.015	55	0.020
2	ST 33-1	HC-P25	100	0.200	130	0.250
3	ST 37-2	HSSE-Co5	20	0.025	45	0.030
4	ST 37-2	HSSE/TiON	40	0.015	55	0.020
5	ST 37-2	HC-P25	100	0.200	130	0.250
6	ST 50-2	HSSE/TiN	40	0.015	55	0.020
7	ST 50-2	HSSE/TiON	40	0.015	55	0.020
8	ST 50-2	HC-P25	100	0.200	130	0.250
9	ST 60-2	HSSE/TiN	40	0.015	55	0.020
10	ST 60-2	HSSE/TiON	40	0.015	55	0.020
11	ST 60-2	HC-P25	100	0.200	130	0.250
12	C 15	HSSE-Co5	20	0.040	45	0.050
13	C 15	HSSE/TiON	25	0.040	35	0.050
14	C 15	HC-P35	70	0.040	100	0.050
15	C 45	HSSE/TiN	25	0.040	35	0.050
16	C 45	HSSE/TiON	25	0.040	35	0.050
17	C 45	HC-P35	70	0.040	100	0.050
18	C 60	HSSE/TiN	25	0.040	35	0.050
19	C 60	HSSE/TiON	25	0.040	35	0.050

END

BEGIN END PAGE PAGE INSERT LINE DELETE LINE NEXT LINE ORDER





**Creating a new cutting data table**

- ▶ Select the Programming and Editing mode of operation.
- ▶ Press the PGM MGT key to select the file manager.
- ▶ Select the directory where the cutting data table is to be stored.
- ▶ Enter any file name with file name extension .CDT, and confirm with ENT.
- ▶ On the right half of the screen, the TNC opens a standard cutting data table or displays various table formats (machine-dependent). These tables differ from each other in the number of cutting speed/feed rate combinations they allow. In this case use the arrow keys to move the highlight onto the table format you wish to select and confirm with ENT. The TNC generates a new, empty cutting data table.

**Data required for the tool table**

- Tool radius—column R (DR)
- Number of teeth (only with tools for milling)—column CUT
- Tool type—column TYPE
- The tool type influences the calculation of the feed rate:  
 Milling tool:  $F = S \cdot f_z \cdot z$   
 All other tools:  $F = S \cdot f_U$   
 S: Spindle speed  
 $f_z$ : Feed per tooth  
 $f_U$ : Feed per revolution  
 z: Number of teeth
- Tool cutting material—column TMAT
- Name of the cutting data table for which this tool will be used—column CDT
- In the tool table, select the tool type, tool cutting material and the name of the cutting data table via soft key (see “Tool table: Tool data for automatic speed/feed rate calculation.” on page 148).



Working with automatic speed / feed rate calculation

- 1 If it has not already been entered, enter the type of workpiece material in the file WMAT.TAB.
- 2 If it has not already been entered, enter the type of cutting material in the file TMAT.TAB.
- 3 If not already entered, enter all of the tool-specific data required for cutting data calculation in the tool table:
  - Tool radius
  - Number of teeth
  - Tool type
  - Tool material
  - The cutting data table for each tool
- 4 If not already entered, enter the cutting data in any cutting data table (CDT file).
- 5 Test Run operating mode: Activate the tool table from which the TNC is to take the tool-specific data (status S).
- 6 In the NC program, set the workpiece material by pressing the WMAT soft key.
- 7 In the NC program, let the TOOL CALL block automatically calculate the spindle speed and feed rate via soft key.

Changing the table structure

Cutting data tables constitute so-called “freely-definable tables” for the TNC. You can change the format of freely definable tables by using the structure editor.

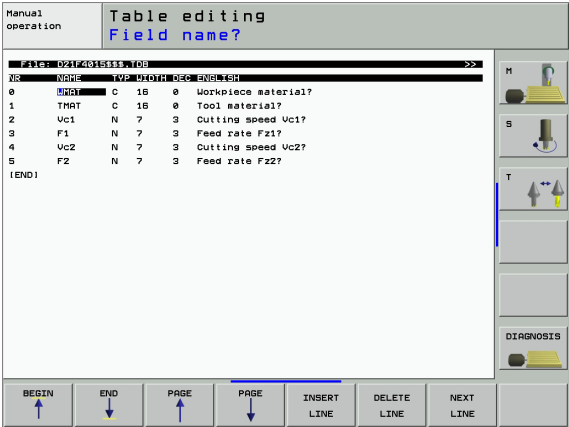


The TNC can process up to 200 characters per line and up to 30 columns.

If you insert an additional column into an existing table, the TNC does not automatically shift the values that have been entered.

Calling the structure editor

Press the EDIT FORMAT soft key (2nd soft-key level). The TNC opens the editing window (see figure at right), in which the table structure is shown “rotated by 90°.” In other words, a line in the editing window defines a column in the associated table. The meanings of the structure commands (header entries) are shown in the table at right.



**Exiting the structure editor**

Press the END key. The TNC changes data that was already in the table into the new format. Elements that the TNC could not convert into the new structure are indicated with a hash mark # (e.g., if you have narrowed the column width).

Structure command	Meaning
NR	Column number
NAME	Overview of columns
TYPE	N: Numerical input C: Alphanumeric input
WIDTH	Width of column. For type N including algebraic sign, comma, and decimal places.
DEC	Number of decimal places (max. 4, effective only for type N)
ENGLISH to HUNGARIAN	Language-dependent dialogs (max. 32 characters)



Data transfer from cutting data tables

If you output a file type .TAB or .CDT via an external data interface, the TNC also transfers the structural definition of the table. The structural definition begins with the line #STRUCTBEGIN and ends with the line #STRUCTEND. The meanings of the individual code words are shown in the table “Structure Command” (see “Changing the table structure” on page 174). Behind #STRUCTEND the TNC saves the actual content of the table.

Configuration file TNC.SYS

You must use the configuration file TNC.SYS if your cutting data tables are not stored in the standard directory TNC:\. In TNC.SYS you must then define the paths in which you have stored your cutting data tables.



The TNC.SYS file must be stored in the root directory TNC:\.

Entries in TNC.SYS	Meaning
WMAT=	Path for workpiece material table
TMAT=	Path for cutting material table
PCDT=	Path for cutting data tables

Example of TNC.SYS

```
WMAT=TNC:\CUTTAB\WMAT_GB.TAB
TMAT=TNC:\CUTTAB\TMAT_GB.TAB
PCDT=TNC:\CUTTAB\
```





# 6

**Programming:  
Programming Contours**



## 6.1 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

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 and have the TNC calculate the missing data.

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

### Miscellaneous functions M

With the TNC's miscellaneous functions you can affect

- Program run, e.g., a program interruption
- Machine functions, such as switching spindle rotation and coolant supply on and off
- Contouring 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 program section only under certain conditions, you also define this machining sequence as a subprogram. In addition, you can have a part program call a separate program for execution.

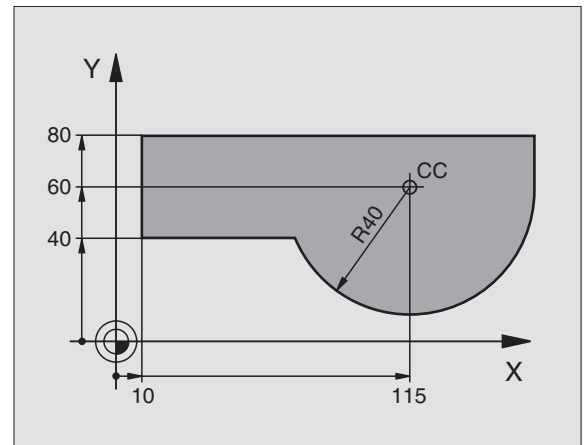
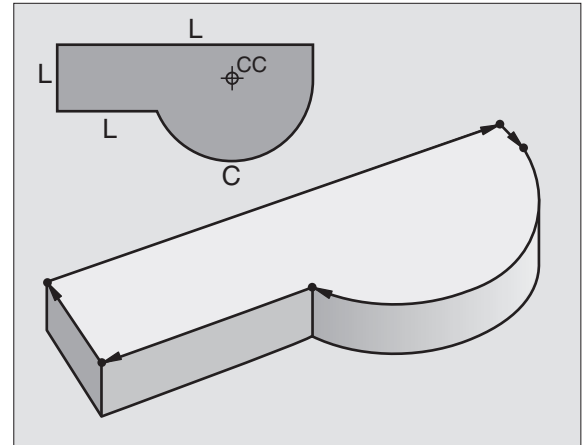
Programming with subprograms and program section repeats is described in Chapter 9.

### Programming with Q parameters

Instead of programming numerical values in a part program, you enter markers called Q parameters. You assign the values to the Q parameters separately with the Q parameter functions. You can use the Q parameters for programming mathematical functions that control program execution or describe a contour.

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

Programming with Q parameters is described in Chapter 10.



## 6.2 Fundamentals of Path Functions

### Programming tool movements for workpiece machining

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

The TNC moves all axes programmed in a single block simultaneously.

#### Movement parallel to the machine axes

The program block contains only one coordinate. The TNC thus moves the tool parallel to the programmed axis.

Depending on the machine tool, the part program is executed by movement of either the tool or the machine table on which the workpiece is clamped. Nevertheless, you always program path contours as if the tool moves and the workpiece remains stationary.

Example:

```
L X+100
```

**L** Path function for a straight line  
**X+100** Coordinate of the end point

The tool retains the Y and Z coordinates and moves to the position X=100 (see figure at upper right).

#### Movement in the main planes

The program block contains two coordinates. The TNC thus moves the tool in the programmed plane.

Example:

```
L X+70 Y+50
```

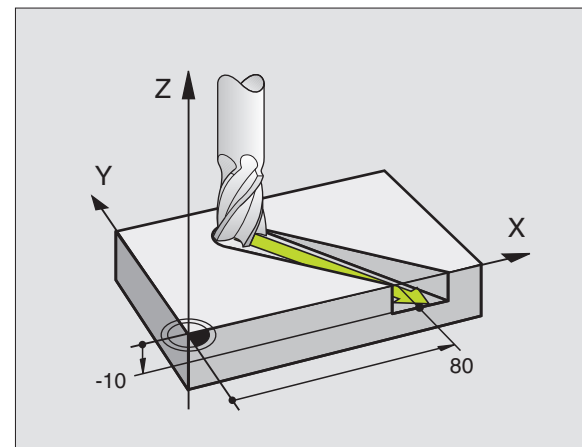
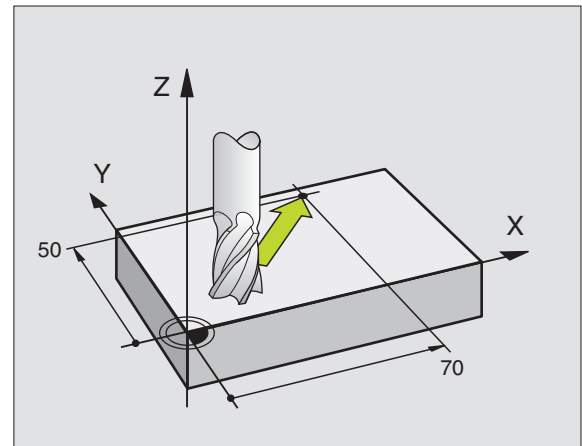
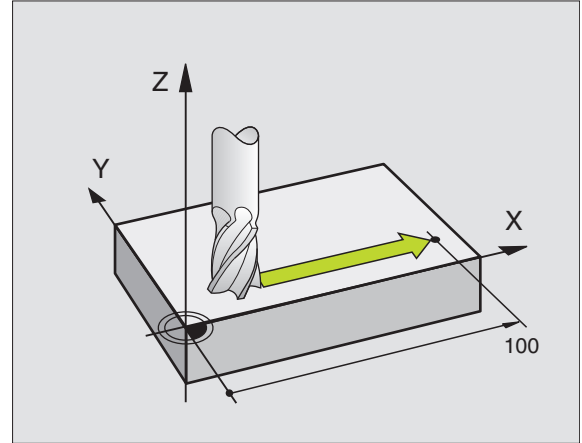
The tool retains the Z coordinate and moves in the XY plane to the position X=70, Y=50 (see figure at center right).

#### Three-dimensional movement

The program block contains three coordinates. The TNC thus moves the tool in space to the programmed position.

Example:

```
L X+80 Y+0 Z-10
```






Entering more than three coordinates

The TNC can control up to 5 axes simultaneously (software option). Machining with 5 axes, for example, moves 3 linear and 2 rotary axes simultaneously.

Such programs are too complex to program at the machine, however, and are usually created with a CAD system.

Example:

```
L X+20 Y+10 Z+2 A+15 C+6 R0 F100 M3
```


 The TNC graphics cannot simulate movements in more than three axes.

Circles and circular arcs

The TNC moves two axes simultaneously in a circular path relative to the workpiece. You can define a circular movement by entering the circle center CC.

When you program a circle, the control assigns it to one of the main planes. This plane is defined automatically when you set the spindle axis during a TOOL CALL:

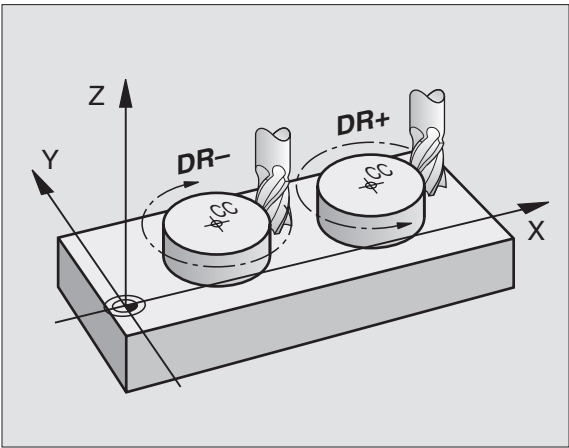
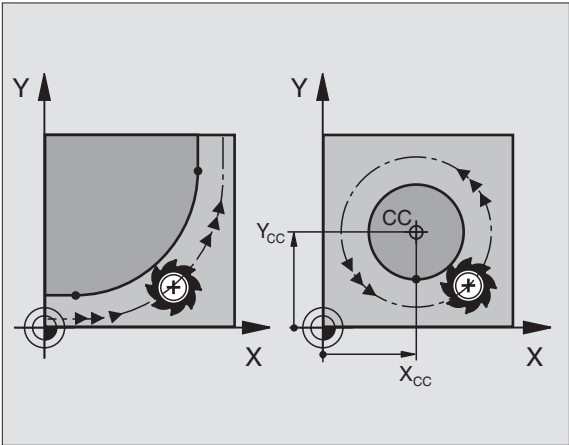
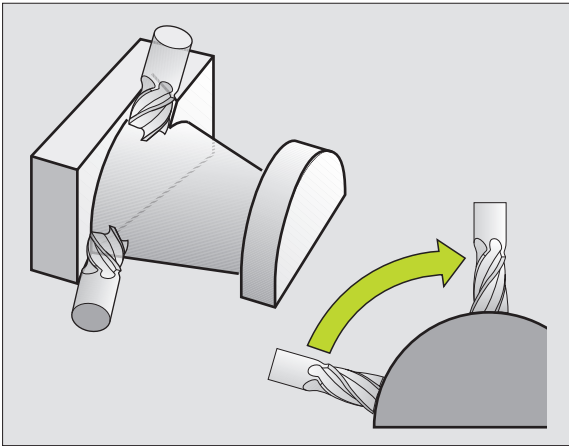
Spindle axis	Main plane
Z	XY, also UV, XV, UY
Y	ZX, also WU, ZU, WX
X	YZ, also VW, YW, VZ

 You can program circles that do not lie parallel to a main plane by using the function for tilting the working plane (see “WORKING PLANE (Cycle 19, software option 1)” on page 438) or Q parameters (see “Principle and Overview” on page 502).

Direction of rotation DR for circular movements

If a circular path has no tangential transition to another contour element, enter the direction of rotation DR:

Clockwise direction of rotation: DR-  
Counterclockwise direction of rotation: DR+





Radius compensation

The radius compensation must be in the block in which you move to the first contour element. You cannot begin radius compensation in a circle block. It must be activated beforehand in a straight-line block (see “Path Contours—Cartesian Coordinates” on page 190) or approach block (APPR block, see “Contour Approach and Departure” on page 183).

Pre-positioning

Before running a part program, always pre-position the tool to prevent the possibility of damaging it or the workpiece.

Creating the program blocks with the path function keys

The gray path function keys initiate the plain language dialog. The TNC asks you successively for all the necessary information and inserts the program block into the part program.

Example—programming a straight line:



Initiate the programming dialog, e.g. for a straight line.

COORDINATES?



10

Enter the coordinates of the straight-line end point.



5



RADIUS COMP.: RL/RR/NO COMP.?



Select the radius compensation (here, press the RL soft key—the tool moves to the left of the programmed contour).

FEED RATE F=? / F MAX = ENT

100



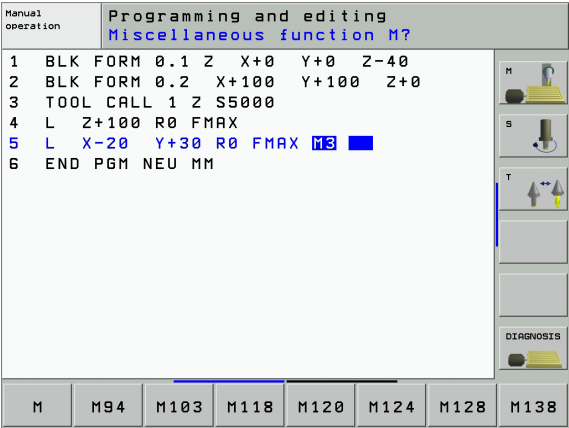
Enter the feed rate (here, 100 mm/min), and confirm your entry with ENT. For programming in inches, enter 100 for a feed rate of 10 ipm.



Move at rapid traverse: press the FMAX soft key, or



Move at automatically calculated speed (cutting data table): press the FAUTO soft key.



### MISCELLANEOUS FUNCTION M?

3

ENT

Enter a miscellaneous function (here, M3), and terminate the dialog with ENT.









The part program now contains the following line:

```
L X+10 Y+5 RL F100 M3
```

# 6.3 Contour Approach and Departure

## 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 desired path function with the corresponding soft key:

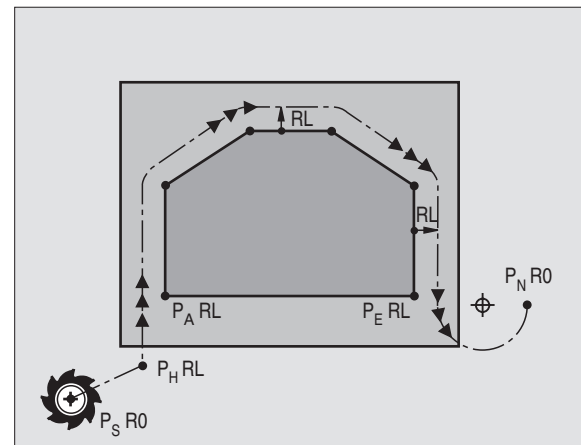
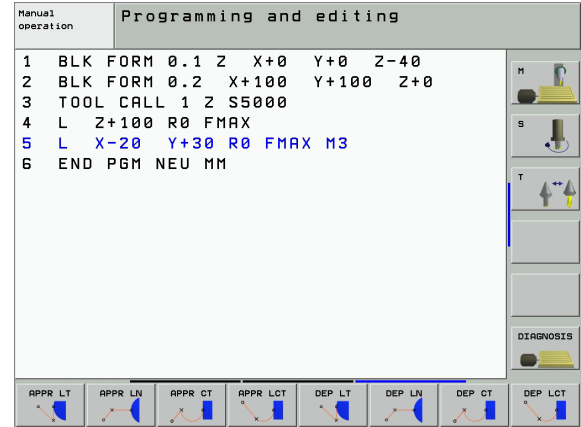
Function	Approach	Departure
Straight line with tangential connection		
Straight line perpendicular to a contour point		
Circular arc with tangential connection		
Circular arc with tangential connection to the contour. Approach and departure to an auxiliary point outside of the contour on a tangentially 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 helix approach and departure with the APPR CT and DEP CT functions.

## Important positions for approach and departure

- 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 (R0).
- Auxiliary point  $P_H$   
Some of the paths for approach and departure go through an auxiliary point  $P_H$  that the TNC calculates from your input in the APPR or DEP block. The TNC moves from the current position to the auxiliary point  $P_H$  at the feed rate last programmed.
- 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 contains a Z axis coordinate, the TNC will first move the tool to  $P_H$  in the working plane, and then move it to the entered depth in the tool axis.



- 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 contains a Z axis coordinate, the TNC will first move the tool to  $P_H$  in the working plane, and then move it to the entered depth in the tool axis.

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



The TNC does not check whether the programmed contour will be damaged when moving from the actual position to the auxiliary point  $P_H$ . Use the test graphics to simulate approach and departure before executing the part program.

With the APPR LT, APPR LN and APPR CT functions, the TNC moves the tool from the actual position to the auxiliary point  $P_H$  at the feed rate that was last programmed. With the APPR LCT function, the TNC 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 TNC 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.

Contour approach without radius compensation: If you program the APPR block with R0, the TNC will calculate the tool path for a tool radius of 0 mm and a radius compensation RR! The radius compensation is necessary to set the direction of contour approach and departure in the APPR/DEP LN and APPR/DEP CT functions.



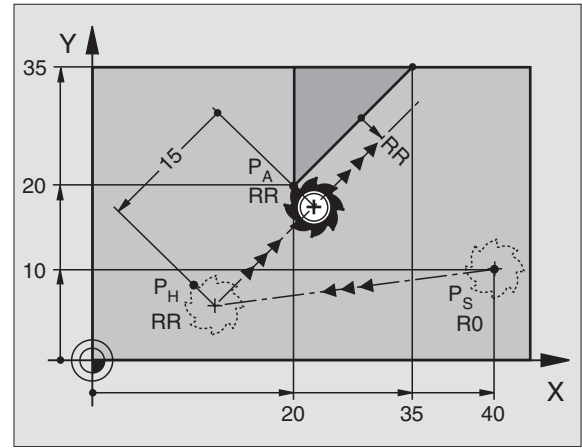
## Approaching on a straight line with tangential connection: APPR LT

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.

- 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 RR/RL for machining



### Example NC blocks

7 L X+40 Y+10 R0 FMAX M3	Approach $P_S$ without radius compensation
8 APPR LT X+20 Y+20 Z-10 LEN15 RR F100	$P_A$ with radius comp. RR, distance $P_H$ to $P_A$ : LEN=15
9 L Y+35 Y+35	End point of the first contour element
10 L ...	Next contour element

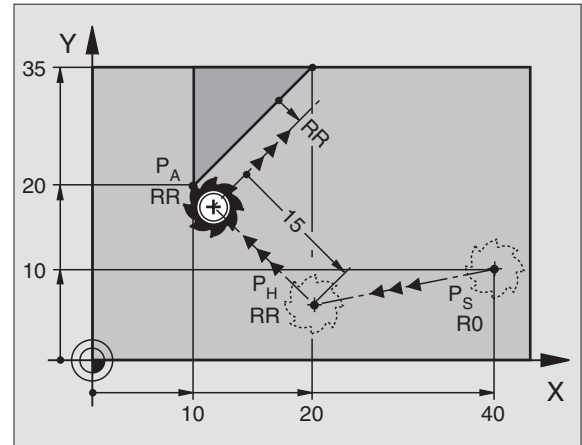
## Approaching on a straight line perpendicular to the first contour point: APPR LN

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 perpendicular to the first contour element. The auxiliary point  $P_H$  is separated by the distance LEN plus the tool radius from the first contour point  $P_A$ .

- 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  $P_A$
- Length: Distance to the auxiliary point  $P_H$ . Always enter LEN as a positive value!
- Radius compensation RR/RL for machining



### Example NC blocks

7 L X+40 Y+10 R0 FMAX M3	Approach $P_S$ without radius compensation
8 APPR LN X+10 Y+20 Z-10 LEN15 RR F100	$P_A$ with radius comp. RR
9 L X+20 Y+35	End point of the first contour element
10 L ...	Next contour element

Approaching on a circular path with tangential connection: APPR CT

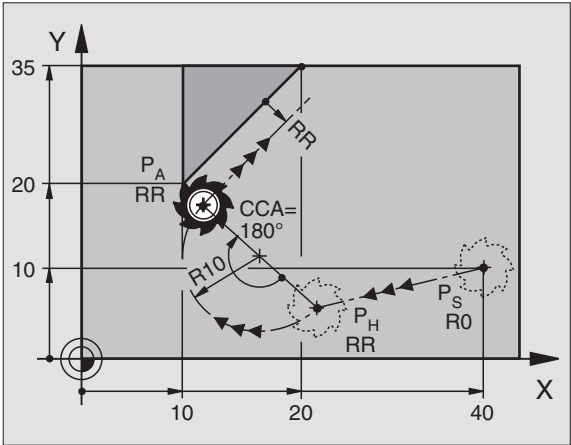
The tool moves on a straight line from the starting point  $P_S$  to an auxiliary point  $P_H$ . It then moves to the first contour point  $P_A$  following a circular arc that is tangential to the first contour element.

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  $360^\circ$
- Radius compensation  $RR/RL$  for machining



Example NC blocks

7 L X+40 Y+10 R0 FMAX M3	Approach $P_S$ without radius compensation
8 APPR CT X+10 Y+20 Z-10 CCA180 R+10 RR F100	$P_A$ with radius comp. $RR$ , radius $R=10$
9 L X+20 Y+35	End point of the first contour element
10 L ...	Next contour element



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

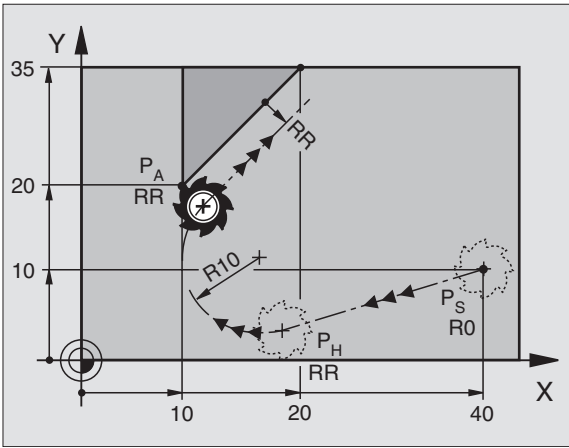
The tool moves on a straight line from the starting point  $P_S$  to an auxiliary point  $P_H$ . It then moves to the first contour point  $P_A$  on a circular arc. The feed rate programmed in the APPR block is in effect.

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.

- 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  $RR/RL$  for machining



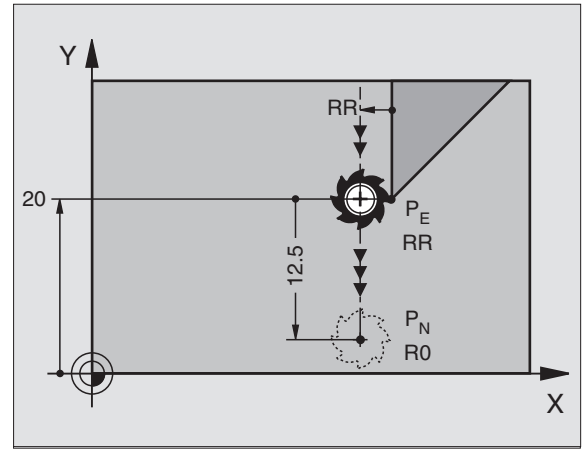
## Example NC blocks

7 L X+40 Y+10 R0 FMAX M3	Approach $P_S$ without radius compensation
8 APPR LCT X+10 Y+20 Z-10 R10 RR F100	$P_A$ with radius comp. $RR$ , radius $R=10$
9 L X+20 Y+35	End point of the first contour element
10 L ...	Next contour element

## Departing on 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.

- 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 NC blocks

23 L Y+20 RR F100

Last contour element:  $P_E$  with radius compensation

24 DEP LT LEN12.5 F100

Depart contour by LEN=12.5 mm

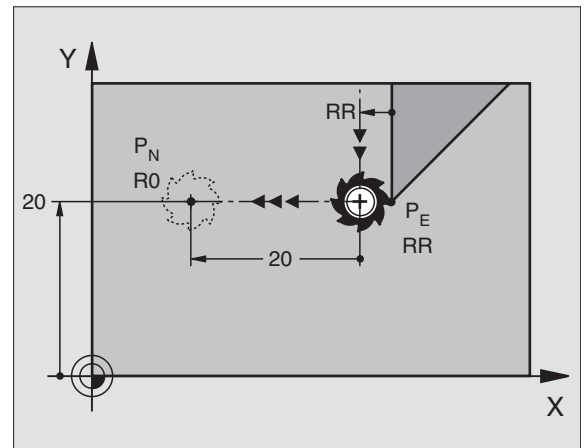
25 L Z+100 FMAX M2

Retract in Z, return to block 1, end program

## Departing on 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.

- 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:
  - LEN: Enter the distance from the last contour element to  $P_N$ .  
Always enter LEN as a positive value!



### Example NC blocks

23 L Y+20 RR F100

Last contour element:  $P_E$  with radius compensation

24 DEP LN LEN+20 F100

Depart perpendicular to contour by LEN=20 mm

25 L Z+100 FMAX M2

Retract in Z, return to block 1, end program



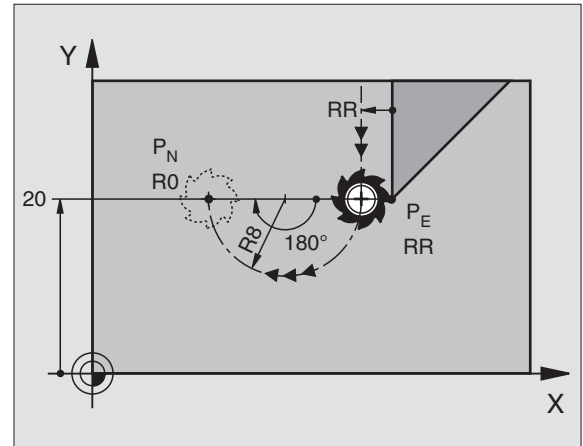
## Departure on a circular path with tangential connection: DEP CT

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

- ▶ 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 of the radius compensation (i.e. to the right with RR or to the left with RL): 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 NC blocks

23 L Y+20 RR F100	Last contour element: $P_E$ with radius compensation
24 DEP CT CCA 180 R+8 F100	Center angle=180°, arc radius=8 mm
25 L Z+100 FMAX M2	Retract in Z, return to block 1, end program

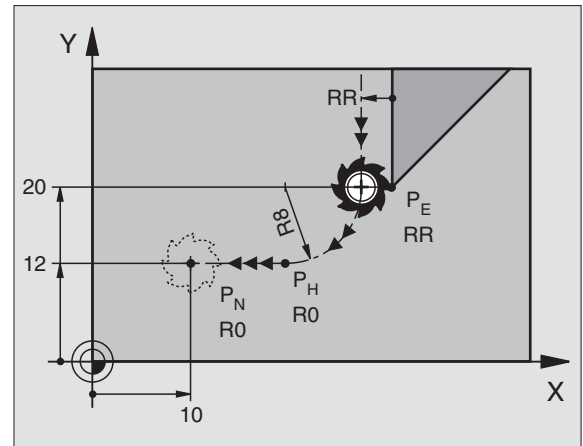
## Departing on a circular arc tangentially connecting the contour and a straight line: DEP LCT

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 then suffices to completely define the tool path.

- ▶ 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 NC blocks

23 L Y+20 RR F100	Last contour element: $P_E$ with radius compensation
24 DEP LCT X+10 Y+12 R+8 F100	Coordinates $P_N$ , arc radius=8 mm
25 L Z+100 FMAX M2	Retract in Z, return to block 1, end program

## 6.4 Path Contours—Cartesian Coordinates

### Overview of path functions

Function	Path function key	Tool movement	Required input
Line <b>L</b>		Straight line	Coordinates of the end points of the straight line
Chamfer <b>CHF</b>		Chamfer between two straight lines	Chamfer side length
Circle Center <b>CC</b>		None	Coordinates of the circle center or pole
Circle <b>C</b>		Circular arc around a circle center CC to an arc end point	Coordinates of the arc end point, direction of rotation
Circular Arc <b>CR</b>		Circular arc with a certain radius	Coordinates of the arc end point, arc radius, direction of rotation
Circular Arc <b>CT</b>		Circular arc with tangential connection to the preceding and subsequent contour elements	Coordinates of the arc end point
Corner Rounding <b>RND</b>		Circular arc with tangential connection to the preceding and subsequent contour elements	Rounding-off radius R
<b>FK</b> Free Contour Programming		Straight line or circular path with any connection to the preceding contour element	see “Path Contours—FK Free Contour Programming” on page 210



## Straight Line L

The TNC 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 block.



► **Coordinates** of the end point of the straight line

Further entries, if necessary:

► **Radius compensation** RL/RR/RO

► **Feed rate** F

► **Miscellaneous function** M

### Example NC blocks

```
7 L X+10 Y+40 RL F200 M3
```

```
8 L IX+20 IY-15
```

```
9 L X+60 IY-10
```

### Actual position capture

You can also generate a straight-line block (L block) by using the ACTUAL-POSITION-CAPTURE key:

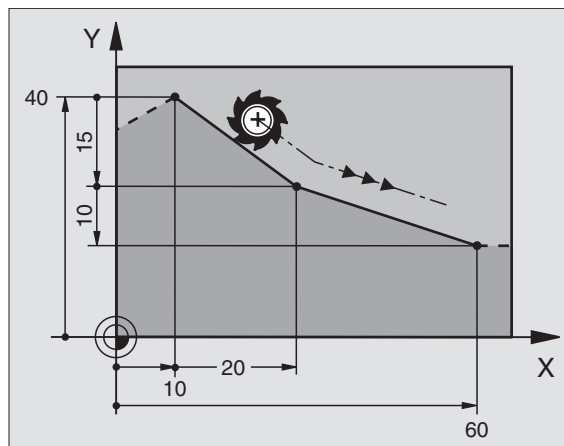
- In the Manual Operation mode, move the tool to the position you wish to capture.
- Switch the screen display to Programming and Editing.
- Select the program block after which you want to insert the L block.



► Press the ACTUAL-POSITION-CAPTURE key: The TNC generates an L block with the actual position coordinates.



In the MOD function, you define the number of axes that the TNC saves in an L block (see "MOD Function" on page 572).



## Inserting a chamfer CHF between two straight lines

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

- The blocks before and after the CHF block must be in the same working plane.
- The radius compensation before and after the chamfer block must be the same.
- An inside chamfer must be large enough to accommodate the current tool.



► **Chamfer side length:** Length of the chamfer

Further entries, if necessary:

► **Feed rate F** (only effective in CHF block)

### Example NC blocks

```
7 L X+0 Y+30 RL F300 M3
```

```
8 L X+40 IY+5
```

```
9 CHF 12 F250
```

```
10 L IX+5 Y+0
```

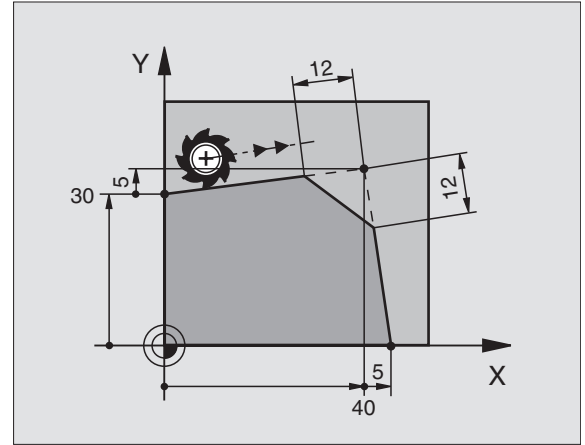


You cannot start a contour with a CHF block.

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



## Corner rounding RND

The RND function is used for rounding off corners.

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

The rounding arc must be large enough to accommodate the tool.



► **Rounding-off radius:** Enter the radius

Further entries, if necessary:

► **Feed rate F** (only effective in RND block)

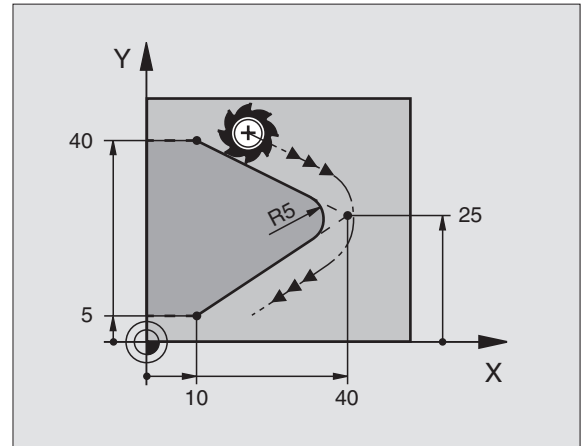
### Example NC blocks

```
5 L X+10 Y+40 RL F300 M3
```

```
6 L X+40 Y+25
```

```
7 RND R5 F100
```

```
8 L 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 working plane.

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

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

You can also use an RND block for a tangential contour approach if you do not want to use an APPR function.

## Circle center CC

You can define a circle center CC for circles that are programmed with the C key (circular path C). This is done in the following ways:

- Entering the Cartesian coordinates of the circle center, or
- Using the circle center defined in an earlier block, or
- Capturing the coordinates with the ACTUAL-POSITION-CAPTURE key.



► **Coordinates CC:** Enter the circle center coordinates, or  
If you want to use the last programmed position, do not enter any coordinates.

### Example NC blocks

```
5 CC X+25 Y+25
```

or

```
10 L X+25 Y+25
```

```
11 CC
```

The program blocks 10 and 11 do not refer to the illustration.

### Duration of effect

The circle center definition remains in effect until a new circle center is programmed. You can also define a circle center for the secondary axes U, V and W.

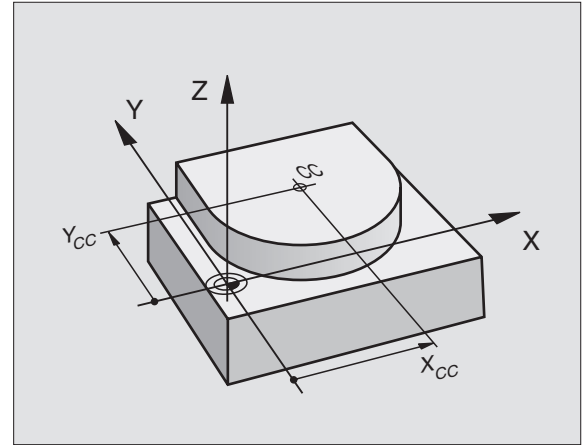
### Entering the circle center CC incrementally

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 CC 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 path C around circle center CC

Before programming a circular path C, you must first enter the circle center CC. The last programmed tool position before the C block is used as the circle starting point.

► Move the tool to the circle starting point.



► **Coordinates** of the circle center



► **Coordinates** of the arc end point

► **Direction of rotation DR**

Further entries, if necessary:

► **Feed rate F**

► **Miscellaneous function M**

### Example NC blocks

```
5 CC X+25 Y+25
```

```
6 L X+45 Y+25 RR F200 M3
```

```
7 C X+45 Y+25 DR+
```

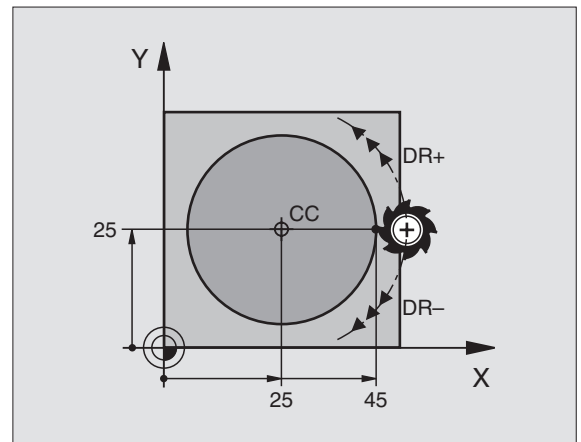
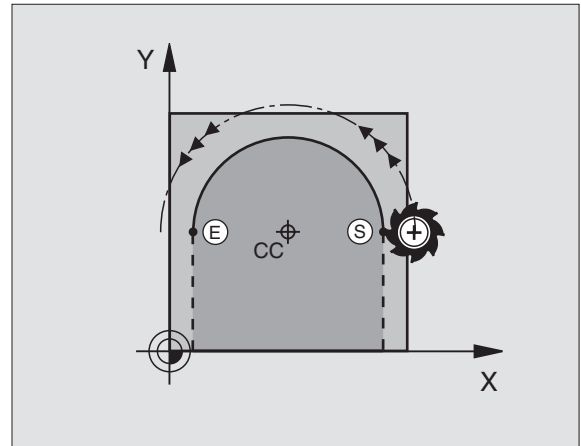
### Full circle

For the end point, enter the same point that you used for the starting point.



The starting and end points of the arc must lie on the circle.

Input tolerance: up to 0.016 mm (selected with MP7431).



## Circular path CR with defined radius

The tool moves on a circular path with the radius R.



- **Coordinates** of the arc end point
  - **Radius R**  
Note: The algebraic sign determines the size of the arc!
  - **Direction of rotation DR**  
Note: The algebraic sign determines whether the arc is concave or convex!
- Further entries, if necessary:
- **Miscellaneous function M**
  - **Feed rate F**

### Full circle

For a full circle, program two CR 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:  $CCA < 180^\circ$

Enter the radius with a positive sign  $R > 0$

Larger arc:  $CCA > 180^\circ$

Enter the radius with a negative sign  $R < 0$

The direction of rotation determines whether the arc is curving outward (convex) or curving inward (concave):

Convex: Direction of rotation DR- (with radius compensation RL)

Concave: Direction of rotation DR+ (with radius compensation RL)

Example NC blocks

```
10 L X+40 Y+40 RL F200 M3
```

```
11 CR X+70 Y+40 R+20 DR- (ARC 1)
```

or

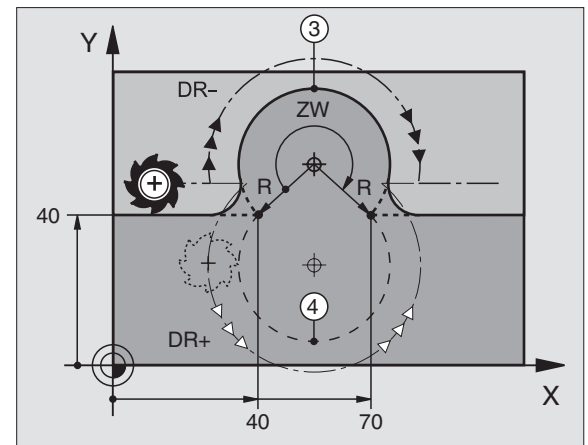
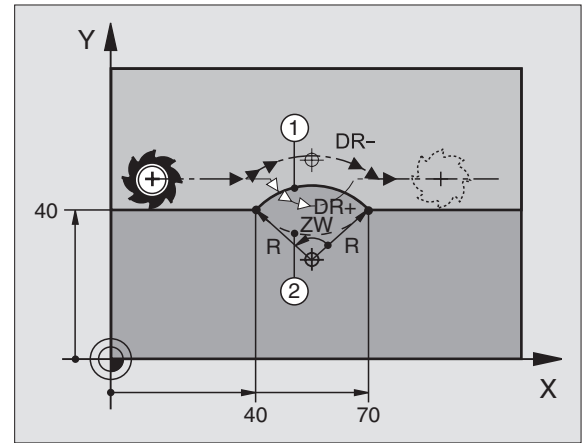
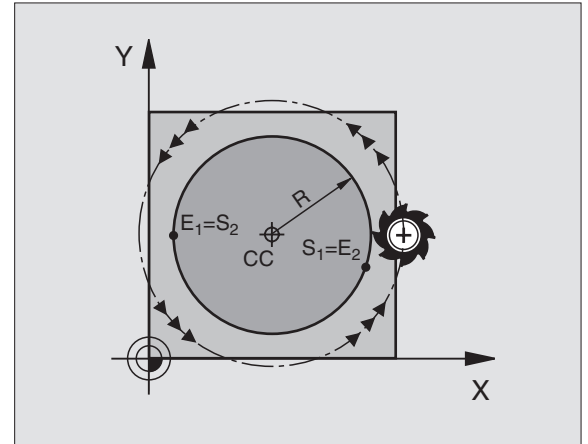
```
11 CR X+70 Y+40 R+20 DR+ (ARC 2)
```

or

```
11 CR X+70 Y+40 R-20 DR- (ARC 3)
```

or

```
11 CR X+70 Y+40 R-20 DR+ (ARC 4)
```







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.

## Circular path CT with tangential connection

The tool moves on an arc that starts tangentially to the previously programmed contour element.

A transition 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 CT block. This requires at least two positioning blocks.



► **Coordinates** of the arc end point

Further entries, if necessary:

► **Feed rate F**

► **Miscellaneous function M**

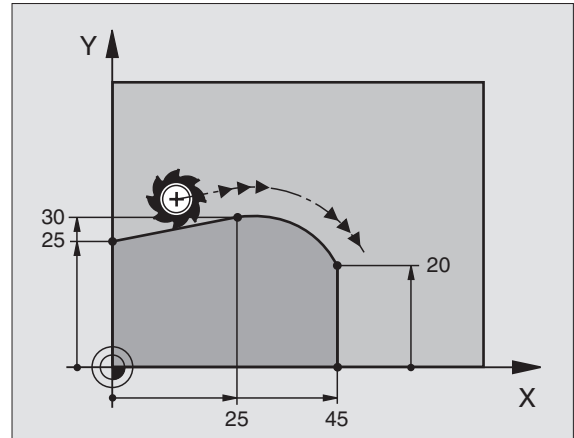
### Example NC blocks

```
7 L X+0 Y+25 RL F300 M3
```

```
8 L X+25 Y+30
```

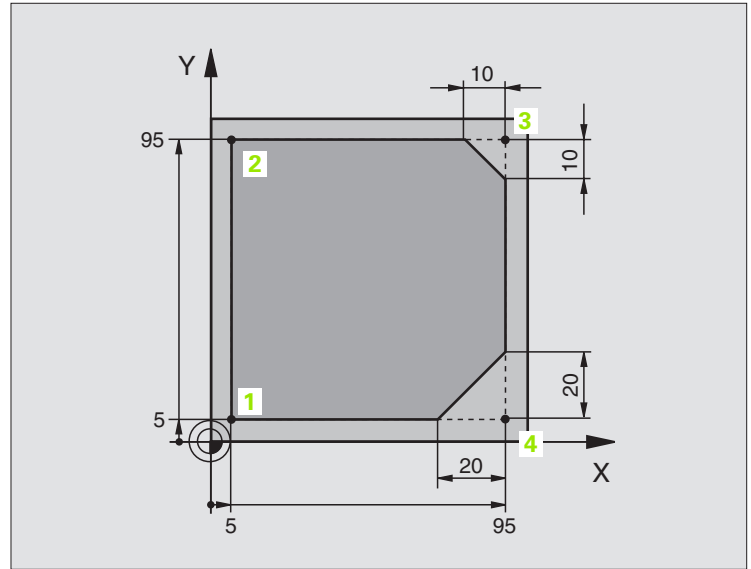
```
9 CT X+45 Y+20
```

```
10 L Y+0
```



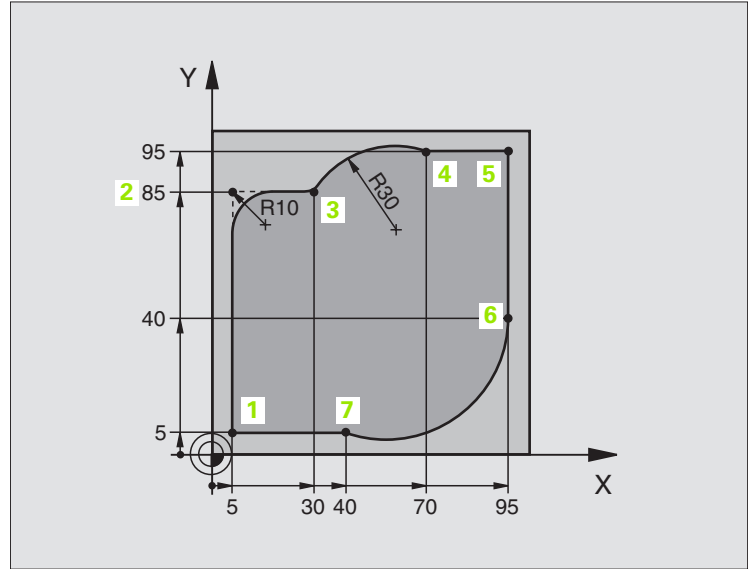
A tangential arc is a two-dimensional operation: the coordinates in the CT block and in the contour element preceding it must be in the same plane as the arc.

## Example: Linear movements and chamfers with Cartesian coordinates



0 BEGIN PGM LINEAR MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	Define blank form for graphic workpiece simulation
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+10	Define tool in the program
4 TOOL CALL 1 Z S4000	Call tool in the spindle axis and with the spindle speed S
5 L Z+250 R0 FMAX	Retract tool in the spindle axis at rapid traverse FMAX
6 L X-10 Y-10 R0 FMAX	Pre-position the tool
7 L Z-5 R0 F1000 M3	Move to working depth at feed rate F = 1000 mm/min
8 APPR LT X+5 X+5 LEN10 RL F300	Approach the contour at point 1 on a straight line with tangential connection
9 L Y+95	Move to point 2
10 L X+95	Point 3: first straight line for corner 3
11 CHF 10	Program chamfer with length 10 mm
12 L Y+5	Point 4: 2nd straight line for corner 3, 1st straight line for corner 4
13 CHF 20	Program chamfer with length 20 mm
14 L X+5	Move to last contour point 1, second straight line for corner 4
15 DEP LT LEN10 F1000	Depart the contour on a straight line with tangential connection
16 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
17 END PGM LINEAR MM	

## Example: Circular movements with Cartesian coordinates

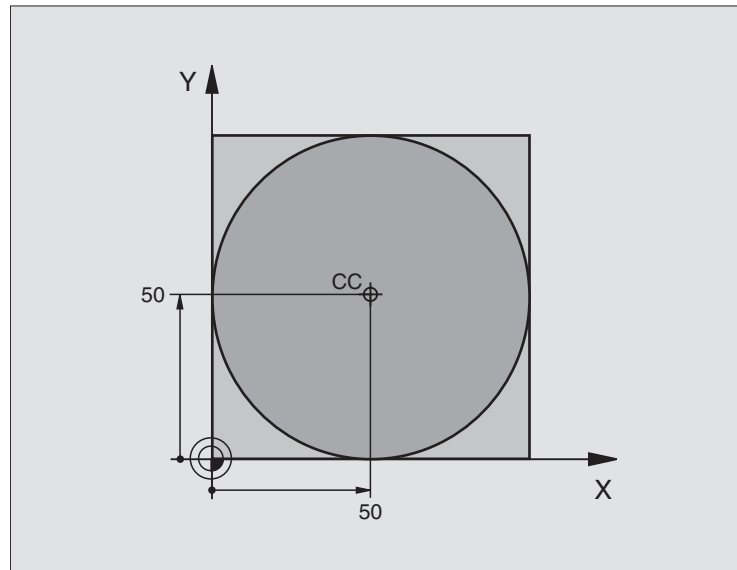


0 BEGIN PGM CIRCULAR MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	Define blank form for graphic workpiece simulation
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+10	Define tool in the program
4 TOOL CALL 1 Z X4000	Call tool in the spindle axis and with the spindle speed S
5 L Z+250 R0 FMAX	Retract tool in the spindle axis at rapid traverse FMAX
6 L X-10 Y-10 R0 FMAX	Pre-position the tool
7 L Z-5 R0 F1000 M3	Move to working depth at feed rate F = 1000 mm/min
8 APPR LCT X+5 Y+5 R5 RL F300	Approach the contour at point 1 on a circular arc with tangential connection
9 L X+5 Y+85	Point 2: first straight line for corner 2
10 RND R10 F150	Insert radius with R = 10 mm, feed rate: 150 mm/min
11 L X+30 Y+85	Move to point 3: Starting point of the arc with CR
12 CR X+70 Y+95 R+30 DR-	Move to point 4: End point of the arc with CR, radius 30 mm
13 L X+95	Move to point 5
14 L X+95 Y+40	Move to point 6
15 CT X+40 Y+5	Move to point 7: End point of the arc, radius with tangential connection to point 6, TNC automatically calculates the radius

16 L X+5	Move to last contour point 1
17 DEP LCT X-20 Y-20 R5 F1000	Depart the contour on a circular arc with tangential connection
18 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
19 END PGM CIRCULAR MM	



# Example: Full circle with Cartesian coordinates



0 BEGIN PGM C-CC MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+12,5	Define the tool
4 TOOL CALL 1 Z S3150	Tool call
5 CC X+50 Y+50	Define the circle center
6 L Z+250 R0 FMAX	Retract the tool
7 L X-40 Y+50 R0 FMAX	Pre-position the tool
8 L Z-5 R0 F1000 M3	Move to working depth
9 APPR LCT X+0 Y+50 R5 RL F300	Approach the starting point of the circle on a circular arc with connection
10 C X+0 DR-	Move to the circle end point (= circle starting point)
11 DEP LCT X-40 Y+50 R5 F1000	Depart the contour on a circular arc with tangential connection
12 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
13 END PGM C-CC MM	

## 6.5 Path Contours – Polar Coordinates









### Overview

With polar coordinates you can define a position in terms of its angle PA and its distance PR relative to a previously defined pole CC (see “Fundamentals” on page 210).

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

Function	Path function key	Tool movement	Required input
Line <b>LP</b>	 + 	Straight line	Polar radius, polar angle of the straight-line end point
Circular Arc <b>CP</b>	 + 	Circular path around circle center/pole CC to arc end point	Polar angle of the arc end point, direction of rotation
Circular Arc <b>CTP</b>	 + 	Circular arc with tangential connection to the preceding contour element	Polar radius, polar angle of the arc end point
Helical interpolation	 + 	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



## Polar coordinate origin: Pole CC

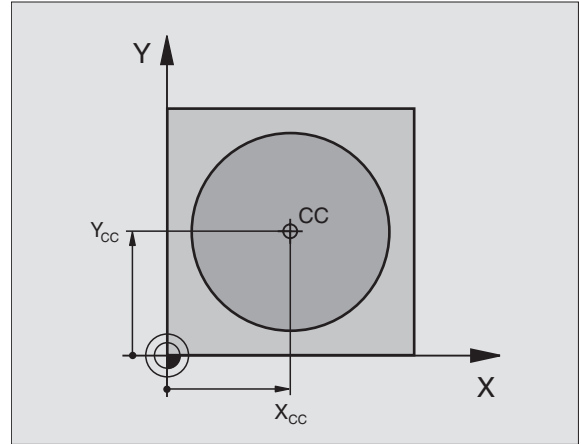
You can define the pole CC anywhere in the part program before blocks containing polar coordinates. Enter the pole in Cartesian coordinates as a circle center in a CC block.



- **Coordinates CC:** Enter Cartesian coordinates for the pole, or  
If you want to use the last programmed position, do not enter any coordinates. Before programming polar coordinates, define the pole CC. You can only define the pole CC in Cartesian coordinates. The pole CC remains in effect until you define a new pole CC.

### Example NC blocks

```
12 CC X+45 Y+25
```



## Straight line LP

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 block.



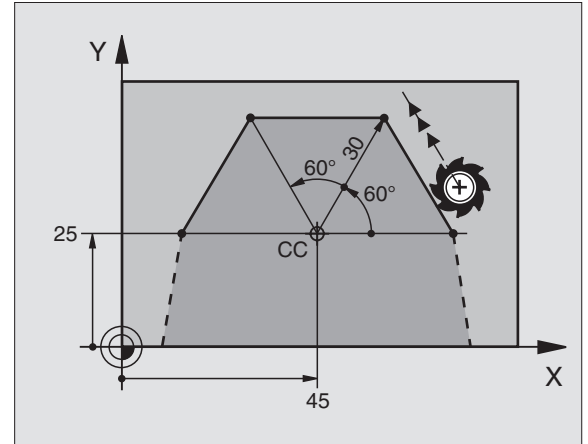
- **Polar coordinates radius PR:** Enter the distance from the pole CC to the straight-line end point.
- **Polar coordinates angle PA:** Angular position of the straight-line end point between  $-360^\circ$  and  $+360^\circ$ .

The sign of PA depends on the angle reference axis:

- Angle from angle reference axis to PR is counterclockwise:  $PA > 0$
- Angle from angle reference axis to PR is clockwise:  $PA < 0$

### Example NC blocks

```
12 CC X+45 Y+25
13 LP PR+30 PA+0 RR F300 M3
14 LP PA+60
15 LP IPA+60
16 LP PA+180
```



## Circular path CP around pole CC

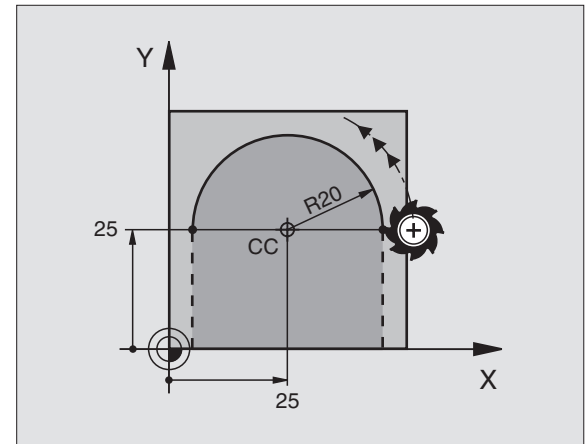
The polar coordinate radius PR is also the radius of the arc. It is defined by the distance from the starting point to the pole CC. The last programmed tool position before the CP block is the starting point of the arc.



- **Polar-coordinates angle PA:** Angular position of the arc end point between  $-5400^\circ$  and  $+5400^\circ$
- **Direction of rotation DR**

### Example NC blocks

```
18 CC X+25 Y+25
19 LP PR+20 PA+0 RR F250 M3
20 CP PA+180 DR+
```



For incremental coordinates, enter the same sign for DR and PA.



## Circular path CTP with tangential connection

The tool moves on a circular path, starting tangentially from a preceding contour element.



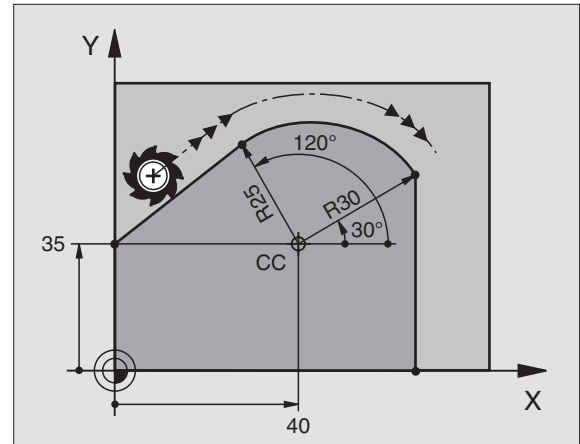
- **Polar coordinates radius PR:** Distance from the arc end point to the pole CC
- **Polar coordinates angle PA:** Angular position of the arc end point

### Example NC blocks

```
12 CC X+40 Y+35
13 L X+0 Y+35 RL F250 M3
14 LP PR+25 PA+120
15 CTP PR+30 PA+30
16 L Y+0
```



The pole CC is **not** the center of the contour arc!



## Helical interpolation

A helix is a combination of a circular movement in a main plane and a linear movement perpendicular to this plane.

A helix is programmed only in polar coordinates.

### Application

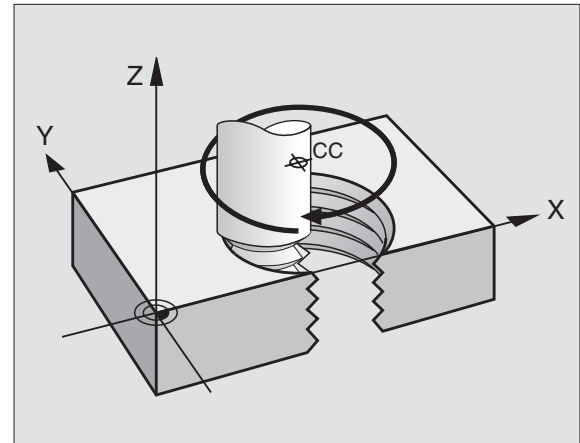
- Large-diameter internal and external threads
- Lubrication grooves

### 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.

For calculating a helix that is to be cut in an upward direction, you need the following data:

Thread revolutions $n$	Thread revolutions + thread overrun at thread beginning and end
Total height $h$	Thread pitch $P$ times thread revolutions $n$
Incremental total angle IPA	Number of revolutions times $360^\circ$ + 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	Radius comp.
Right-handed	Z+	DR+	RL
Left-handed	Z+	DR-	RR
Right-handed	Z-	DR-	RR
Left-handed	Z-	DR+	RL

External thread			
Right-handed	Z+	DR+	RR
Left-handed	Z+	DR-	RL
Right-handed	Z-	DR-	RL
Left-handed	Z-	DR+	RR

Programming a helix



Always enter the same algebraic sign for the direction of rotation DR and the incremental total angle IPA. The tool may otherwise move in a wrong path and damage the contour.

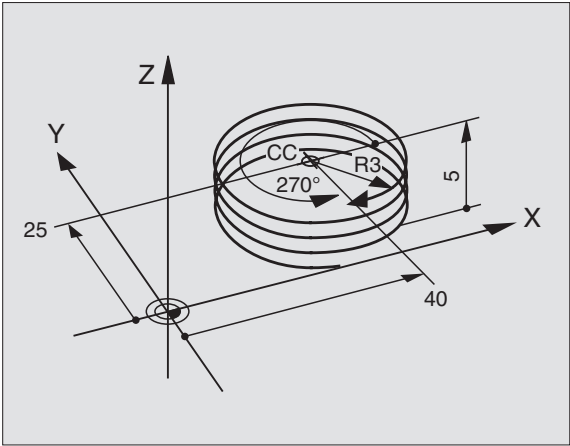
For the total angle IPA, you can enter a value from -5400° to +5400°. If the thread has more than 15 revolutions, program the helix in a program section repeat (see “Program Section Repeats” on page 488).



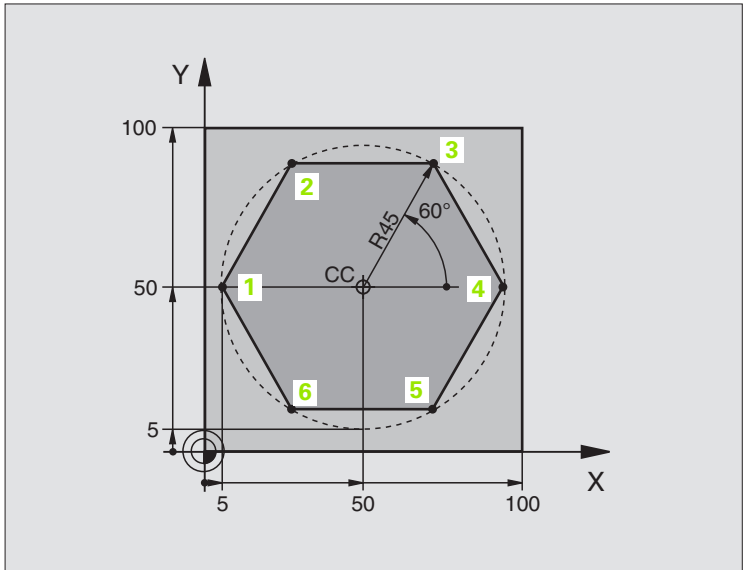
- **Polar coordinates angle:** Enter the total angle of tool traverse along the helix in incremental dimensions. **After entering the angle, specify the tool axis with an axis selection key.**
- **Coordinate:** Enter the coordinate for the height of the helix in incremental dimensions.
- **Direction of rotation DR**  
Clockwise helix: DR-  
Counterclockwise helix: DR+

Example NC blocks: Thread M6 x 1 mm with 5 revolutions

```
12 CC X+40 Y+25
13 L Z+0 F100 M3
14 LP PR+3 PA+270 RL F50
15 CP IPA-1800 IZ+5 DR-
```



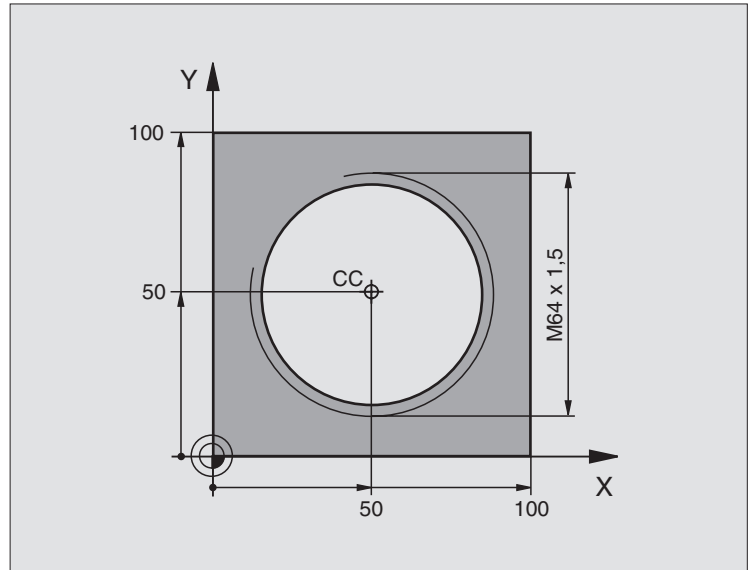
# Example: Linear movement with polar coordinates



0 BEGIN PGM LINEARPO MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+7,5	Define the tool
4 TOOL CALL 1 Z S4000	Tool call
5 CC X+50 Y+50	Define the datum for polar coordinates
6 L Z+250 R0 FMAX	Retract the tool
7 LP PR+60 PA+180 R0 FMAX	Pre-position the tool
8 L Z-5 R0 F1000 M3	Move to working depth
9 APPR PLCT PR+45 PA+180 R5 RL F250	Approach the contour at point 1 on a circular arc with tangential connection
10 LP PA+120	Move to point 2
11 LP PA+60	Move to point 3
12 LP PA+0	Move to point 4
13 LP PA-60	Move to point 5
14 LP PA-120	Move to point 6
15 LP PA+180	Move to point 1
16 DEPART PLCT PR+60 PA+180 R5 F1000	Depart the contour on a circular arc with tangential connection
17 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
18 END PGM LINEARPO MM	



## Example: Helix



0 BEGIN PGM HELIX MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+5	Define the tool
4 TOOL CALL 1 Z S1400	Tool call
5 L Z+250 R0 FMAX	Retract the tool
6 L X+50 Y+50 R0 FMAX	Pre-position the tool
7 CC	Transfer the last programmed position as the pole
8 L Z-12,75 R0 F1000 M3	Move to working depth
9 APPR PCT PR+32 PA-182 CCA180 R+2 RL F100	Approach the contour on a circular arc with tangential connection
10 CP IPA+3240 IZ+13.5 DR+ F200	Helical interpolation
11 DEP CT CCA180 R+2	Depart the contour on a circular arc with tangential connection
12 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
13 END PGM HELIX MM	

To cut a thread with more than 16 revolutions

...	
8 L Z-12.75 R0 F1000	
9 APPR PCT PR+32 PA-180 CCA180 R+2 RL F100	
10 LBL 1	Identify beginning of program section repeat
11 CP IPA+360 IZ+1.5 DR+ F200	Enter the thread pitch as an incremental IZ dimension
12 CALL LBL 1 REP 24	Program the number of repeats (thread revolutions)
13 DEP CT CCA180 R+2	
...	



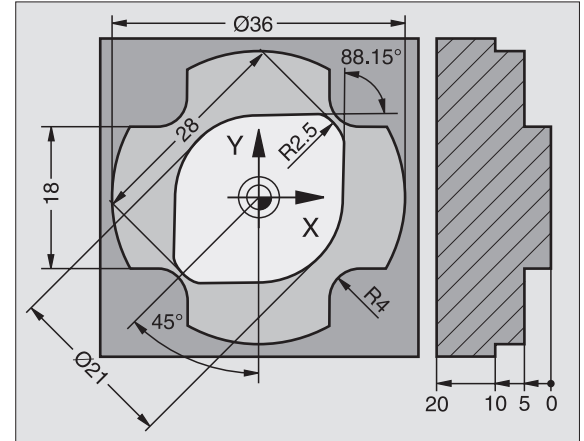
## 6.6 Path Contours—FK Free Contour Programming

### 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 may, for example, have only the following data on a specific contour element:

- Known coordinates on the contour element or in its proximity
- Coordinate data that are referenced to another contour element
- Directional data and data regarding the course of the contour

You can enter such dimensional data directly by using the FK free contour programming function. The TNC derives the contour from the known coordinate data and supports the programming dialog with the interactive programming graphics. The figure to the upper right shows a workpiece drawing for which FK programming is the most convenient programming method.



#### The following prerequisites for FK programming must be observed:

The FK free contour programming feature can only be used for programming contour elements that lie in the working plane. The working plane is defined in the first BLK FORM block of the part program.

You must enter all available data for every contour element. Even the data that does not change must be entered in every 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 a program, the FK contour must be fully defined before you can return to conventional programming.

The TNC needs a fixed point from which it can calculate the contour elements. 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 block.

If the first 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 to fully define the direction of contour approach.

Do not program an FK contour immediately after an LBL label.



### Create FK programs for TNC 4xx:

For a TNC 4xx to be able to read-in FK programs created on an iTNC 530, the individual FK elements within a block must be in the same sequence as displayed in the soft-key row.

## Graphics during FK programming



If you wish to use graphic support during FK programming, select the PROGRAM + GRAPHICS screen layout (see “Programming and editing” on page 41).

Incomplete coordinate data often are not sufficient to fully define a workpiece contour. In this case, the TNC indicates the possible solutions in the FK graphic. You can then select the contour that matches the drawing. The FK graphic displays the elements of the workpiece contour in different colors:

- White** The contour element is fully defined.
- Green** The entered data describe a limited number of possible solutions: select the correct one.
- Red** The entered data are not sufficient to determine the contour element: enter further data.

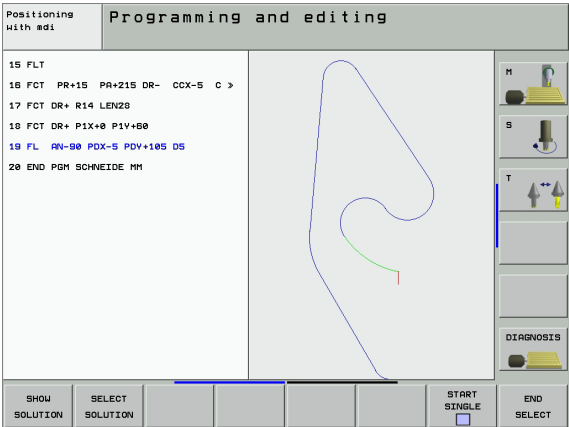
If the entered data permit a limited number of possible solutions and the contour element is displayed in green, select the correct contour element as follows:



► Press the SHOW SOLUTION soft key repeatedly until the correct contour element is displayed. Use the zoom function (2nd soft-key row) if you cannot distinguish possible solutions in the standard setting.



► If the displayed contour element matches the drawing, select the contour element with SELECT SOLUTION.



If you do not yet wish to select a green contour element, press the EDIT soft key to continue the FK dialog.



Select the green contour elements as soon as possible with the SELECT SOLUTION soft key. This way you can reduce the ambiguity of subsequent elements.

The machine tool builder may use other colors for the FK graphics.

NC blocks from a program that you called with PGM CALL are displayed in another color.

## Show block number in graphic window

To show a block number in the graphic window:



- Set the SHOW OMIT BLOCK NR. soft key to SHOW (soft-key row 3)

## Converting FK programs into HEIDENHAIN conversational format



If you wish to use graphic support during FK programming, select the PROGRAM + GRAPHICS screen layout (see “Programming and editing” on page 41).

The result of conversion depends on the setting of the AUTO DRAW soft key (3rd soft-key row):



- 3. Select the soft-key row.



- Select the soft-key row with functions for converting programs.



- Convert the FK blocks of the selected program. The TNC converts all FK blocks into straight-line blocks (L) and circular-arc blocks (CC, C).



The name of the file created by the TNC consists of the old file name and the extension **\_NC**. Example:

- File name of the FK program: **HEBEL.H**
- File name of the conversational dialog program converted by the TNC: **HEBEL\_NC.H**

The resolution of the created conversational program is 0.1 µm.






The converted program includes the comment after the converted NC blocks **SNR** and a number. The number indicates the block number of the FK program from which the respective conversational block was calculated.



### Initiating the FK dialog

If you press the gray FK button, the TNC displays the soft keys you can use to initiate an FK dialog: See the following table. Press the FK button a second time to deselect the soft keys.

If you initiate the FK dialog with one of these soft keys, the TNC shows additional soft-key rows that you can use for entering known coordinates, directional data and data regarding the course of the contour.

Contour element	Soft key
Straight line with tangential connection	
Straight line without tangential connection	
Circular arc with tangential connection	
Circular arc without tangential connection	
Pole for FK programming	



## Free programming of straight lines

### 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 TNC displays additional soft keys.
- ▶ Enter all known data in the block by using these soft keys. The FK graphic displays the programmed contour element in red until sufficient data is entered. If the entered data describes several solutions, the graphic will display the contour element in green (see “Graphics during FK programming” on page 211).

### Straight line with tangential connection

If the straight line connects tangentially to another contour element, initiate the dialog with the FLT 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 block by using the soft keys.

## Free programming of circular arcs

### 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 TNC 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 block by using these soft keys. The FK graphic displays the programmed contour element in red until sufficient data is entered. If the entered data describes several solutions, the graphic will display the contour element in green (see “Graphics during FK programming” on page 211).

### 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 block by using the soft keys.

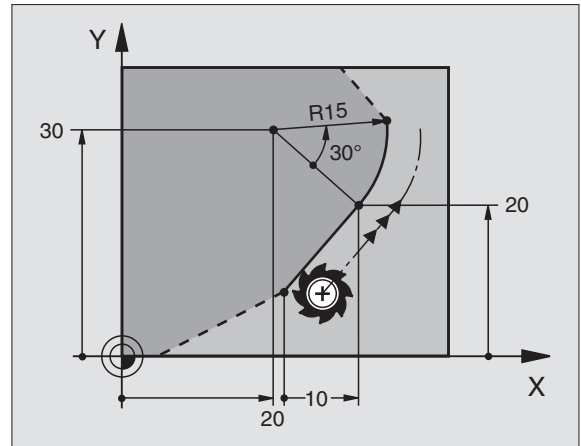
## Input possibilities

### End point coordinates






Known data	Soft keys	
Cartesian coordinates X and Y		
Polar coordinates referenced to FPOL		

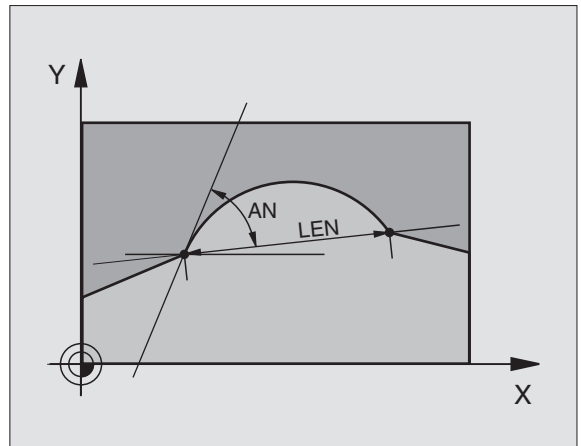
### Example NC blocks

7 FPOL X+20 Y+30
8 FL IX+10 Y+20 RR F100
9 FCT PR+15 IPA+30 DR+ R15



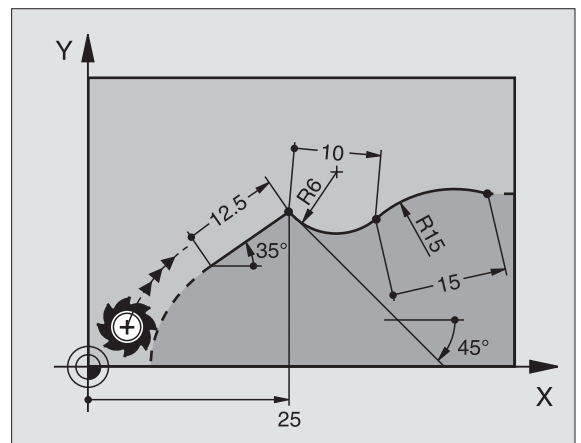
### Direction and length of contour elements

Known data	Soft keys
Length of a straight line	
Gradient angle of a straight line	
Chord length LEN of the arc	
Gradient angle AN of the entry tangent	
Center angle of the arc	



### Example NC blocks

27 FLT X+25 LEN 12.5 AN+35 RL F200
28 FC DR+ R6 LEN 10 A-45
29 FCT DR- R15 LEN 15



Circle center CC, radius and direction of rotation in the FC/FCT block

The TNC calculates a circle center for free-programmed arcs from the data you enter. This makes it possible to program full circles in an FK program block.

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 block in which another FPOL is defined.

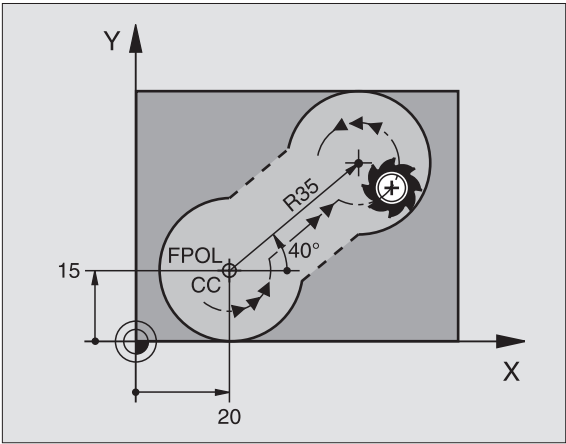


A circle center that was calculated or programmed conventionally is then no longer valid as a pole or circle center for the new FK contour: If you enter conventional polar coordinates that refer to a pole from a CC block you have defined previously, then you must enter the pole again in a CC block after the FK contour.

Known data	Soft keys	
Circle center in Cartesian coordinates		
Circle center in polar coordinates		
Rotational direction of the arc		
Radius of the arc		

Example NC blocks

```
10 FC CCX+20 CCY+15 DR+ R15
11 FPOL X+20 Y+15
12 FL AN+40
13 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 blocks of an FK section.



Beginning of contour:	CLSD+
End of contour:	CLSD-

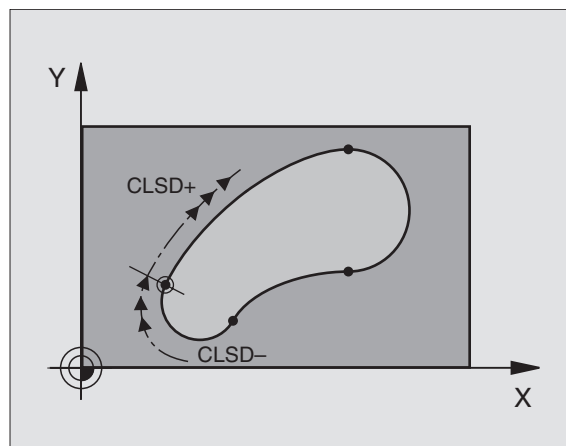
Example NC blocks

```
12 L X+5 Y+35 RL F500 M3
```

```
13 FC DR- R15 CLSD+ CCX+20 CCY+35
```

```
...
```

```
17 FCT DR- R+15 CLSD-
```













Auxiliary points







You can enter the coordinates of auxiliary points that are located on the contour or in its proximity for both free-programmed straight lines and free-programmed circular arcs.

Auxiliary points on a contour

The auxiliary points are located on a straight line or on the extension of a straight line, or on a circular arc.

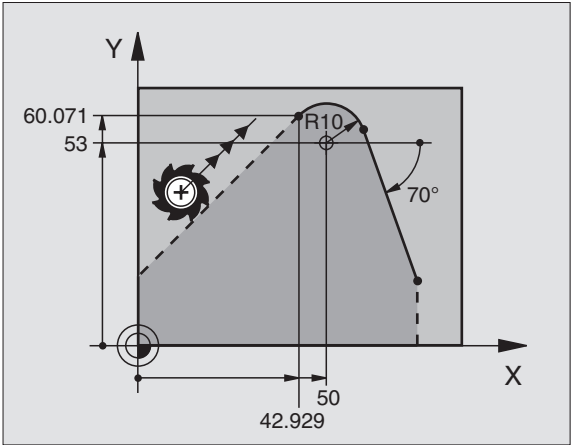
Known data	Soft keys		
X coordinate of an auxiliary point P1 or P2 of a straight line			
Y coordinate of an auxiliary point P1 or P2 of a straight line			
X coordinate of an auxiliary point P1, P2 or P3 of a circular arc			
Y coordinate of an auxiliary point P1, P2 or P3 of a circular arc			

Auxiliary points near a contour

Known data	Soft keys	
X and Y coordinates of an auxiliary point near a straight line		
Distance auxiliary point/straight line		
X and Y coordinates of an auxiliary point near a circular arc		
Distance auxiliary point/circular arc		




Example NC blocks

13 FC DR- R10 P1X+42.929 P1Y+60.071
14 FLT AH-70 PDX+50 PDY+53 D10









Data relative to block N: Direction and distance of the contour element

Known data	Soft key
Angle between a straight line and another element or between the entry tangent of the arc and another element	
Straight line parallel to another contour element	
Distance from a straight line to a parallel contour element	

Example NC blocks

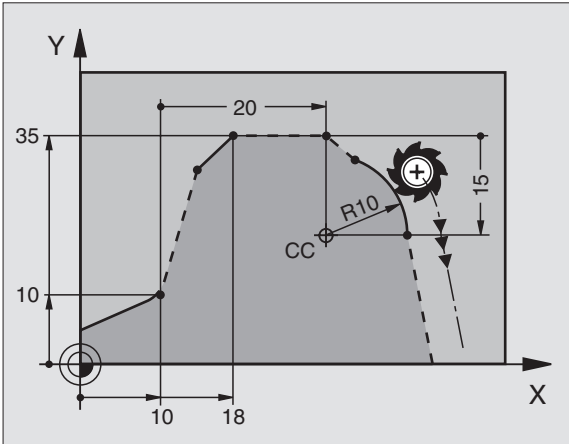
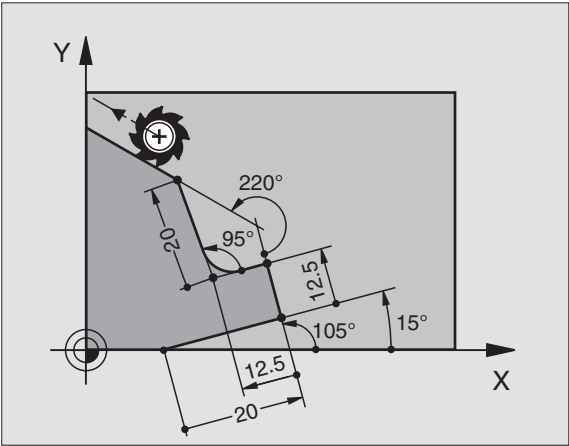
```
17 FL LEN 20 AH+15
18 FL AN+105 LEN 12.5
19 FL PAR 17 DP 12.5
20 FSELECT 2
21 FL LEN 20 IAH+95
22 FL IAH+220 RAN 18
```

Data relative to block N: Circle center CC

Known data	Soft key	
Cartesian coordinates of the circle center relative to block N		
Polar coordinates of the circle center relative to block N		

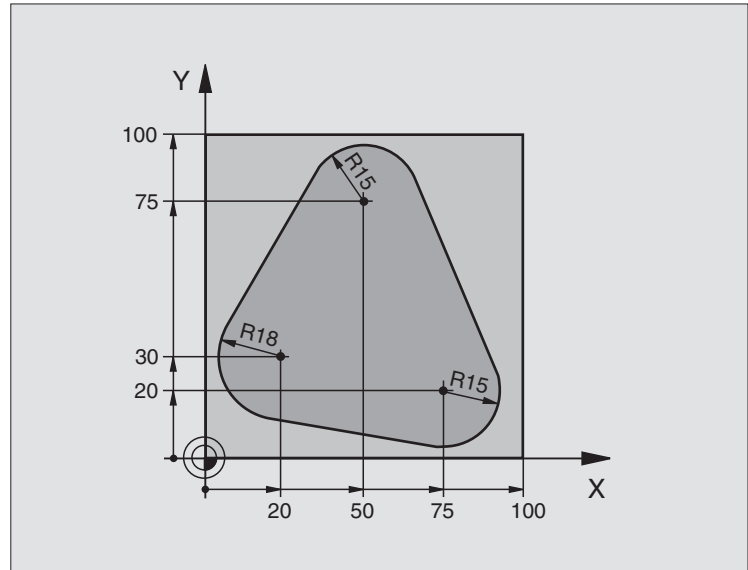
Example NC blocks

```
12 FL X+10 Y+10 RL
13 FL ...
14 FL X+18 Y+35
15 FL ...
16 FL ...
17 FC DR- R10 CCA+0 ICCX+20 ICCY-15 RCCX12 RCCY14
```



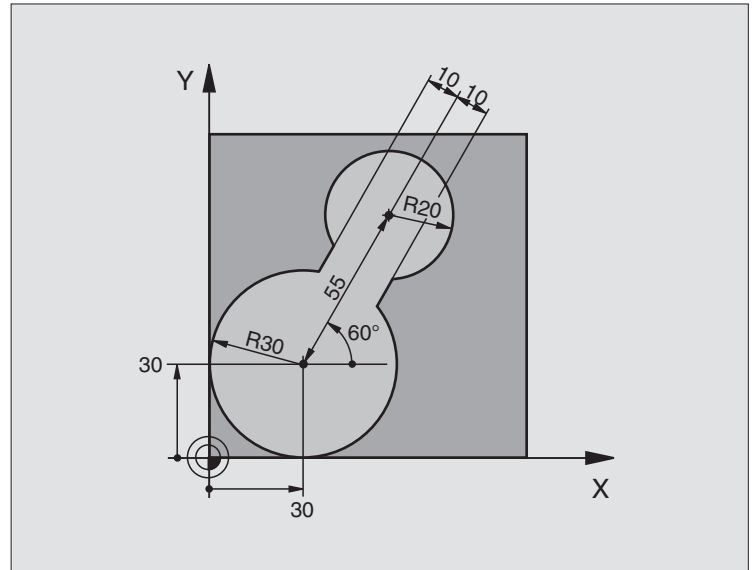


## Example: FK programming 1



0 BEGIN PGM FK1 MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+10	Define the tool
4 TOOL CALL 1 Z S500	Tool call
5 L Z+250 R0 FMAX	Retract the tool
6 L X-20 Y+30 R0 FMAX	Pre-position the tool
7 L Z-10 R0 F1000 M3	Move to working depth
8 APPR CT X+2 Y+30 CCA90 R+5 RL F250	Approach the contour on a circular arc with tangential connection
9 FC DR- R18 CLSD+ CCX+20 CCY+30	FK contour section:
10 FLT	Program all known data for each contour element
11 FCT DR- R15 CCX+50 CCY+75	
12 FLT	
13 FCT DR- R15 CCX+75 CCY+20	
14 FLT	
15 FCT DR- R18 CLSD- CCX+20 CCY+30	
16 DEP CT CCA90 R+5 F1000	Depart the contour on a circular arc with tangential connection
17 L X-30 Y+0 R0 FMAX	
18 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
19 END PGM FK1 MM	

## Example: FK programming 2

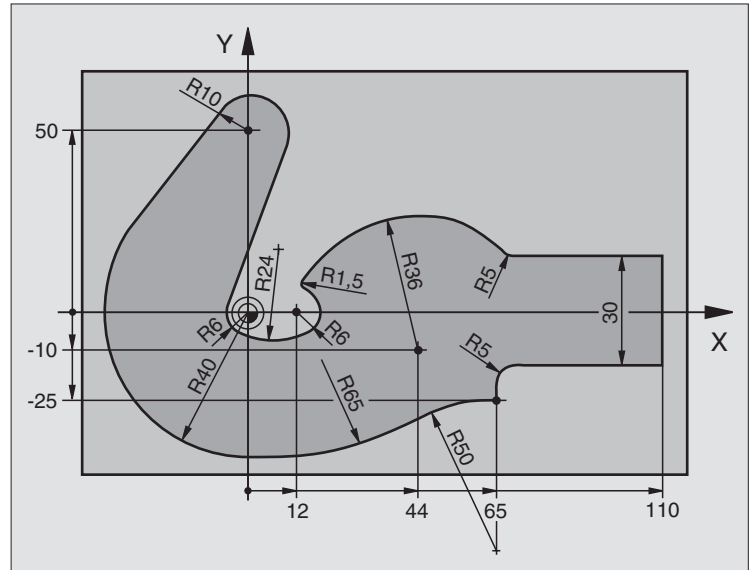


0 BEGIN PGM FK2 MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+2	Define the tool
4 TOOL CALL 1 Z S4000	Tool call
5 L Z+250 R0 FMAX	Retract the tool
6 L X+30 Y+30 R0 FMAX	Pre-position the tool
7 L Z+5 R0 FMAX M3	Pre-position the tool in the tool axis
8 L Z-5 R0 F100	Move to working depth

9 APPR LCT X+0 Y+30 R5 RR F350	Approach the contour on a circular arc with tangential connection
10 FPOL X+30 Y+30	FK contour section:
11 FC DR- R30 CCX+30 CCY+30	Program all known data for each contour element
12 FL AN+60 PDX+30 PDY+30 D10	
13 FSELECT 3	
14 FC DR- R20 CCPR+55 CCPA+60	
15 FSELECT 2	
16 FL AN-120 PDX+30 PDY+30 D10	
17 FSELECT 3	
18 FC X+0 DR- R30 CCX+30 CCY+30	
19 FSELECT 2	
20 DEP LCT X+30 Y+30 R5	Depart the contour on a circular arc with tangential connection
21 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
22 END PGM FK2 MM	



## Example: FK programming 3



0 BEGIN PGM FK3 MM	
1 BLK FORM 0.1 Z X-45 Y-45 Z-20	Define the workpiece blank
2 BLK FORM 0.2 X+120 Y+70 Z+0	
3 TOOL DEF 1 L+0 R+3	Define the tool
4 TOOL CALL 1 Z S4500	Tool call
5 L Z+250 R0 FMAX	Retract the tool
6 L X-70 Y+0 R0 FMAX	Pre-position the tool
7 L Z-5 R0 F1000 M3	Move to working depth

8 APPR CT X-40 Y+0 CCA90 R+5 RL F250	Approach the contour on a circular arc with tangential connection
9 FC DR- R40 CCX+0 CCY+0	FK contour section:
10 FLT	Program all known data for each contour element
11 FCT DR- R10 CCX+0 CCY+50	
12 FLT	
13 FCT DR+ R6 CCX+0 CCY+0	
14 FCT DR+ R24	
15 FCT DR+ R6 CCX+12 CCY+0	
16 FSELECT 2	
17 FCT DR- R1.5	
18 FCT DR- R36 CCX+44 CCY-10	
19 FSELECT 2	
20 FCT CT+ R5	
21 FLT X+110 Y+15 AN+0	
22 FL AN-90	
23 FL X+65 AN+180 PAR21 DP30	
24 RND R5	
25 FL X+65 Y-25 AN-90	
26 FC DR+ R50 CCX+65 CCY-75	
27 FCT DR- R65	
28 FSELECT	
29 FCT Y+0 DR- R40 CCX+0 CCY+0	
30 FSELECT 4	
31 DEP CT CCA90 R+5 F1000	Depart the contour on a circular arc with tangential connection
32 L X-70 R0 FMAX	
33 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
34 END PGM FK3 MM	



## 6.7 Contour Movements—Spline Interpolation (Software Option 2)

### Function

If you wish to machine contours that are described in a CAD system as splines, you can transfer them directly to the TNC and execute them. The TNC features a spline interpolator for executing third-degree polynomials in two, three, four, or five axes.



You cannot edit spline blocks in the TNC. Exception: Feed rate **F** and miscellaneous function **M** in the spline block.

#### Example: Block format for three axes

7 L X+28.338 Y+19.385 Z-0.5 FMAX	Spline starting point
8 SPL X24.875 Y15.924 Z-0.5 K3X-4.688E-002 K2X2.459E-002 K1X3.486E+000 K3Y-4.563E-002 K2Y2.155E-002 K1Y3.486E+000 K3Z0.000E+000 K2Z0.000E+000 K1Z0.000E+000 F10000	Spline end point Spline parameters for X axis Spline parameters for Y axis Spline parameters for Z axis
9 SPL X17.952 Y9.003 Z-0.500 K3X5.159E-002 K2X-5.644E-002 K1X6.928E+000 K3Y3.753E-002 K2Y-2.644E-002 K1Y6.910E+000 K3Z0.000E+000 K2Z0.000E+000 K1Z0.000E+000	Spline end point Spline parameters for X axis Spline parameters for Y axis Spline parameters for Z axis
10 ...	

The TNC executes the spline block according to the following third-degree polynomials:

$$X(t) = K3X \cdot t^3 + K2X \cdot t^2 + K1X \cdot t + X$$

$$Y(t) = K3Y \cdot t^3 + K2Y \cdot t^2 + K1Y \cdot t + Y$$

$$Z(t) = K3Z \cdot t^3 + K2Z \cdot t^2 + K1Z \cdot t + Z$$

whereby the variable  $t$  runs from 1 to 0. The incrementation of  $t$  depends on the feed rate and the length of the spline.

#### Example: Block format for five axes

7 L X+33.909 X-25.838 Z+75.107 A+17 B-10.103 FMAX	Spline starting point
8 SPL X+39.824 Y-28.378 Z+77.425 A+17.32 B-12.75 K3X+0.0983 K2X-0.441 K1X-5.5724 K3Y-0.0422 K2Y+0.1893 1Y+2.3929 K3Z+0.0015 K2Z-0.9549 K1Z+3.0875 K3A+0.1283 K2A-0.141 K1A-0.5724 K3B+0.0083 K2B-0.413 E+2 K1B-1.5724 E+1 F10000	Spline end point Spline parameters for X axis Spline parameters for Y axis Spline parameters for Z axis Spline parameters for A axis Spline parameters for B axis with exponential notation
9 ...	



The TNC executes the spline block according to the following third-degree polynomials:

$$X(t) = K3X \cdot t^3 + K2X \cdot t^2 + K1X \cdot t + X$$

$$Y(t) = K3Y \cdot t^3 + K2Y \cdot t^2 + K1Y \cdot t + Y$$

$$Z(t) = K3Z \cdot t^3 + K2Z \cdot t^2 + K1Z \cdot t + Z$$

$$A(t) = K3A \cdot t^3 + K2A \cdot t^2 + K1A \cdot t + A$$

$$B(t) = K3B \cdot t^3 + K2B \cdot t^2 + K1B \cdot t + B$$

whereby the variable  $t$  runs from 1 to 0. The incrementation of  $t$  depends on the feed rate and the length of the spline.



For every end-point coordinate in the spline block, the spline parameters K3 to K1 must be programmed. The end-point coordinates can be programmed in any sequence within the spline block.

The TNC always expects the spline parameters K for each axis in the sequence K3, K2, K1.

Beside the principal axes X, Y and Z, the TNC can also process the secondary axes U, V and W, and the rotary axes A, B and C. The respective corresponding axis must then be programmed in the spline parameter K (e.g. K3A+0.0953 K2A-0.441 K1A+0.5724).

If the absolute value of a spline parameter K becomes greater than 9.999 999 99, then the post processor must output K in exponential notation (e.g. K3X+1.2750 E2).

The TNC can execute a program with spline blocks even when the working plane is tilted.

Ensure that the transitions from one spline to the next are as tangential as possible (directional changes of less than 0.1°). The TNC otherwise performs an exact stop if the filter functions are disabled, resulting in a jolting of the machine tool. If the filter functions are active, the TNC decreases the feed rate accordingly at these positions.

The spline starting point can deviate from the end point of the previous contour by no more than 1 µm. Larger deviations will provoke an error message.

#### Input ranges

- Spline end point: -99 999.9999 to +99 999.9999
- Spline parameter K: -9.999 999 99 to +9.999 999 99
- Exponent for spline parameter K: -255 to +255 (whole number).









# 7

**Programming:  
Miscellaneous Functions**



## 7.1 Entering Miscellaneous Functions M and STOP

### Fundamentals

With the TNC's miscellaneous functions – also called M functions – you can affect:

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



The machine tool builder may add some M functions that are not described in this User's Manual. Refer to your machine manual.

You can enter up to two M functions at the end of a positioning block or in a separate block. The TNC displays the following dialog question:

**Miscellaneous function M ?**

You usually enter only the number of the M function in the programming dialog. Some M functions can be programmed with additional parameters. In this case, the dialog is continued for the parameter input.

In the Manual Operation and Electronic Handwheel modes of operation, the M functions are entered with the M soft key.



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.

M functions come into effect in the block in which they are called.

Some M functions are effective only in the block in which they are programmed. Unless the M function is only effective blockwise, either you must cancel it in a subsequent block with a separate M function, or it is automatically canceled by the TNC at the end of the program.

### Entering an M function in a STOP block

If you program a STOP block, the program run or test run is interrupted at the block, for example for tool inspection. You can also enter an M function in a STOP block:



- ▶ To program an interruption of program run, press the STOP key.
- ▶ Enter miscellaneous function M.

Example NC blocks

```
87 STOP M6
```

## 7.2 Miscellaneous Functions for Program Run Control, Spindle and Coolant

### Overview

M	Effect	Effective at block	start	End
<b>M00</b>	Stop program run Spindle STOP Coolant OFF			■
<b>M01</b>	Optional program STOP			■
<b>M02</b>	Stop program run Spindle STOP Coolant OFF Go to block 1 Clear the status display (depends on MP7300)			■
<b>M03</b>	Spindle ON clockwise		■	
<b>M04</b>	Spindle ON counterclockwise		■	
<b>M05</b>	Spindle STOP			■
<b>M06</b>	Tool change Spindle STOP Program run stop (depends on MP7440)			■
<b>M08</b>	Coolant ON		■	
<b>M09</b>	Coolant OFF			■
<b>M13</b>	Spindle ON clockwise Coolant ON		■	
<b>M14</b>	Spindle ON counterclockwise Coolant ON		■	
<b>M30</b>	Same as M02			■



## 7.3 Miscellaneous Functions for Coordinate Data

### Programming machine-referenced coordinates: M91/M92

#### Scale reference point

On the scale, a reference mark indicates the position of the scale reference point.

#### Machine datum

The machine datum is required for the following tasks:

- Defining the limits of traverse (software limit switches)
- Moving to machine-referenced positions (such as tool change positions)
- Setting the workpiece datum

The distance in each axis from the scale reference point to the machine datum is defined by the machine tool builder in a machine parameter.

#### Standard behavior

The TNC references coordinates to the workpiece datum, see “Datum Setting (Without a 3-D Touch Probe)” on page 62.

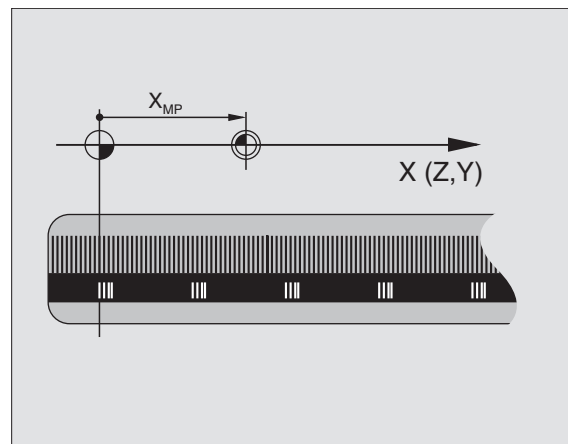
#### Behavior with M91—Machine datum

If you want the coordinates in a positioning block to be referenced to the machine datum, end the block with M91.



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 TNC screen are referenced to the machine datum. Switch the display of coordinates in the status display to REF (see “Status Displays” on page 43).



## Behavior with M92—Additional machine datum



In addition to the machine datum, the machine tool builder can also define an additional machine-based position as a reference point.

For each axis, the machine tool builder defines the distance between the machine datum and this additional machine datum. Refer to the machine manual for more information.

If you want the coordinates in a positioning block to be based on the additional machine datum, end the block with M92.



Radius compensation remains the same in blocks that are programmed with M91 or M92. The tool length, however, is **not** compensated.

### Effect

M91 and M92 are effective only in the blocks in which they are programmed.

M91 and M92 take effect at the start of block.

### Workpiece datum

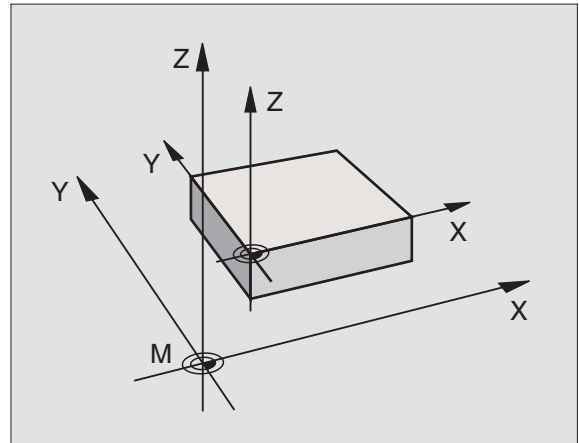
If you want the coordinates to always be referenced to the machine datum, you can inhibit datum setting for one or more axes.

If datum setting is inhibited for all axes, the TNC no longer displays the soft key DATUM SET in the Manual Operation mode.

The figure at right shows coordinate systems with the machine datum 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 set datum (see "Showing the Workpiece in the Working Space" on page 592).



## Activating the most recently entered datum: M104

### Function

When processing pallet tables, the TNC may overwrite your most recently entered datum with values from the pallet table. With M104 you can reactivate the original datum.

### Effect

M104 is effective only in the blocks in which it is programmed.

M104 becomes effective at the end of block.

## Moving to positions in a non-tilted coordinate system with a tilted working plane: M130

### Standard behavior with a tilted working plane

The TNC places the coordinates in the positioning blocks in the tilted coordinate system.

### Behavior with M130

The TNC places coordinates in straight line blocks in the untilted coordinate system.

The TNC then positions the (tilted) tool to the programmed coordinates of the untilted system.



Subsequent positioning blocks or fixed cycles are carried out in a tilted coordinate system. This can lead to problems in fixed cycles with absolute pre-positioning.

The function M130 is allowed only if the tilted working plane function is active.

### Effect

M130 functions blockwise in straight-line blocks without tool radius compensation.

## 7.4 Miscellaneous Functions for Contouring Behavior

### Smoothing corners: M90

#### Standard behavior

The TNC stops the tool briefly in positioning blocks without tool radius compensation. This is called an exact stop.

In program blocks with radius compensation (RR/RL), the TNC automatically inserts a transition arc at outside corners.

#### Behavior with M90

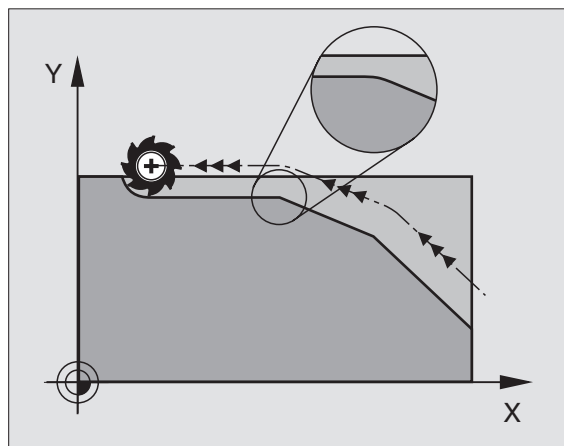
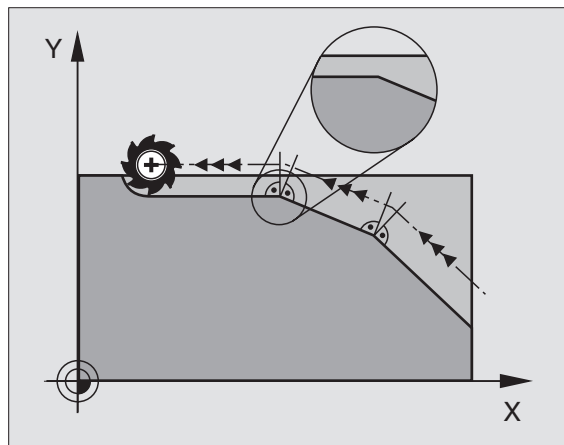
The tool moves at corners with constant speed: This provides a smoother, more continuous surface. Machining time is also reduced. See figure at center right.

Application example: Surface consisting of a series of straight line segments.

#### Effect

M90 is effective only in the blocks in which it is programmed with M90.

M90 becomes effective at the start of block. Operation with servo lag must be active.



## Insert rounding arc between straight lines: M112

### Compatibility

For reasons of compatibility, the M112 function is still available. However, to define the tolerance for fast contour milling, HEIDENHAIN recommends the use of the TOLERANCE cycle (see "Special Cycles" on page 446).

## Do not include points when executing non-compensated line blocks: M124

### Standard behavior

The TNC runs all line blocks that have been entered in the active program.

### Behavior with M124

When running **non-compensated line blocks** with very small point intervals, you can use parameter **T** to define a minimum point interval up to which the TNC will not include points during execution.

### Effect

M124 becomes effective at the start of block.

The TNC automatically resets M124 if you select a new program.

### Programming M124

If you enter M124 in a positioning block, the TNC continues the dialog for this block by asking you the minimum distance between points **T**.

You can also define **T** through Q parameters (see "Programming: Q Parameters" on page 501).



## Machining small contour steps: M97

### Standard behavior

The TNC inserts a transition arc at outside corners. If the contour steps are very small, however, the tool would damage the contour.

In such cases the TNC interrupts program run and generates the error message "Tool radius too large."

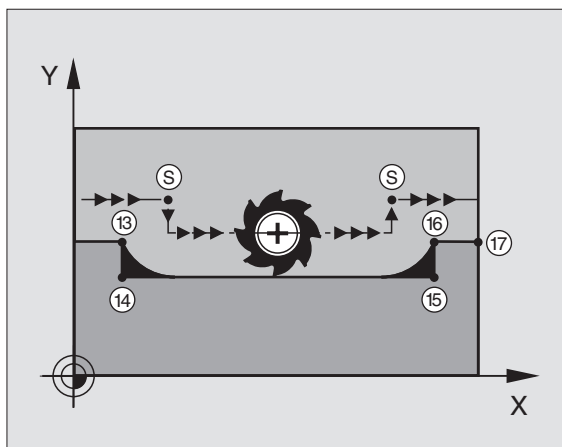
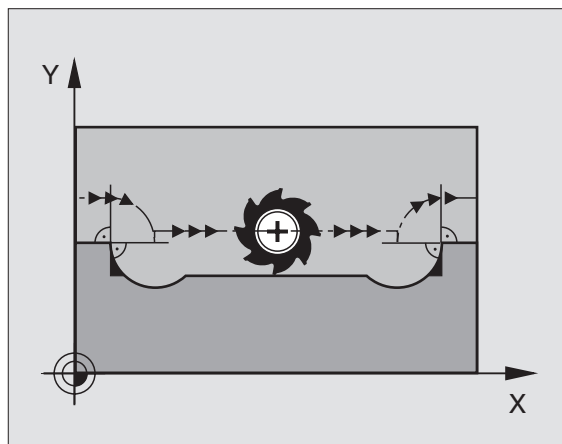
### Behavior with M97

The TNC calculates the intersection of the contour elements—as at inside corners—and moves the tool over this point.

Program M97 in the same block as the outside corner.



Instead of **M97** you should use the much more powerful function **M120 LA** (see "Calculating the radius-compensated path in advance (LOOK AHEAD): M120" on page 242)!



Effect

M97 is effective only in the blocks in which it is programmed.



A corner machined with M97 will not be completely finished. You may wish to rework the contour with a smaller tool.

Example NC blocks

5 T00L DEF L ... R+20	Large tool radius
...	
13 L X... Y... R... F... M97	Move to contour point 13
14 L IY-0.5 ... R... F...	Machine small contour step 13 to 14
15 L IX+100 ...	Move to contour point 15
16 L IY+0.5 ... R... F... M97	Machine small contour step 15 to 16
17 L X... Y...	Move to contour point 17



## Machining open contours: M98

### Standard behavior

The TNC 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 miscellaneous function M98, the TNC temporarily suspends radius compensation to ensure that both corners are completely machined.

### Effect

M98 is effective only in the blocks in which it is programmed.

M98 takes effect at the end of block.

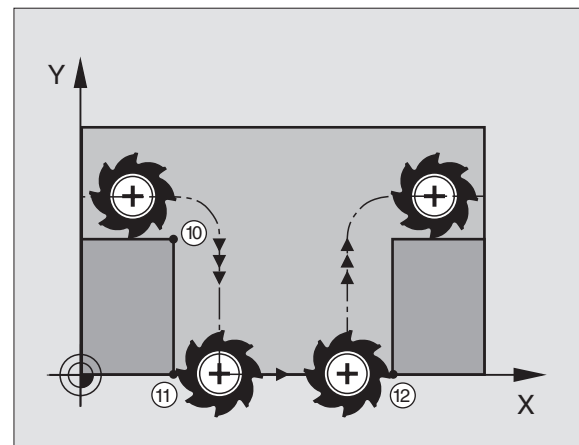
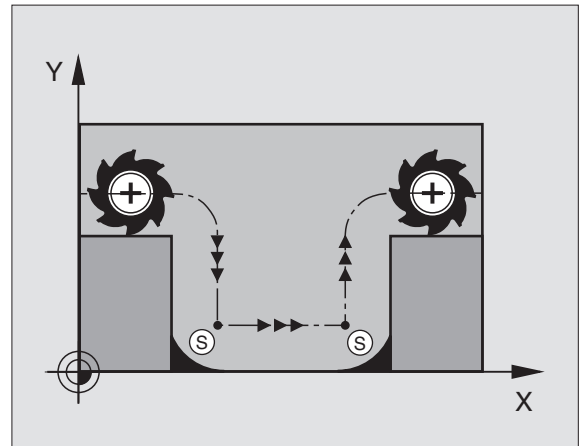
### Example NC blocks

Move to the contour points 10, 11 and 12 in succession:

```
10 L X... Y... RL F
```

```
11 L X... IY... M98
```

```
12 L IX+ ...
```



Feed rate factor for plunging movements: M103

Standard behavior

The TNC moves the tool at the last programmed feed rate, regardless of the direction of traverse.

Behavior with M103

The TNC 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 enter M103 in a positioning block, the TNC continues the dialog by asking you the factor F.

Effect

M103 becomes effective at the start of block.  
To cancel M103, program M103 once again without a factor.



M103 is also effective in an active tilted working plane.  
The feed rate reduction is then effective during traverse in the negative direction of the **tilted** tool axis.

Example NC blocks

The feed rate for plunging is to be 20% of the feed rate in the plane.

...	Actual contouring feed rate (mm/min):
17 L X+20 Y+20 RL F500 M103 F20	500
18 L Y+50	500
19 L IZ-2.5	100
20 L IY+5 IZ-5	141
21 L IX+50	500
22 L Z+5	500



## Feed rate in millimeters per spindle revolution: M136

### Standard behavior

The TNC moves the tool at the programmed feed rate F in mm/min.

### Behavior with M136

With M136, the TNC does not move the tool in mm/min, but rather at the programmed feed rate F in millimeters per spindle revolution. If you change the spindle speed by using the spindle override, the TNC changes the feed rate accordingly.

### Effect

M136 becomes effective at the start of block.

You can cancel M136 by programming M137.



## Feed rate for circular arcs: M109/M110/M111

### Standard behavior

The TNC applies the programmed feed rate to the path of the tool center.

### Behavior at circular arcs with M109

The TNC adjusts the feed rate for circular arcs at inside and outside contours so that the feed rate at the tool cutting edge remains constant.

### Behavior at circular arcs with M110

The TNC keeps the feed rate constant for circular arcs at inside contours only. At outside contours, the feed rate is not adjusted.



M110 is also effective for the inside machining of circular arcs using contour cycles. If you define M109 or M110 before calling a machining cycle, the adjusted feed rate is also effective for circular arcs within machining cycles. The initial state is restored after finishing or aborting a machining cycle.

### Effect

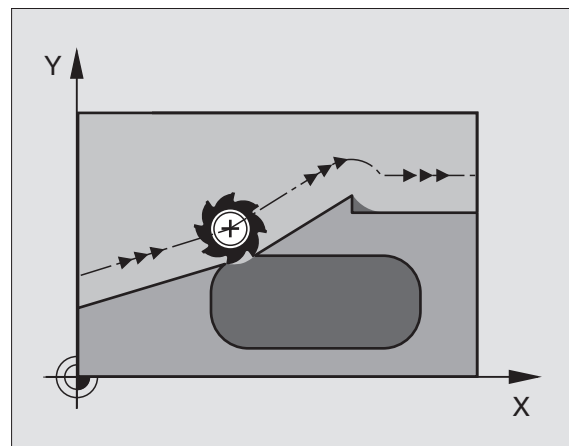
M109 and M110 become effective at the start of block.  
To cancel M109 and M110, enter M111.

## Calculating the radius-compensated path in advance (LOOK AHEAD): M120

### Standard behavior

If the tool radius is larger than the contour step that is to be machined with radius compensation, the TNC interrupts program run and generates an error message. M97 (see "Machining small contour steps: M97" on page 237) inhibits the error message, but this results in dwell marks and will also move the corner.

If the programmed contour contains undercut features, the tool may damage the contour.



### Behavior with M120

The TNC checks radius-compensated paths for contour undercuts and tool path intersections, and calculates the tool path in advance from the current block. Areas of the contour that might be damaged by the tool are not machined (dark areas in figure at right). You can also use M120 to calculate the radius compensation for digitized data or data created on an external programming system. This means that deviations from the theoretical tool radius can be compensated.

Use LA (**L**ook **A**head) behind M120 to define the number of blocks (maximum: 99) that you want the TNC to calculate in advance. Note that the larger the number of blocks you choose, the higher the block processing time will be.

### Input

If you enter M120 in a positioning block, the TNC continues the dialog for this block by asking you the number of blocks LA that are to be calculated in advance.

### Effect

M120 must be located in an NC block that also contains radius compensation RL or RR. M120 is then effective from this block until

- radius compensation is canceled, or
- M120 LA0 is programmed, or
- M120 is programmed without LA, or
- another program is called with PGM CALL.

M120 becomes effective at the start of block.

### Limitations

- After an external or internal stop, you can only re-enter the contour with the function RESTORE POS. AT N.
- When using the path functions RND and CHF, the blocks before and after them must contain only coordinates in the working plane.
- If you want to approach the contour on a tangential path, you must use the function APPR LCT. The block with APPR LCT must contain only coordinates of the working plane.
- If you want to depart the contour on a tangential path, use the function DEP LCT. The block with DEP LCT must contain only coordinates of the working plane.



## Superimposing handwheel positioning during program run: M118

### Standard behavior

In the program run modes, the TNC moves the tool as defined in the part program.

### Behavior with M118

M118 permits manual corrections by handwheel during program run. Just program M118 and enter an axis-specific value (linear or rotary axis) in millimeters.

### Input

If you enter M118 in a positioning block, the TNC continues the dialog for this block by asking you the axis-specific values. The coordinates are entered with the orange axis direction buttons or the ASCII keyboard.

### Effect

Cancel handwheel positioning by programming M118 once again without coordinate input.

M118 becomes effective at the start of block.

### Example NC blocks

You want to be able to use the handwheel during program run to move the tool in the working plane X/Y by  $\pm 1$  mm and in the rotary axis B by  $\pm 5^\circ$  from the programmed value:

```
L X+0 Y+38.5 RL F125 M118 X1 Y1 B5
```



M118 is always effective in the original coordinate system, even if the working plane is tilted.

M118 also functions in the Positioning with MDI mode of operation!

If M118 is active, the MANUAL OPERATION function is not available after a program interruption.



## Retraction from the contour in the tool-axis direction: M140

### Standard behavior

In the program run modes, the TNC moves the tool as defined in the part program.

### Behavior with M104

With M140 MB (move back) you can enter a path in the direction of the tool axis for departure from the contour.

### Input

If you enter M140 in a positioning block, the TNC continues the dialog and asks for the desired path of tool departure from the contour. Enter the requested path that the tool should follow when departing the contour, or press the MAX soft key to move to the limit of the traverse range.

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 TNC moves the tool along the entered path at rapid traverse.

### Effect

M140 is effective only in the block in which it is programmed.

M140 becomes effective at the start of the block.

### Example NC blocks

Block 250: Retract the tool 50 mm from the contour.

Block 251: Move the tool to the limit of the traverse range.

```
250 L X+0 Y+38.5 F125 M140 MB 50 F750
```

```
251 L X+0 Y+38.5 F125 M140 MB MAX
```



M140 is also effective if the tilted-working-plane function, M114 or M128 is active. On machines with tilting heads, the TNC then moves the tool in the tilted coordinate system.

With the **FN18: SYSREAD ID230 NR6** function you can find the distance from the current position to the limit of the traverse range in the positive tool axis.

With **M140 MB MAX** you can only retract in positive direction.



## Suppressing touch probe monitoring: M141

### Standard behavior

When the stylus is deflected, the TNC outputs an error message as soon as you attempt to move a machine axis.

### Behavior with M141

The TNC 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 connection with measuring cycle 3 in order to retract the stylus by means of a positioning block after it has been deflected.



If you use M141, make sure that you retract the touch probe in the correct direction.

M141 functions only for movements with straight-line blocks.

### Effect

M141 is effective only in the block in which it is programmed.

M141 becomes effective at the start of the block.

## Delete modal program information: M142

### Standard behavior

The TNC resets modal program information in the following situations:

- Select a new program.
- Execute a miscellaneous function M02, M30, or an END PGM block (depending on MP7300).
- Defining cycles for basic behavior with a new value

### Behavior with M142

All modal program information except for basic rotation, 3-D rotation and Q parameters are reset.



The function **M142** is not permitted during a mid-program startup.

### Effect

M142 is effective only in the block in which it is programmed.

M142 becomes effective at the start of the block.

## Delete 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 TNC erases a programmed basic rotation from the NC program.



The function **M143** is not permitted during a mid-program startup.

### Effect

M143 is effective only in the block in which it is programmed.

M143 becomes effective at the start of the block.



## Automatically retract tool from the contour at an NC stop: M148

### Standard behavior

At an NC stop the TNC stops all traverse movements. The tool stops moving at the point of interruption.

### Behavior with M148



The M148 function must be enabled by the machine tool builder.

The TNC retracts the tool by 0.1 mm in the direction of the tool axis if, in the **LIFTOFF** column of the tool table, you set the parameter **Y** for the active tool (see “Tool table: Standard tool data” on page 146).



Remember that, especially on curved surfaces, the surface can be damaged during return to the contour. Back the tool off before returning to the contour!

### Effect

M148 remains in effect until deactivated with M149.

M148 becomes effective at the start of block, M149 at the end of block.

## Suppress limit switch message: M150

### Standard behavior

The TNC stops program run with an error message if the tool were to leave the active working space during a positioning block. The error message is output before the positioning block is executed.

### Behavior with M150

If the end point of a positioning block with M150 is outside the current working space, the TNC moves the tool to the edge of the working space, and then continues the program run without an error message.



#### **Danger of collision!**

Keep in mind that the approach path to the position programmed after the M150 block might be changed significantly!

M150 is also effective on traverse range limits defined with the MOD function.

### Effect

M150 is effective only in the block in which it is programmed.

M150 becomes effective at the start of block.



## 7.5 Miscellaneous Functions for Rotary Axes

### Feed rate in mm/min on rotary axes A, B, C: M116 (software option 1)

#### Standard behavior

The TNC interprets the programmed feed rate in a rotary axis in degrees per minute. The contouring 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



The machine geometry must be entered in Machine Parameters 7510 and following by the machine tool builder.

M116 works only on rotary tables. M116 cannot be used with swivel heads. If your machine is equipped with a table/head combination, the TNC ignores the swivel-head rotary axes.

M116 is also effective in an active tilted working plane.

The TNC interprets the programmed feed rate in a rotary axis in mm/min. With this miscellaneous function, the TNC calculates the feed rate for each block at the start of the block. With a rotary axis, the feed rate is not changed during execution of the block even if the tool moves toward the center of the rotary axis.

#### Effect

M116 is effective in the working plane.

With M117 you can reset M116. M116 is also canceled at the end of the program.

M116 becomes effective at the start of block.

# Shorter-path traverse of rotary axes: M126

## Standard behavior

The standard behavior of the TNC while positioning rotary axes whose display has been reduced to values less than 360° depends on Machine Parameter 7682. In MP7682 is set whether the TNC should consider the difference between nominal and actual position, or whether the TNC should always (even without M126) choose the shortest path traverse to the programmed position. Examples:

Actual position	Nominal position	Traverse
350°	10°	−340°
10°	340°	+330°

## Behavior with M126

With M126, the TNC will move the axis on the shorter path of traverse if you reduce display of a rotary axis to a value less than 360°. Examples:

Actual position	Nominal position	Traverse
350°	10°	+20°
10°	340°	−30°

## Effect

M126 becomes effective at the start of block.  
To cancel M126, enter M127. At the end of program, M126 is automatically canceled.



## Reducing display of a rotary axis to a value less than 360°: M94

### Standard behavior

The TNC 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 TNC first reduces the current angular value to a value less than 360° and then moves the tool to the programmed value. If several rotary axes are active, M94 will reduce the display of all rotary axes. As an alternative you can enter a rotary axis after M94. The TNC then reduces the display only of this axis.

Example NC blocks

To reduce display of all active rotary axes:

```
L M94
```

To reduce display of the C axis only:

```
L M94 C
```

To reduce display of all active rotary axes and then move the tool in the C axis to the programmed value:

```
L C+180 FMAX M94
```

### Effect

M94 is effective only in the block in which it is programmed.

M94 becomes effective at the start of block.



## Automatic compensation of machine geometry when working with tilted axes: M114 (software option 2)

### Standard behavior

The TNC moves the tool to the positions given in the part program. If the position of a tilted axis changes in the program, the resulting offset in the linear axes must be calculated by a postprocessor and traversed in a positioning block. As the machine geometry is also relevant, the NC program must be calculated separately for each machine tool.

### Behavior with M114



The machine geometry must be entered in Machine Parameters 7510 and following by the machine tool builder.

If the position of a controlled tilted axis changes in the program, the TNC automatically compensates the tool offset by a 3-D length compensation. As the geometry of the individual machine tools is set in machine parameters, the TNC also compensates machine-specific offsets automatically. Programs only need to be calculated by the postprocessor once, even if they are being run on different machines with TNC control.

If your machine tool does not have controlled tilted axes (head tilted manually or positioned by the PLC), you can enter the current valid swivel head position after M114 (e.g. M114 B+45, Q parameters permitted).

The radius compensation must be calculated by a CAD system or by a postprocessor. A programmed radius compensation RL/RR will result in an error message.

If the tool length compensation is calculated by the TNC, the programmed feed rate refers to the point of the tool. Otherwise it refers to the tool datum.



If your machine tool is equipped with a swivel head that can be tilted under program control, you can interrupt program run and change the position of the tilted axis, for example with the handwheel.

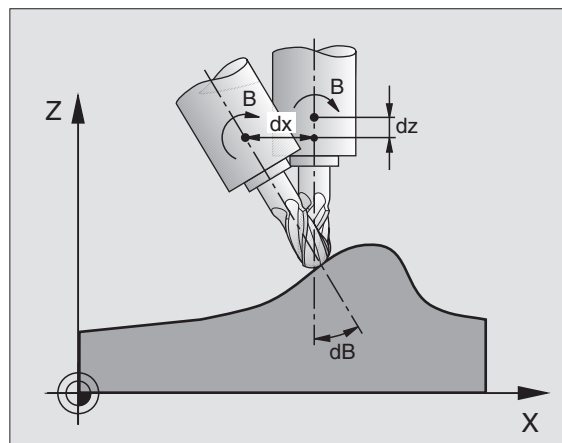
With the RESTORE POS. AT N function, you can then resume program run at the block at which the part program was interrupted. If M114 is active, the TNC automatically calculates the new position of the tilted axis.

If you wish to use the handwheel to change the position of the tilted axis during program run, use M118 in conjunction with M128.

### Effect

M114 becomes effective at the start of block, M115 at the end of block. M114 is not effective when tool radius compensation is active.

To cancel M114, enter M115. At the end of program, M114 is automatically canceled.



## Maintaining the position of the tool tip when positioning with tilted axes (TCPM): M128 (software option 2)

### Standard behavior

The TNC moves the tool to the positions given in the part program. If the position of a tilted axis changes in the program, the resulting offset in the linear axes must be calculated and traversed in a positioning block (see figure for M114).

### Behavior with M128 (TCPM: Tool Center Point Management)



The machine geometry must be entered in MPs 7510 and following by the machine tool builder.

If the position of a controlled tilted axis changes in the program, the position of the tool tip to the workpiece remains the same.

If you wish to use the handwheel to change the position of the tilted axis during program run, use **M128** in conjunction with **M118**. Handwheel positioning in a machine-based coordinate system is possible when **M128** is active.



For tilted axes with Hirth coupling: Do not change the position of the tilted axis until after retracting the tool. Otherwise you might damage the contour.


After **M128** you can program another feed rate, at which the TNC will carry out the compensation movements in the linear axes. If you program no feed rate here, or if you program a larger feed rate than is defined in MP7471, the feed rate from MP7471 will be effective.

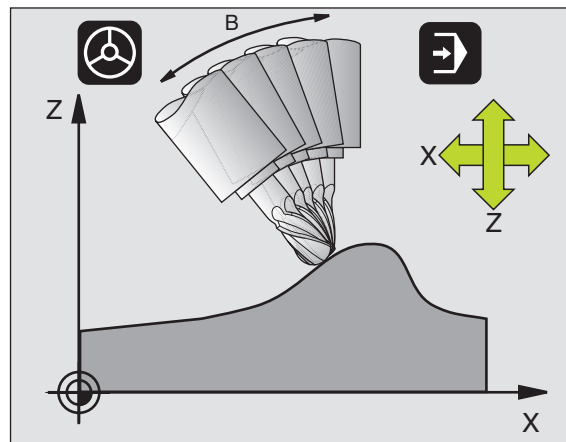


Reset **M128** before positioning with **M91** or **M92** and before a **TOOL CALL**.

To avoid contour gouging you must use only spherical cutters with **M128**.

The tool length must refer to the spherical center of the tool tip.

If M128 is active, the TNC shows the symbol  in the status display.



**M128 on tilting tables**

If you program a tilting table movement while **M128** is active, the TNC rotates the coordinate system accordingly. If, for example, you rotate the C axis by 90° (through a positioning command or datum shift) and then program a movement in the X axis, the TNC executes the movement in the machine axis Y.

The TNC also transforms the defined datum, which has been shifted by the movement of the rotary table.

**M128 with 3-D tool compensation**

If you carry out a 3-D tool compensation with active **M128** and active radius compensation **RL/RR**, the TNC will automatically position the rotary axes for certain machine geometrical configurations (Peripheral milling, see "Three-Dimensional Tool Compensation (Software Option 2)" on page 163).

**Effect**

**M128** becomes effective at the start of block, **M129** at the end of block. **M128** is also effective in the manual operating modes and remains active even after a change of mode. The feed rate for the compensation movement will be effective until you program a new feed rate or until you reset **M128** with **M129**.

To cancel **M128** enter **M129**. The TNC also resets **M128** if you select a new program in a program run operating mode.

Example NC blocks

Feed rate of 1000 mm/min for compensation movements.

```
L X+0 Y+38.5 IB-15 RL F125 M128 F1000
```



## Exact stop at corners with nontangential transitions: M134

### Standard behavior

The standard behavior of the TNC during positioning with rotary axes is to insert a transitional element in nontangential contour transitions. The contour of the transitional element depends on the acceleration, the rate of acceleration (jerk), and the defined tolerance for contour deviation.



With MP7440 you can change the standard behavior of the TNC so that M134 becomes active automatically whenever a program is selected (see “General User Parameters” on page 606).

### Behavior with M134

The TNC moves the tool during positioning with rotary axes so as to perform an exact stop at nontangential contour transitions.

### Effect

M134 becomes effective at the start of block, M135 at the end of block.

You can reset M134 with M135. The TNC also resets M134 if you select a new program in a program run operating mode.

## Selecting tilting axes: M138

### Standard behavior

The TNC performs M114 and M128, and tilts the working plane, only in those axes for which the machine tool builder has set the appropriate machine parameters.

### Behavior with M138

The TNC performs the above functions only in those tilting axes that you have defined using M138.

### Effect

M138 becomes effective at the start of block.

You can reset M138 by reprogramming it without entering any axes.

Example NC blocks

Perform the above-mentioned functions only in the tilting axis C:

```
L Z+100 RO FMAX M138 C
```

## Compensating the machine's kinematic configuration for ACTUAL/NOMINAL positions at end of block: M144 (software option 2)

### Standard behavior

The TNC moves the tool to the positions given in the part program. If the position of a tilted axis changes in the program, the resulting offset in the linear axes must be calculated, and traversed in a positioning block.

### Behavior with M144

The TNC calculates into the position value any changes in the machine's kinematic configuration which result, for example, from adding a spindle attachment. If the position of a controlled tilted axis changes, the position of the tool tip to the workpiece is also changed. The resulting offset is calculated in the position display.



Positioning blocks with M91/M92 are permitted if M144 is active.

The position display in the operating modes FULL SEQUENCE and SINGLE BLOCK 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 function in connection with M114, M128 or a tilted working plane.

You can cancel M144 by programming M145.



The machine geometry must be defined by the machine tool builder in MPs 7502 and following. The machine tool builder decides upon the behavior of the machine in the automatic and manual operating modes. Refer to your machine manual.



## 7.6 Miscellaneous Functions for Laser Cutting Machines

### Principle

The TNC can control the cutting efficiency of a laser by transferring voltage values through the S-analog output. You can influence laser efficiency during program run through the miscellaneous functions M200 to M204.

#### Entering miscellaneous functions for laser cutting machines

If you enter an M function for laser cutting machines in a positioning block, the TNC continues the dialog by asking you the required parameters for the programmed function.

All miscellaneous functions for laser cutting machines become effective at the start of the block.

### Output the programmed voltage directly: M200

#### Behavior with M200

The TNC outputs the value programmed after M200 as the voltage V.

Input range: 0 to 9.999 V

#### Effect

M200 remains in effect until a new voltage is output through M200, M201, M202, M203 or M204.

### Output voltage as a function of distance: M201

#### Behavior with M201

M201 outputs the voltage in dependence on the distance to be covered. The TNC increases or decreases the current voltage linearly to the value programmed for V.

Input range: 0 to 9.999 V

#### Effect

M201 remains in effect until a new voltage is output through M200, M201, M202, M203 or M204.

## Output voltage as a function of speed: M202

### Behavior with M202

The TNC outputs the voltage as a function of speed. In the machine parameters, the machine tool builder defines up to three characteristic curves FNR in which specific feed rates are assigned to specific voltages. Use miscellaneous function M202 to select the curve FNR from which the TNC is to determine the output voltage.

Input range: 1 to 3

### Effect

M202 remains in effect until a new voltage is output through M200, M201, M202, M203 or M204.

## Output voltage as a function of time (time-dependent ramp): M203

### Behavior with M203

The TNC outputs the voltage V as a function of the time TIME. The TNC increases or decreases the current voltage linearly to the value programmed for V within the time programmed for TIME.

### Input range

Voltage V: 0 to 9.999 Volt  
TIME: 0 to 1.999 seconds

### Effect

M203 remains in effect until a new voltage is output through M200, M201, M202, M203 or M204.

## Output voltage as a function of time (time-dependent pulse): M204

### Behavior with M204

The TNC outputs a programmed voltage as a pulse with a programmed duration TIME.

### Input range

Voltage V: 0 to 9.999 Volt  
TIME: 0 to 1.999 seconds

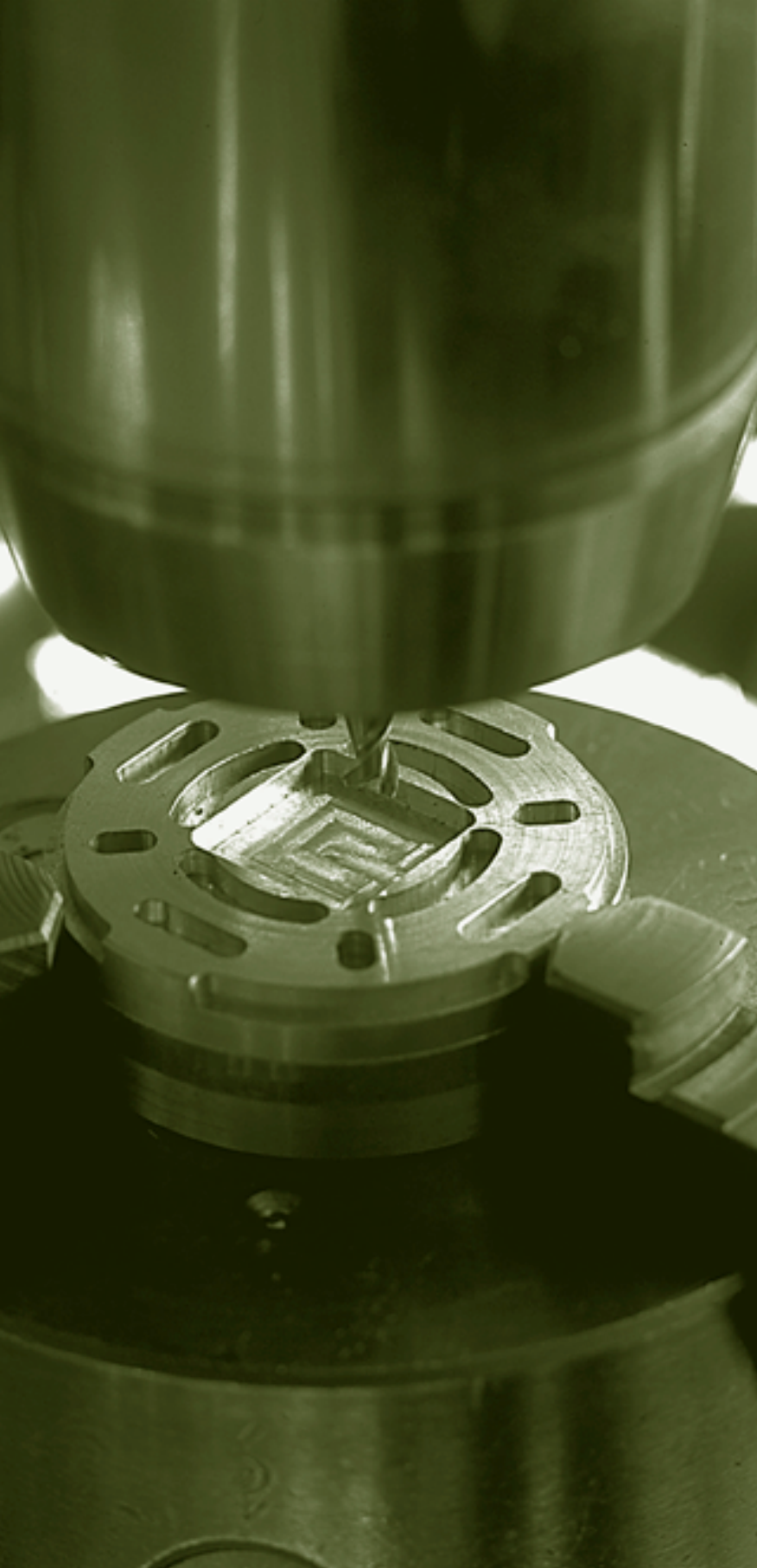
### Effect

M204 remains in effect until a new voltage is output through M200, M201, M202, M203 or M204.









# 8

**Programming: Cycles**



## 8.1 Working with Cycles

Frequently recurring machining cycles that comprise several working steps are stored in the TNC memory as standard cycles. Coordinate transformations and other special cycles are also provided as standard cycles (for an overview: see "Group of cycles" on page 264).

Fixed cycles with numbers 200 and above use Q parameters as transfer parameters. Parameters with specific functions that are required in several cycles always have the same number: For example, Q200 is always assigned the set-up clearance, Q202 the plunging depth, etc.



Fixed cycles sometimes execute extensive operations. For safety reasons, you should run a graphical program test before machining (see "Test Run" on page 558).

### Machine-specific cycles

In addition to the HEIDENHAIN cycles, many machine tool builders offer their own cycles in the TNC. These cycles are available in a separate cycle-number range:

- Cycles 300 to 399  
Machine-specific cycles that are to be defined through the CYCLE DEF key
- Cycles 500 to 599  
Machine-specific cycles that are to be defined through the TOUCH PROBE key



Refer to your machine manual for a description of the specific function.

Sometimes, machine-specific cycles also use transfer parameters, which HEIDENHAIN already use in the standard cycles. The TNC executes DEF-active cycles as soon as they are defined (See also "Calling cycles" on page 265). It executes CALL-active cycles only after they have been called (See also "Calling cycles" on page 265). When DEF-active cycles and CALL-active cycles are used simultaneously, it is important to prevent overwriting of transfer parameters already in use. Use the following procedure:

- ▶ As a rule, always program DEF-active cycles before CALL-active cycles.
- ▶ If you do want to program a DEF-active cycle between the definition and call of a CALL-active cycle, do it only if there is no common use of specific transfer parameters.

## Defining a cycle using soft keys

CYCL  
DEF

- ▶ The soft-key row shows the available groups of cycles.

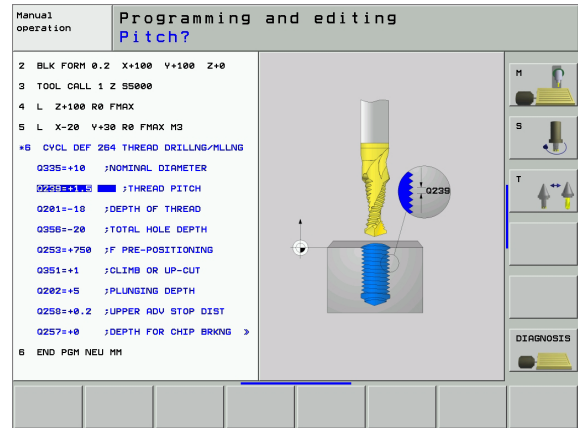
DRILLING/  
THREAD

- ▶ Press the soft key for the desired group of cycles, for example DRILLING for the drilling cycles.

262  
THREAD

- ▶ Select the desired cycle, for example THREAD MILLING. The TNC initiates the programming dialog and asks all required input values. At the same time a graphic of the input parameters is displayed in the right screen window. The parameter that is asked for in the dialog prompt is highlighted

- ▶ Enter all parameters requested by the TNC and conclude each entry with the ENT key.
- ▶ The TNC ends the dialog when all required data has been entered.



## Defining a cycle using the GOTO function

CYCL  
DEF

- ▶ The soft-key row shows the available groups of cycles.

GOTO  
□

- ▶ The TNC shows an overview of cycles in a pop-up window.
- ▶ Choose the desired cycle with the arrow keys, or
- ▶ Choose the desired cycle with CTRL and the arrow keys (for pagewise scrolling), or
- ▶ Enter the cycle number and confirm it with the ENT key. The TNC then initiates the cycle dialog as described above.

### Example NC blocks

7 CYCL DEF 200 DRILLING

Q200=2 ;SET-UP CLEARANCE

Q201=3 ;DEPTH

Q206=150 ;FEED RATE FOR PLUNGING

Q202=5 ;INFEEED DEPTH

Q210=0 ;DWELL TIME AT TOP

Q203=+0 ;SURFACE COORDINATE

Q204=50 ;2ND SET-UP CLEARANCE

Q211=0.25 ;DWELL TIME AT DEPTH

Group of cycles	Soft key
Cycles for pecking, reaming, boring, counterboring, tapping and thread milling	DRILLING/ THREAD
Cycles for milling pockets, studs and slots	POCKETS/ STUDS/ SLOTS
Cycles for producing point patterns, such as circular or linear hole patterns	PATTERN
SL (Subcontour List) cycles which allow the contour-parallel machining of relatively complex contours consisting of several overlapping subcontours, cylinder surface interpolation	SL I I
Cycles for face milling of flat or twisted surfaces	MULTIPASS MILLING
Coordinate transformation cycles which enable datum shift, rotation, mirror image, enlarging and reducing for various contours	COORD. TRANSF.
Special cycles such as dwell time, program call, oriented spindle stop and tolerance	SPECIAL CYCLES



If you use indirect parameter assignments in fixed cycles with numbers greater than 200 (e.g. **Q210 = Q1**), any change in the assigned parameter (e.g. Q1) will have no effect after the cycle definition. Define the cycle parameter (e.g. **Q210**) directly in such cases.

If you define a feed-rate parameter for fixed cycles greater than 200, then instead of entering a numerical value you can use soft keys to assign the feed rate defined in the **TOOL CALL** block (FAUTO soft key), or rapid traverse (FMAX soft key).

If you want to delete a block that is part of a cycle, the TNC asks you whether you want to delete the whole cycle.



## Calling cycles



### Prerequisites

The following data must always be programmed before a cycle call:

- **BLK FORM** for graphic display (needed only for test graphics)
- Tool call
- Direction of spindle rotation (M functions M3/M4)
- Cycle definition (CYCL DEF)

For some cycles, additional prerequisites must be observed. They are detailed in the descriptions for each cycle.

The following cycles become effective automatically as soon as they are defined in the part program. These cycles cannot and must not be called:

- Cycle 220 for point patterns on circles and Cycle 221 for point patterns on lines
- SL Cycle 14 CONTOUR GEOMETRY
- SL Cycle 20 CONTOUR DATA
- Cycle 32 TOLERANCE
- Coordinate Transformation Cycles
- Cycle 9 DWELL TIME

You can call all other cycles with the functions described as follows.

### Calling a cycle with CYCL CALL

The **CYCL CALL** function calls the fixed cycle that was last defined. The starting point of the cycle is the position that was programmed last before the CYCL CALL block.

CYCL  
CALL

- ▶ To program the cycle call, press the CYCL CALL key.
- ▶ Press the CYCL CALL M soft key to enter a cycle call.
- ▶ If necessary, enter the miscellaneous function M (for example **M3** to switch the spindle on), or end the dialog by pressing the END key

### Calling a cycle with CYCL CALL PAT

The **CYCL CALL PAT** function calls the most recently defined fixed cycle at all positions defined in a point table (see "Point Tables" on page 268).



## Calling a cycle with CYCL CALL POS

The **CYCL CALL POS** function calls the fixed cycle that was last defined. The starting point of the cycle is the position that you defined in the **CYCL CALL POS** block.

The TNC moves using positioning logic to the position defined in the **CYCL CALL POS** block.

- If the current position in the tool axis is greater than the top surface of the workpiece (Q203), the iTNC moves the tool to the programmed position first in the machining plane and then in the tool axis.
- If the current tool position in the tool axis is below the top surface of the workpiece (Q203), the TNC moves the tool to the programmed position first in the tool axis to the clearance height and then in the working plane to the programmed position.



Three coordinate axes must always be programmed in the **CYCL CALL POS** block. With the coordinate in the tool axis you can easily change the starting position. It serves as an additional datum shift.

The feed rate most recently defined in the **CYCL CALL POS** block applies only for traverse to the start position programmed in this block.

As a rule, the TNC moves without radius compensation (R0) to the position defined in the **CYCL CALL POS** block.

If you use **CYCL CALL POS** to call a cycle in which a start position is defined (for example Cycle 212), then the position defined in the cycles serves as an additional shift on the position defined in the **CYCL CALL POS** block. You should therefore always define the start position to be set in the cycle as 0.

## Cycle call with M99/89

The **M99** function, which is active only in the block in which it is programmed, calls the last defined fixed cycle once. You can program **M99** at the end of a positioning block. The TNC moves to this position and then calls the last defined fixed cycle.

If the TNC is to execute the cycle automatically after every positioning block, program the first cycle call with **M89** (depending on machine parameter 7440).

To cancel the effect of **M89**, program:

- **M99** in the positioning block in which you move to the last starting point, or
- Define with **CYCL DEF** a new fixed cycle

## Working with the secondary axes U/V/W

The TNC performs infeed movements in the axis that was defined in the TOOL CALL block as the spindle axis. It performs movements in the working plane only in the principal axes X, Y or Z. Exceptions:

- You program secondary axes for the side lengths in cycles 3 SLOT MILLING and 4 POCKET MILLING.
- You program secondary axes in the first block of the contour geometry subprogram of an SL cycle.
- In Cycles 5 (CIRCULAR POCKET), 251 (RECTANGULAR POCKET), 252 (CIRCULAR POCKET), 253 (SLOT) and 254 (CIRCULAR SLOT), the TNC machines the cycle in the axis that you programmed in the last positioning block before the cycle call. When tool axis Z is active, the following combinations are permissible:
  - X/Y
  - X/V
  - U/Y
  - U/V



## 8.2 Point Tables


### Function

You should create a point table whenever you want to run a cycle, or several cycles in sequence, on an irregular point pattern.

If you are using drilling cycles, the coordinates of the working plane in the point table represent the hole centers. If you are using milling cycles, the coordinates of the working plane in the point table represent the starting-point coordinates of the respective cycle (e.g. center-point coordinates of a circular pocket). Coordinates in the spindle axis correspond to the coordinate of the workpiece surface.

### Creating a point table


Select the **Programming and Editing** mode of operation.




To call the File Manager, press the PGM MGT key.

FILE NAME ?


NEW.PNT



Enter the name and file type of the point table and confirm your entry with the ENT key.




To select the unit of measure, press the MM or INCH soft key. The TNC changes to the program blocks window and displays an empty point table.



With the soft key INSERT LINE, insert new lines and enter the coordinates of the desired machining position.

Repeat the process until all desired coordinates have been entered.



With the soft keys X OFF/ON, Y OFF/ON, Z OFF/ON (second soft-key row), you can specify which coordinates you want to enter in the point table.





### Hiding single points from the machining process

In the **FADE** column of the points table you can specify if the defined point is to be hidden during the machining process (see “Optional Block Skip” on page 569).



In the table, select the point to be hidden.



Select the FADE column



Activate the hiding, or



Deactivate the hiding



## Selecting a point table in the program

In the Programming and Editing mode of operation, select the program for which you want to activate the point table:



Press the PGM CALL key to call the function for selecting the point table.



Press the POINT TABLE soft key.

Enter the name of the point table and confirm your entry with the END key. If the point table is not stored in the same directory as the NC program, you must enter the complete path.

### Example NC block

```
7 SEL PATTERN "TNC:\DIRKT5\NUST35.PNT"
```

## Calling a cycle in connection with point tables



With **CYCL CALL PAT** the TNC runs the point table that you last defined (even if you defined the point table in a program that was nested with **CALL PGM**).

If you want the TNC to call the last defined fixed cycle at the points defined in a point table, then program the cycle call with **CYCLE CALL PAT**:



- ▶ To program the cycle call, press the CYCL CALL key.
- ▶ Press the CYCL CALL PAT soft key to call a point table.
- ▶ Enter the feed rate at which the TNC is to move from point to point (if you make no entry the TNC will move at the last programmed feed rate; FMAX not valid).
- ▶ If required, enter a miscellaneous function M, then confirm with the END key.

The TNC retracts the tool to the safety clearance between the starting points. Depending on which is greater, the TNC uses either the spindle axis coordinate from the cycle call or the value from cycle parameter Q204 as the safety clearance.

If you want to move at reduced feed rate when pre-positioning in the spindle axis, use the miscellaneous function M103 (see "Feed rate factor for plunging movements: M103" on page 240).



### Effect of the point tables with SL cycles and Cycle 12

The TNC interprets the points as an additional datum shift.

### Effect of the point tables with Cycles 200 to 208 and 262 to 267

The TNC interprets the points of the working plane as coordinates of the hole centers. If you want to use the coordinate defined in the point table for the spindle axis as the starting point coordinate, you must define the workpiece surface coordinate (Q203) as 0.

### Effect of the point tables with Cycles 210 to 215

The TNC interprets the points as an additional datum shift. If you want to use the points defined in the point table as starting-point coordinates, you must define the starting points and the workpiece surface coordinate (Q203) in the respective milling cycle as 0.

### Effect of the point tables with Cycles 251 to 254

The TNC interprets the points of the working plane as coordinates of the cycle starting point. If you want to use the coordinate defined in the point table for the spindle axis as the starting point coordinate, you must define the workpiece surface coordinate (Q203) as 0.
















#### Applies to all 2xx cycles




As soon as the current tool axis position lies below the clearance height in with **CYCL CALL PAT**, the TNC displays the error message **PNT: Clearance plane too small**. The clearance height is calculated from the sum of the workpiece surface coordinate (Q203) and the 2nd set-up clearance (Q204, or set-up clearance Q200, if the value of Q200 is greater than Q204).

## 8.3 Cycles for Drilling, Tapping and Thread Milling

### Overview

Cycle	Soft key
240 CENTERING With automatic pre-positioning, 2nd set-up clearance, optional entry of the centering diameter or centering depth	
200 DRILLING With automatic pre-positioning, 2nd set-up clearance	
201 REAMING With automatic pre-positioning, 2nd set-up clearance	
202 BORING With automatic pre-positioning, 2nd set-up clearance	
203 UNIVERSAL DRILLING With automatic pre-positioning, 2nd set-up clearance, chip breaking, and decrementing	
204 BACK BORING With automatic pre-positioning, 2nd set-up clearance	
205 UNIVERSAL PECKING With automatic pre-positioning, 2nd set-up clearance, chip breaking, and advanced stop distance	
208 BORE MILLING With automatic pre-positioning, 2nd set-up clearance	
206 TAPPING NEW With a floating tap holder, with automatic pre-positioning, 2nd set-up clearance	
207 RIGID TAPPING NEW Without a floating tap holder, with automatic pre-positioning, 2nd set-up clearance	
209 TAPPING W/ CHIP BRKG Without a floating tap holder, with automatic pre-positioning, 2nd set-up clearance, chip breaking	
262 THREAD MILLING Cycle for milling a thread in pre-drilled material	
263 THREAD MILLNG/CNTSNKG Cycle for milling a thread in pre-drilled material and machining a countersunk chamfer	



Cycle	Soft key
264 THREAD DRILLING/MLLNG Cycle for drilling into the solid material with subsequent milling of the thread with a tool	
265 HEL.THREAD DRLG/MLG Cycle for milling the thread into the solid material	
267 OUTSIDE THREAD MLLNG Cycle for milling an external thread and machining a countersunk chamfer	



## CENTERING (Cycle 240)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to set-up clearance above the workpiece surface.
- 2 The tool is centered at the programmed feed rate F to the entered centering diameter or centering depth.
- 3 If defined, the tool remains at the centering depth.
- 4 Finally, the tool path is retraced to set-up clearance or—if programmed—to the 2nd set-up clearance at rapid traverse FMAX.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

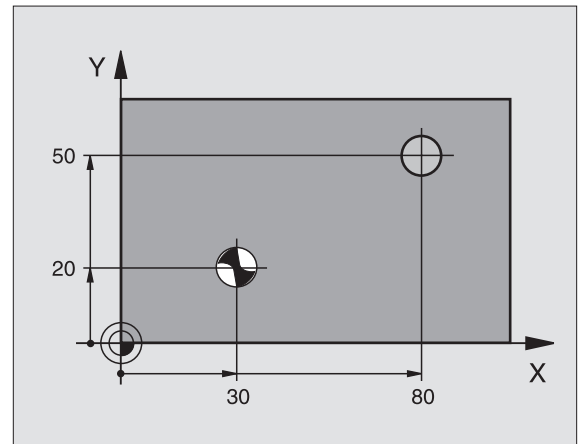
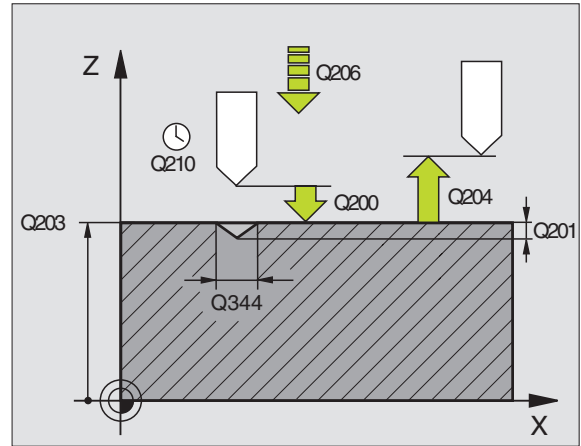
The algebraic sign for the cycle parameter Q344 (diameter) or Q201 (depth) determines the working direction. If you program the diameter or depth = 0, the cycle will not be executed.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive diameter or depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface. Enter a positive value.
- ▶ **Select Depth/Diameter (0/1)** Q343: Select whether centering is based on the entered diameter or depth. If centering is based on the entered diameter, the point angle of the tool must be defined in the **CUT** column of the tool table TOOL.T.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and centering bottom (tip of centering taper). Only effective if Q343=0 is defined.
- ▶ **Diameter (algebraic sign)** Q344: Centering diameter. Only effective if Q343=1 is defined.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool during centering in mm/min.
- ▶ **Dwell time at depth** Q211: Time in seconds that the tool remains at the hole bottom.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.

Example: NC blocks

10	L	Z+100	R0	FMAX
11	CYCL	DEF	240	CENTERING
	Q200=2		;SET-UP CLEARANCE	
	Q343=1		;SELECT THE DEPTH/DIA.	
	Q201=+0		;DEPTH	
	Q344=-9		;DIAMETER	
	Q206=250		;FEED RATE FOR PLUNGING	
	Q211=0.1		;DWELL TIME AT DEPTH	
	Q203=+20		;SURFACE COORDINATE	
	Q204=100		;2ND SET-UP CLEARANCE	
12	CYCL	CALL	X+30 Y+20 Z+0	FMAX M3
13	CYCL	CALL	X+80 Y+50 Z+0	FMAX
14	L	Z+100	FMAX	M2





## DRILLING (Cycle 200)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to set-up clearance above the workpiece surface.
- 2 The tool drills to the first plunging depth at the programmed feed rate F.
- 3 The TNC returns the tool at FMAX to the set-up clearance, dwells there (if a dwell time was entered), and then moves at FMAX to the set-up clearance above the first plunging depth.
- 4 The tool then drills deeper by the plunging depth at the programmed feed rate F.
- 5 The TNC repeats this process (2 to 4) until the programmed total hole depth is reached.
- 6 At the hole bottom, the tool path is retraced to set-up clearance or—if programmed—to the 2nd set-up clearance in rapid traverse FMAX.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

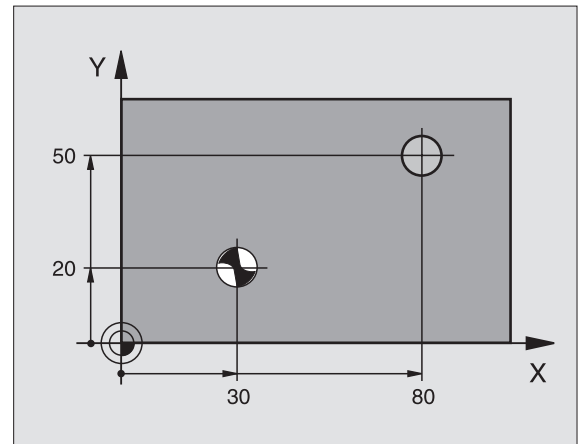
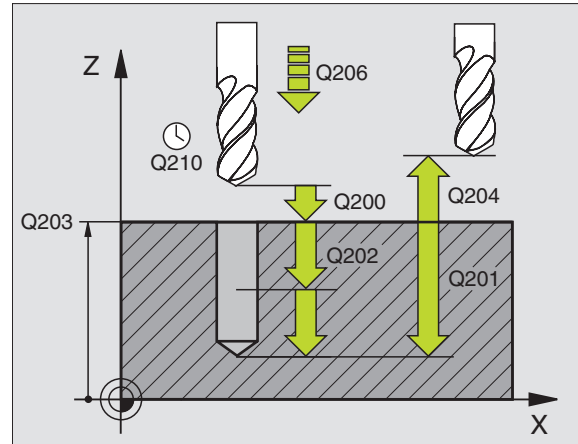
The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface. Enter a positive value.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of hole (tip of drill taper).
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool during drilling in mm/min.
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut. The depth does not have to be a multiple of the plunging depth. The TNC will go to depth in one movement if:
  - the plunging depth is equal to the depth
  - the plunging depth is greater than the depth
- ▶ **Dwell time at top** Q210: Time in seconds that the tool remains at set-up clearance after having been retracted from the hole for chip release.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Dwell time at depth** Q211: Time in seconds that the tool remains at the hole bottom.

**Example: NC blocks**

10	L	Z+100	R0	FMAX
11	CYCL	DEF	200	DRILLING
	Q200=2		;SET-UP CLEARANCE	
	Q201=-15		;DEPTH	
	Q206=250		;FEED RATE FOR PLUNGING	
	Q202=5		;INFEEED DEPTH	
	Q210=0		;DWELL TIME AT TOP	
	Q203=+20		;SURFACE COORDINATE	
	Q204=100		;2ND SET-UP CLEARANCE	
	Q211=0.1		;DWELL TIME AT DEPTH	
12	L	X+30	Y+20	FMAX M3
13	CYCL	CALL		
14	L	X+80	Y+50	FMAX M99
15	L	Z+100	FMAX	M2



## REAMING (Cycle 201)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2 The tool reams to the entered depth at the programmed feed rate F.
- 3 If programmed, the tool remains at the hole bottom for the entered dwell time.
- 4 The tool then retracts to set-up clearance at the feed rate F, and from there—if programmed—to the 2nd set-up clearance in FMAX.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

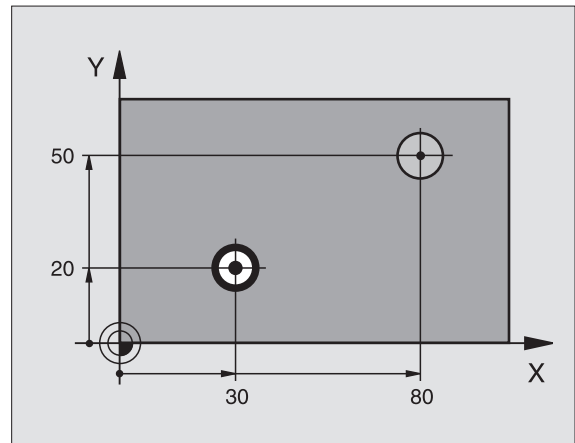
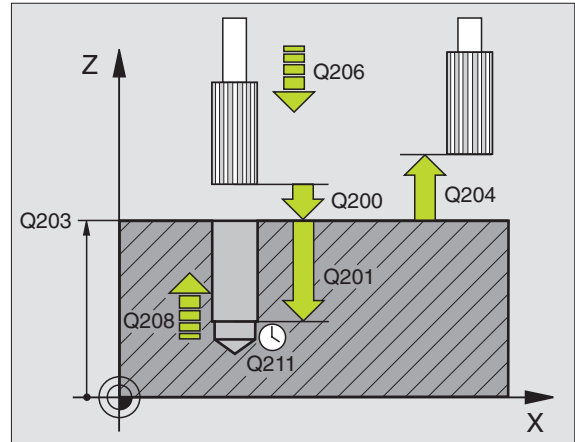
The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of hole.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool during reaming in mm/min.
- ▶ **Dwell time at depth** Q211: Time in seconds that the tool remains at the hole bottom.
- ▶ **Retraction feed rate** Q208: Traversing speed of the tool in mm/min when retracting from the hole. If you enter Q208 = 0, the tool retracts at the reaming feed rate.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.

Example: NC blocks

```
10 L Z+100 R0 FMAX
11 CYCL DEF 201 REAMING
    Q200=2      ;SET-UP CLEARANCE
    Q201=-15    ;DEPTH
    Q206=100    ;FEED RATE FOR PLUNGING
    Q211=0.5    ;DWELL TIME AT DEPTH
    Q208=250    ;RETRACTION FEED RATE
    Q203=+20    ;SURFACE COORDINATE
    Q204=100    ;2ND SET-UP CLEARANCE
12 L X+30 Y+20 FMAX M3
13 CYCL CALL
14 L X+80 Y+50 FMAX M9
15 L Z+100 FMAX M2
```



## BORING (Cycle 202)



Machine and control must be specially prepared by the machine tool builder for use of this cycle.

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to set-up clearance above the workpiece surface.
- 2 The tool drills to the programmed depth at the feed rate for plunging.
- 3 If programmed, the tool remains at the hole bottom for the entered dwell time with active spindle rotation for cutting free.
- 4 The TNC then orients the spindle to the position that is defined in parameter Q336.
- 5 If retraction is selected, the tool retracts in the programmed direction by 0.2 mm (fixed value).
- 6 The tool then retracts to set-up clearance at the retraction rate, and from there—if programmed—to the 2nd set-up clearance at FMAX. If Q214=0, the tool point remains on the wall of the hole.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

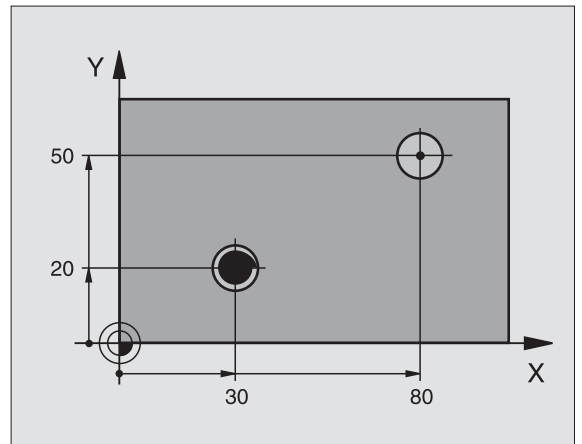
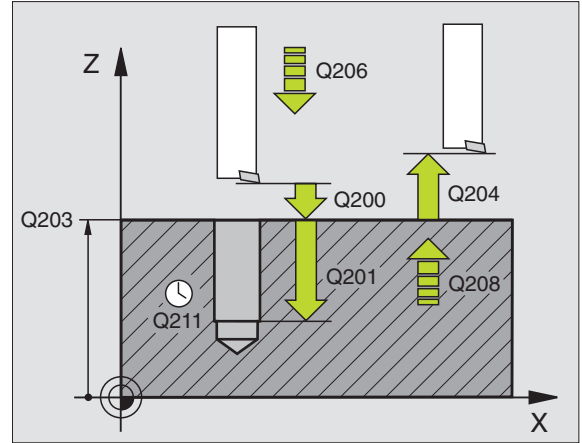
After the cycle is completed, the TNC restores the coolant and spindle conditions that were active before the cycle call.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of hole.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool during boring in mm/min.
- ▶ **Dwell time at depth** Q211: Time in seconds that the tool remains at the hole bottom.
- ▶ **Retraction feed rate** Q208: Traversing speed of the tool in mm/min when retracting from the hole. If you enter Q208 = 0, the tool retracts at feed rate for plunging.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Disengaging direction** (0/1/2/3/4) Q214: Determine the direction in which the TNC retracts the tool at the hole bottom (after spindle orientation).
  - 0 Do not retract tool
  - 1 Retract tool in the negative ref. axis direction
  - 2 Retract tool in the neg. secondary axis direction
  - 3 Retract tool in the positive ref. axis direction
  - 4 Retract tool in the pos. secondary axis direction



**Danger of collision**

Select a disengaging direction in which the tool moves away from the edge of the hole.

Check the position of the tool tip when you program a spindle orientation to the angle that you enter in Q336 (for example, in the Positioning with Manual Data Input mode of operation). Set the angle so that the tool tip is parallel to a coordinate axis.

During retraction the TNC automatically takes an active rotation of the coordinate system into account.

- ▶ **Angle for spindle orientation** Q336 (absolute value): Angle at which the TNC positions the tool before retracting it.

**Example:**

10	L	Z+100	R0	FMAX
11	CYCL	DEF	202	REAMING
		Q200=2	;SET-UP CLEARANCE	
		Q201=-15	;DEPTH	
		Q206=100	;FEED RATE FOR PLUNGING	
		Q211=0.5	;DWELL TIME AT DEPTH	
		Q208=250	;RETRACTION FEED RATE	
		Q203=+20	;SURFACE COORDINATE	
		Q204=100	;2ND SET-UP CLEARANCE	
		Q214=1	;DISENGAGING DIRECTN	
		Q336=0	;ANGLE OF SPINDLE	
12	L	X+30	Y+20	FMAX M3
13	CYCL	CALL		
14	L	X+80	Y+50	FMAX M99



## UNIVERSAL DRILLING (Cycle 203)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2 The tool drills to the first plunging depth at the programmed feed rate F.
- 3 If you have programmed chip breaking, the tool then retracts by the entered retraction value. If you are working without chip breaking, the tool retracts at the retraction feed rate to the set-up clearance, remains there—if programmed—for the entered dwell time, and advances again at FMAX to the set-up clearance above the first PLUNGING DEPTH.
- 4 The tool then advances with another infeed at the programmed feed rate. If programmed, the plunging depth is decreased after each infeed by the decrement.
- 5 The TNC repeats this process (2 to 4) until the programmed total hole depth is reached.
- 6 The tool remains at the hole bottom—if programmed—for the entered dwell time to cut free, and then retracts to set-up clearance at the retraction feed rate. If programmed, the tool moves to the 2nd set-up clearance at FMAX.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

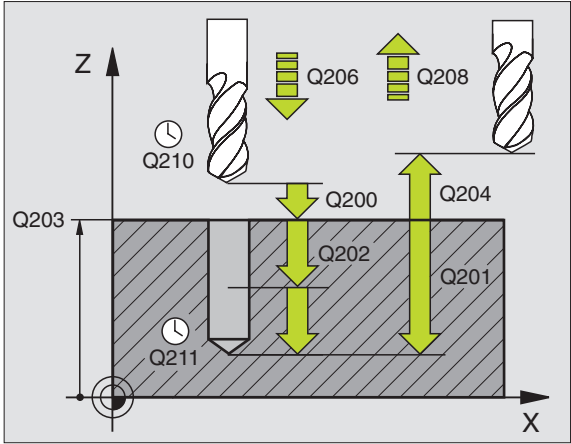
### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of hole (tip of drill taper).
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool during drilling in mm/min.
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut. The depth does not have to be a multiple of the plunging depth. The TNC will go to depth in one movement if:
  - the plunging depth is equal to the depth
  - the plunging depth is greater than the depth
- ▶ **Dwell time at top** Q210: Time in seconds that the tool remains at set-up clearance after having been retracted from the hole for chip release.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Decrement** Q212 (incremental value): Value by which the TNC decreases the plunging depth Q202 after each infeed.
- ▶ **No. of breaks before retracting** Q213: Number of chip breaks after which the TNC is to withdraw the tool from the hole for chip release. For chip breaking, the TNC retracts the tool each time by the value in Q256.
- ▶ **Minimum plunging depth** Q205 (incremental value): If you have entered a decrement, the TNC limits the plunging depth to the value entered with Q205.
- ▶ **Dwell time at depth** Q211: Time in seconds that the tool remains at the hole bottom.
- ▶ **Retraction feed rate** Q208: Traversing speed of the tool in mm/min when retracting from the hole. If you enter Q208 = 0, the TNC retracts the tool at the feed rate in Q206.
- ▶ **Retraction rate for chip breaking** Q256 (incremental value): Value by which the TNC retracts the tool during chip breaking.



Example: NC blocks

11 CYCL DEF 203 UNIVERSAL DRILLING	
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q202=5	;INFEED DEPTH
Q210=0	;DWELL TIME AT TOP
Q203=+20	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q212=0.2	;DECREMENT
Q213=3	;BREAKS
Q205=3	;MIN. PLUNGING DEPTH
Q211=0.25	;DWELL TIME AT DEPTH
Q208=500	;RETRACTION FEED RATE
Q256=0.2	;DIST. FOR CHIP BRKNG





## BACK BORING (Cycle 204)



Machine and control must be specially prepared by the machine tool builder for use of this cycle.

Special boring bars for upward cutting are required for this cycle.

This cycle allows holes to be bored from the underside of the workpiece.

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to set-up clearance above the workpiece surface.
- 2 The TNC then orients the spindle to the 0° position with an oriented spindle stop and displaces the tool by the off-center distance.
- 3 The tool is then plunged into the already bored hole at the feed rate for pre-positioning until the tooth has reached set-up clearance on the underside of the workpiece.
- 4 The TNC then centers the tool again over the bore hole, switches on the spindle and the coolant and moves at the feed rate for boring to the depth of bore.
- 5 If a dwell time is entered, the tool will pause at the top of the bore hole and will then be retracted from the hole again. The TNC carries out another oriented spindle stop and the tool is once again displaced by the off-center distance.
- 6 The TNC moves the tool at the pre-positioning feed rate to the set-up clearance and then, if entered, to the 2nd set-up clearance with FMAX.



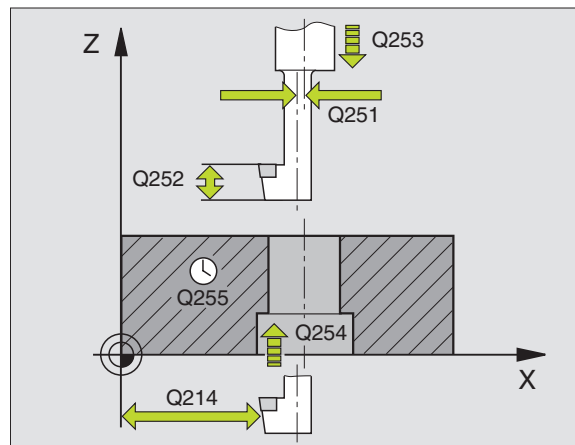
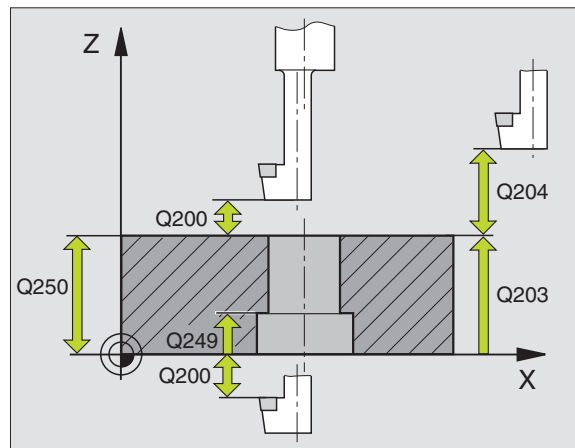
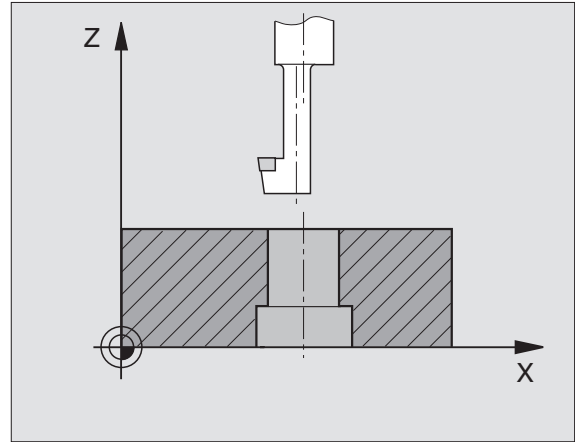
### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign for the cycle parameter depth determines the working direction. Note: A positive sign bores in the direction of the positive spindle axis.

The entered tool length is the total length to the underside of the boring bar and not just to the tooth.

When calculating the starting point for boring, the TNC considers the tooth length of the boring bar and the thickness of the material.





- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth of counterbore** Q249 (incremental value): Distance between underside of workpiece and the top of the hole. A positive sign means the hole will be bored in the positive spindle axis direction.
- ▶ **Material thickness** Q250 (incremental value): Thickness of the workpiece.
- ▶ **Off-center distance** Q251 (incremental value): Off-center distance for the boring bar; value from tool data sheet.
- ▶ **Tool edge height** Q252 (incremental value): Distance between the underside of the boring bar and the main cutting tooth; value from tool data sheet.
- ▶ **Feed rate for pre-positioning** Q253: Traversing speed of the tool when moving in and out of the workpiece, in mm/min.
- ▶ **Feed rate for countersinking** Q254: Traversing speed of the tool during countersinking in mm/min.
- ▶ **Dwell time** Q255: Dwell time in seconds at the top of the bore hole.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Disengaging direction (0/1/2/3/4)** Q214: Determine the direction in which the TNC displaces the tool by the off-center distance (after spindle orientation).
  - 1 Retract tool in the negative ref. axis direction
  - 2 Retract tool in the neg. secondary axis direction
  - 3 Retract tool in the positive ref. axis direction
  - 4 Retract tool in the pos. secondary axis direction

Example: NC blocks

11 CYCL DEF 204 BACK BORING	
Q200=2	;SET-UP CLEARANCE
Q249=+5	;DEPTH OF COUNTERBORE
Q250=20	;MATERIAL THICKNESS
Q251=3.5	;OFF-CENTER DISTANCE
Q252=15	;TOOL EDGE HEIGHT
Q253=750	;F PRE-POSITIONING
Q254=200	;F COUNTERBORING
Q255=0	;DWELL TIME
Q203=+20	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q214=1	;DISENGAGING DIRECTN
Q336=0	;ANGLE OF SPINDLE





### **Danger of collision!**

Check the position of the tool tip when you program a spindle orientation to the angle that you enter in Q336 (for example, in the Positioning with Manual Data Input mode of operation). Set the angle so that the tool tip is parallel to a coordinate axis. Select a disengaging direction in which the tool moves away from the edge of the hole.

- **Angle for spindle orientation** Q336 (absolute value): Angle at which the TNC positions the tool before it is plunged into or retracted from the bore hole.



## UNIVERSAL PECKING (Cycle 205)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2 If you enter a deepened starting point, the TNC move at the defined positioning feed rate to the set-up clearance above the deepened starting point.
- 3 The tool drills to the first plunging depth at the programmed feed rate F.
- 4 If you have programmed chip breaking, the tool then retracts by the entered retraction value. If you are working without chip breaking, the tool is moved at rapid traverse to the set-up clearance and then at FMAX to the entered starting position above the first plunging depth.
- 5 The tool then advances with another infeed at the programmed feed rate. If programmed, the plunging depth is decreased after each infeed by the decrement.
- 6 The TNC repeats this process (2 to 4) until the programmed total hole depth is reached.
- 7 The tool remains at the hole bottom—if programmed—for the entered dwell time to cut free, and then retracts to set-up clearance at the retraction feed rate. If programmed, the tool moves to the 2nd set-up clearance at FMAX.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

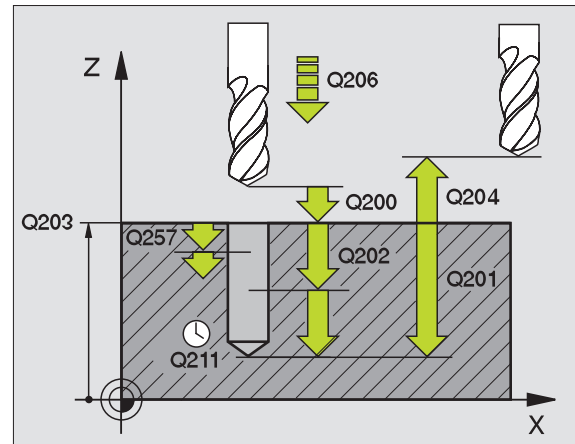
Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!



- ▶ **Set-up clearance Q200** (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth Q201** (incremental value): Distance between workpiece surface and bottom of hole (tip of drill taper).
- ▶ **Feed rate for plunging Q206**: Traversing speed of the tool during drilling in mm/min.
- ▶ **Plunging depth Q202** (incremental value): Infeed per cut. The depth does not have to be a multiple of the plunging depth. The TNC will go to depth in one movement if:
  - the plunging depth is equal to the depth
  - the plunging depth is greater than the depth
- ▶ **Workpiece surface coordinate Q203** (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance Q204** (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Decrement Q212** (incremental value): Value by which the TNC decreases the plunging depth Q202.
- ▶ **Minimum plunging depth Q205** (incremental value): If you have entered a decrement, the TNC limits the plunging depth to the value entered with Q205.
- ▶ **Upper advanced stop distance Q258** (incremental value): Set-up clearance for rapid traverse positioning when the TNC moves the tool again to the current plunging depth after retraction from the hole; value for the first plunging depth.
- ▶ **Lower advanced stop distance Q259** (incremental value): Set-up clearance for rapid traverse positioning when the TNC moves the tool again to the current plunging depth after retraction from the hole; value for the last plunging depth.



If you enter Q258 not equal to Q259, the TNC will change the advance stop distances between the first and last plunging depths at the same rate.



- ▶ **Infeed depth for chip breaking** Q257 (incremental value): Depth at which the TNC carries out chip breaking. There is no chip breaking if 0 is entered.
- ▶ **Retraction rate for chip breaking** Q256 (incremental value): Value by which the TNC retracts the tool during chip breaking.
- ▶ **Dwell time at depth** Q211: Time in seconds that the tool remains at the hole bottom.
- ▶ **Deepened starting point** Q379 (incremental with respect to the workpiece surface): Starting position of drilling if a shorter tool has already pilot drilled to a certain depth. The TNC moves at the **feed rate for pre-positioning** from the set-up clearance to the deepened starting point.
- ▶ **Feed rate for pre-positioning** Q253: Traversing velocity of the tool during positioning from the set-up clearance to a deepened starting point in mm/min. Effective only if Q379 is entered not equal to 0.



If you use Q379 to enter a deepened starting point, the TNC merely changes the starting point of the infeed movement. Retraction movements are not changed by the TNC, therefore they are calculated with respect to the coordinate of the workpiece surface.

Example: NC blocks

11 CYCL DEF 205 UNIVERSAL PECKING	
Q200=2	;SET-UP CLEARANCE
Q201=-80	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q202=15	;INFEED DEPTH
Q203=+100	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q212=0.5	;DECREMENT
Q205=3	;MIN. PLUNGING DEPTH
Q258=0.5	;UPPER ADV STOP DIST
Q259=1	;LOWER ADV STOP DIST
Q257=5	;DEPTH FOR CHIP BRKNG
Q256=0.2	;DIST. FOR CHIP BRKNG
Q211=0.25	;DWELL TIME AT DEPTH
Q379=7.5	;STARTING POSITION
Q253=750	;F PRE-POSITIONING



## BORE MILLING (Cycle 208)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface and then moves the tool to the bore hole circumference on a rounded arc (if enough space is available).
- 2 The tool mills in a helix from the current position to the first plunging depth at the programmed feed rate F.
- 3 When the drilling depth is reached, the TNC once again traverses a full circle to remove the material remaining after the initial plunge
- 4 The TNC then positions the tool at the center of the hole again
- 5 Finally the TNC returns to the set-up clearance at FMAX. If programmed, the tool moves to the 2nd set-up clearance at FMAX.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

If you have entered the bore hole diameter to be the same as the tool diameter, the TNC will bore directly to the entered depth without any helical interpolation.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





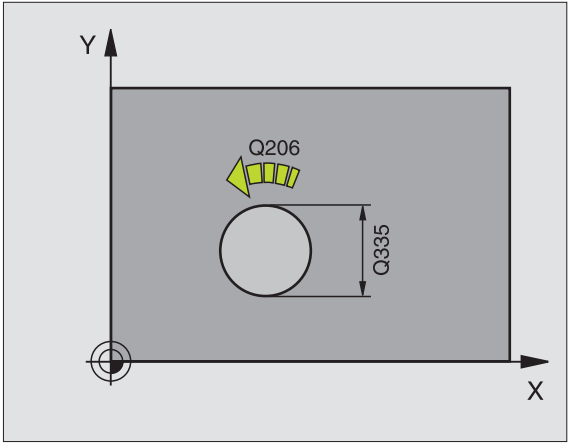
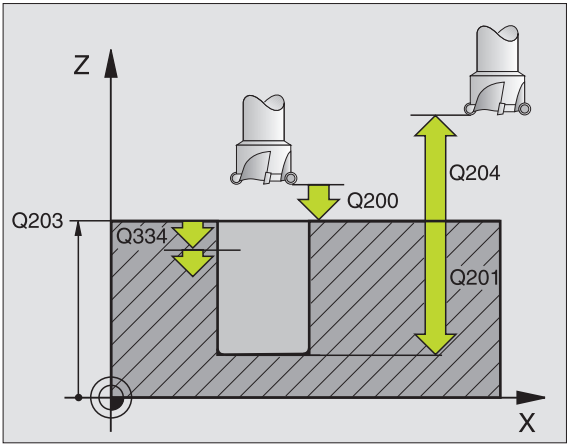
- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool lower edge and workpiece surface.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of hole.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool during helical drilling in mm/min.
- ▶ **Infeed per helix** Q334 (incremental value): Depth of the tool plunge with each helix (=360°).



Note that if the infeed distance is too large, the tool or the workpiece may be damaged.

To prevent the infeeds from being too large, enter the maximum plunge angle of the tool in the **ANGLE** column of the tool table, (see "Tool Data" on page 144). The TNC then automatically calculates the max. infeed permitted and changes your entered value accordingly.

- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Nominal diameter** Q335 (absolute value): Bore-hole diameter. If you have entered the nominal diameter to be the same as the tool diameter, the TNC will bore directly to the entered depth without any helical interpolation.
- ▶ **Roughing diameter** Q342 (absolute value): As soon as you enter a value greater than 0 in Q342, the TNC no longer checks the ratio between the nominal diameter and the tool diameter. This allows you to rough-mill holes whose diameter is more than twice as large as the tool diameter.



**Example: NC blocks**

12 CYCL DEF 208 BORE MILLING	
Q200=2	;SET-UP CLEARANCE
Q201=-80	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q334=1.5	;INFED DEPTH
Q203=+100	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q335=25	;NOMINAL DIAMETER
Q342=0	;ROUGHING DIAMETER





## TAPPING NEW with floating tap holder (Cycle 206)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2 The tool drills to the total hole depth in one movement.
- 3 Once the tool has reached the total hole depth, the direction of spindle rotation is reversed and the tool is retracted to the set-up clearance at the end of the dwell time. If programmed, the tool moves to the 2nd set-up clearance at FMAX.
- 4 At the set-up clearance, the direction of spindle rotation reverses once again.



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

A floating tap holder is required for tapping. It must compensate the tolerances between feed rate and spindle speed during the tapping process.

When a cycle is being run, the spindle speed override knob is disabled. The feed-rate override knob is active only within a limited range, which is defined by the machine tool builder (refer to your machine manual).

For tapping right-hand threads activate the spindle with M3, for left-hand threads use M4.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





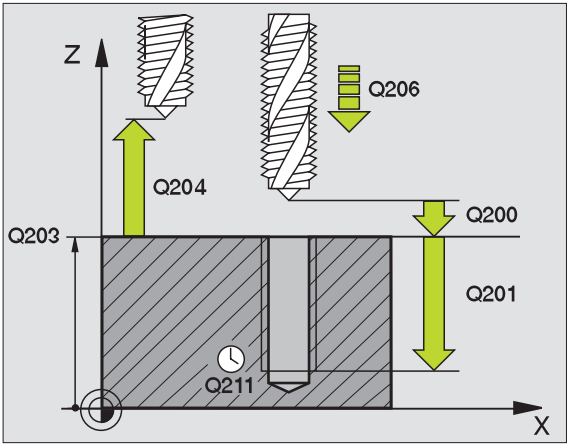
- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip (at starting position) and workpiece surface. Standard value: approx. 4 times the thread pitch.
- ▶ **Total hole depth** Q201 (thread length, incremental value): Distance between workpiece surface and end of thread.
- ▶ **Feed rate F** Q206: Traversing speed of the tool during tapping.
- ▶ **Dwell time at bottom** Q211: Enter a value between 0 and 0.5 seconds to avoid wedging of the tool during retraction.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.

The feed rate is calculated as follows:  $F = S \times p$

- F: Feed rate (mm/min)
- S: Spindle speed (rpm)
- p: Thread pitch (mm)

**Retracting after a program interruption**

If you interrupt program run during tapping with the machine stop button, the TNC will display a soft key with which you can retract the tool.



**Example: NC blocks**

25 CYCL DEF 206 TAPPING NEW	
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q211=0.25	;DWELL TIME AT DEPTH
Q203=+25	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE



## RIGID TAPPING without a floating tap holder NEW (Cycle 207)



Machine and control must be specially prepared by the machine tool builder for use of this cycle.

The TNC cuts the thread without a floating tap holder in one or more passes.

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2 The tool drills to the total hole depth in one movement.
- 3 Once the tool has reached the total hole depth, the direction of spindle rotation is reversed and the tool is retracted to the set-up clearance at the end of the dwell time. If programmed, the tool moves to the 2nd set-up clearance at FMAX.
- 4 The TNC stops the spindle turning at set-up clearance



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign for the total hole depth parameter determines the working direction.

The TNC calculates the feed rate from the spindle speed. If the spindle speed override is used during tapping, the feed rate is automatically adjusted.

The feed-rate override knob is disabled.

At the end of the cycle the spindle comes to a stop. Before the next operation, restart the spindle with M3 (or M4).



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!

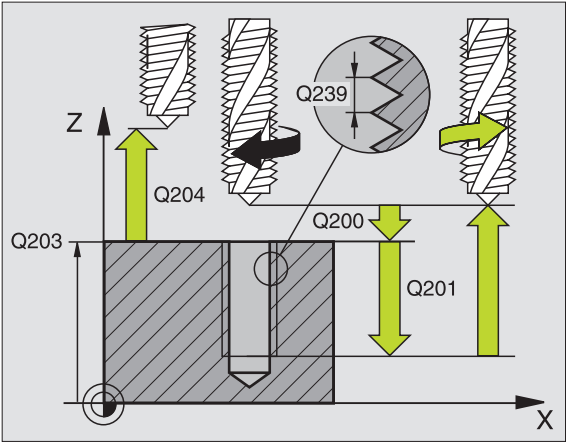




- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip (at starting position) and workpiece surface.
- ▶ **Total hole depth** Q201 (incremental value): Distance between workpiece surface and end of thread.
- ▶ **Pitch** Q239  
Pitch of the thread. The algebraic sign differentiates between right-hand and left-hand threads:  
+= right-hand thread  
-= left-hand thread
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.

**Retracting after a program interruption**

If you interrupt program run during thread cutting with the machine stop button, the TNC will display the soft key MANUAL OPERATION. If you press the MANUAL OPERATION key, you can retract the tool under program control. Simply press the positive axis direction button of the active tool axis.



**Example: NC blocks**

26 CYCL DEF 207 RIGID TAPPING NEW	
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q239=+1	;PITCH
Q203=+25	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE



## TAPPING WITH CHIP BREAKING (Cycle 209)



Machine and control must be specially prepared by the machine tool builder for use of this cycle.

The tool machines the thread in several passes until it reaches the programmed depth. You can define in a parameter whether the tool is to be retracted completely from the hole for chip breaking.

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface. There it carries out an oriented spindle stop.
- 2 The tool moves to the programmed infeed depth, reverses the direction of spindle rotation and retracts by a specific distance or completely for chip release, depending on the definition .
- 3 It then reverses the direction of spindle rotation again and advances to the next infeed depth.
- 4 The TNC repeats this process (2 to 3) until the programmed thread depth is reached.
- 5 The tool is then retracted to set-up clearance. If programmed, the tool moves to the 2nd set-up clearance at FMAX.
- 6 The TNC stops the spindle turning at set-up clearance



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign for the parameter thread depth determines the working direction.

The TNC calculates the feed rate from the spindle speed. If the spindle speed override is used during tapping, the feed rate is automatically adjusted.

The feed-rate override knob is disabled.

At the end of the cycle the spindle comes to a stop. Before the next operation, restart the spindle with M3 (or M4).



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!

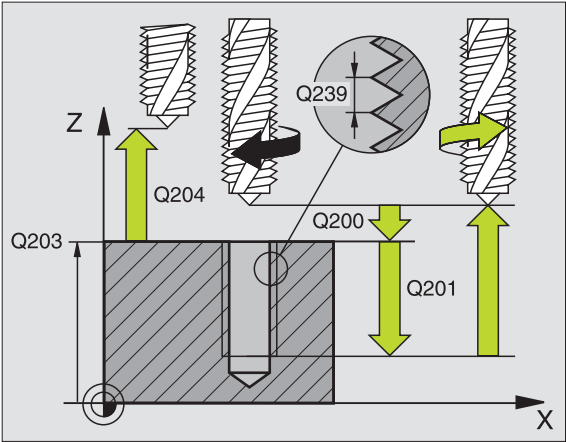




- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip (at starting position) and workpiece surface.
- ▶ **Thread depth** Q201 (incremental value): Distance between workpiece surface and end of thread.
- ▶ **Pitch** Q239  
Pitch of the thread. The algebraic sign differentiates between right-hand and left-hand threads:  
+= right-hand thread  
-= left-hand thread
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Infeed depth for chip breaking** Q257 (incremental value): Depth at which TNC carries out chip breaking
- ▶ **Retraction rate for chip breaking** Q256: The TNC multiplies the pitch Q239 by the programmed value and retracts the tool by the calculated value during chip breaking. If you enter Q256 = 0, the TNC retracts the tool completely from the hole (to the set-up clearance) for chip release.
- ▶ **Angle for spindle orientation** Q336 (absolute value): Angle at which the TNC positions the tool before machining the thread. This allows you to regroove the thread, if required.

**Retracting after a program interruption**

If you interrupt program run during thread cutting with the machine stop button, the TNC will display the soft key MANUAL OPERATION. If you press the MANUAL OPERATION key, you can retract the tool under program control. Simply press the positive axis direction button of the active tool axis.



**Example: NC blocks**

26 CYCL DEF 209 TAPPING W/ CHIP BRKG	
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q239=+1	;PITCH
Q203=+25	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q257=5	;DEPTH FOR CHIP BRKNG
Q256=+25	;DIST. FOR CHIP BRKNG
Q336=50	;ANGLE OF SPINDLE



## Fundamentals of thread milling

### Prerequisites

- Your machine tool should feature internal spindle cooling (cooling lubricant at least 30 bar, compressed air supply at least 6 bar).
- Thread milling usually leads to distortions of the thread profile. To correct this effect, you need tool-specific compensation values which are given in the tool catalog or are available from the tool manufacturer. You program the compensation with the delta value for the tool radius DR in the tool call.
- The Cycles 262, 263, 264 and 267 can only be used with rightward rotating tools. For Cycle 265 you can use rightward and leftward rotating tools.
- The working direction is determined by the following input parameters: Algebraic sign Q239 (+ = right-hand thread / – = left-hand thread) and milling method Q351 (+1 = climb / –1 = up-cut). The table below illustrates the interrelation between the individual input parameters for rightward rotating tools.

Internal thread	Pitch	Climb/Up-cut	Work direction
Right-handed	+	+1(RL)	Z+
Left-handed	–	–1(RR)	Z+
Right-handed	+	–1(RR)	Z–
Left-handed	–	+1(RL)	Z–

External thread	Pitch	Climb/Up-cut	Work direction
Right-handed	+	+1(RL)	Z–
Left-handed	–	–1(RR)	Z–
Right-handed	+	–1(RR)	Z+
Left-handed	–	+1(RL)	Z+





### **Danger of collision!**

Always program the same algebraic sign for the infeeds: Cycles comprise several sequences of operation that are independent of each other. The order of precedence according to which the work direction is determined is described with the individual cycles. For example, if you only want to repeat the countersinking process of a cycle, enter 0 for the thread depth. The work direction will then be determined from the countersinking depth.

### **Procedure in case of a tool break**

If a tool break occurs during thread cutting, stop the program run, change to the Positioning with MDI operating mode and move the tool in a linear path to the hole center. You can then retract the tool in the infeed axis and replace it.



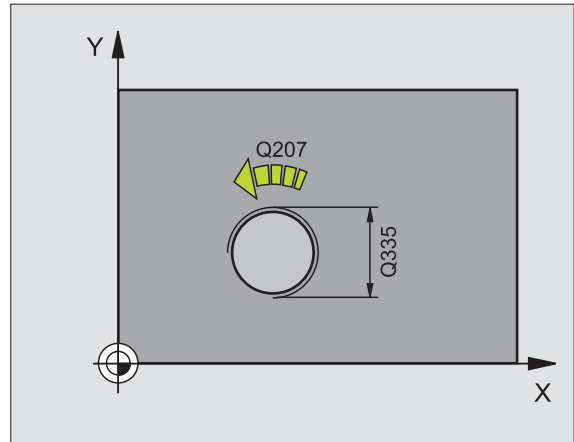
The TNC references the programmed feed rate during thread milling to the tool cutting edge. Since the TNC, however, always displays the feed rate relative to the path of the tool tip, the displayed value does not match the programmed value.

The machining direction of the thread changes if you execute a thread milling cycle in connection with Cycle 8 MIRRORING in only one axis.



## THREAD MILLING (Cycle 262)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.
- 2 The tool moves at the programmed feed rate for pre-positioning to the starting plane. The starting plane is derived from the algebraic sign of the thread pitch, the milling method (climb or up-cut milling) and the number of threads per step.
- 3 The tool then approaches the nominal thread diameter tangentially in a helical movement. Before the helical approach, a compensating motion of the tool axis is carried out in order to begin at the programmed starting plane for the thread path.
- 4 Depending on the setting of the parameter for the number of threads, the tool mills the thread in one, in several spaced or in one continuous helical movement.
- 5 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 6 At the end of the cycle, the TNC retracts the tool in rapid traverse to set-up clearance or, if programmed, to the 2nd set-up clearance



### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign for the cycle parameter thread depth determines the working direction. If you program the thread DEPTH = 0, the cycle will not be executed.

The thread diameter is approached in a semi-circle from the center. A pre-positioning movement to the side is carried out if the pitch of the tool diameter is four times smaller than the thread diameter.

Note that the TNC makes a compensating movement in the tool axis before the approach movement. The length of the compensating movement depends on the thread pitch. Ensure sufficient space in the hole!



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

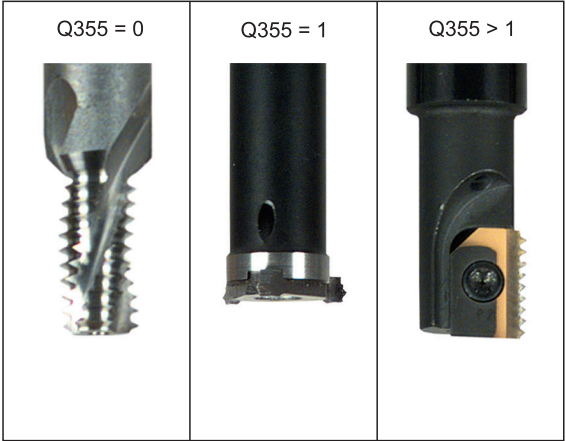
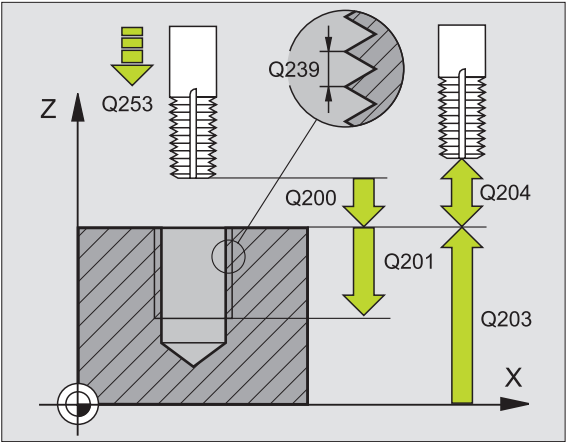
### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





- ▶ **Nominal diameter** Q335: Nominal thread diameter.
- ▶ **Thread pitch** Q239: Pitch of the thread. The algebraic sign differentiates between right-hand and left-hand threads:
  - + = right-hand thread
  - = left-hand thread
- ▶ **Thread depth** Q201 (incremental value): Distance between workpiece surface and root of thread.
- ▶ **Threads per step** Q355: Number of thread revolutions by which the tool is offset, (see figure at lower right):
  - 0 = one 360° helical path to the depth of thread.
  - 1 = continuous helical path over the entire length of the thread
  - >1 = several helical paths with approach and departure; between them, the TNC offsets the tool by Q355, multiplied by the pitch
- ▶ **Feed rate for pre-positioning** Q253: Traversing speed of the tool when moving in and out of the workpiece, in mm/min.
- ▶ **Climb or up-cut** Q351: Type of milling operation with M03.
  - +1 = climb milling
  - 1 = up-cut milling
- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.



Example: NC blocks

25 CYCL DEF 262 THREAD MILLING	
Q335=10	;NOMINAL DIAMETER
Q239=+1.5	;PITCH
Q201=-20	;THREAD DEPTH
Q355=0	;THREADS PER STEP
Q253=750	;F PRE-POSITIONING
Q351=+1	;CLIMB OR UP-CUT
Q200=2	;SET-UP CLEARANCE
Q203=+30	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q207=500	;FEED RATE FOR MILLING



## THREAD MILLING/COUNTERSINKING (Cycle 263)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.

### Countersinking

- 2 The tool moves at the feed rate for pre-positioning to the countersinking depth minus the set-up clearance, and then at the feed rate for countersinking to the countersinking depth.
- 3 If a safety clearance to the side has been entered, the TNC immediately positions the tool at the feed rate for pre-positioning to the countersinking depth.
- 4 Then, depending on the available space, the TNC makes a tangential approach to the core diameter, either tangentially from the center or with a pre-positioning move to the side, and follows a circular path.

### Countersinking at front

- 5 The tool moves at the feed rate for pre-positioning to the sinking depth at front.
- 6 The TNC positions the tool without compensation from the center on a semicircle to the offset at front, and then follows a circular path at the feed rate for countersinking.
- 7 The tool then moves in a semicircle to the hole center.

### Thread milling

- 8 The TNC moves the tool at the programmed feed rate for pre-positioning to the starting plane for the thread. The starting plane is determined from the thread pitch and the type of milling (climb or up-cut).
- 9 Then the tool moves tangentially on a helical path to the thread diameter and mills the thread with a 360° helical motion.
- 10 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.



- 11 At the end of the cycle, the TNC retracts the tool in rapid traverse to set-up clearance or, if programmed, to the 2nd set-up clearance



## Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign of the cycle parameters depth of thread, countersinking depth or sinking depth at front determines the working direction. The working direction is defined in the following sequence:

1st Depth of thread

2nd Countersinking depth

3rd Depth at front

If you program a depth parameter to be 0, the TNC does not execute that step.

If you want to countersink with the front of the tool, define the countersinking depth as 0.

Program the thread depth as a value smaller than the countersinking depth by at least one-third the thread pitch.



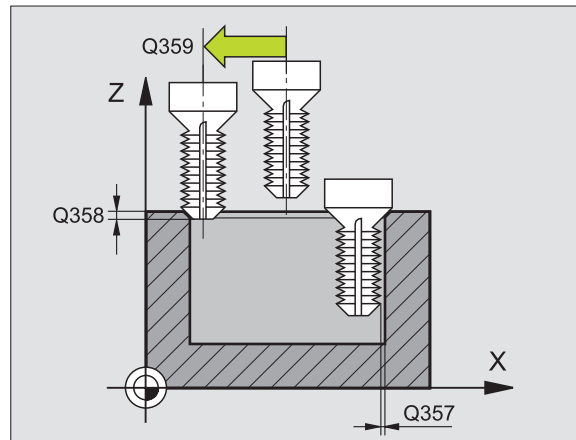
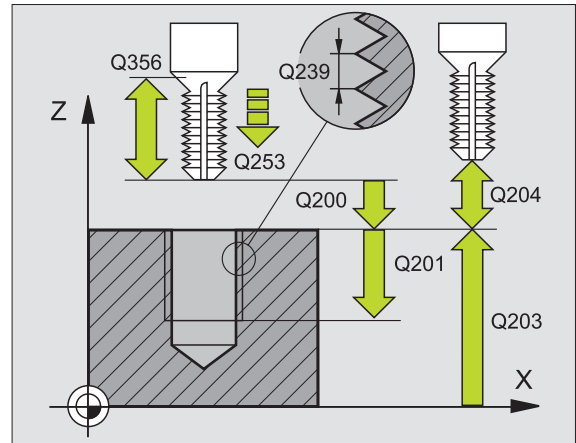
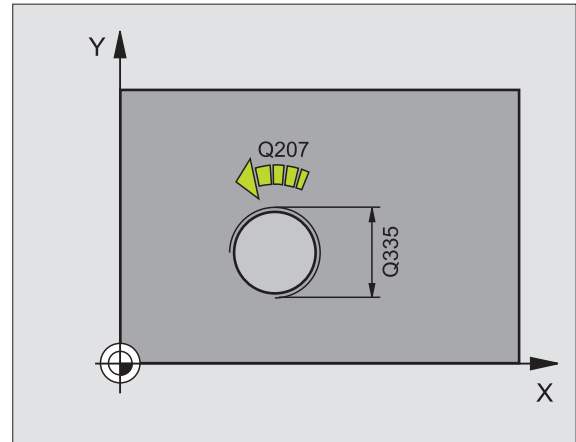
Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

## Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!



- ▶ **Nominal diameter** Q335: Nominal thread diameter.
- ▶ **Thread pitch** Q239: Pitch of the thread. The algebraic sign differentiates between right-hand and left-hand threads:  
 += right-hand thread  
 - = left-hand thread
- ▶ **Thread depth** Q201 (incremental value): Distance between workpiece surface and root of thread.
- ▶ **Countersinking depth** Q356 (incremental value): Distance between tool point and the top surface of the workpiece.
- ▶ **Feed rate for pre-positioning** Q253: Traversing speed of the tool when moving in and out of the workpiece, in mm/min.
- ▶ **Climb or up-cut** Q351: Type of milling operation with M03.  
 +1 = climb milling  
 -1 = up-cut milling
- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Set-up clearance to the side** Q357 (incremental value): Distance between tool tooth and the wall.
- ▶ **Depth at front** Q358 (incremental value): Distance between tool tip and the top surface of the workpiece for countersinking at the front of the tool.
- ▶ **Countersinking offset at front** Q359 (incremental value): Distance by which the TNC moves the tool center away from the hole center.



## 8.3 Cycles for Drilling, Tapping and Thread Milling



- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Feed rate for countersinking** Q254: Traversing speed of the tool during countersinking in mm/min.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.

Example: NC blocks

25	CYCL DEF	263	THREAD MLLNG/CNTSNKG
	Q335=10		;NOMINAL DIAMETER
	Q239=+1.5		;PITCH
	Q201=-16		;THREAD DEPTH
	Q356=-20		;COUNTERSINKING DEPTH
	Q253=750		;F PRE-POSITIONING
	Q351=+1		;CLIMB OR UP-CUT
	Q200=2		;SET-UP CLEARANCE
	Q357=0.2		;CLEARANCE TO SIDE
	Q358=+0		;DEPTH AT FRONT
	Q359=+0		;OFFSET AT FRONT
	Q203=+30		;SURFACE COORDINATE
	Q204=50		;2ND SET-UP CLEARANCE
	Q254=150		;F COUNTERBORING
	Q207=500		;FEED RATE FOR MILLING



## THREAD DRILLING/MILLING (Cycle 264)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.

### Drilling

- 2 The tool drills to the first plunging depth at the programmed feed rate for plunging.
- 3 If you have programmed chip breaking, the tool then retracts by the entered retraction value. If you are working without chip breaking, the tool is moved at rapid traverse to the set-up clearance and then at FMAX to the entered starting position above the first plunging depth.
- 4 The tool then advances with another infeed at the programmed feed rate.
- 5 The TNC repeats this process (2 to 4) until the programmed total hole depth is reached.

### Countersinking at front

- 6 The tool moves at the feed rate for pre-positioning to the sinking depth at front.
- 7 The TNC positions the tool without compensation from the center on a semicircle to the offset at front, and then follows a circular path at the feed rate for countersinking.
- 8 The tool then moves in a semicircle to the hole center.

### Thread milling

- 9 The TNC moves the tool at the programmed feed rate for pre-positioning to the starting plane for the thread. The starting plane is determined from the thread pitch and the type of milling (climb or up-cut).
- 10 Then the tool moves tangentially on a helical path to the thread diameter and mills the thread with a 360° helical motion.
- 11 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 12 At the end of the cycle, the TNC retracts the tool in rapid traverse to set-up clearance or, if programmed, to the 2nd set-up clearance





### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign of the cycle parameters depth of thread, countersinking depth or sinking depth at front determines the working direction. The working direction is defined in the following sequence:

1st: Depth of thread

2nd: Total hole depth

3rd: Depth at front

If you program a depth parameter to be 0, the TNC does not execute that step.

Program the thread depth as a value smaller than the total hole depth by at least one-third the thread pitch.



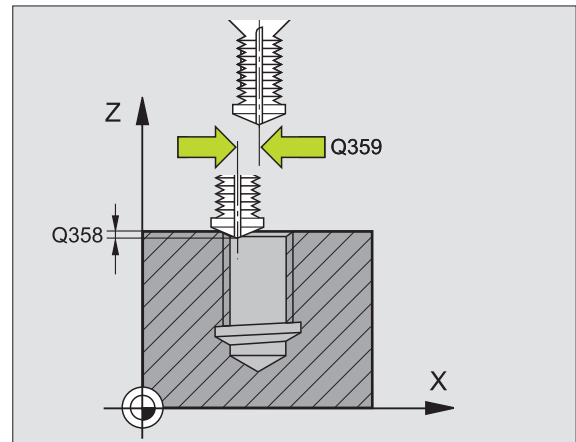
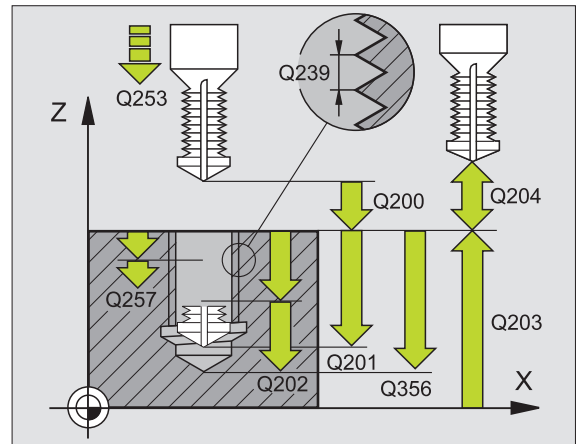
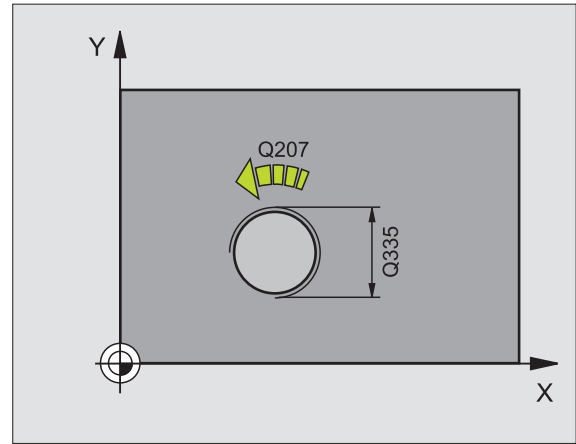
Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!



- ▶ **Nominal diameter** Q335: Nominal thread diameter.
- ▶ **Thread pitch** Q239: Pitch of the thread. The algebraic sign differentiates between right-hand and left-hand threads:
  - + = right-hand thread
  - = left-hand thread
- ▶ **Thread depth** Q201 (incremental value): Distance between workpiece surface and root of thread.
- ▶ **Total hole depth** Q356 (incremental value): Distance between workpiece surface and bottom of hole.
- ▶ **Feed rate for pre-positioning** Q253: Traversing speed of the tool when moving in and out of the workpiece, in mm/min.
- ▶ **Climb or up-cut** Q351: Type of milling operation with M03.
  - +1 = climb milling
  - 1 = up-cut milling
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut. The depth does not have to be a multiple of the plunging depth. The TNC will go to depth in one movement if:
  - the plunging depth is equal to the depth
  - the plunging depth is greater than the depth
- ▶ **Upper advanced stop distance** Q258 (incremental value): Set-up clearance for rapid traverse positioning when the TNC moves the tool again to the current plunging depth after retraction from the hole.
- ▶ **Infeed depth for chip breaking** Q257 (incremental value): Depth at which TNC carries out chip breaking. There is no chip breaking if 0 is entered.
- ▶ **Retraction rate for chip breaking** Q256 (incremental value): Value by which the TNC retracts the tool during chip breaking.
- ▶ **Depth at front** Q358 (incremental value): Distance between tool tip and the top surface of the workpiece for countersinking at the front of the tool.
- ▶ **Countersinking offset at front** Q359 (incremental value): Distance by which the TNC moves the tool center away from the hole center.



- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool during drilling in mm/min.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.

Example: NC blocks

25 CYCL DEF 264 THREAD DRILLING/MILLING	
Q335=10	;NOMINAL DIAMETER
Q239=+1.5	;PITCH
Q201=-16	;THREAD DEPTH
Q356=-20	;TOTAL HOLE DEPTH
Q253=750	;F PRE-POSITIONING
Q351=+1	;CLIMB OR UP-CUT
Q202=5	;INFEED DEPTH
Q258=0.2	;ADVANCED STOP DISTANCE
Q257=5	;DEPTH FOR CHIP BRKNG
Q256=0.2	;DIST. FOR CHIP BRKNG
Q358=+0	;DEPTH AT FRONT
Q359=+0	;OFFSET AT FRONT
Q200=2	;SET-UP CLEARANCE
Q203=+30	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q206=150	;FEED RATE FOR PLUNGING
Q207=500	;FEED RATE FOR MILLING



## HELICAL THREAD DRILLING/MILLING (Cycle 265)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.

### Countersinking at front

- 2 If countersinking is before thread milling, the tool moves at the feed rate for countersinking to the sinking depth at front. If countersinking is after thread milling, the tool moves at the feed rate for pre-positioning to the countersinking depth.
- 3 The TNC positions the tool without compensation from the center on a semicircle to the offset at front, and then follows a circular path at the feed rate for countersinking.
- 4 The tool then moves in a semicircle to the hole center.

### Thread milling

- 5 The tool moves at the programmed feed rate for pre-positioning to the starting plane for the thread.
- 6 The tool then approaches the thread diameter tangentially in a helical movement.
- 7 The tool moves on a continuous helical downward path until it reaches the thread depth.
- 8 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 9 At the end of the cycle, the TNC retracts the tool in rapid traverse to set-up clearance or, if programmed, to the 2nd set-up clearance.



#### Before programming, note the following:

Program a positioning block for the starting point (hole center) in the working plane with radius compensation R0.

The algebraic sign of the cycle parameters depth of thread or sinking depth at front determines the working direction. The working direction is defined in the following sequence:

- 1st Depth of thread
- 2nd Depth at front

If you program a depth parameter to be 0, the TNC does not execute that step.

The type of milling (up-cut/climb) is determined by the thread (right-hand/left-hand) and the direction of tool rotation, since it is only possible to work in the direction of the tool.



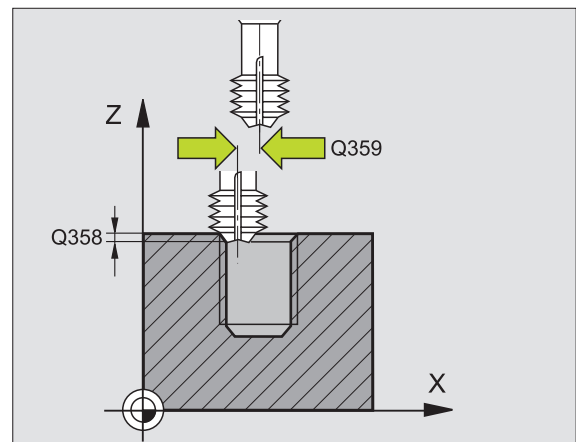
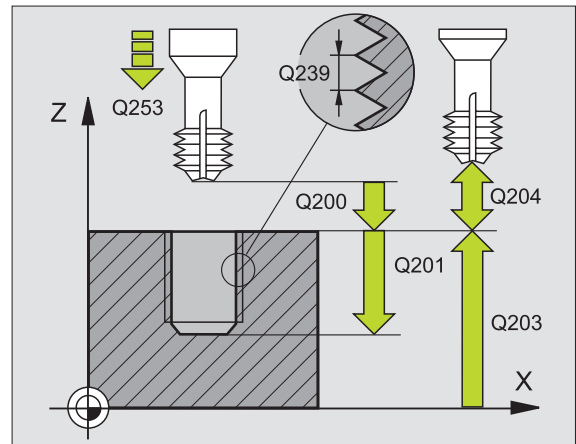
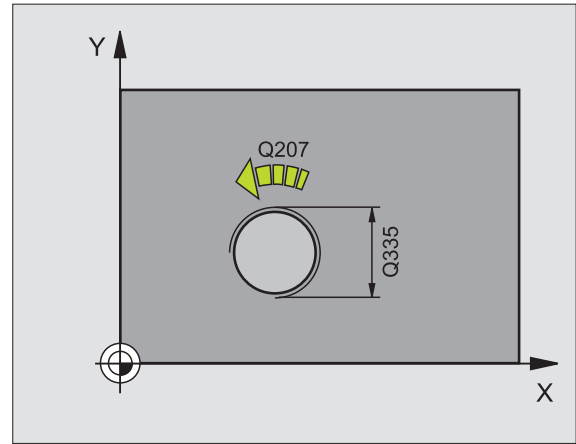


Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### **Danger of collision!**

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!

- ▶ **Nominal diameter** Q335: Nominal thread diameter.
- ▶ **Thread pitch** Q239: Pitch of the thread. The algebraic sign differentiates between right-hand and left-hand threads:  
 += right-hand thread  
 -= left-hand thread
- ▶ **Thread depth** Q201 (incremental value): Distance between workpiece surface and root of thread.
- ▶ **Feed rate for pre-positioning** Q253: Traversing speed of the tool when moving in and out of the workpiece, in mm/min.
- ▶ **Depth at front** Q358 (incremental value): Distance between tool tip and the top surface of the workpiece for countersinking at the front of the tool.
- ▶ **Countersinking offset at front** Q359 (incremental value): Distance by which the TNC moves the tool center away from the hole center.
- ▶ **Countersink** Q360: Execution of the chamfer  
 0 = before thread machining  
 1 = after thread machining
- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.



## 8.3 Cycles for Drilling, Tapping and Thread Milling

- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Feed rate for countersinking** Q254: Traversing speed of the tool during countersinking in mm/min.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.

Example: NC blocks

25 CYCL DEF 265 HEL. THREAD DRLG/MLG	
Q335=10	;NOMINAL DIAMETER
Q239=+1.5	;PITCH
Q201=-16	;THREAD DEPTH
Q253=750	;F PRE-POSITIONING
Q358=+0	;DEPTH AT FRONT
Q359=+0	;OFFSET AT FRONT
Q360=0	;COUNTERSINKING
Q200=2	;SET-UP CLEARANCE
Q203=+30	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q254=150	;F COUNTERBORING
Q207=500	;FEED RATE FOR MILLING



## OUTSIDE THREAD MILLING (Cycle 267)

- 1 The TNC positions the tool in the tool axis at rapid traverse FMAX to the programmed set-up clearance above the workpiece surface.

### Countersinking at front

- 2 The TNC moves on the reference axis of the working plane from the center of the stud to the starting point for countersinking at front. The position of the starting point is determined by the thread radius, tool radius and pitch.
- 3 The tool moves at the feed rate for pre-positioning to the sinking depth at front.
- 4 The TNC positions the tool without compensation from the center on a semicircle to the offset at front, and then follows a circular path at the feed rate for countersinking.
- 5 The tool then moves in a semicircle to the starting point.

### Thread milling

- 6 The TNC positions the tool to the starting point if there has been no previous countersinking at front. Starting point for thread milling = starting point for countersinking at front.
- 7 The tool moves at the programmed feed rate for pre-positioning to the starting plane. The starting plane is derived from the algebraic sign of the thread pitch, the milling method (climb or up-cut milling) and the number of threads per step.
- 8 The tool then approaches the thread diameter tangentially in a helical movement.
- 9 Depending on the setting of the parameter for the number of threads, the tool mills the thread in one, in several spaced or in one continuous helical movement.
- 10 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.



- 11 At the end of the cycle, the TNC retracts the tool in rapid traverse to set-up clearance or, if programmed, to the 2nd set-up clearance



## Before programming, note the following:

Program a positioning block for the starting point (stud center) in the working plane with radius compensation R0.

The offset required before countersinking at the front should be determined ahead of time. You must enter the value from the center of the stud to the center of the tool (uncorrected value).

The algebraic sign of the cycle parameters depth of thread or sinking depth at front determines the working direction. The working direction is defined in the following sequence:

1st Depth of thread

2nd Depth at front

If you program a depth parameter to be 0, the TNC does not execute that step.

The algebraic sign for the cycle parameter thread depth determines the working direction.



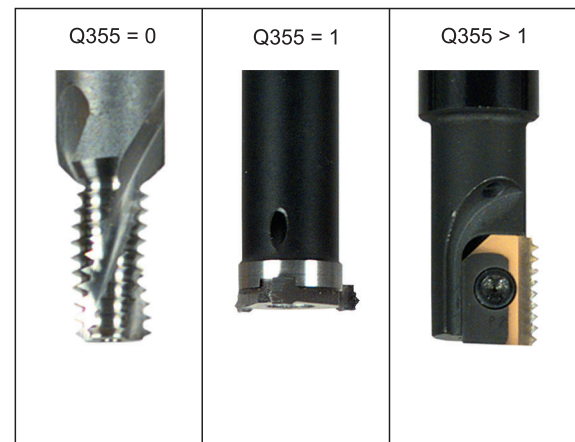
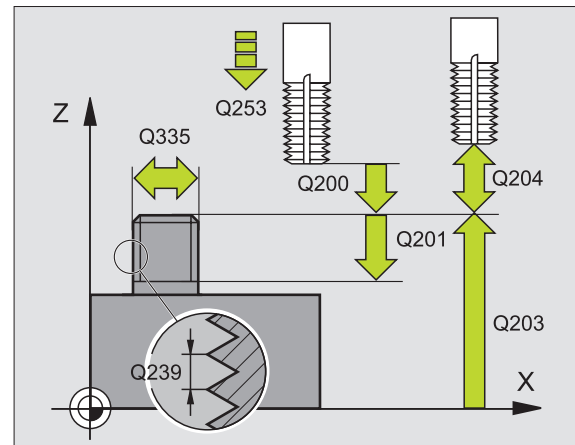
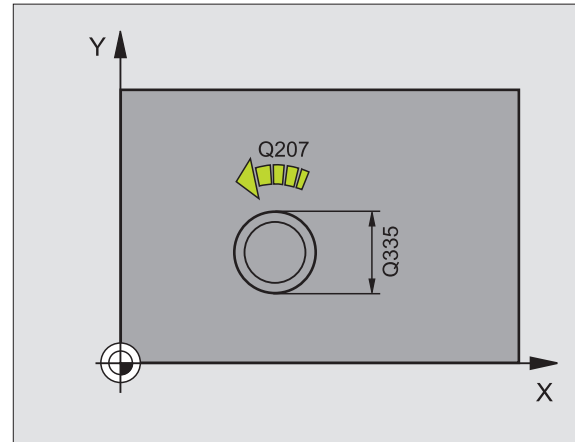
Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

## Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!



- ▶ **Nominal diameter** Q335: Nominal thread diameter.
- ▶ **Thread pitch** Q239: Pitch of the thread. The algebraic sign differentiates between right-hand and left-hand threads:
  - + = right-hand thread
  - = left-hand thread
- ▶ **Thread depth** Q201 (incremental value): Distance between workpiece surface and root of thread.
- ▶ **Threads per step** Q355: Number of thread revolutions by which the tool is offset, see figure at lower right:
  - 0 = one helical line to the thread depth
  - 1 = continuous helical path over the entire length of the thread
  - >1 = several helical paths with approach and departure; between them, the TNC offsets the tool by Q355, multiplied by the pitch
- ▶ **Feed rate for pre-positioning** Q253: Traversing speed of the tool when moving in and out of the workpiece, in mm/min.
- ▶ **Climb or up-cut** Q351: Type of milling operation with M03.
  - +1 = climb milling
  - 1 = up-cut milling



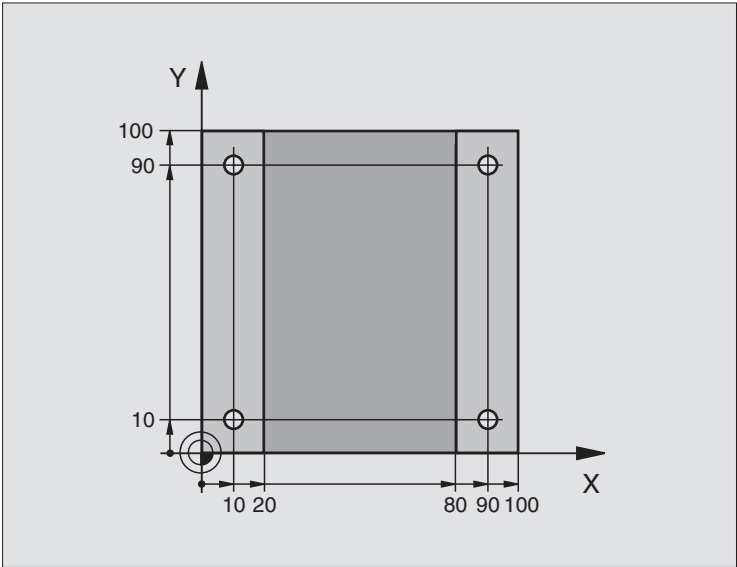
- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth at front** Q358 (incremental value): Distance between tool tip and the top surface of the workpiece for countersinking at the front of the tool.
- ▶ **Countersinking offset at front** Q359 (incremental value): Distance by which the TNC moves the tool center away from the stud center.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Feed rate for countersinking** Q254: Traversing speed of the tool during countersinking in mm/min.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.

Example: NC blocks

25 CYCL DEF 267 OUTSIDE THREAD MLLNG	
Q335=10	;NOMINAL DIAMETER
Q239=+1.5	;PITCH
Q201=-20	;THREAD DEPTH
Q355=0	;THREADS PER STEP
Q253=750	;F PRE-POSITIONING
Q351=+1	;CLIMB OR UP-CUT
Q200=2	;SET-UP CLEARANCE
Q358=+0	;DEPTH AT FRONT
Q359=+0	;OFFSET AT FRONT
Q203=+30	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q254=150	;F COUNTERBORING
Q207=500	;FEED RATE FOR MILLING



Example: Drilling cycles



0 BEGIN PGM C200 MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+3	Define the tool
4 TOOL CALL 1 Z S4500	Tool call
5 L Z+250 R0 FMAX	Retract the tool
6 CYCL DEF 200 DRILLING	Define cycle
Q200=2 ;SET-UP CLEARANCE	
Q201=-15 ;DEPTH	
Q206=250 ;FEED RATE FOR PLNGNG	
Q202=5 ;INFEED DEPTH	
Q210=0 ;DWELL TIME AT TOP	
Q203=-10 ;SURFACE COORDINATE	
Q204=20 ;2ND SET-UP CLEARANCE	
Q211=0.2 ;DWELL TIME AT DEPTH	



7 L X+10 Y+10 R0 FMAX M3	Approach hole 1, spindle ON
8 CYCL CALL	Call the cycle
9 L Y+90 R0 FMAX M99	Approach hole 2, call cycle
10 L X+90 R0 FMAX M99	Approach hole 3, call cycle
11 L Y+10 R0 FMAX M99	Approach hole 4, call cycle
12 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
13 END PGM C200 MM	



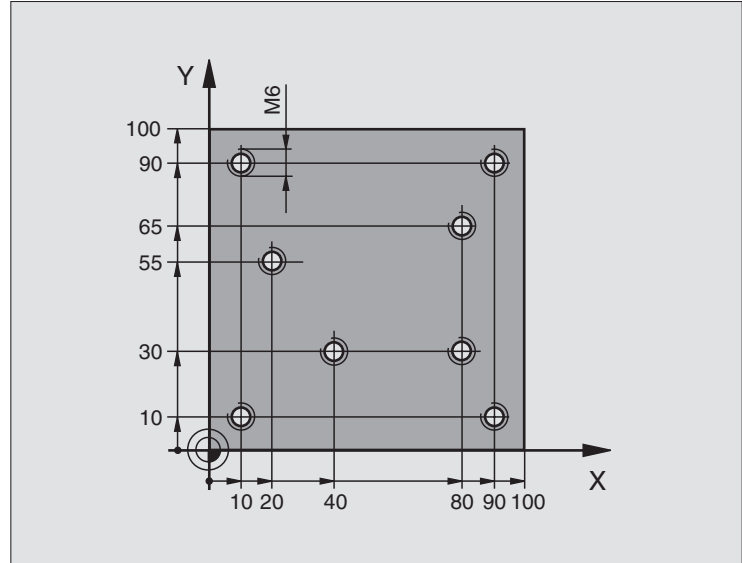
## Example: Calling drilling cycles in connection with point tables

The drill hole coordinates are stored in the point table TAB1.PNT and are called by the TNC with **CYCL CALL PAT.**

The tool radii are selected so that all work steps can be seen in the test graphics.

### Program sequence

- Centering
- Drilling
- Tapping



<b>0 BEGIN PGM 1 MM</b>	
<b>1 BLK FORM 0.1 Z X+0 Y+0 Z-20</b>	Define the workpiece blank
<b>2 BLK FORM 0.2 X+100 Y+100 Y+0</b>	
<b>3 TOOL DEF 1 L+0 R+4</b>	Tool definition of center drill
<b>4 TOOL DEF 2 L+0 2.4</b>	Define tool: drill
<b>5 TOOL DEF 3 L+0 R+3</b>	Tool definition of tap
<b>6 TOOL CALL 1 Z S5000</b>	Tool call of centering drill
<b>7 L Z+10 R0 F5000</b>	Move tool to clearance height (enter a value for F)
	The TNC positions to the clearance height after every cycle
<b>8 SEL PATTERN "TAB1"</b>	Defining point tables
<b>9 CYCL DEF 200 DRILLING</b>	Cycle definition: Centering
<b>Q200=2 ;SET-UP CLEARANCE</b>	
<b>Q201=-2 ;DEPTH</b>	
<b>Q206=150 ;FEED RATE FOR PLNGNG</b>	
<b>Q202=2 ;INFED DEPTH</b>	
<b>Q210=0 ;DWELL TIME AT TOP</b>	
<b>Q203=+0 ;SURFACE COORDINATE</b>	0 must be entered here, effective as defined in point table
<b>Q204=0 ;2ND SET-UP CLEARANCE</b>	0 must be entered here, effective as defined in point table
<b>Q211=0.2 ;DWELL TIME AT DEPTH</b>	



## 8.3 Cycles for Drilling, Tapping and Thread Milling

10 CYCL CALL PAT F5000 M3	Cycle call in connection with point table TAB1.PNT
	Feed rate between points: 5000 mm/min
11 L Z+100 R0 FMAX M6	Retract the tool, change the tool
12 TOOL CALL 2 Z S5000	Call toll: drill
13 L Z+10 R0 F5000	Move tool to clearance height (enter a value for F)
14 CYCL DEF 200 DRILLING	Cycle definition: drilling
Q200=2 ;SET-UP CLEARANCE	
Q201=-25 ;DEPTH	
Q206=150 ;FEED RATE FOR PECKING	
Q202=5 ;INFEEED DEPTH	
Q210=0 ;DWELL TIME AT TOP	
Q203=+0 ;SURFACE COORDINATE	0 must be entered here, effective as defined in point table
Q204=0 ;2ND SET-UP CLEARANCE	0 must be entered here, effective as defined in point table
Q211=0.2 ;DWELL TIME AT DEPTH	
15 CYCL CALL PAT F5000 M3	Cycle call in connection with point table TAB1.PNT
16 L Z+100 R0 FMAX M6	Retract the tool, change the tool
17 TOOL CALL 3 Z S200	Tool call for tap
18 L Z+50 R0 FMAX	Move tool to clearance height
19 CYCL DEF 206 TAPPING NEW	Cycle definition for tapping
Q200=2 ;SET-UP CLEARANCE	
Q201=-25 ;THREAD DEPTH	
Q206=150 ;FEED RATE FOR PECKING	
Q211=0 ;DWELL TIME AT DEPTH	
Q203=+0 ;SURFACE COORDINATE	0 must be entered here, effective as defined in point table
Q204=0 ;2ND SET-UP CLEARANCE	0 must be entered here, effective as defined in point table
20 CYCL CALL PAT F5000 M3	Cycle call in connection with point table TAB1.PNT
21 L Z+100 R0 FMAX M2	Retract in the tool axis, end program
22 END PGM 1 MM	













Point table TAB1.PNT

TAB1. PNT MM			
NR	X	Y	Z
0	+10	+10	+0
1	+40	+30	+0
2	+90	+10	+0
3	+80	+30	+0
4	+80	+65	+0
5	+90	+90	+0
6	+10	+90	+0
7	+20	+55	+0
[END]			



# 8.4 Cycles for Milling Pockets, Studs and Slots

## Overview

Cycle	Soft key
251 RECTANGULAR POCKET Roughing/finishing cycle with selection of machining operation and helical plunging	
252 CIRCULAR POCKET Roughing/finishing cycle with selection of machining operation and helical plunging	
253 SLOT MILLING Roughing/finishing cycle with selection of machining operation and reciprocal plunging	
254 CIRCULAR SLOT Roughing/finishing cycle with selection of machining operation and reciprocal plunging	
212 POCKET FINISHING (rectangular) Finishing cycle with automatic pre-positioning, 2nd set-up clearance	
213 STUD FINISHING (rectangular) Finishing cycle with automatic pre-positioning, 2nd set-up clearance	
214 C. POCKET FINISHING Finishing cycle with automatic pre-positioning, 2nd set-up clearance	
215 CIRCULAR STUD FINISHING Finishing cycle with automatic pre-positioning, 2nd set-up clearance	
210 SLOT RECIP. PLNG Roughing/finishing cycle with automatic pre-positioning, with reciprocating plunge infeed	
211 CIRCULAR SLOT Roughing/finishing cycle with automatic pre-positioning, with reciprocating plunge infeed	





## RECTANGULAR POCKET (Cycle 251)

Use Cycle 251 RECTANGULAR POCKET to completely machine rectangular pockets. Depending on the cycle parameters, the following machining alternatives are available:

- Complete machining: Roughing, floor finishing, side finishing
- Only roughing
- Only floor finishing and side finishing
- Only floor finishing
- Only side finishing



With an inactive tool table you must always plunge vertically (Q366=0) because you cannot define a plunging angle.

### Roughing

- 1** The tool plunges the workpiece at the pocket center and advances to the first plunging depth. Specify the plunging strategy with Parameter Q366.
- 2** The TNC roughs out the pocket from the inside out, taking the overlap factor (Parameter Q370) and the finishing allowance (Parameter Q368 and Q369) into account.
- 3** At the end of the roughing operation, the TNC moves the tool tangentially away from the pocket wall, then moves by the set-up clearance above the current pecking depth and returns from there at rapid traverse to the pocket center.
- 4** This process is repeated until the programmed pocket depth is reached.



## Finishing

- 5 Inasmuch as finishing allowances are defined, the TNC then finishes the pocket walls, in multiple infeeds if so specified. The pocket wall is approached tangentially.
- 6 Then the TNC finishes the floor of the pocket from the inside out. The pocket floor is approached tangentially.



### Before programming, note the following:

Pre-position the tool in the machining plane to the starting position with radius compensation R0. Note Parameter Q367 (pocket position).

The TNC runs the cycle in the axes (machining plane) with which you approached the starting position. For example, in X and Y if you programmed **CYCL CALL POS X... Y...** or in U and V if you programmed **CYCL CALL POS U... V...**

The TNC automatically pre-positions the tool in the tool axis. Note Parameter Q204 (2nd set-up clearance).

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

At the end of the cycle, the TNC returns the tool to the starting position.

At the end of a roughing operation, the TNC positions the tool back to the pocket center at rapid traverse. The tool is above the current pecking depth by the set-up clearance. Enter the set-up clearance so that the tool cannot jam because of chips.



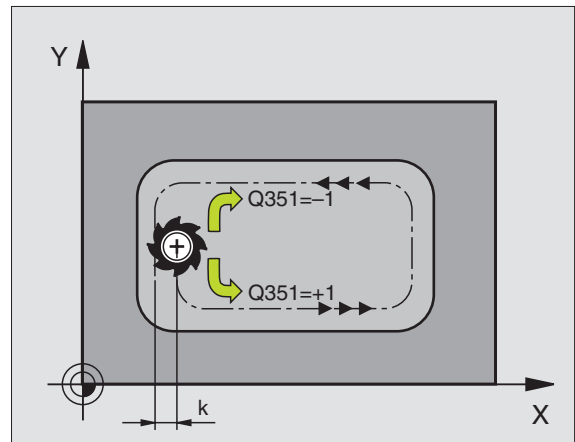
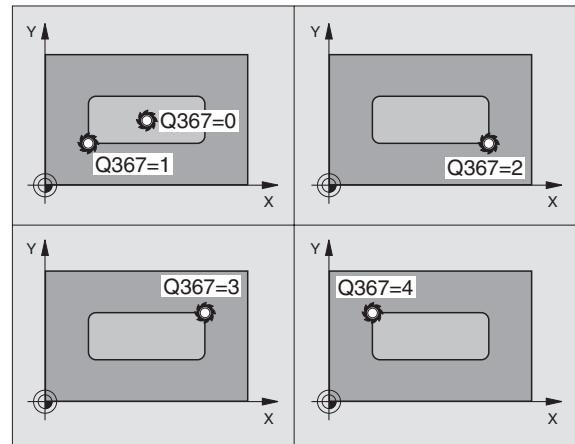
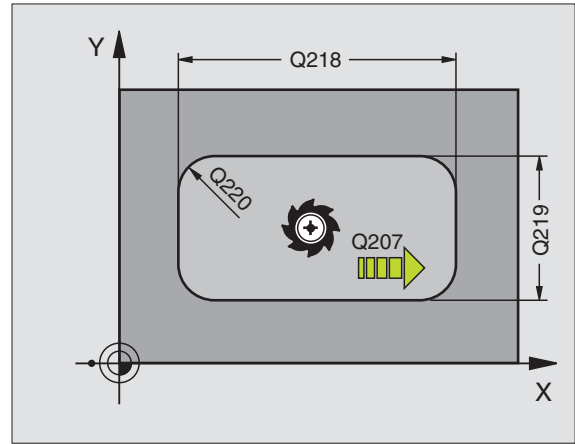
Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

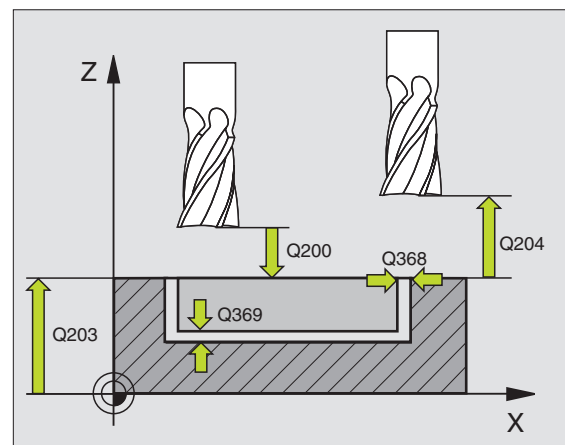
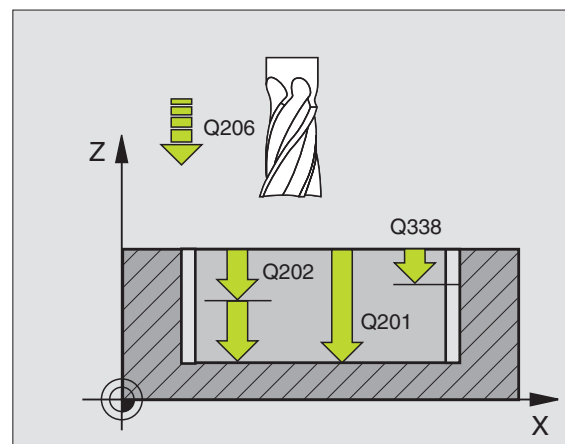
Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!



- **Machining operation (0/1/2)** Q215: Define the machining operation:  
**0:** Roughing and finishing  
**1:** Only roughing  
**2:** Only finishing  
 Side finishing and floor finishing are only executed if the finishing allowances (Q368, Q369) have been defined.
- **1st side length** Q218 (incremental value): Pocket length, parallel to the reference axis of the working plane.
- **2nd side length** Q219 (incremental value): Pocket length, parallel to the minor axis of the working plane.
- **Corner radius** Q220: Radius of the pocket corner: If you make no entry here, the TNC assumes that the corner radius is equal to the tool radius.
- **Finishing allowance for side** Q368 (incremental value): Finishing allowance in the working plane.
- **Angle of rotation** Q224 (absolute): Angle by which the entire pocket is rotated. The center of rotation is the position at which the tool is located when the cycle is called.
- **Pocket position** Q367: Position of the pocket in reference to the position of the tool when the cycle is called (see figure at center right):  
**0:** Tool position = Center of pocket  
**1:** Tool position = Lower left corner  
**2:** Tool position = Lower right corner  
**3:** Tool position = Upper right corner  
**4:** Tool position = Upper left corner
- **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- **Climb or up-cut** Q351: Type of milling operation with M03.  
**+1** = climb milling  
**-1** = up-cut milling



- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and pocket floor.
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut. Enter a value greater than 0.
- ▶ **Finishing allowance for floor** Q369 (incremental value): Finishing allowance in the tool axis.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool while moving to depth in mm/min.
- ▶ **Infeed for finishing** Q338 (incremental value): Infeed per cut. Q338=0: Finishing in one infeed.
- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Absolute coordinate of the workpiece surface
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.



- **Path overlap factor** Q370:  $Q370 \times \text{tool radius} = \text{stepover factor } k$ .
- **Plunging strategy** Q366: Type of plunging strategy.
  - 0 = vertical plunging. In the tool table, the plunging angle **ANGLE** for the active tool must be defined as  $90^\circ$ . Otherwise the TNC displays an error message.
  - 1 = helical plunging. In the tool table, the plunging angle **ANGLE** for the active tool must be defined not equal to 0. Otherwise the TNC displays an error message.
  - 2 = reciprocating plunge. In the tool table, the plunging angle **ANGLE** for the active tool must be defined as not equal to 0. The TNC will otherwise display an error message. The reciprocation length depends on the plunging angle. As a minimum value the TNC uses twice the tool diameter.
- **Feed rate for finishing** Q385: Traversing speed of the tool during side and floor finishing in mm/min.

**Example: NC blocks**

8 CYCL DEF 251 RECTANGULAR POCKET	
Q215=0	;MACHINING OPERATION
Q218=80	;1ST SIDE LENGTH
Q219=60	;2ND SIDE LENGTH
Q220=5	;CORNER RADIUS
Q368=0.2	;ALLOWANCE FOR SIDE
Q224=+0	;ANGLE OF ROTATION
Q367=0	;POCKET POSITION
Q207=500	;FEED RATE FOR MILLING
Q351=+1	;CLIMB OR UP-CUT
Q201=-20	;DEPTH
Q202=5	;INFEEED DEPTH
Q369=0.1	;ALLOWANCE FOR FLOOR
Q206=150	;FEED RATE FOR PLNGNG
Q338=5	;INFEEED FOR FINISHING
Q200=2	;SET-UP CLEARANCE
Q203=+0	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q370=1	;TOOL PATH OVERLAP
Q366=1	;PLUNGING
Q385=500	;FEED RATE FOR FINISHING
9 CYCL CALL POS X+50 Y+50 Z+0 FMAX M3	



## CIRCULAR POCKET (Cycle 252)

Use Cycle 252 CIRCULAR POCKET to completely machine circular pockets. Depending on the cycle parameters, the following machining alternatives are available:

- Complete machining: Roughing, floor finishing, side finishing
- Only roughing
- Only floor finishing and side finishing
- Only floor finishing
- Only side finishing



With an inactive tool table you must always plunge vertically (Q366=0) because you cannot define a plunging angle.

### Roughing

- 1 The tool plunges the workpiece at the pocket center and advances to the first plunging depth. Specify the plunging strategy with Parameter Q366.
- 2 The TNC roughs out the pocket from the inside out, taking the overlap factor (Parameter Q370) and the finishing allowance (Parameter Q368 and Q369) into account.
- 3 At the end of the roughing operation, the TNC moves the tool tangentially away from the pocket wall, then moves by the set-up clearance above the current pecking depth and returns from there at rapid traverse to the pocket center.
- 4 This process is repeated until the programmed pocket depth is reached.

**Finishing**

- 5 Inasmuch as finishing allowances are defined, the TNC then finishes the pocket walls, in multiple infeeds if so specified. The pocket wall is approached tangentially.
- 6 Then the TNC finishes the floor of the pocket from the inside out. The pocket floor is approached tangentially.

**Before programming, note the following:**

Pre-position the tool in the machining plane to the starting position (circle center) with radius compensation R0.

The TNC runs the cycle in the axes (machining plane) with which you approached the starting position. For example, in X and Y if you programmed **CYCL CALL POS X... Y...** or in U and V if you programmed **CYCL CALL POS U... V...**

The TNC automatically pre-positions the tool in the tool axis. Note Parameter Q204 (2nd set-up clearance).

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

At the end of the cycle, the TNC returns the tool to the starting position.

At the end of a roughing operation, the TNC positions the tool back to the pocket center at rapid traverse. The tool is above the current pecking depth by the set-up clearance. Enter the set-up clearance so that the tool cannot jam because of chips.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

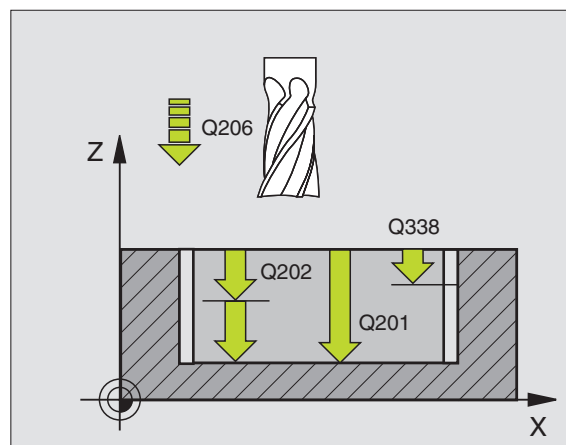
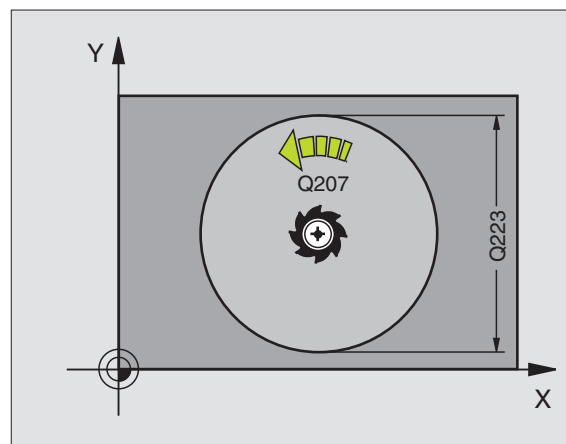
**Danger of collision!**

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!



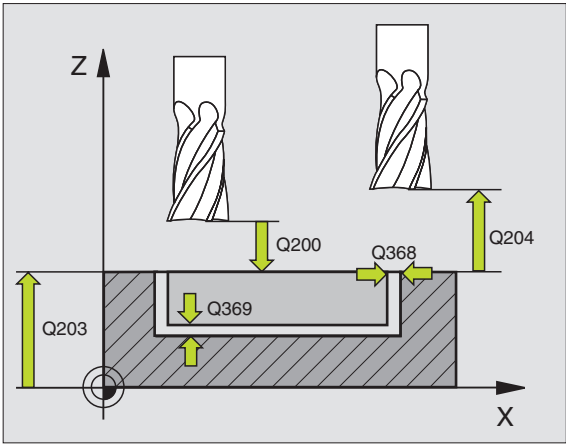


- ▶ **Machining operation (0/1/2)** Q215: Define the machining operation:  
**0:** Roughing and finishing  
**1:** Only roughing  
**2:** Only finishing  
 Side finishing and floor finishing are only executed if the finishing allowances (Q368, Q369) have been defined.
- ▶ **Circle diameter** Q223: Diameter of the finished pocket.
- ▶ **Finishing allowance for side** Q368 (incremental value): Finishing allowance in the working plane.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- ▶ **Climb or up-cut** Q351: Type of milling operation with M03.  
**+1** = climb milling  
**-1** = up-cut milling
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and pocket floor.
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut. Enter a value greater than 0.
- ▶ **Finishing allowance for floor** Q369 (incremental value): Finishing allowance in the tool axis.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool while moving to depth in mm/min.
- ▶ **Infeed for finishing** Q338 (incremental value): Infeed per cut. Q338=0: Finishing in one infeed.





- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Absolute coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Path overlap factor** Q370:  $Q370 \times \text{tool radius} = \text{stepover factor } k$ .
- ▶ **Plunging strategy** Q366: Type of plunging strategy.
  - 0 = vertical plunging. In the tool table, the plunging angle **ANGLE** for the active tool must be defined as 90°. Otherwise the TNC displays an error message.
  - 1 = helical plunging. In the tool table, the plunging angle **ANGLE** for the active tool must be defined not equal to 0. Otherwise the TNC displays an error message.
- ▶ **Feed rate for finishing** Q385: Traversing speed of the tool during side and floor finishing in mm/min.



## Example: NC blocks

8 CYCL DEF 252 CIRCULAR POCKET	
Q215=0	;MACHINING OPERATION
Q223=60	;CIRCLE DIAMETER
Q368=0.2	;ALLOWANCE FOR SIDE
Q207=500	;FEED RATE FOR MILLING
Q351=+1	;CLIMB OR UP-CUT
Q201=-20	;DEPTH
Q202=5	;INFEEED DEPTH
Q369=0.1	;ALLOWANCE FOR FLOOR
Q206=150	;FEED RATE FOR PLNGNG
Q338=5	;INFEEED FOR FINISHING
Q200=2	;SET-UP CLEARANCE
Q203=+0	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q370=1	;TOOL PATH OVERLAP
Q366=1	;PLUNGING
Q385=500	;FEED RATE FOR FINISHING
9 CYCL CALL POS X+50 Y+50 Z+0 FMAX M3	



## SLOT MILLING (Cycle 253)

Use Cycle 253 to completely machine a slot. Depending on the cycle parameters, the following machining alternatives are available:

- Complete machining: Roughing, floor finishing, side finishing
- Only roughing
- Only floor finishing and side finishing
- Only floor finishing
- Only side finishing



With an inactive tool table you must always plunge vertically (Q366=0) because you cannot define a plunging angle.

### Roughing

- 1 Starting from the left slot arc center, the tool moves in a reciprocating motion at the plunging angle defined in the tool table to the first infeed depth. Specify the plunging strategy with Parameter Q366.
- 2 The TNC roughs out the slot from the inside out, taking the finishing allowances (parameter Q368) into account.
- 3 This process is repeated until the programmed slot depth is reached.

## Finishing

- 4 Inasmuch as finishing allowances are defined, the TNC then finishes the slot walls, in multiple infeeds if so specified. The slot side is approached tangentially in the right slot arc.
- 5 Then the TNC finishes the floor of the slot from the inside out. The slot floor is approached tangentially.



### Before programming, note the following:

Pre-position the tool in the machining plane to the starting position with radius compensation R0. Note Parameter Q367 (slot position).

The TNC runs the cycle in the axes (machining plane) with which you approached the starting position. For example, in X and Y if you programmed **CYCL CALL POS X... Y...** or in U and V if you programmed **CYCL CALL POS U... V...**

The TNC automatically pre-positions the tool in the tool axis. Note Parameter Q204 (2nd set-up clearance).

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

If the slot width is greater than twice the tool diameter, the TNC roughs the slot correspondingly from inside out. You can therefore mill any slots with small tools, too.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

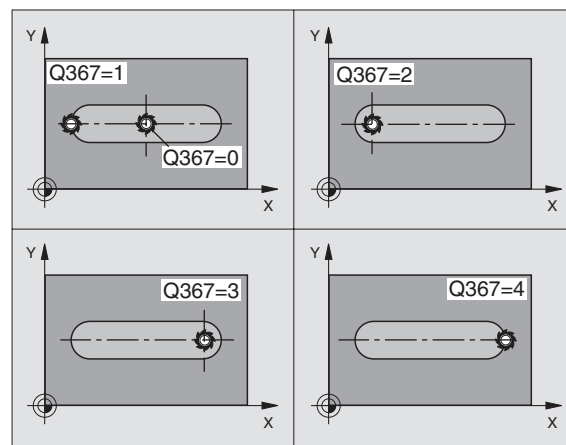
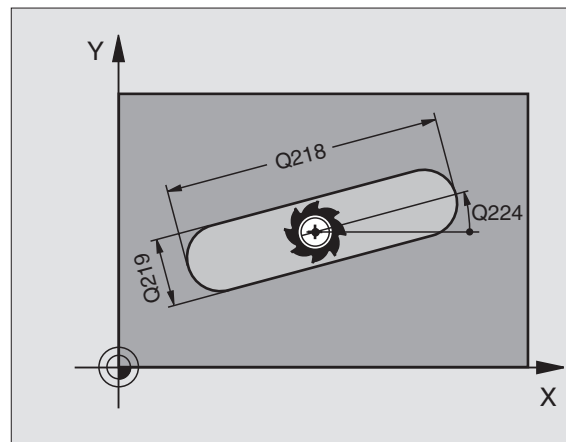
### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!

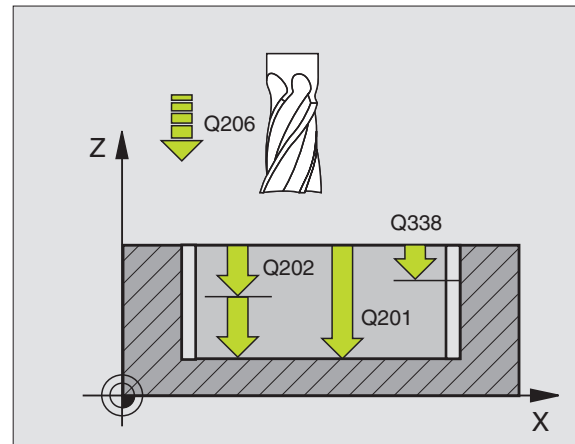




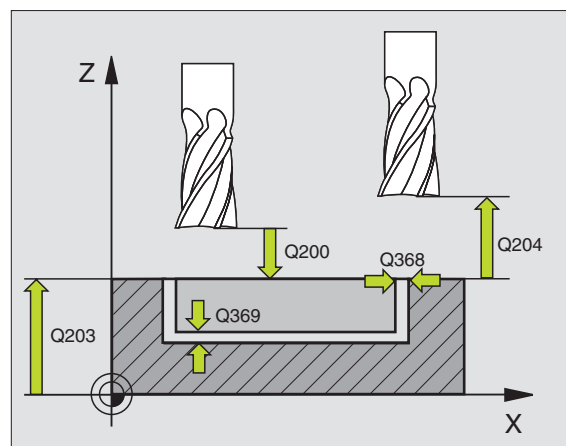
- ▶ **Machining operation (0/1/2)** Q215: Define the machining operation:  
**0:** Roughing and finishing  
**1:** Only roughing  
**2:** Only finishing  
 Side finishing and floor finishing are only executed if the finishing allowances (Q368, Q369) have been defined.
- ▶ **Slot length** Q218 (value parallel to the reference axis of the working plane): Enter the length of the slot
- ▶ **Slot width** Q219 (value parallel to the secondary axis of the working plane): Enter the slot width. If you enter a slot width that equals the tool diameter, the TNC will carry out the roughing process only (slot milling). Maximum slot width for roughing: Twice the tool diameter
- ▶ **Finishing allowance for side** Q368 (incremental value): Finishing allowance in the working plane.
- ▶ **Angle of rotation** Q224 (absolute): Angle by which the entire slot is rotated. The center of rotation is the position at which the tool is located when the cycle is called.
- ▶ **Slot position (0/1/2/3/4)** Q367: Position of the slot in reference to the position of the tool when the cycle is called (see figure at center right):  
**0:** Tool position = Center of slot  
**1:** Tool position = Left end of slot  
**2:** Tool position = Center of left slot circle  
**3:** Tool position = Center of right slot circle  
**4:** Tool position = Right end of slot
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- ▶ **Climb or up-cut** Q351: Type of milling operation with M03.  
**+1** = climb milling  
**-1** = up-cut milling



- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of slot.
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut. Enter a value greater than 0.
- ▶ **Finishing allowance for floor** Q369 (incremental value): Finishing allowance in the tool axis.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool while moving to depth in mm/min.
- ▶ **Infeed for finishing** Q338 (incremental value): Infeed per cut. Q338=0: Finishing in one infeed.



- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Absolute coordinate of the workpiece surface
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Plunging strategy** Q366: Type of plunging strategy.
  - 0 = vertical plunging. In the tool table, the plunging angle **ANGLE** for the active tool must be defined as 90°. Otherwise the TNC displays an error message.
  - 1 = helical plunging. In the tool table, the plunging angle **ANGLE** for the active tool must be defined not equal to 0. The TNC will otherwise display an error message. Plunge on a helical path only if there is enough space.
  - 2 = reciprocating plunge. In the tool table, the plunging angle **ANGLE** for the active tool must be defined as not equal to 0. Otherwise the TNC displays an error message.
- ▶ **Feed rate for finishing** Q385: Traversing speed of the tool during side and floor finishing in mm/min.



## Example: NC blocks

### 8 CYCL DEF 253 SLOT MILLING

Q215=0 ;MACHINING OPERATION

Q218=80 ;SLOT LENGTH

Q219=12 ;SLOT WIDTH

Q368=0.2 ;ALLOWANCE FOR SIDE

Q224=+0 ;ANGLE OF ROTATION

Q367=0 ;SLOT POSITION

Q207=500 ;FEED RATE FOR MILLING

Q351=+1 ;CLIMB OR UP-CUT

Q201=-20 ;DEPTH

Q202=5 ;INFEEED DEPTH

Q369=0.1 ;ALLOWANCE FOR FLOOR

Q206=150 ;FEED RATE FOR PLNGNG

Q338=5 ;INFEEED FOR FINISHING

Q200=2 ;SET-UP CLEARANCE

Q203=+0 ;SURFACE COORDINATE

Q204=50 ;2ND SET-UP CLEARANCE

Q366=1 ;PLUNGING

Q385=500 ;FEED RATE FOR FINISHING

9 CYCL CALL POS X+50 Y+50 Z+0 FMAX M3

## CIRCULAR SLOT (Cycle 254)

Use Cycle 254 to completely machine a circular slot. Depending on the cycle parameters, the following machining alternatives are available:

- Complete machining: Roughing, floor finishing, side finishing
- Only roughing
- Only floor finishing and side finishing
- Only floor finishing
- Only side finishing



With an inactive tool table you must always plunge vertically (Q366=0) because you cannot define a plunging angle.

### Roughing

- 1** The tool moves in a reciprocating motion in the slot center at the plunging angle defined in the tool table to the first infeed depth. Specify the plunging strategy with Parameter Q366.
- 2** The TNC roughs out the slot from the inside out, taking the finishing allowances (parameter Q368) into account.
- 3** This process is repeated until the programmed slot depth is reached.



## Finishing

- 4 Inasmuch as finishing allowances are defined, the TNC then finishes the slot walls, in multiple infeeds if so specified. The slot side is approached tangentially.
- 5 Then the TNC finishes the floor of the slot from the inside out.. The slot floor is approached tangentially.



### Before programming, note the following:

Pre-position the tool in the machining plane with radius compensation R0. Define Parameter Q367 (**Reference for slot position**) appropriately.

The TNC runs the cycle in the axes (machining plane) with which you approached the starting position. For example, in X and Y if you programmed **CYCL CALL POS X... Y...** or in U and V if you programmed **CYCL CALL POS U... V...**

The TNC automatically pre-positions the tool in the tool axis. Note Parameter Q204 (2nd set-up clearance).

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

If the slot width is greater than twice the tool diameter, the TNC roughs the slot correspondingly from inside out. You can therefore mill any slots with small tools, too.



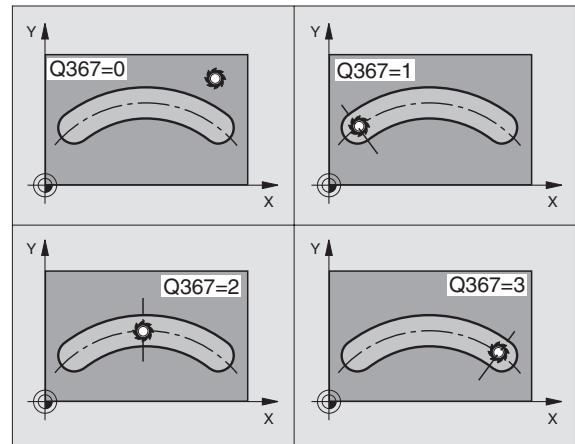
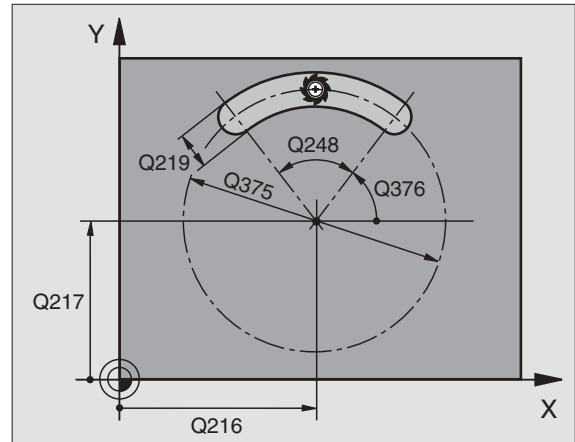
Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

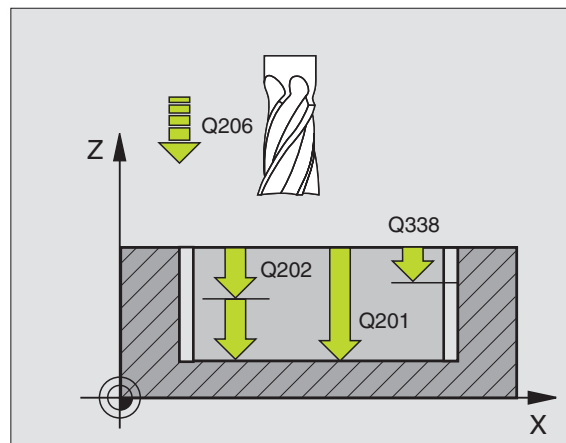
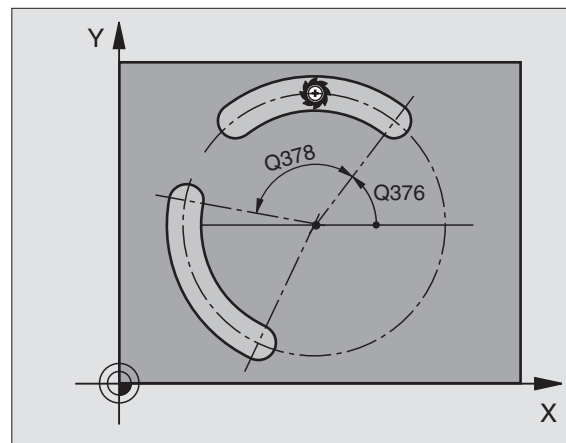
Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!



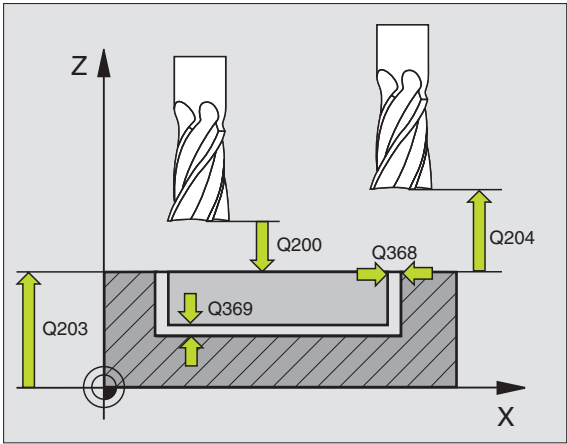
- **Machining operation (0/1/2)** Q215: Define the machining operation:  
**0:** Roughing and finishing  
**1:** Only roughing  
**2:** Only finishing  
 Side finishing and floor finishing are only executed if the finishing allowances (Q368, Q369) have been defined.
- **Slot width** Q219 (value parallel to the secondary axis of the working plane): Enter the slot width. If you enter a slot width that equals the tool diameter, the TNC will carry out the roughing process only (slot milling). Maximum slot width for roughing: Twice the tool diameter
- **Finishing allowance for side** Q368 (incremental value): Finishing allowance in the working plane.
- **Pitch circle diameter** Q375: Enter the diameter of the pitch circle.
- **Reference for slot position (0/1/2/3)** Q367:  
 Position of the slot in reference to the position of the tool when the cycle is called (see figure at center right):  
**0:** The tool position is not taken into account. The slot position is determined from the entered pitch circle center and the starting angle.  
**1:** Tool position = Center of left slot circle. Starting angle Q376 refers to this position. The entered pitch circle center is not taken into account.  
**2:** Tool position = Center of center line. Starting angle Q376 refers to this position. The entered pitch circle center is not taken into account.  
**3:** Tool position = Center of right slot circle. Starting angle Q376 refers to this position. The entered pitch circle center is not taken into account.
- **Center in 1st axis** Q216 (absolute value): Center of the pitch circle in the reference axis of the working plane. **Only effective if Q367 = 0.**
- **Center in 2nd axis** Q217 (absolute value): Center of the pitch circle in the minor axis of the working plane. **Only effective if Q367 = 0.**
- **Starting angle** Q376 (absolute value): Enter the polar angle of the starting point.
- **Angular length** Q248 (incremental value): Enter the angular length of the slot.



- ▶ **Angle increment** Q378 (incremental): Angle by which the entire slot is rotated. The center of rotation is at the center of the pitch circle.
- ▶ **Number of repetitions** Q377: Number of machining operations on the pitch circle.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- ▶ **Climb or up-cut** Q351: Type of milling operation with M03.  
**+1** = climb milling  
**-1** = up-cut milling
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of slot.
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut. Enter a value greater than 0.
- ▶ **Finishing allowance for floor** Q369 (incremental value): Finishing allowance in the tool axis.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool while moving to depth in mm/min.
- ▶ **Infeed for finishing** Q338 (incremental value): Infeed per cut. Q338=0: Finishing in one infeed.



- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Absolute coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Plunging strategy** Q366: Type of plunging strategy.
  - 0 = vertical plunging. In the tool table, the plunging angle **ANGLE** for the active tool must be defined as 90°. Otherwise the TNC displays an error message.
  - 1 = helical plunging. In the tool table, the plunging angle **ANGLE** for the active tool must be defined not equal to 0. The TNC will otherwise display an error message. Plunge on a helical path only if there is enough space.
  - 2 = reciprocating plunge. In the tool table, the plunging angle **ANGLE** for the active tool must be defined as not equal to 0. Otherwise the TNC displays an error message.
- ▶ **Feed rate for finishing** Q385: Traversing speed of the tool during side and floor finishing in mm/min.



Example: NC blocks

8 CYCL DEF 254 CIRCULAR SLOT	
Q215=0	;MACHINING OPERATION
Q219=12	;SLOT WIDTH
Q368=0.2	;ALLOWANCE FOR SIDE
Q375=80	;PITCH CIRCLE DIA.
Q367=0	;REF. SLOT POSITION
Q216=+50	;CENTER IN 1ST AXIS
Q217=+50	;CENTER IN 2ND AXIS
Q376=+45	;STARTING ANGLE
Q248=90	;ANGULAR LENGTH
Q378=0	;STEPPING ANGLE
Q377=1	;NR OF REPETITIONS
Q207=500	;FEED RATE FOR MILLING
Q351=+1	;CLIMB OR UP-CUT
Q201=-20	;DEPTH
Q202=5	;INFEEED DEPTH
Q369=0.1	;ALLOWANCE FOR FLOOR
Q206=150	;FEED RATE FOR PLNGNG
Q338=5	;INFEEED FOR FINISHING
Q200=2	;SET-UP CLEARANCE
Q203=+0	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q366=1	;PLUNGING
Q385=500	;FEED RATE FOR FINISHING
9 CYCL CALL POS X+50 Y+50 Z+0 FMAX M3	



## POCKET FINISHING (Cycle 212)

- 1 The TNC automatically moves the tool in the tool axis to set-up clearance, or—if programmed—to the 2nd set-up clearance, and subsequently to the center of the pocket.
- 2 From the pocket center, the tool moves in the working plane to the starting point for machining. The TNC takes the allowance and tool radius into account for calculating the starting point. If necessary, the TNC penetrates at the pocket center.
- 3 If the tool is at the 2nd set-up clearance, it moves in rapid traverse FMAX to set-up clearance, and from there advances to the first plunging depth at the feed rate for plunging.
- 4 The tool then moves tangentially to the contour of the finished part and, using climb milling, machines one revolution.
- 5 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 6 This process (3 to 5) is repeated until the programmed depth is reached.
- 7 At the end of the cycle, the TNC retracts the tool in rapid traverse to set-up clearance, or—if programmed—to the 2nd set-up clearance, and finally to the center of the pocket (end position = starting position).



### Before programming, note the following:

The TNC automatically pre-positions the tool in the tool axis and working plane.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

If you want to clear and finish the pocket with the same tool, use a center-cut end mill (ISO 1641) and enter a low feed rate for plunging.

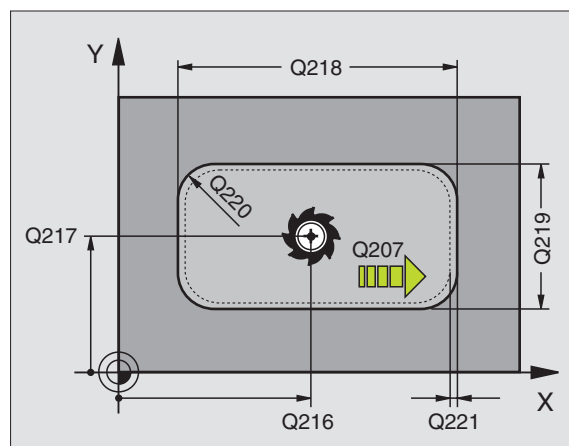
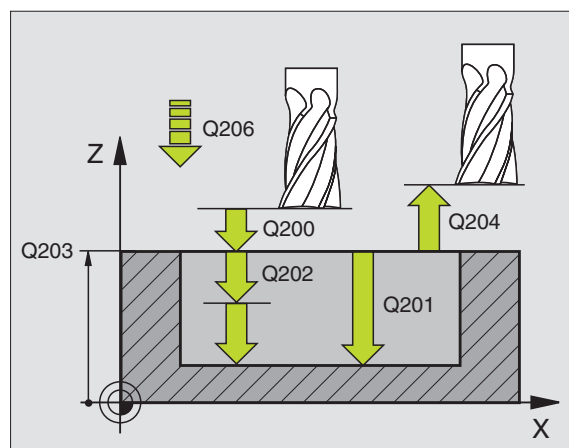
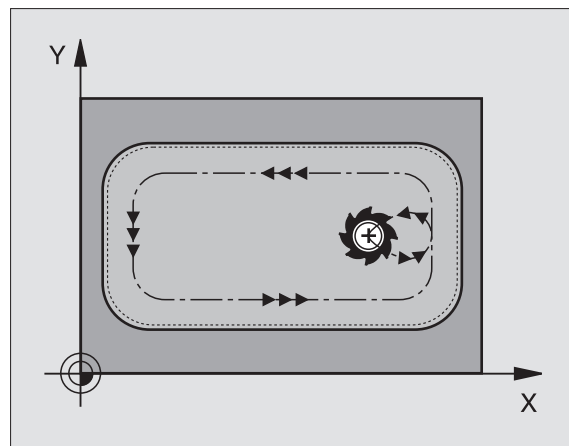
Minimum size of the pocket: 3 times the tool radius.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of pocket.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool in mm/min when moving to depth. If you are plunge-cutting into the material, enter a value lower than that defined in Q207.
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut. Enter a value greater than 0.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Center in 1st axis** Q216 (absolute value): Center of the pocket in the reference axis of the working plane.
- ▶ **Center in 2nd axis** Q217 (absolute value): Center of the pocket in the minor axis of the working plane.
- ▶ **1st side length** Q218 (incremental value): Pocket length, parallel to the reference axis of the working plane.
- ▶ **2nd side length** Q219 (incremental value): Pocket length, parallel to the minor axis of the working plane.
- ▶ **Corner radius** Q220: Radius of the pocket corner: If you make no entry here, the TNC assumes that the corner radius is equal to the tool radius.
- ▶ **Allowance in 1st axis** Q221 (incremental value): Allowance for pre-positioning in the reference axis of the working plane referenced to the length of the pocket.

**Example: NC blocks**

354 CYCL DEF 212 POCKET FINISHING	
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q202=5	;INFED DEPTH
Q207=500	;FEED RATE FOR MILLING
Q203=+30	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q216=+50	;CENTER IN 1ST AXIS
Q217=+50	;CENTER IN 2ND AXIS
Q218=80	;1ST SIDE LENGTH
Q219=60	;2ND SIDE LENGTH
Q220=5	;CORNER RADIUS
Q221=0	;OVERSIZE



## STUD FINISHING (Cycle 213)

- 1 The TNC moves the tool in the tool axis to set-up clearance, or—if programmed—to the 2nd set-up clearance, and subsequently to the center of the stud.
- 2 From the stud center, the tool moves in the working plane to the starting point for machining. The starting point lies to the right of the stud by a distance approx. 3.5 times the tool radius.
- 3 If the tool is at the 2nd set-up clearance, it moves in rapid traverse FMAX to set-up clearance, and from there advances to the first plunging depth at the feed rate for plunging.
- 4 The tool then moves tangentially to the contour of the finished part and, using climb milling, machines one revolution.
- 5 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 6 This process (3 to 5) is repeated until the programmed depth is reached.
- 7 At the end of the cycle, the TNC retracts the tool in FMAX to set-up clearance, or—if programmed—to the 2nd set-up clearance, and finally to the center of the stud (end position = starting position).



### Before programming, note the following:

The TNC automatically pre-positions the tool in the tool axis and working plane.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

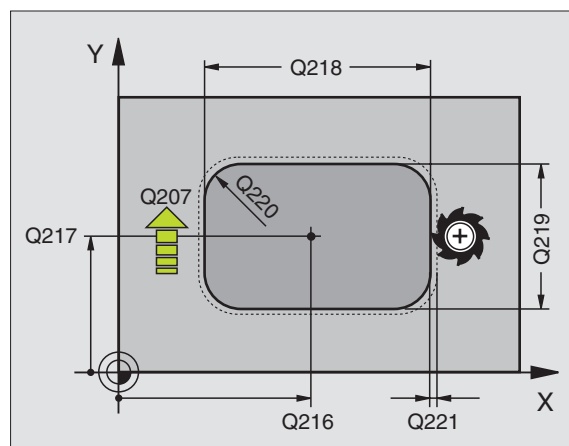
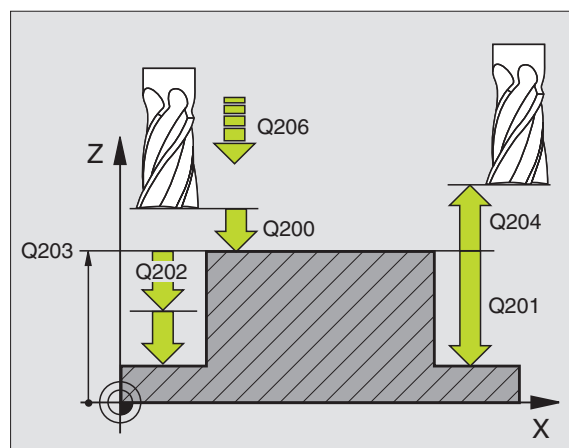
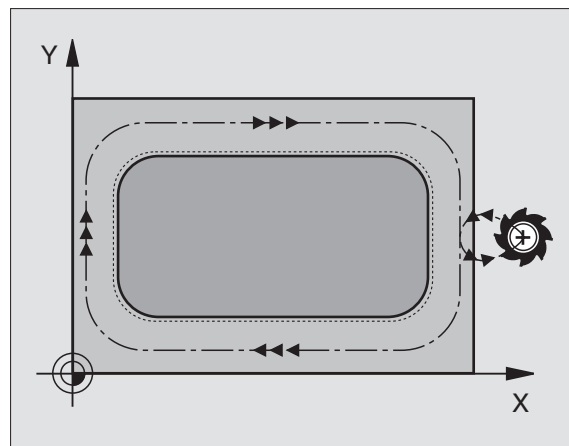
If you want to clear and finish the stud with the same tool, use a center-cut end mill (ISO 1641) and enter a low feed rate for plunging.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of stud.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool in mm/min when moving to depth. If you are plunge-cutting into the material, enter a low value; if you have already cleared the stud, enter a higher feed rate.
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut. Enter a value greater than 0.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Center in 1st axis** Q216 (absolute value): Center of the stud in the reference axis of the working plane.
- ▶ **Center in 2nd axis** Q217 (absolute value): Center of the stud in the minor axis of the working plane.
- ▶ **1st side length** Q218 (incremental value): Stud length, parallel to the reference axis of the working plane.
- ▶ **2nd side length** Q219 (incremental value): Stud length, parallel to the minor axis of the working plane.
- ▶ **Corner radius** Q220: Radius of the stud corner.
- ▶ **Allowance in 1st axis** Q221 (incremental value): Allowance for pre-positioning in the reference axis of the working plane referenced to the length of the stud.

**Example: NC blocks**

35 CYCL DEF 213 STUD FINISHING	
Q200=2	;SET-UP CLEARANCE
Q291=-20	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q202=5	;INFEEED DEPTH
Q207=500	;FEED RATE FOR MILLING
Q203=+30	;SURFACE COORDINATE
Q294=50	;2ND SET-UP CLEARANCE
Q216=+50	;CENTER IN 1ST AXIS
Q217=+50	;CENTER IN 2ND AXIS
Q218=80	;1ST SIDE LENGTH
Q219=60	;2ND SIDE LENGTH
Q220=5	;CORNER RADIUS
Q221=0	;OVERSIZE



## CIRCULAR POCKET FINISHING (Cycle 214)

- 1 The TNC automatically moves the tool in the tool axis to set-up clearance, or—if programmed—to the 2nd set-up clearance, and subsequently to the center of the pocket.
- 2 From the pocket center, the tool moves in the working plane to the starting point for machining. The TNC takes the workpiece blank diameter and tool radius into account for calculating the starting point. If you enter a workpiece blank diameter of 0, the TNC plunge-cuts into the pocket center.
- 3 If the tool is at the 2nd set-up clearance, it moves in rapid traverse FMAX to set-up clearance, and from there advances to the first plunging depth at the feed rate for plunging.
- 4 The tool then moves tangentially to the contour of the finished part and, using climb milling, machines one revolution.
- 5 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 6 This process (3 to 5) is repeated until the programmed depth is reached.
- 7 At the end of the cycle, the TNC retracts the tool in rapid traverse (FMAX) to set-up clearance, or, if programmed, to the 2nd set-up clearance and then to the center of the pocket (end position = starting position).



### Before programming, note the following:

The TNC automatically pre-positions the tool in the tool axis and working plane.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

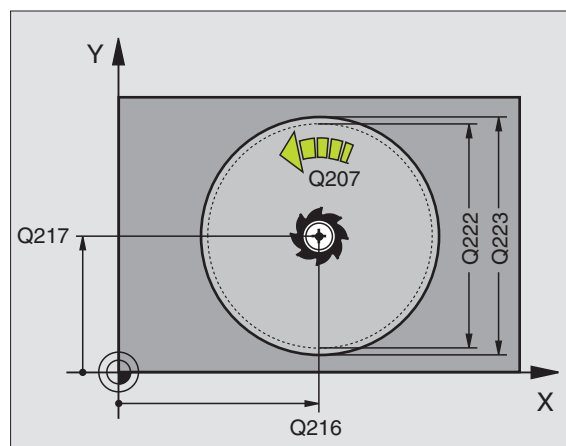
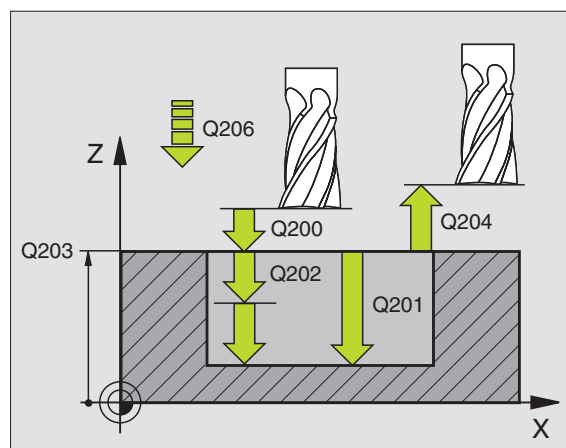
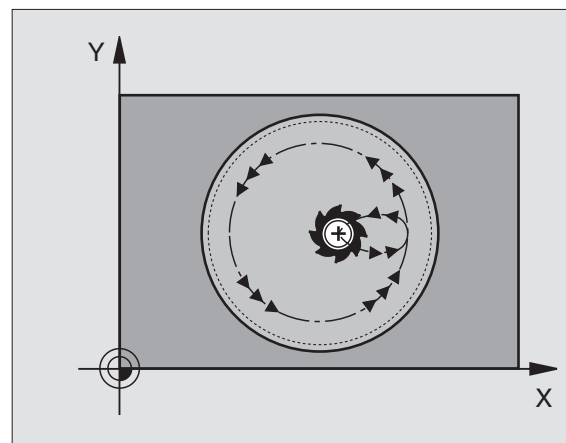
If you want to clear and finish the pocket with the same tool, use a center-cut end mill (ISO 1641) and enter a low feed rate for plunging.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!







- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of pocket.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool in mm/min when moving to depth. If you are plunge-cutting into the material, enter a value lower than that defined in Q207.
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Center in 1st axis** Q216 (absolute value): Center of the pocket in the reference axis of the working plane.
- ▶ **Center in 2nd axis** Q217 (absolute value): Center of the pocket in the minor axis of the working plane.
- ▶ **Workpiece blank diameter** Q222: Diameter of the premachined pocket for calculating the pre-position. Enter the workpiece blank diameter to be less than the diameter of the finished part.
- ▶ **Finished part diameter** Q223: Diameter of the finished pocket. Enter the diameter of the finished part to be greater than the workpiece blank diameter and greater than the tool diameter.

**Example: NC blocks**

42 CYCL DEF 214 C. POCKET FINISHING	
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q202=5	;INFEEED DEPTH
Q207=500	;FEED RATE FOR MILLING
Q203=+30	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q216=+50	;CENTER IN 1ST AXIS
Q217=+50	;CENTER IN 2ND AXIS
Q222=79	;WORKPIECE BLANK DIA.
Q223=80	;FINISHED PART DIA.



## CIRCULAR STUD FINISHING (Cycle 215)

- 1 The TNC automatically moves the tool in the tool axis to set-up clearance, or—if programmed—to the 2nd set-up clearance, and subsequently to the center of the stud.
- 2 From the stud center, the tool moves in the working plane to the starting point for machining. The starting point lies to the right of the stud at a distance of approx. twice the tool radius.
- 3 If the tool is at the 2nd set-up clearance, it moves in rapid traverse FMAX to set-up clearance, and from there advances to the first plunging depth at the feed rate for plunging.
- 4 The tool then moves tangentially to the contour of the finished part and, using climb milling, machines one revolution.
- 5 After this, the tool departs the contour tangentially and returns to the starting point in the working plane.
- 6 This process (3 to 5) is repeated until the programmed depth is reached.
- 7 At the end of the cycle, the TNC retracts the tool in FMAX to set-up clearance, or—if programmed—to the 2nd set-up clearance, and finally to the center of the pocket (end position = starting position).



### Before programming, note the following:

The TNC automatically pre-positions the tool in the tool axis and working plane.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

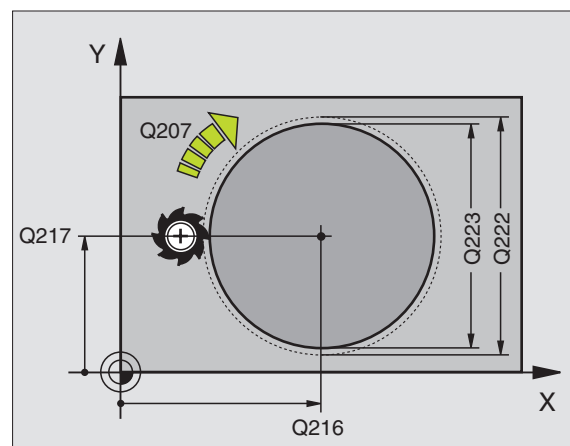
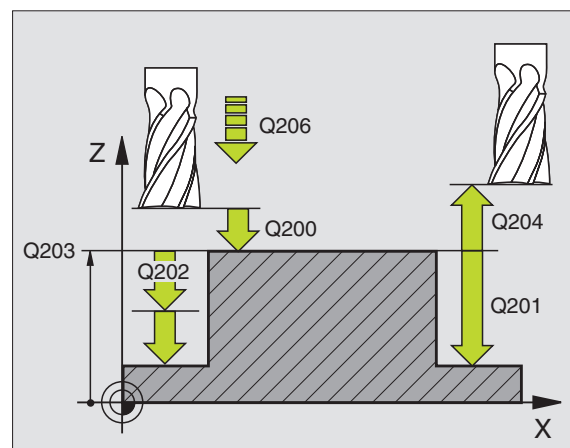
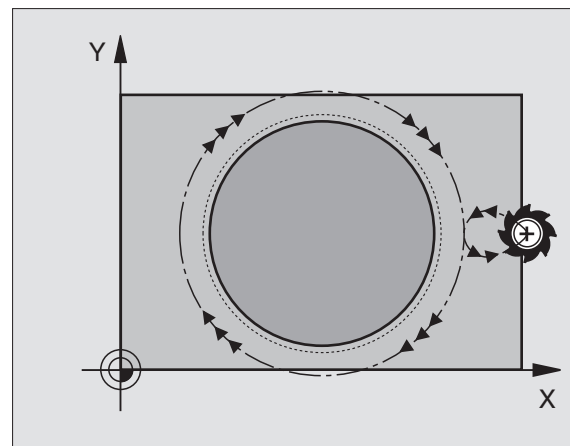
If you want to clear and finish the stud with the same tool, use a center-cut end mill (ISO 1641) and enter a low feed rate for plunging.



Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!





- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of stud.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool in mm/min when moving to depth. If you are plunge-cutting into the material, enter a low value; if you have already cleared the stud, enter a higher feed rate.
- ▶ **Plunging depth** Q202 (incremental value): Infeed per cut. Enter a value greater than 0.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Center in 1st axis** Q216 (absolute value): Center of the stud in the reference axis of the working plane.
- ▶ **Center in 2nd axis** Q217 (absolute value): Center of the stud in the minor axis of the working plane.
- ▶ **Workpiece blank diameter** Q222: Diameter of the premachined stud for calculating the pre-position. Enter the workpiece blank diameter to be greater than the diameter of the finished part.
- ▶ **Diameter of finished part** Q223: Diameter of the finished stud. Enter the diameter of the finished part to be less than the workpiece blank diameter.

**Example: NC blocks**

43 CYCL DEF 215 C. STUD FINISHING	
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q206=150	;FEED RATE FOR PLUNGING
Q202=5	;INFED DEPTH
Q207=500	;FEED RATE FOR MILLING
Q203=+30	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q216=+50	;CENTER IN 1ST AXIS
Q217=+50	;CENTER IN 2ND AXIS
Q222=81	;WORKPIECE BLANK DIA.
Q223=80	;FINISHED PART DIA.



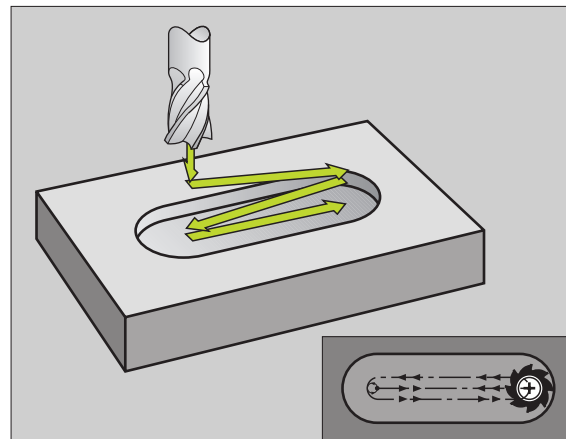
## SLOT (oblong hole) with reciprocating plunge-cut (Cycle 210)

### Roughing

- 1 At rapid traverse, the TNC positions the tool in the tool axis to the 2nd set-up clearance and subsequently to the center of the left circle. From there, the TNC positions the tool to set-up clearance above the workpiece surface.
- 2 The tool moves at the feed rate for milling to the workpiece surface. From there, the cutter advances in the longitudinal direction of the slot—plunge-cutting obliquely into the material—until it reaches the center of the right circle.
- 3 The tool then moves back to the center of the left circle, again with oblique plunge-cutting. This process is repeated until the programmed milling depth is reached.
- 4 At the milling depth, the TNC moves the tool for the purpose of face milling to the other end of the slot and then back to the center of the slot.

### Finishing

- 5 The TNC positions the tool in the center of the left circle and then moves it tangentially in a semicircle to the left end of the slot. The tool subsequently climb mills the contour (with M3), and if so entered, in more than one infeed.
- 6 When the tool reaches the end of the contour, it departs the contour tangentially and returns to the center of the left circle.
- 7 At the end of the cycle, the tool is retracted in rapid traverse FMAX to set-up clearance and—if programmed—to the 2nd set-up clearance.



### Before programming, note the following:

The TNC automatically pre-positions the tool in the tool axis and working plane.

During roughing the tool plunges into the material with a sideward reciprocating motion from one end of the slot to the other. Pilot drilling is therefore unnecessary.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

The cutter diameter must not be larger than the slot width and not smaller than a third of the slot width.

The cutter diameter must be smaller than half the slot length. The TNC otherwise cannot execute this cycle.



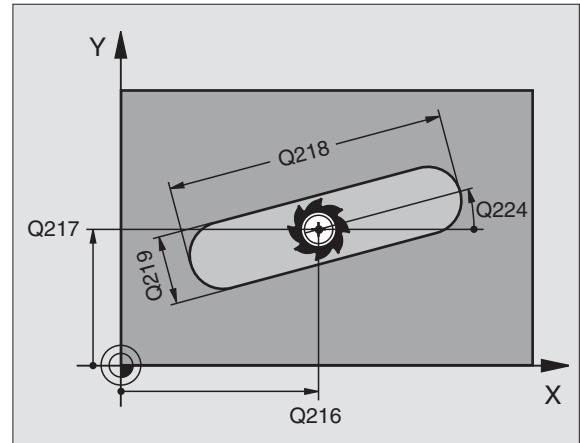
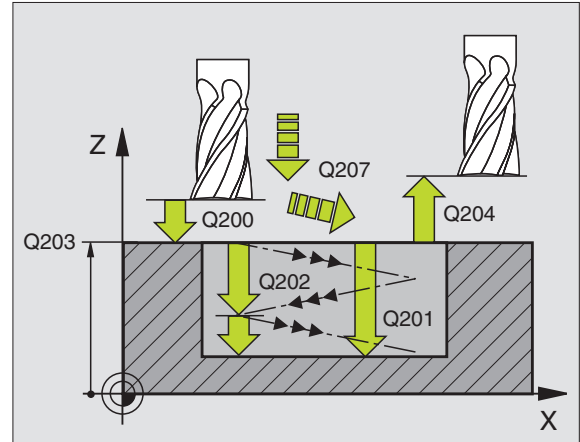
Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

### Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!



- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of slot.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- ▶ **Plunging depth** Q202 (incremental value): Total extent by which the tool is fed in the tool axis during a reciprocating movement.
- ▶ **Machining operation (0/1/2)** Q215: Define the machining operation:  
**0:** Roughing and finishing  
**1:** Only roughing  
**2:** Only finishing
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Z coordinate at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Center in 1st axis** Q216 (absolute value): Center of the slot in the reference axis of the working plane.
- ▶ **Center in 2nd axis** Q217 (absolute value): Center of the slot in the minor axis of the working plane.
- ▶ **1st side length** Q218 (value parallel to the reference axis of the working plane): Enter the length of the slot
- ▶ **2nd side length** Q219 (value parallel to the secondary axis of the working plane): Enter the slot width. If you enter a slot width that equals the tool diameter, the TNC will carry out the roughing process only (slot milling).



- ▶ **Angle of rotation** Q224 (absolute value): Angle by which the entire slot is rotated. The center of rotation lies in the center of the slot.
- ▶ **Infeed for finishing** Q338 (incremental value): Infeed per cut. Q338=0: Finishing in one infeed.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool while moving to depth in mm/min. Effective only during finishing if infeed for finishing is entered.

Example: NC blocks

51	CYCL DEF 210	SLOT RECIP. PLNG
Q200=2		;SET-UP CLEARANCE
Q201=-20		;DEPTH
Q207=500		;FEED RATE FOR MILLING
Q202=5		;INFEEED DEPTH
Q215=0		;MACHINING OPERATION
Q203=+30		;SURFACE COORDINATE
Q204=50		;2ND SET-UP CLEARANCE
Q216=+50		;CENTER IN 1ST AXIS
Q217=+50		;CENTER IN 2ND AXIS
Q218=80		;1ST SIDE LENGTH
Q219=12		;2ND SIDE LENGTH
Q224=+15		;ANGLE OF ROTATION
Q338=5		;INFEEED FOR FINISHING
Q206=150		;FEED RATE FOR PLUNGING



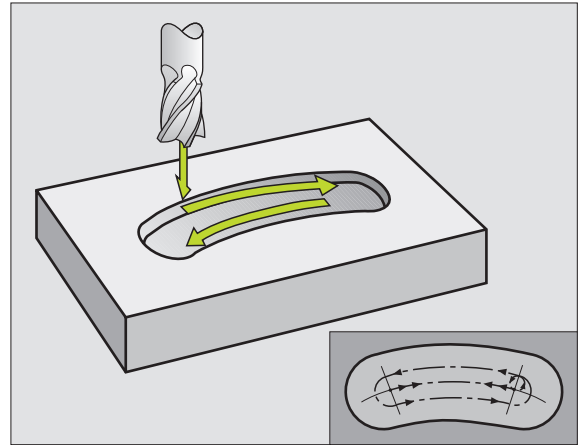
## CIRCULAR SLOT (oblong hole) with reciprocating plunge-cut (Cycle 211)

### Roughing

- 1 At rapid traverse, the TNC positions the tool in the tool axis to the 2nd set-up clearance and subsequently to the center of the right circle. From there, the tool is positioned to the programmed set-up clearance above the workpiece surface.
- 2 The tool moves at the milling feed rate to the workpiece surface. From there, the cutter advances—plunge-cutting obliquely into the material—to the other end of the slot.
- 3 The tool then moves at a downward angle back to the starting point, again with oblique plunge-cutting. This process (2 to 3) is repeated until the programmed milling depth is reached.
- 4 At the milling depth, the TNC moves the tool for the purpose of face milling to the other end of the slot.

### Finishing

- 5 The TNC advances the tool from the slot center tangentially to the contour of the finished part. The tool subsequently climb mills the contour (with M3), and if so entered, in more than one infeed. The starting point for the finishing process is the center of the right circle.
- 6 When the tool reaches the end of the contour, it departs the contour tangentially.
- 7 At the end of the cycle, the tool is retracted in rapid traverse FMAX to set-up clearance and—if programmed—to the 2nd set-up clearance.



#### Before programming, note the following:

The TNC automatically pre-positions the tool in the tool axis and working plane.

During roughing the tool plunges into the material with a helical sideward reciprocating motion from one end of the slot to the other. Pilot drilling is therefore unnecessary.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

The cutter diameter must not be larger than the slot width and not smaller than a third of the slot width.

The cutter diameter must be smaller than half the slot length. The TNC otherwise cannot execute this cycle.



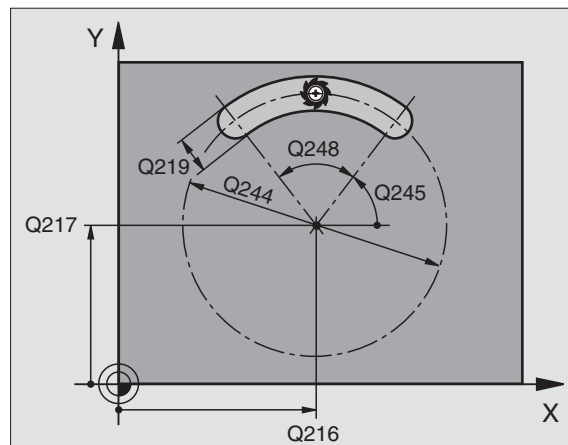
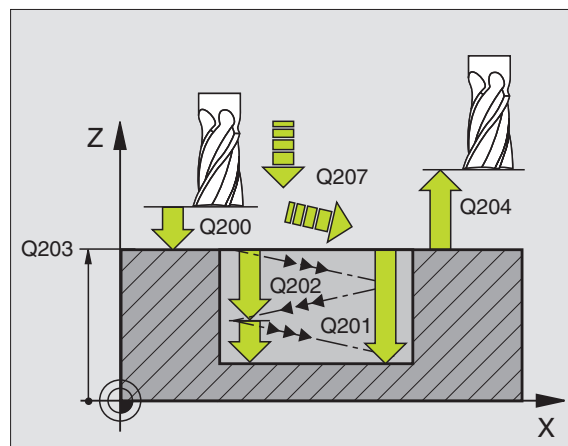
Enter in MP7441 bit 2 whether the TNC should output an error message (bit 2=1) or not (bit 2=0) if a positive depth is entered.

## Danger of collision!

Keep in mind that the TNC reverses the calculation for pre-positioning when a **positive depth is entered**. This means that the tool moves at rapid traverse in the tool axis at safety clearance **below** the workpiece surface!



- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Depth** Q201 (incremental value): Distance between workpiece surface and bottom of slot.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- ▶ **Plunging depth** Q202 (incremental value): Total extent by which the tool is fed in the tool axis during a reciprocating movement.
- ▶ **Machining operation (0/1/2)** Q215: Define the machining operation:  
**0:** Roughing and finishing  
**1:** Only roughing  
**2:** Only finishing
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Z coordinate at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Center in 1st axis** Q216 (absolute value): Center of the slot in the reference axis of the working plane.
- ▶ **Center in 2nd axis** Q217 (absolute value): Center of the slot in the minor axis of the working plane.
- ▶ **Pitch circle diameter** Q244: Enter the diameter of the pitch circle.
- ▶ **2nd side length** Q219: Enter the slot width. If you enter a slot width that equals the tool diameter, the TNC will carry out the roughing process only (slot milling).
- ▶ **Starting angle** Q245 (absolute value): Enter the polar angle of the starting point.





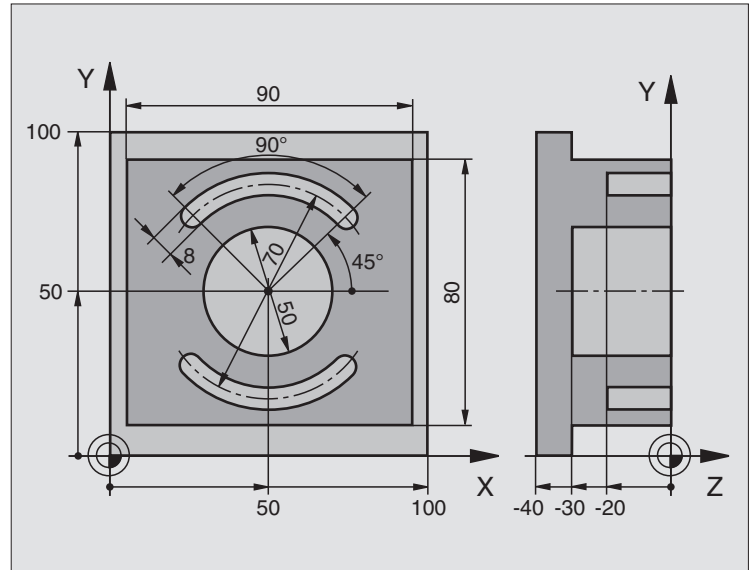
- **Angular length** Q248 (incremental value): Enter the angular length of the slot.
- **Infeed for finishing** Q338 (incremental value): Infeed per cut. Q338=0: Finishing in one infeed.
- **Feed rate for plunging** Q206: Traversing speed of the tool while moving to depth in mm/min. Effective only during finishing if infeed for finishing is entered.

Example: NC blocks

52 CYCL DEF 211 CIRCULAR SLOT	
Q200=2	;SET-UP CLEARANCE
Q201=-20	;DEPTH
Q207=500	;FEED RATE FOR MILLING
Q202=5	;INFEEED DEPTH
Q215=0	;MACHINING OPERATION
Q203=+30	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q216=+50	;CENTER IN 1ST AXIS
Q217=+50	;CENTER IN 2ND AXIS
Q244=80	;PITCH CIRCLE DIA.
Q219=12	;2ND SIDE LENGTH
Q245=+45	;STARTING ANGLE
Q248=90	;ANGULAR LENGTH
Q338=5	;INFEEED FOR FINISHING
Q206=150	;FEED RATE FOR PLUNGING



## Example: Milling pockets, studs and slots



0 BEGIN PGM C210 MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-40	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+6	Define the tool for roughing/finishing
4 TOOL DEF 2 L+0 R+3	Define slotting mill
5 TOOL CALL 1 Z S3500	Call the tool for roughing/finishing
6 L Z+250 R0 FMAX	Retract the tool

<b>7 CYCL DEF 213 STUD FINISHING</b>	Define cycle for machining the contour outside
Q200=2 ;SET-UP CLEARANCE	
Q201=-30 ;DEPTH	
Q206=250 ;FEED RATE FOR PLNGNG	
Q202=5 ;INFEED DEPTH	
Q207=250 ;FEED RATE FOR MILLING	
Q203=+0 ;SURFACE COORDINATE	
Q204=20 ;2ND SET-UP CLEARANCE	
Q216=+50 ;CENTER IN 1ST AXIS	
Q217=+50 ;CENTER IN 2ND AXIS	
Q218=90 ;1ST SIDE LENGTH	
Q219=80 ;2ND SIDE LENGTH	
Q220=0 ;CORNER RADIUS	
Q221=5 ;OVERSIZE	
<b>8 CYCL CALL M3</b>	Call cycle for machining the contour outside
<b>9 CYCL DEF 252 CIRCULAR POCKET</b>	Define CIRCULAR POCKET MILLING cycle
Q215=0 ;MACHINING OPERATION	
Q223=50 ;CIRCLE DIAMETER	
Q368=0.2 ;ALLOWANCE FOR SIDE	
Q207=500 ;FEED RATE FOR MILLING	
Q351=+1 ;CLIMB OR UP-CUT	
Q201=-30 ;DEPTH	
Q202=5 ;INFEED DEPTH	
Q369=0.1 ;ALLOWANCE FOR FLOOR	
Q206=150 ;FEED RATE FOR PLNGNG	
Q338=5 ;INFEED FOR FINISHING	
Q200=2 ;SET-UP CLEARANCE	
Q203=+0 ;SURFACE COORDINATE	
Q204=50 ;2ND SET-UP CLEARANCE	
Q370=1 ;TOOL PATH OVERLAP	
Q366=1 ;PLUNGING	
Q385=750 ;FEED RATE FOR FINISHING	
<b>10 CYCL CALL POS X+50 Y+50 Z+0 FMAX</b>	Call CIRCULAR POCKET MILLING cycle
<b>11 L Z+250 R0 FMAX M6</b>	Tool change



## 8.4 Cycles for Milling Pockets, Studs and Slots



12 TOLL CALL 2 Z S5000	Call slotting mill
13 CYCL DEF 254 CIRCULAR SLOT	Define SLOT cycle
Q215=0 ;MACHINING OPERATION	
Q219=8 ;SLOT WIDTH	
Q368=0.2 ;ALLOWANCE FOR SIDE	
Q375=70 ;PITCH CIRCLE DIA.	
Q367=0 ;REF. SLOT POSITION	No pre-positioning in X/Y required
Q216=+50 ;CENTER IN 1ST AXIS	
Q217=+50 ;CENTER IN 2ND AXIS	
Q376=+45 ;STARTING ANGLE	
Q248=90 ;ANGULAR LENGTH	
Q378=180 ;STEPPING ANGLE	Starting point for second slot
Q377=2 ;NR OF REPETITIONS	
Q207=500 ;FEED RATE FOR MILLING	
Q351=+1 ;CLIMB OR UP-CUT	
Q201=-20 ;DEPTH	
Q202=5 ;INFEEED DEPTH	
Q369=0.1 ;ALLOWANCE FOR FLOOR	
Q206=150 ;FEED RATE FOR PLNGNG	
Q338=5 ;INFEEED FOR FINISHING	
Q200=2 ;SET-UP CLEARANCE	
Q203=+0 ;SURFACE COORDINATE	
Q204=50 ;2ND SET-UP CLEARANCE	
Q366=1 ;PLUNGING	
14 CYCL CALL X+50 Y+50 FMAX M3	Call SLOT cycle
15 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
16 END PGM C210 MM	



## 8.5 Cycles for Machining Point Patterns

### Overview

The TNC provides two cycles for machining point patterns directly:

Cycle	Soft key
220 CIRCULAR PATTERN	
221 LINEAR PATTERN	

You can combine Cycle 220 and Cycle 221 with the following fixed cycles:



If you have to machine irregular point patterns, use **CYCL CALL PAT** (see "Point Tables" on page 268) to develop point tables.

- Cycle 200 DRILLING
- Cycle 201 REAMING
- Cycle 202 BORING
- Cycle 203 UNIVERSAL DRILLING
- Cycle 204 BACK BORING
- Cycle 205 UNIVERSAL PECKING
- Cycle 206 TAPPING NEW with a floating tap holder
- Cycle 207 RIGID TAPPING NEW without a floating tap holder
- Cycle 208 BORE MILLING
- Cycle 209 TAPPING WITH CHIP BREAKING
- Cycle 212 POCKET FINISHING
- Cycle 213 STUD FINISHING
- Cycle 214 CIRCULAR POCKET FINISHING
- Cycle 215 CIRCULAR STUD FINISHING
- Cycle 251 RECTANGULAR POCKET
- Cycle 252 CIRCULAR POCKET MILLING
- Cycle 253 SLOT MILLING
- Cycle 254 CIRCULAR SLOT
- Cycle 262 THREAD MILLING
- Cycle 263 THREAD MILLING/COUNTERSINKING
- Cycle 264 THREAD DRILLING/MILLING
- Cycle 265 HELICAL THREAD DRILLING/MILLING
- Cycle 267 OUTSIDE THREAD MILLING



## CIRCULAR PATTERN (Cycle 220)

- 1 At rapid traverse, the TNC moves the tool from its current position to the starting point for the first machining operation.

Sequence:

- Move to 2nd set-up clearance (spindle axis)
  - Approach the starting point in the spindle axis.
  - Move to the set-up clearance above the workpiece surface (spindle axis).
- 2 From this position, the TNC executes the last defined fixed cycle.
  - 3 The tool then approaches on a straight line or circular arc the starting point for the next machining operation. The tool stops at set-up clearance (or 2nd set-up clearance).
  - 4 This process (1 to 3) is repeated until all machining operations have been executed.



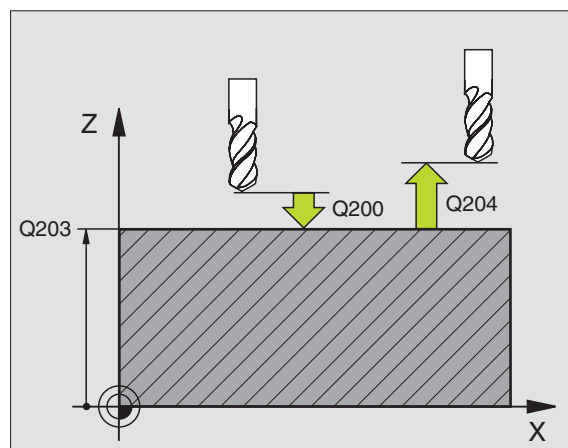
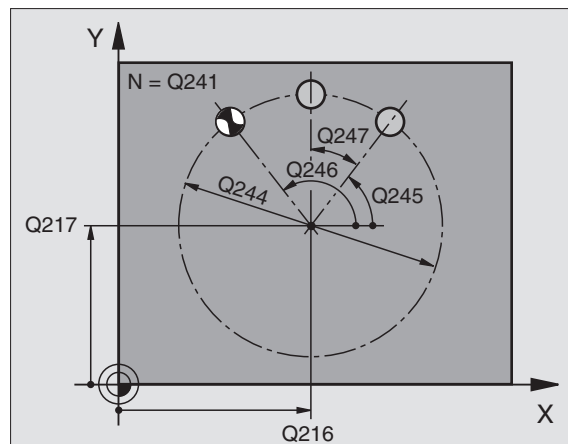
### Before programming, note the following:

Cycle 220 is DEF active, which means that Cycle 220 calls the last defined fixed cycle automatically.

If you combine Cycle 220 with one of the fixed cycles 200 to 209, 212 to 215, 251 to 265 or 267, the set-up clearance, workpiece surface and 2nd set-up clearance that you defined in Cycle 220 will be effective for the selected fixed cycle.



- **Center in 1st axis** Q216 (absolute value): Center of the pitch circle in the reference axis of the working plane.
- **Center in 2nd axis** Q217 (absolute value): Center of the pitch circle in the minor axis of the working plane.
- **Pitch circle diameter** Q244: Diameter of the pitch circle.
- **Starting angle** Q245 (absolute value): Angle between the reference axis of the working plane and the starting point for the first machining operation on the pitch circle.
- **Stopping angle** Q246 (absolute value): Angle between the reference axis of the working plane and the starting point for the last machining operation on the pitch circle (does not apply to complete circles). Do not enter the same value for the stopping angle and starting angle. If you enter the stopping angle greater than the starting angle, machining will be carried out counterclockwise; otherwise, machining will be clockwise.



- ▶ **Stepping angle** Q247 (incremental value): Angle between two machining operations on a pitch circle. If you enter an angle step of 0, the TNC will calculate the angle step from the starting and stopping angles and the number of pattern repetitions. If you enter a value other than 0, the TNC will not take the stopping angle into account. The sign for the angle step determines the working direction (– = clockwise).
- ▶ **Number of repetitions** Q241: Number of machining operations on a pitch circle.
- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface. Enter a positive value.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Moving to clearance height** Q301: Definition of how the tool is to move between machining processes.  
**0:** Move between operations to the set-up clearance  
**1:** Move between operations to 2nd set-up clearance
- ▶ **Type of traverse?** **Line=0/Arc=1** Q365: Definition of the path function with which the tool is to move between machining operations.  
**0:** Move between operations on a straight line  
**1:** Move between operations on the pitch circle

Example: NC blocks

53 CYCL DEF 220 POLAR PATTERN	
Q216=+50	;CENTER IN 1ST AXIS
Q217=+50	;CENTER IN 2ND AXIS
Q244=80	;PITCH CIRCLE DIA.
Q245=+0	;STARTING ANGLE
Q246=+360	;STOPPING ANGLE
Q247=+0	;STEPPING ANGLE
Q241=8	;NR OF REPETITIONS
Q200=2	;SET-UP CLEARANCE
Q203=+30	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q301=1	;TRAVERSE TO CLEARANCE HEIGHT
Q365=0	;TYPE OF TRAVERSE



## LINEAR PATTERN (Cycle 221)



### Before programming, note the following:

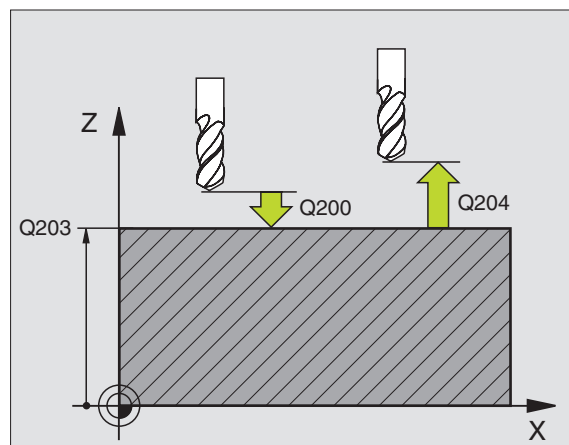
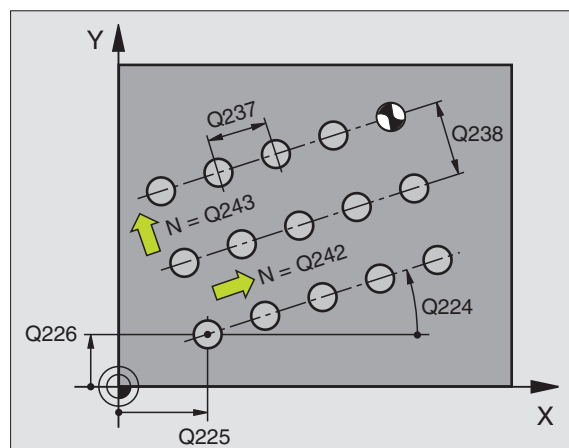
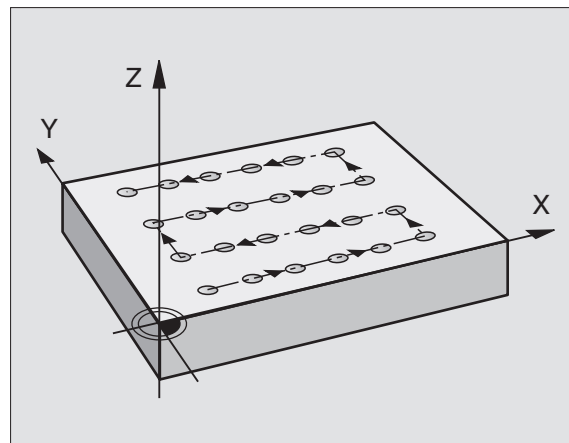
Cycle 221 is DEF active, which means that Cycle 221 calls the last defined fixed cycle automatically.

If you combine Cycle 221 with one of the fixed cycles 200 to 209, 212 to 215, 251 to 265 or 267, the set-up clearance, workpiece surface and 2nd set-up clearance that you defined in Cycle 221 will be effective for the selected fixed cycle.

- 1 The TNC automatically moves the tool from its current position to the starting point for the first machining operation.

Sequence:

- Move to 2nd set-up clearance (spindle axis)
  - Approach the starting point in the spindle axis.
  - Move to the set-up clearance above the workpiece surface (spindle axis).
- 2 From this position, the TNC executes the last defined fixed cycle.
  - 3 The tool then approaches the starting point for the next machining operation in the positive reference axis direction at set-up clearance (or 2nd set-up clearance).
  - 4 This process (1 to 3) is repeated until all machining operations on the first line have been executed. The tool is located above the last point on the first line.
  - 5 The tool subsequently moves to the last point on the second line where it carries out the machining operation.
  - 6 From this position, the tool approaches the starting point for the next machining operation in the negative reference axis direction.
  - 7 This process (6) is repeated until all machining operations in the second line have been executed.
  - 8 The tool then moves to the starting point of the next line.
  - 9 All subsequent lines are processed in a reciprocating movement.







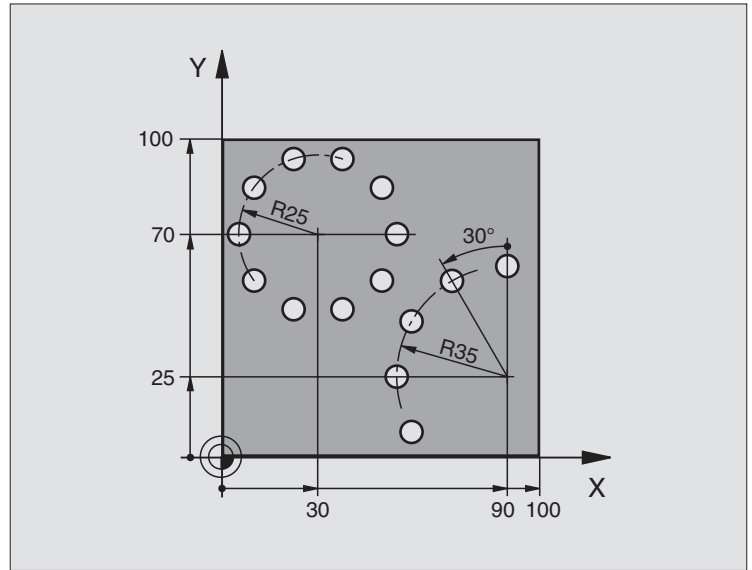
- ▶ **Starting point 1st axis** Q225 (absolute value): Coordinate of the starting point in the reference axis of the working plane.
- ▶ **Starting point 2nd axis** Q226 (absolute value): Coordinate of the starting point in the minor axis of the working plane.
- ▶ **Spacing in 1st axis** Q237 (incremental value): Spacing between each point on a line.
- ▶ **Spacing in 2nd axis** Q238 (incremental value): Spacing between each line.
- ▶ **Number of columns** Q242: Number of machining operations on a line.
- ▶ **Number of lines** Q243: Number of passes.
- ▶ **Angle of rotation** Q224 (absolute value): Angle by which the entire pattern is rotated. The center of rotation lies in the starting point.
- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Workpiece surface coordinate** Q203 (absolute value): Coordinate of the workpiece surface.
- ▶ **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.
- ▶ **Moving to clearance height** Q301: Definition of how the tool is to move between machining processes.
  - 0:** Move to set-up clearance
  - 1:** Move to 2nd set-up clearance between the measuring points.

**Example: NC blocks**

54 CYCL DEF 221 CARTESIAN PATTERN	
Q225=+15	;STARTING PNT 1ST AXIS
Q226=+15	;STARTING PNT 2ND AXIS
Q237=+10	;SPACING IN 1ST AXIS
Q238=+8	;SPACING IN 2ND AXIS
Q242=6	;NUMBER OF COLUMNS
Q243=4	;NUMBER OF LINES
Q224=+15	;ANGLE OF ROTATION
Q200=2	;SET-UP CLEARANCE
Q203=+30	;SURFACE COORDINATE
Q204=50	;2ND SET-UP CLEARANCE
Q301=1	;TRAVERSE TO CLEARANCE HEIGHT



## Example: Circular hole patterns



0 BEGIN PGM PATTERN MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-40	Define the workpiece blank
2 BLK FORM 0.2 Y+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+3	Define the tool
4 TOOL CALL 1 Z S3500	Tool call
5 L Z+250 R0 FMAX M3	Retract the tool
6 CYCL DEF 200 DRILLING	Cycle definition: drilling
Q200=2 ;SET-UP CLEARANCE	
Q201=-15 ;DEPTH	
Q206=250 ;FEED RATE FOR PLNGNG	
Q202=4 ;INFED DEPTH	
Q210=0 ;DWELL TIME	
Q203=+0 ;SURFACE COORDINATE	
Q204=0 ;2ND SET-UP CLEARANCE	
Q211=0.25 ;DWELL TIME AT DEPTH	

<b>7 CYCL DEF 220 POLAR PATTERN</b>	Define cycle for circular pattern 1, CYCL 200 is called automatically,
Q216=+30 ;CENTER IN 1ST AXIS	Q200, Q203 and Q204 are effective as defined in Cycle 220.
Q217=+70 ;CENTER IN 2ND AXIS	
Q244=50 ;PITCH CIRCLE DIA.	
Q245=+0 ;STARTING ANGLE	
Q246=+360 ;STOPPING ANGLE	
Q247=+0 ;STEPPING ANGLE	
Q241=10 ;NR OF REPETITIONS	
Q200=2 ;SET-UP CLEARANCE	
Q203=+0 ;SURFACE COORDINATE	
Q204=100 ;2ND SET-UP CLEARANCE	
Q301=1 ;TRAVERSE TO CLEARANCE HEIGHT	
Q365=0 ;TYPE OF TRAVERSE	
<b>8 CYCL DEF 220 POLAR PATTERN</b>	Define cycle for circular pattern 2, CYCL 200 is called automatically,
Q216=+90 ;CENTER IN 1ST AXIS	Q200, Q203 and Q204 are effective as defined in Cycle 220.
Q217=+25 ;CENTER IN 2ND AXIS	
Q244=70 ;PITCH CIRCLE DIA.	
Q245=+90 ;STARTING ANGLE	
Q246=+360 ;STOPPING ANGLE	
Q247=30 ;STEPPING ANGLE	
Q241=5 ;NR OF REPETITIONS	
Q200=2 ;SET-UP CLEARANCE	
Q203=+0 ;SURFACE COORDINATE	
Q204=100 ;2ND SET-UP CLEARANCE	
Q301=1 ;TRAVERSE TO CLEARANCE HEIGHT	
Q365=0 ;TYPE OF TRAVERSE	
<b>9 L Z+250 R0 FMAX M2</b>	Retract in the tool axis, end program
<b>10 END PGM PATTERN MM</b>	



# 8.6 SL Cycles

## Fundamentals

SL Cycles enable you to form complex contours by combining up to 12 subcontours (pockets or islands). You define the individual subcontours in subprograms. The TNC calculates the total contour from the subcontours (subprogram numbers) that you enter in Cycle 14 CONTOUR GEOMETRY.



The memory capacity for programming an SL cycle (all contour subprograms) is limited. The number of possible contour elements depends on the type of contour (inside or outside contour) and the number of subcontours. For example, you can program up to approx. 1024 line blocks.

SL cycles conduct comprehensive and complex internal calculations as well as the resulting machining operations. For safety reasons, always run a graphical program test before machining! This is a simple way of finding out whether the TNC-calculated program will provide the desired results.

### Characteristics of the subprograms

- Coordinate transformations are allowed. If they are programmed within the subcontour they are also effective in the following subprograms, but they need not be reset after the cycle call.
- The TNC ignores feed rates F and miscellaneous functions M.
- The TNC recognizes a pocket if the tool path lies inside the contour, for example if you machine the contour clockwise with radius compensation RR.
- The TNC recognizes an island if the tool path lies outside the contour, for example if you machine the contour clockwise with radius compensation RL.
- The subprograms must not contain tool axis coordinates.
- The working plane is defined in the first coordinate block of the subprogram. The secondary axes U,V,W are permitted.
- If you use Q parameters, then only perform the calculations and assignments within the affected contour subprograms.

### Example: Program structure: Machining with SL Cycles

```
0 BEGIN PGM SL2 MM
...
12 CYCL DEF 140 CONTOUR GEOMETRY ...
13 CYCL DEF 20.0 CONTOUR DATA ...
...
16 CYCL DEF 21.0 PILOT DRILLING ...
17 CYCL CALL
...
18 CYCL DEF 22.0 ROUGH-OUT ...
19 CYCL CALL
...
22 CYCL DEF 23.0 FLOOR FINISHING ...
23 CYCL CALL
...
26 CYCL DEF 24.04 SIDE FINISHING ...
27 CYCL CALL
...
50 L Z+250 R0 FMAX M2
51 LBL 1
...
55 LBL 0
56 LBL 2
...
60 LBL 0
...
99 END PGM SL2 MM
```



**Characteristics of the fixed cycles**

- The TNC automatically positions the tool to the set-up clearance before a cycle.
- Each level of infeed depth is milled without interruptions since the cutter traverses around islands instead of over them.
- The radius of “inside corners” can be programmed—the tool keeps moving to prevent surface blemishes at inside corners (this applies for the outermost pass in the Rough-out and Side Finishing cycles).
- The contour is approached on a tangential arc for side finishing.
- For floor finishing, the tool again approaches the workpiece in a tangential arc (for tool axis Z, for example, the arc may be in the Z/X plane).
- The contour is machined throughout in either climb or up-cut milling.









With MP7420 you can determine where the tool is positioned at the end of Cycles 21 to 24.






The machining data (such as milling depth, finishing allowance and set-up clearance) are entered as CONTOUR DATA in Cycle 20.



Overview of SL Cycles

Cycle	Soft key
14 CONTOUR GEOMETRY (essential)	
20 CONTOUR DATA (essential)	
21 PILOT DRILLING (optional)	
22 ROUGH-OUT (essential)	
23 FLOOR FINISHING (optional)	
24 SIDE FINISHING (optional)	

Enhanced cycles:

Cycle	Soft key
25 CONTOUR TRAIN	
27 CYLINDER SURFACE	
28 CYLINDER SURFACE slot milling	
29 CYLINDER SURFACE ridge milling	
39 CYLINDER SURFACE outside contour milling	



## CONTOUR (Cycle 14)

All subprograms that are superimposed to define the contour are listed in Cycle 14 CONTOUR GEOMETRY.



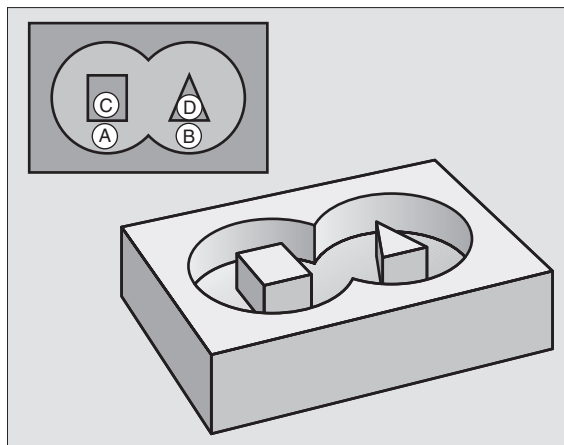
### Before programming, note the following:

Cycle 14 is DEF active which means that it becomes effective as soon as it is defined in the part program.

You can list up to 12 subprograms (subcontours) in Cycle 14.

14  
LBL 1...N

- **Label numbers for the contour:** Enter all label numbers for the individual subprograms that are to be superimposed to define the contour. Confirm every label number with the ENT key. When you have entered all numbers, conclude entry with the END key.



Overlapping contours

Pockets and islands can be overlapped to form a new contour. You can thus enlarge the area of a pocket by another pocket or reduce it by an island.

Subprograms: Overlapping pockets



The subsequent programming examples are contour subprograms that are called by Cycle 14 CONTOUR GEOMETRY in a main program.

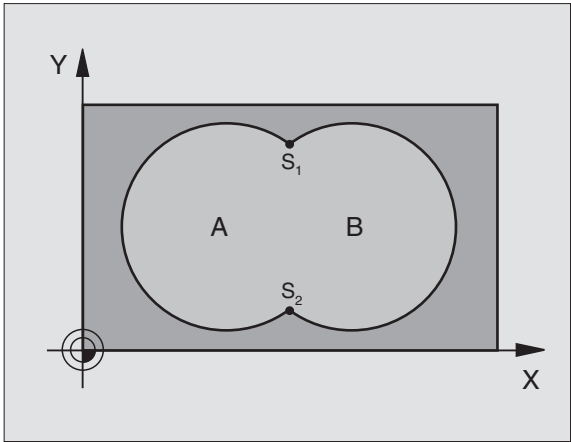
Pockets A and B overlap.  
The TNC calculates the points of intersection  $S_1$  and  $S_2$ . They do not have to be programmed.  
The pockets are programmed as full circles.

Subprogram 1: Pocket A

```
51 LBL 1
52 L X+10 Y+50 RR
53 CC X+35 Y+50
54 C X+10 Y+50 DR-
55 LBL 0
```

Subprogram 2: Pocket B

```
56 LBL 2
57 L X+90 Y+50 RR
58 CC X+65 Y+50
59 C X+90 Y+50 DR-
60 LBL 0
```



Example: NC blocks

```
12 CYCL DEF 14.0 CONTOUR GEOMETRY
13 CYCL DEF 14.1 CONTOUR LABEL 1/2/3/4
```





**Area of inclusion**

Both surfaces A and B are to be machined, including the overlapping area:

- The surfaces A and B must be pockets.
- The first pocket (in Cycle 14) must start outside the second pocket.

Surface A:

51 LBL 1

52 L X+10 Y+50 RR

53 CC X+35 Y+50

54 C X+10 Y+50 DR-

55 LBL 0

Surface B:

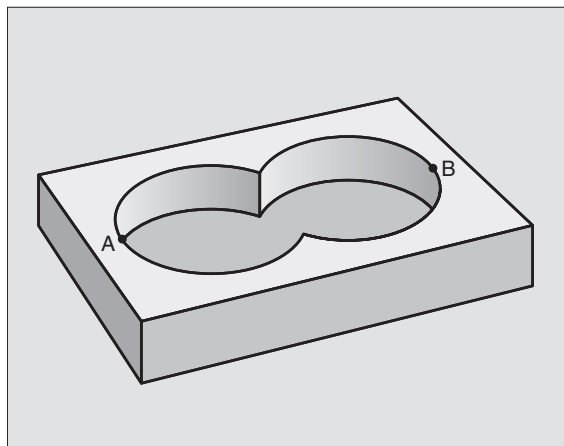
56 LBL 2

57 L X+90 Y+50 RR

58 CC X+65 Y+50

59 C X+90 Y+50 DR-

60 LBL 0

**Area of exclusion**

Surface A is to be machined without the portion overlapped by B:

- Surface A must be a pocket and B an island.
- A must start outside of B.
- B must start inside of A.

Surface A:

51 LBL 1

52 L X+10 Y+50 RR

53 CC X+35 Y+50

54 C X+10 Y+50 DR-

55 LBL 0

Surface B:

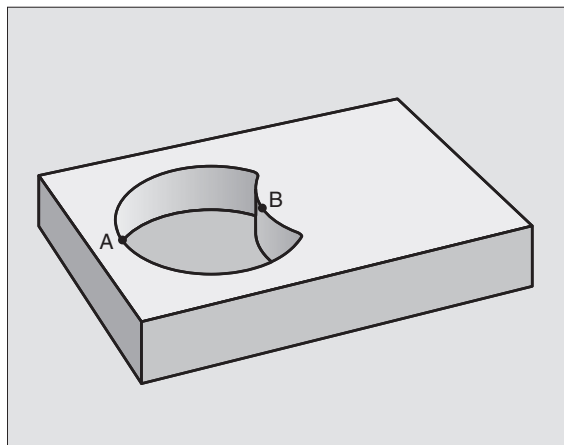
56 LBL 2

57 L X+90 Y+50 RL

58 CC X+65 Y+50

59 C X+90 Y+50 DR-

60 LBL 0



Area of intersection

Only the area where A and B overlap is to be machined. (The areas covered by A or B alone are to be left unmachined.)

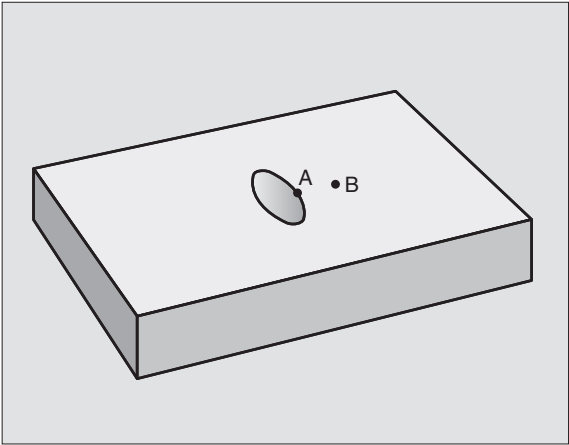
- A and B must be pockets.
- A must start inside of B.

Surface A:

51	LBL	1
52	L	X+60 Y+50 RR
53	CC	X+35 Y+50
54	C	X+60 Y+50 DR-
55	LBL	0

Surface B:

56	LBL	2
57	L	X+90 Y+50 RR
58	CC	X+65 Y+50
59	C	X+90 Y+50 DR-
60	LBL	0



## CONTOUR DATA (Cycle 20)

Machining data for the subprograms describing the subcontours are entered in Cycle 20.



### Before programming, note the following:

Cycle 20 is DEF active which means that it becomes effective as soon as it is defined in the part program.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH=0, the TNC performs the cycle at the depth 0.

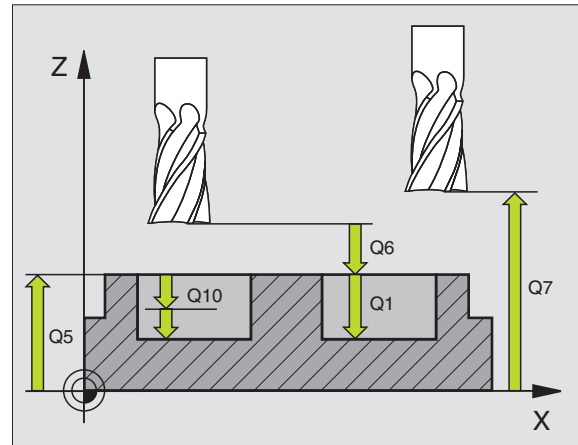
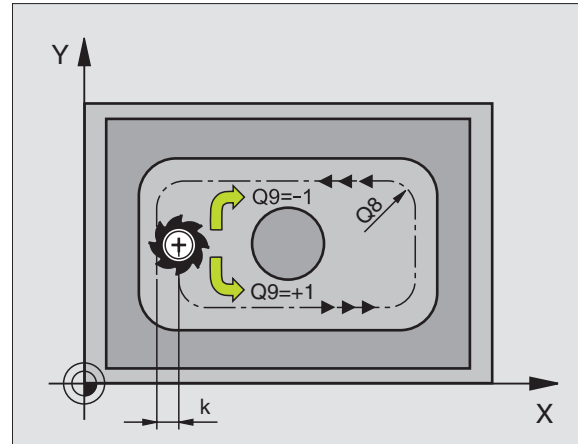
The machining data entered in Cycle 20 are valid for Cycles 21 to 24.

If you are using the SL Cycles in Q parameter programs, the Cycle Parameters Q1 to Q20 cannot be used as program parameters.

20  
CONTOUR  
DATA

- ▶ **Milling depth** Q1 (incremental value): Distance between workpiece surface and bottom of pocket.
- ▶ **Path overlap** factor Q2:  $Q2 \times \text{tool radius} = \text{stepover factor } k$ .
- ▶ **Finishing allowance for side** Q3 (incremental value): Finishing allowance in the working plane
- ▶ **Finishing allowance for floor** Q4 (incremental value): Finishing allowance in the tool axis.
- ▶ **Workpiece surface coordinate** Q5 (absolute value): Absolute coordinate of the workpiece surface
- ▶ **Set-up clearance** Q6 (incremental value): Distance between tool tip and workpiece surface.
- ▶ **Clearance height** Q7 (absolute value): Absolute height at which the tool cannot collide with the workpiece (for intermediate positioning and retraction at the end of the cycle).
- ▶ **Inside corner radius** Q8: Inside "corner" rounding radius; entered value is referenced to the tool midpoint path.
- ▶ **Direction of rotation ? Clockwise = -1** Q9: Machining direction for pockets.
  - Clockwise (Q9 = -1 up-cut milling for pocket and island)
  - Counterclockwise (Q9 = +1 climb milling for pocket and island)

You can check the machining parameters during a program interruption and overwrite them if required.



### Example: NC blocks

#### 57 CYCL DEF 20.0 CONTOUR DATA

Q1=-20	;MILLING DEPTH
Q2=1	;TOOL PATH OVERLAP
Q3=+0.2	;ALLOWANCE FOR SIDE
Q4=+0.1	;ALLOWANCE FOR FLOOR
Q5=+30	;SURFACE COORDINATE
Q6=2	;SET-UP CLEARANCE
Q7=+80	;CLEARANCE HEIGHT
Q8=0.5	;ROUNDING RADIUS
Q9=+1	;DIRECTION OF ROTATION



PILOT DRILLING (Cycle 21)



When calculating the infeed points, the TNC does not account for the delta value **DR** programmed in a **TOOL CALL** block.

In narrow areas, the TNC may not be able to carry out pilot drilling with a tool that is larger than the rough-out tool.

Process

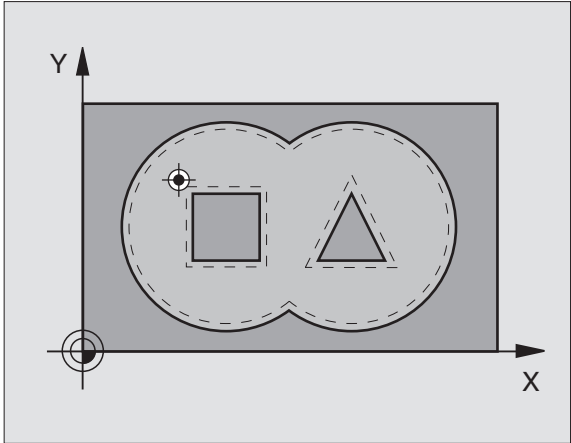
- 1 The tool drills from the current position to the first plunging depth at the programmed feed rate F.
- 2 When it reaches the first plunging depth, the tool retracts in rapid traverse FMAX to the starting position and advances again to the first plunging depth minus the advanced stop distance *t*.
- 3 The advanced stop distance is automatically calculated by the control:
  - At a total hole depth of up to 30 mm: *t* = 0.6 mm
  - At a total hole depth exceeding 30 mm: *t* = hole depth / 50
  - Maximum advanced stop distance: 7 mm
- 4 The tool then advances with another infeed at the programmed feed rate F.
- 5 The TNC repeats this process (1 to 4) until the programmed total hole depth is reached.
- 6 After a dwell time at the hole bottom, the tool is returned to the starting position in rapid traverse FMAX for chip breaking.

Application

Cycle 21 is for PILOT DRILLING of the cutter infeed points. It accounts for the allowance for side and the allowance for floor as well as the radius of the rough-out tool. The cutter infeed points also serve as starting points for roughing.



- **Plunging depth** Q10 (incremental value): Dimension by which the tool drills in each infeed (negative sign for negative working direction).
- **Feed rate for plunging** Q11: Traversing speed in mm/min during drilling.
- **Rough-out tool number** Q13: Tool number of the roughing mill.



Example: NC blocks

58 CYCL DEF 21.0 PILOT DRILLING	
Q10=+5	;INFEED DEPTH
Q11=100	;FEED RATE FOR PLUNGING
Q13=1	;ROUGH-OUT TOOL



## ROUGH-OUT (Cycle 22)

- 1 The TNC positions the tool over the cutter infeed point, taking the allowance for side into account.
- 2 In the first plunging depth, the tool mills the contour from inside outward at the milling feed rate.
- 3 First the island contours (C and D in the figure at right) are rough-milled until the pocket contour (A, B) is approached.
- 4 In the next step the TNC moves the tool to the next plunging depth and repeats the roughing procedure until the program depth is reached.
- 5 Finally the TNC retracts the tool to the clearance height.

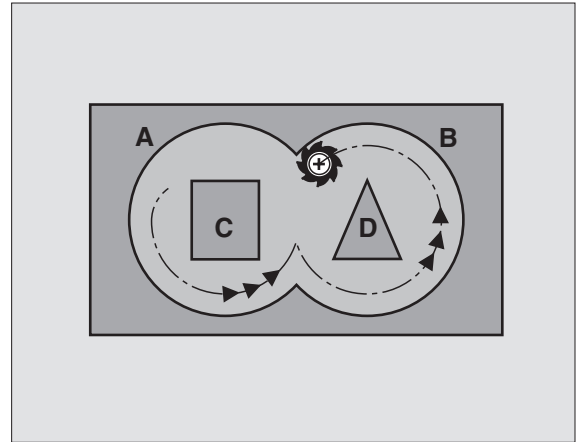


### Before programming, note the following:

This cycle requires a center-cut end mill (ISO 1641) or pilot drilling with Cycle 21.

You define the plunging behavior of Cycle 22 with parameter Q19 and with the tool table in the ANGLE and LCUTS columns:

- If Q19=0 is defined, the TNC always plunges perpendicularly, even if a plunge angle (ANGLE) is defined for the active tool.
- If you define the ANGLE=90°, the TNC plunges perpendicularly. The reciprocation feed rate Q19 is used as plunging feed rate.
- If the reciprocation feed rate Q19 is defined in Cycle 22 and ANGLE is defined between 0.1 and 89.999 in the tool table, the TNC plunges helically at the defined ANGLE.
- If the reciprocation feed is defined in Cycle 22 and no ANGLE is in the tool table, the TNC displays an error message.
- If geometrical conditions do not allow helical plunging (slot geometry), the TNC tries a reciprocating plunge. The reciprocation length is calculated from LCUTS and ANGLE (reciprocation length = LCUTS / tan ANGLE)



### Example: NC blocks

```

59 CYCL DEF 22.0 ROUGH-OUT
  Q10=+5    ;INFEED DEPTH
  Q11=100   ;FEED RATE FOR PLUNGING
  Q12=350   ;FEED RATE FOR ROUGHING
  Q18=1     ;COARSE ROUGHING TOOL
  Q19=150   ;RECIPROCATION FEED RATE
  Q208=99999;RETRACTION FEED RATE
  
```



- ▶ **Plunging depth** Q10 (incremental value): Dimension by which the tool plunges in each infeed.
- ▶ **Feed rate for plunging** Q11: Traversing speed of the tool in mm/min during penetration.
- ▶ **Feed rate for milling** Q12: Traversing speed for milling in mm/min.
- ▶ **Coarse roughing tool number** Q18: Number of the tool with which the TNC has already coarse-roughed the contour. If there was no coarse roughing, enter "0"; if you enter a value other than zero, the TNC will only rough-out the portion that could not be machined with the coarse roughing tool.  
If the portion that is to be roughed cannot be approached from the side, the TNC will mill in a reciprocating plunge-cut. For this purpose you must enter the tool length LCUTS in the tool table TOOL.T (see "Tool Data" on page 144) and define the maximum plunging ANGLE of the tool. The TNC will otherwise generate an error message.
- ▶ **Reciprocation feed rate** Q19: Traversing speed of the tool in mm/min during reciprocating plunge-cut.
- ▶ **Retraction feed rate** Q208: Traversing speed of the tool in mm/min when retracting after machining. If you enter Q208 = 0, the TNC retracts the tool at the feed rate in Q12.

FLOOR FINISHING (Cycle 23)

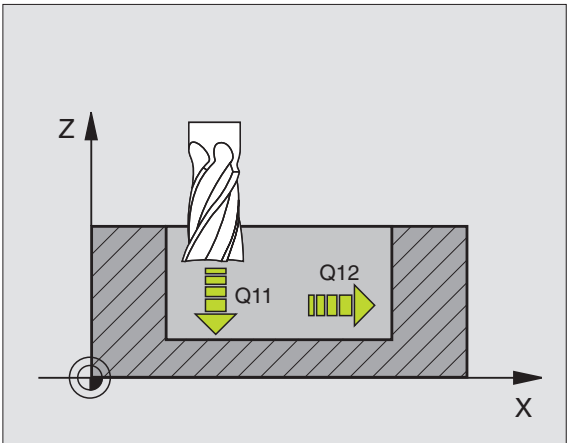


The TNC automatically calculates the starting point for finishing. The starting point depends on the available space in the pocket.

The tool approaches the machining plane smoothly (in a vertically tangential arc). The tool then clears the finishing allowance remaining from rough-out.



- ▶ **Feed rate for plunging** Q11: Traversing speed of the tool during penetration.
- ▶ **Feed rate for milling** Q12: Traversing speed for milling.
- ▶ **Retraction feed rate** Q208: Traversing speed of the tool in mm/min when retracting after machining. If you enter Q208 = 0, the TNC retracts the tool at the feed rate in Q12.



Example: NC blocks

```
60 CYCL DEF 23.0 FLOOR FINISHING
Q11=100 ;FEED RATE FOR PLUNGING
Q12=350 ;FEED RATE FOR ROUGHING
Q208=99999;RETRACTION FEED RATE
```



# SIDE FINISHING (Cycle 24)

The subcontours are approached and departed on a tangential arc. Each subcontour is finish-milled separately.



## Before programming, note the following:

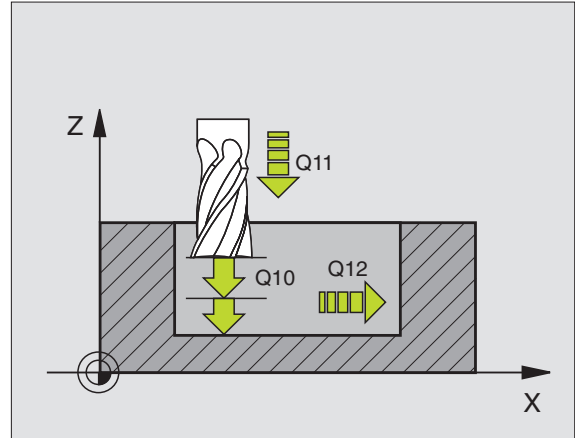
The sum of allowance for side (Q14) and the radius of the finish mill must be smaller than the sum of allowance for side (Q3, Cycle 20) and the radius of the rough mill.

This calculation also holds if you run Cycle 24 without having roughed out with Cycle 22; in this case, enter "0" for the radius of the rough mill.

You can use Cycle 24 also for contour milling. Then you must:

- define the contour to be milled as a single island (without pocket limit), and
- enter the finishing allowance (Q3) in Cycle 20 to be greater than the sum of the finishing allowance Q14 + radius of the tool being used.

The TNC automatically calculates the starting point for finishing. The starting point depends on the available space in the pocket and the allowance programmed in Cycle 20.



## Example: NC blocks

61 CYCL DEF 24.0 SIDE FINISHING	
Q9=+1	;DIRECTION OF ROTATION
Q10=+5	;INFEEED DEPTH
Q11=100	;FEED RATE FOR PLUNGING
Q12=350	;FEED RATE FOR ROUGHING
Q14=+0	;ALLOWANCE FOR SIDE



- ▶ **Direction of rotation ? Clockwise = -1 Q9:**  
Machining direction:  
+1:Counterclockwise rotation  
-1:Clockwise rotation
- ▶ **Plunging depth Q10** (incremental value): Dimension by which the tool plunges in each infeed.
- ▶ **Feed rate for plunging Q11:** Traversing speed of the tool during penetration.
- ▶ **Feed rate for milling Q12:** Traversing speed for milling.
- ▶ **Finishing allowance for side Q14** (incremental value): Enter the allowed material for several finish-milling operations. If you enter Q14 = 0, the remaining finishing allowance will be cleared.



CONTOUR TRAIN (Cycle 25)

In conjunction with Cycle 14 CONTOUR GEOMETRY, this cycle facilitates the machining of open contours (i.e. where the starting point of the contour is not the same as its end point).

Cycle 25 CONTOUR TRAIN offers considerable advantages over machining an open contour using positioning blocks:

- The TNC monitors the operation to prevent undercuts and surface blemishes. It is recommended that you run a graphic simulation of the contour before execution.
- If the radius of the selected tool is too large, the corners of the contour may have to be reworked.
- The contour can be machined throughout by up-cut or by climb milling. The type of milling even remains effective when the contours are mirrored.
- The tool can traverse back and forth for milling in several infeeds: This results in faster machining.
- Allowance values can be entered in order to perform repeated rough-milling and finish-milling operations.



Before programming, note the following:

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

The TNC takes only the first label of Cycle 14 CONTOUR GEOMETRY into account.

The memory capacity for programming an SL cycle is limited. For example, you can program up to 1024 straight-line blocks in one SL cycle.

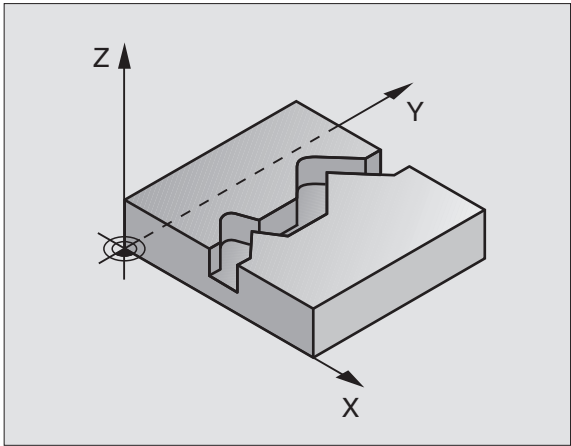
Cycle 20 CONTOUR DATA is not required.

Positions that are programmed in incremental dimensions immediately after Cycle 25 are referenced to the position of the tool at the end of the cycle.



Danger of collision!

- To avoid collisions,
- Do not program positions in incremental dimensions immediately after Cycle 25 since they are referenced to the position of the tool at the end of the cycle.
  - Move the tool to defined (absolute) positions in all main axes, since the position of the tool at the end of the cycle is not identical to the position of the tool at the start of the cycle.



Example: NC blocks

62 CYCL DEF 25.0 CONTOUR TRAIN	
Q1=-20	;MILLING DEPTH
Q3=+0	;ALLOWANCE FOR SIDE
Q5=+0	;SURFACE COORDINATE
Q7=+50	;CLEARANCE HEIGHT
Q10=+5	;INFEEED DEPTH
Q11=100	;FEED RATE FOR PLUNGING
Q12=350	;FEED RATE FOR MILLING
Q15=-1	;CLIMB OR UP-CUT







- ▶ **Milling depth** Q1 (incremental value): Distance between workpiece surface and contour floor.
- ▶ **Finishing allowance for side** Q3 (incremental value): Finishing allowance in the working plane.
- ▶ **Workpiece surface coordinate** Q5 (absolute value): Absolute coordinate of the workpiece surface referenced to the workpiece datum.
- ▶ **Clearance height** Q7 (absolute value): Absolute height at which the tool cannot collide with the workpiece. Position for tool retraction at the end of the cycle.
- ▶ **Plunging depth** Q10 (incremental value): Dimension by which the tool plunges in each infeed.
- ▶ **Feed rate for plunging** Q11: Traversing speed of the tool in the tool axis.
- ▶ **Feed rate for milling** Q12: Traversing speed of the tool in the working plane.
- ▶ **Climb or up-cut ? Up-cut = -1** Q15:  
 Climb milling: Input value = +1  
 Up-cut milling: Input value = -1  
 To enable climb milling and up-cut milling alternately in several infeeds: Input value = 0



## CYLINDER SURFACE (Cycle 27, software option 1)



Machine and control must be specially prepared by the machine tool builder for use of this cycle.

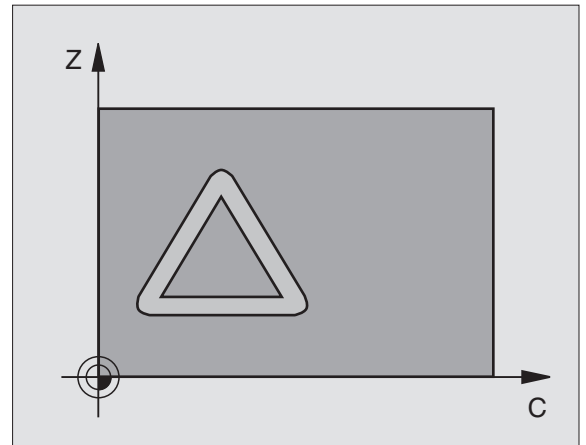
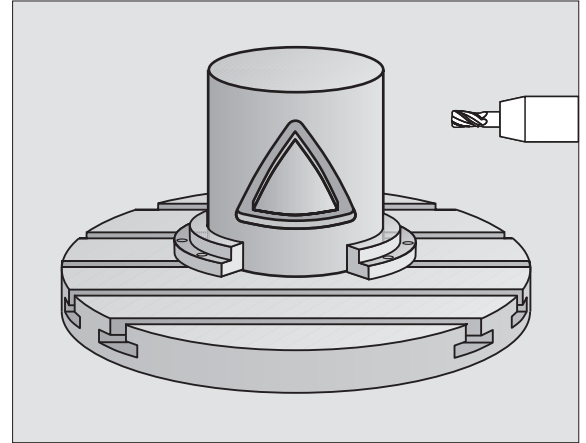
This cycle enables you to program a contour in two dimensions and then roll it onto a cylindrical surface for 3-D machining. Use Cycle 28 if you wish to mill guide notches onto the cylinder surface.

The contour is described in a subprogram identified in Cycle 14 CONTOUR GEOMETRY.

The subprogram contains coordinates in a rotary axis and in its parallel axis. The rotary axis C, for example, is parallel to the Z axis. The path functions L, CHF, CR, RND APPR (except APPR LCT) and DEP are available.

The dimensions in the rotary axis can be entered as desired either in degrees or in mm (or inches). You can select the desired dimension type in the cycle definition.

- 1 The TNC positions the tool over the cutter infeed point, taking the allowance for side into account.
- 2 At the first plunging depth, the tool mills along the programmed contour at the milling feed rate Q12.
- 3 At the end of the contour, the TNC returns the tool to the set-up clearance and returns to the point of penetration;
- 4 Steps 1 to 3 are repeated until the programmed milling depth Q1 is reached.
- 5 Then the tool moves to the set-up clearance.





### Before programming, note the following:

The memory capacity for programming an SL cycle is limited. For example, you can program up to 1024 straight-line blocks in one SL cycle.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

This cycle requires a center-cut end mill (ISO 1641).

The cylinder must be set up centered on the rotary table.

The tool axis must be perpendicular to the rotary table. If this is not the case, the TNC will generate an error message.

This cycle can also be used in a tilted working plane.

The TNC checks whether the compensated and non-compensated tool paths lie within the display range of the rotary axis, which is defined in machine parameter 810.x. If the error message "Contour programming error" is output, set MP 810.x = 0.



- ▶ **Milling depth** Q1 (incremental value): Distance between the cylindrical surface and the floor of the contour.
- ▶ **Finishing allowance for side** Q3 (incremental value): Finishing allowance in the plane of the unrolled cylindrical surface. This allowance is effective in the direction of the radius compensation.
- ▶ **Set-up clearance** Q6 (incremental value): Distance between the tool tip and the cylinder surface.
- ▶ **Plunging depth** Q10 (incremental value): Dimension by which the tool plunges in each infeed.
- ▶ **Feed rate for plunging** Q11: Traversing speed of the tool in the tool axis.
- ▶ **Feed rate for milling** Q12: Traversing speed of the tool in the working plane.
- ▶ **Cylinder radius** Q16: Radius of the cylinder on which the contour is to be machined.
- ▶ **Dimension type ? ang./lin.** Q17: The dimensions for the rotary axis of the subprogram are given either in degrees (0) or in mm/inches (1).

### Example: NC blocks

63 CYCL DEF 27.0 CYLINDER SURFACE	
Q1=-8	;MILLING DEPTH
Q3=+0	;ALLOWANCE FOR SIDE
Q6=+0	;SET-UP CLEARANCE
Q10=+3	;INFEEED DEPTH
Q11=100	;FEED RATE FOR PLUNGING
Q12=350	;FEED RATE FOR MILLING
Q16=25	;RADIUS
Q17=0	;DIMENSION TYPE



## CYLINDER SURFACE slot milling (Cycle 28, software option 1)



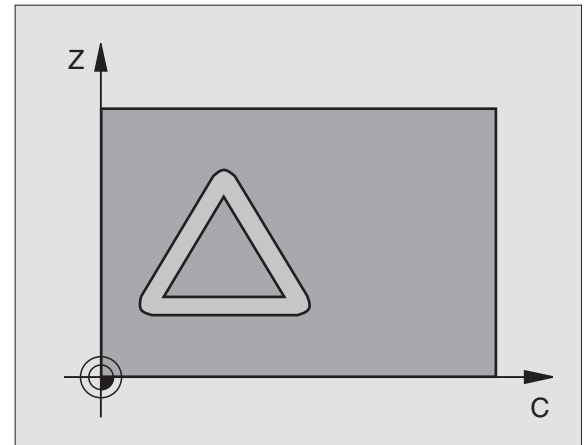
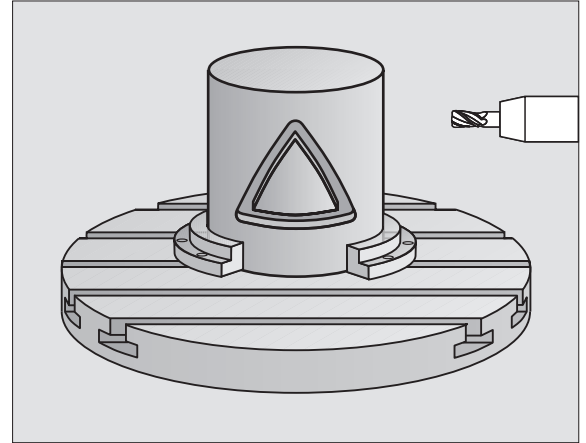
Machine and control must be specially prepared by the machine tool builder for use of this cycle.

This cycle enables you to program a guide notch in two dimensions and then transfer it onto a cylindrical surface. Unlike Cycle 27, with this cycle the TNC adjusts the tool so that, with radius compensation active, the walls of the slot are nearly parallel. You can machine exactly parallel walls by using a tool that is exactly as wide as the slot.

The smaller the tool is with respect to the slot width, the larger the distortion in circular arcs and oblique line segments. To minimize this process-related distortion, you can define in parameter Q21 a tolerance with which the TNC machines a slot approaching a slot machined with a tool of the same width.

Program the midpoint path of the contour together with the tool radius compensation. With the radius compensation you specify whether the TNC cuts the slot with climb milling or up-cut milling.

- 1 The TNC positions the tool over the cutter infeed point.
- 2 At the first plunging depth, the tool mills along the programmed slot wall at the milling feed rate Q12 while respecting the finishing allowance for the side.
- 3 At the end of the contour, the TNC moves the tool to the opposite wall and returns to the infeed point.
- 4 Steps 2 to 3 are repeated until the programmed milling depth Q1 is reached.
- 5 If you have defined the tolerance in Q21, the TNC then remachines the slot walls to be as parallel as possible.
- 6 Finally, the tool retracts in the tool axis to the clearance height or to the position last programmed before the cycle (depending on machine parameter 7420).



**Before programming, note the following:**

The memory capacity for programming an SL cycle is limited. For example, you can program up to 1024 straight-line blocks in one SL cycle.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program  $\text{DEPTH} = 0$ , the cycle will not be executed.

This cycle requires a center-cut end mill (ISO 1641).

The cylinder must be set up centered on the rotary table.

The tool axis must be perpendicular to the rotary table. If this is not the case, the TNC will generate an error message.

This cycle can also be used in a tilted working plane.

The TNC checks whether the compensated and non-compensated tool paths lie within the display range of the rotary axis, which is defined in machine parameter 810.x. If the error message "Contour programming error" is output, set  $\text{MP } 810.x = 0$ .





- ▶ **Milling depth** Q1 (incremental value): Distance between the cylindrical surface and the floor of the contour.
- ▶ **Finishing allowance for side** Q3 (incremental value): Finishing allowance on the slot wall. The finishing allowance reduces the slot width by twice the entered value.
- ▶ **Set-up clearance** Q6 (incremental value): Distance between the tool tip and the cylinder surface.
- ▶ **Plunging depth** Q10 (incremental value): Dimension by which the tool plunges in each infeed.
- ▶ **Feed rate for plunging** Q11: Traversing speed of the tool in the tool axis.
- ▶ **Feed rate for milling** Q12: Traversing speed of the tool in the working plane.
- ▶ **Cylinder radius** Q16: Radius of the cylinder on which the contour is to be machined.
- ▶ **Dimension type ? ang./lin.** Q17: The dimensions for the rotary axis of the subprogram are given either in degrees (0) or in mm/inches (1).
- ▶ **Slot width** Q20: Width of the slot to be machined.
- ▶ **Tolerance?** Q21: If you use a tool smaller than the programmed slot width Q20, process-related distortion occurs on the slot wall wherever the slot follows the path of an arc or oblique line. If you define the tolerance Q21, the TNC adds a subsequent milling operation to ensure that the slot dimensions are as close as possible to those of a slot that has been milled with a tool exactly as wide as the slot. With Q21 you define the permitted deviation from this ideal slot. The number of subsequent milling operations depends on the cylinder radius, the tool used, and the slot depth. The smaller the tolerance is defined, the more exact the slot is and the longer the remachining takes. **Recommendation:** Use a tolerance of 0.02 mm

Example: NC blocks

63 CYCL DEF 28.0 CYLINDER SURFACE		
Q1=-8	;MILLING DEPTH	
Q3=+0	;ALLOWANCE FOR SIDE	
Q6=+0	;SET-UP CLEARANCE	
Q10=+3	;INFEED DEPTH	
Q11=100	;FEED RATE FOR PLUNGING	
Q12=350	;FEED RATE FOR MILLING	
Q16=25	;RADIUS	
Q17=0	;DIMENSION TYPE	
Q20=12	;SLOT WIDTH	
Q21=0	;TOLERANCE	



## CYLINDER SURFACE ridge milling (Cycle 29, software option 1)

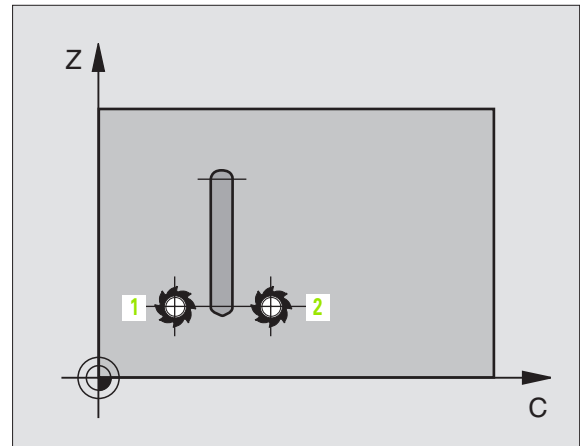
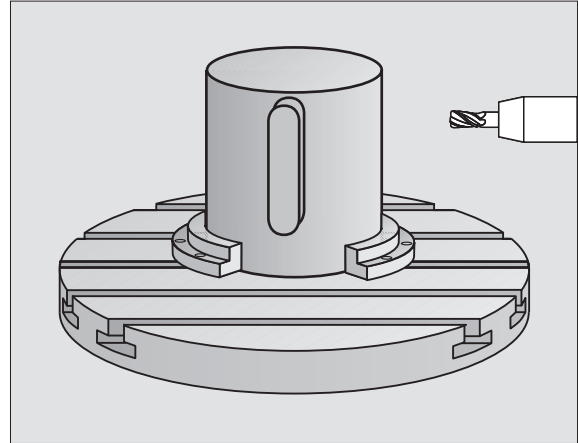


Machine and control must be specially prepared by the machine tool builder for use of this cycle.

This cycle enables you to program a ridge in two dimensions and then transfer it onto a cylindrical surface. With this cycle the TNC adjusts the tool so that, with radius compensation active, the walls of the slot are always parallel. Program the midpoint path of the ridge together with the tool radius compensation. With the radius compensation you specify whether the TNC cuts the ridge with climb milling or up-cut milling.

At the ends of the ridge the TNC always adds a semicircle whose radius is half the ridge width.

- 1** The TNC positions the tool over the starting point of machining. The TNC calculates the starting point from the ridge width and the tool diameter. It is located next to the first point defined in the contour subprogram, offset by half the ridge width and the tool diameter. The radius compensation determines whether machining begins from the left (**1**, RL = climb milling) or the right of the ridge (**2**, RR = up-cut milling) (see figure at center right).
- 2** After the TNC has positioned to the first plunging depth, the tool moves on a circular arc at the milling feed rate Q12 tangentially to the ridge wall. If so programmed, it will leave metal for the finishing allowance.
- 3** At the first plunging depth, the tool mills along the programmed ridge wall at the milling feed rate Q12 until the stud is completed.
- 4** The tool then departs the ridge wall on a tangential path and returns to the starting point of machining.
- 5** Steps 2 to 4 are repeated until the programmed milling depth Q1 is reached.
- 6** Finally, the tool retracts in the tool axis to the clearance height or to the position last programmed before the cycle (depending on machine parameter 7420).





**Before programming, note the following:**

Ensure that the tool has enough space laterally for contour approach and departure.

The memory capacity for programming an SL cycle is limited. For example, you can program up to 1024 straight-line blocks in one SL cycle.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

The cylinder must be set up centered on the rotary table.

The tool axis must be perpendicular to the rotary table. If this is not the case, the TNC will generate an error message.

This cycle can also be used in a tilted working plane.

The TNC checks whether the compensated and non-compensated tool paths lie within the display range of the rotary axis, which is defined in machine parameter 810.x. If the error message "Contour programming error" is output, set MP 810.x = 0.



- ▶ **Milling depth** Q1 (incremental value): Distance between the cylindrical surface and the floor of the contour.
- ▶ **Finishing allowance for side** Q3 (incremental value): Finishing allowance on the ridge wall. The finishing allowance increases the ridge width by twice the entered value.
- ▶ **Set-up clearance** Q6 (incremental value): Distance between the tool tip and the cylinder surface.
- ▶ **Plunging depth** Q10 (incremental value): Dimension by which the tool plunges in each infeed.
- ▶ **Feed rate for plunging** Q11: Traversing speed of the tool in the tool axis.
- ▶ **Feed rate for milling** Q12: Traversing speed of the tool in the working plane.
- ▶ **Cylinder radius** Q16: Radius of the cylinder on which the contour is to be machined.
- ▶ **Dimension type ? ang./lin.** Q17: The dimensions for the rotary axis of the subprogram are given either in degrees (0) or in mm/inches (1).
- ▶ **Ridge width** Q20: Width of the ridge to be machined.

**Example: NC blocks**

63 CYCL DEF 29.0 CYLINDER SURFACE RIDGE	
Q1=-8	;MILLING DEPTH
Q3=+0	;ALLOWANCE FOR SIDE
Q6=+0	;SET-UP CLEARANCE
Q10=+3	;INFEEED DEPTH
Q11=100	;FEED RATE FOR PLUNGING
Q12=350	;FEED RATE FOR MILLING
Q16=25	;RADIUS
Q17=0	;DIMENSION TYPE
Q20=12	;RIDGE WIDTH





## CYLINDER SURFACE outside contour milling (Cycle 39, software option 1)

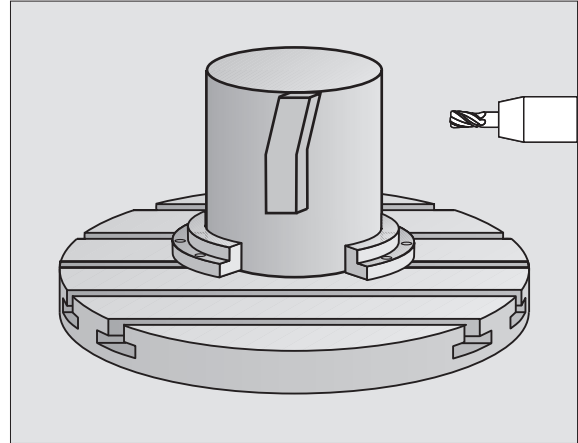


Machine and control must be specially prepared by the machine tool builder for use of this cycle.

This cycle enables you to program an open contour in two dimensions and then roll it onto a cylindrical surface for 3-D machining. With this cycle the TNC adjusts the tool so that, with radius compensation active, the wall of the open contour is always parallel to the cylinder axis.

Unlike Cycles 28 and 29, in the contour subprogram you define the actual contour to be machined.

- 1** The TNC positions the tool over the starting point of machining. The TNC locates the starting point next to the first point defined in the contour subprogram, offset by the tool diameter.
- 2** After the TNC has positioned to the first plunging depth, the tool moves on a circular arc at the milling feed rate Q12 tangentially to the contour. If so programmed, it will leave metal for the finishing allowance.
- 3** At the first plunging depth, the tool mills along the programmed contour at the milling feed rate Q12 until the contour train is completed.
- 4** The tool then departs the ridge wall on a tangential path and returns to the starting point of machining.
- 5** Steps 2 to 4 are repeated until the programmed milling depth Q1 is reached.
- 6** Finally, the tool retracts in the tool axis to the clearance height or to the position last programmed before the cycle (depending on machine parameter 7420).





**Before programming, note the following:**

Ensure that the tool has enough space laterally for contour approach and departure.

The memory capacity for programming an SL cycle is limited. For example, you can program up to 1024 straight-line blocks in one SL cycle.

The algebraic sign for the cycle parameter DEPTH determines the working direction. If you program DEPTH = 0, the cycle will not be executed.

The cylinder must be set up centered on the rotary table.

The tool axis must be perpendicular to the rotary table. If this is not the case, the TNC will generate an error message.

This cycle can also be used in a tilted working plane.

The TNC checks whether the compensated and non-compensated tool paths lie within the display range of the rotary axis, which is defined in machine parameter 810.x. If the error message "Contour programming error" is output, set MP 810.x = 0.



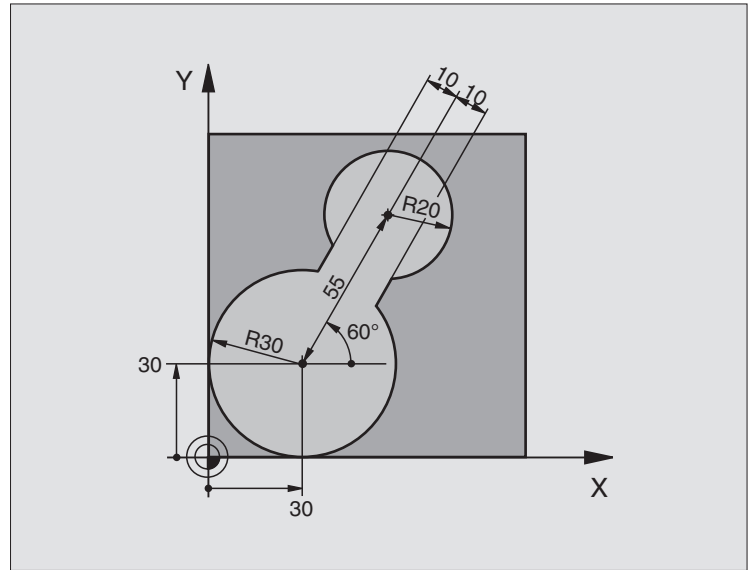
- ▶ **Milling depth** Q1 (incremental value): Distance between the cylindrical surface and the floor of the contour.
- ▶ **Finishing allowance for side** Q3 (incremental value): Finishing allowance on the contour wall.
- ▶ **Set-up clearance** Q6 (incremental value): Distance between the tool tip and the cylinder surface.
- ▶ **Plunging depth** Q10 (incremental value): Dimension by which the tool plunges in each infeed.
- ▶ **Feed rate for plunging** Q11: Traversing speed of the tool in the tool axis.
- ▶ **Feed rate for milling** Q12: Traversing speed of the tool in the working plane.
- ▶ **Cylinder radius** Q16: Radius of the cylinder on which the contour is to be machined.
- ▶ **Dimension type ? ang./lin.** Q17: The dimensions for the rotary axis of the subprogram are given either in degrees (0) or in mm/inches (1).

**Example: NC blocks**

63 CYCL DEF 39.0 CYL. SURFACE CONTOUR	
Q1=-8	;MILLING DEPTH
Q3=+0	;ALLOWANCE FOR SIDE
Q6=+0	;SET-UP CLEARANCE
Q10=+3	;INFEEED DEPTH
Q11=100	;FEED RATE FOR PLUNGING
Q12=350	;FEED RATE FOR MILLING
Q16=25	;RADIUS
Q17=0	;DIMENSION TYPE



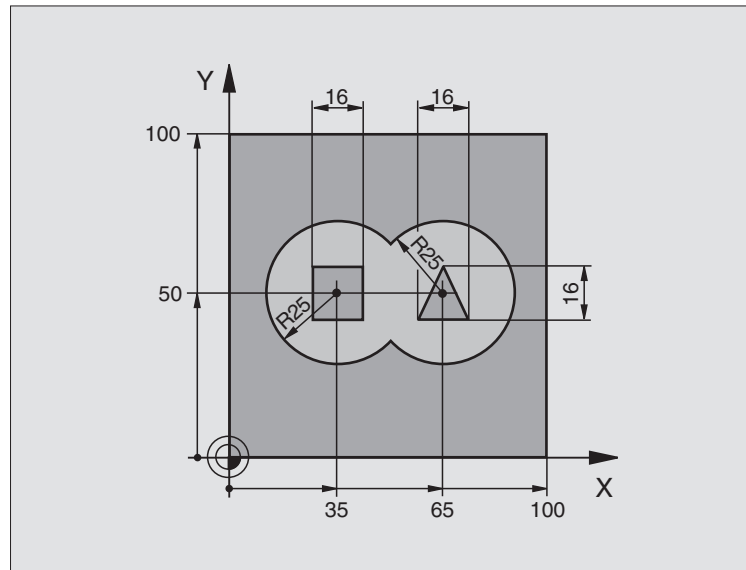
## Example: Roughing-out and fine-roughing a pocket



0 BEGIN PGM C20 MM	
1 BLK FORM 0.1 Z X-10 Y-10 Z-40	
2 BLK FORM 0.2 X+100 Y+100 Z+0	Define the workpiece blank
3 TOOL DEF 1 L+0 R+15	Tool definition: coarse roughing tool
4 TOOL DEF 2 L+0 R+7.5	Tool definition: fine roughing tool
5 TOOL CALL 1 Z S2500	Tool call: coarse roughing tool
6 L Z+250 R0 FMAX	Retract the tool
7 CYCL DEF 14.0 CONTOUR GEOMETRY	Define contour subprogram
8 CYCL DEF 14.1 CONTOUR LABEL 1	
9 CYCL DEF 20.0 CONTOUR DATA	Define general machining parameters
Q1=-20 ;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=+100 ;CLEARANCE HEIGHT	
Q8=0.1 ;ROUNDING RADIUS	
Q9=-1 ;DIRECTION OF ROTATION	

10 CYCL DEF 22.0 ROUGH-OUT	Cycle definition: Coarse roughing
Q10=5 ;INFEED DEPTH	
Q11=100 ;FEED RATE FOR PLUNGING	
Q12=350 ;FEED RATE FOR ROUGHING	
Q18=0 ;COARSE ROUGHING TOOL	
Q19=150 ;RECIPROCATION FEED RATE	
Q208=30000;RETRACTION FEED RATE	
11 CYCL CALL M3	Cycle call: Coarse roughing
12 L Z+250 R0 FMAX M6	Tool change
13 TOOL CALL 2 Z S3000	Tool call: fine roughing tool
14 CYCL DEF 22.0 ROUGH-OUT	Define the fine roughing cycle
Q10=5 ;INFEED DEPTH	
Q11=100 ;FEED RATE FOR PLUNGING	
Q12=350 ;FEED RATE FOR ROUGHING	
Q18=1 ;COARSE ROUGHING TOOL	
Q19=150 ;RECIPROCATION FEED RATE	
Q208=30000;RETRACTION FEED RATE	
15 CYCL CALL M3	Cycle call: Fine roughing
16 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
17 LBL 1	Contour subprogram
18 L X+0 Y+30 RR	see "Example: FK programming 2" on page 222
19 FC DR- R30 CCX+30 CCY+30	
20 FL AN+60 PDX+30 PDY+30 D10	
21 FSELECT 3	
22 FPOL X+30 Y+30	
23 FC DR- R20 CCPR+55 CCPA+60	
24 FSELECT 2	
25 FL AN-120 PDX+30 PDY+30 D10	
26 FSELECT 3	
27 FC X+0 DR- R30 CCX+30 CCY+30	
28 FSELECT 2	
29 LBL 0	
30 END PGM C20 MM	

### Example: Pilot drilling, roughing-out and finishing overlapping contours



0 BEGIN PGM C21 MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-40	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+6	Define tool: drill
4 TOOL DEF 2 L+0 R+6	Define the tool for roughing/finishing
5 TOOL CALL 1 Z S2500	Call toll: drill
6 L Z+250 R0 FMAX	Retract the tool
7 CYCL DEF 14.0 CONTOUR GEOMETRY	Define contour subprogram
8 CYCL DEF 14.1 CONTOUR LABEL 1/2/3/4	
9 CYCL DEF 20.0 CONTOUR DATA	Define general machining parameters
Q1=-20 ;MILLING DEPTH	
Q2=1 ;TOOL PATH OVERLAP	
Q3=+0.5 ;ALLOWANCE FOR SIDE	
Q4=+0.5 ;ALLOWANCE FOR FLOOR	
Q5=+0 ;SURFACE COORDINATE	
Q6=2 ;SET-UP CLEARANCE	
Q7=+100 ;CLEARANCE HEIGHT	
Q8=0.1 ;ROUNDING RADIUS	
Q9=-1 ;DIRECTION OF ROTATION	

## 8.6 SL Cycles

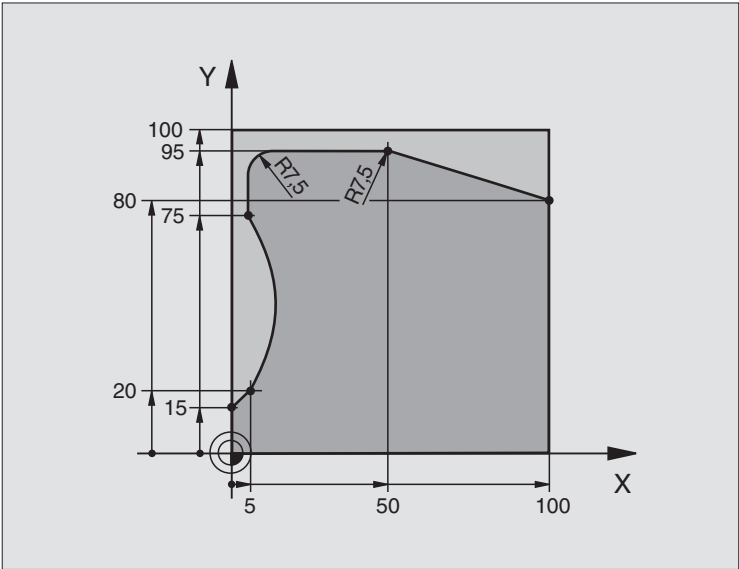
10 CYCL DEF 21.0 PILOT DRILLING	Cycle definition: Pilot drilling
Q10=5 ;INFEED DEPTH	
Q11=250 ;FEED RATE FOR PLUNGING	
Q13=2 ;ROUGH-OUT TOOL	
11 CYCL CALL M3	Cycle call: Pilot drilling
12 L T+250 R0 FMAX M6	Tool change
13 TOOL CALL 2 Z S3000	Call the tool for roughing/finishing
14 CYCL DEF 22.0 ROUGH-OUT	Cycle definition: Rough-out
Q10=5 ;INFEED DEPTH	
Q11=100 ;FEED RATE FOR PLUNGING	
Q12=350 ;FEED RATE FOR ROUGHING	
Q18=0 ;COARSE ROUGHING TOOL	
Q19=150 ;RECIPROCATION FEED RATE	
Q208=30000;RETRACTION FEED RATE	
15 CYCL CALL M3	Cycle call: Rough-out
16 CYCL DEF 23.0 FLOOR FINISHING	Cycle definition: Floor finishing
Q11=100 ;FEED RATE FOR PLUNGING	
Q12=200 ;FEED RATE FOR ROUGHING	
Q208=30000;RETRACTION FEED RATE	
17 CYCL CALL	Cycle call: Floor finishing
18 CYCL DEF 24.0 SIDE FINISHING	Cycle definition: Side finishing
Q9=+1 ;DIRECTION OF ROTATION	
Q10=5 ;INFEED DEPTH	
Q11=100 ;FEED RATE FOR PLUNGING	
Q12=400 ;FEED RATE FOR ROUGHING	
Q14=+0 ;ALLOWANCE FOR SIDE	
19 CYCL CALL	Cycle call: Side finishing
20 L Z+250 R0 FMAX M2	Retract in the tool axis, end program



21 LBL 1	Contour subprogram 1: left pocket
22 CC X+35 Y+50	
23 L X+10 Y+50 RR	
24 C X+10 DR-	
25 LBL 0	
26 LBL 2	Contour subprogram 2: right pocket
27 CC X+65 Y+50	
28 L X+90 Y+50 RR	
29 C X+90 DR-	
30 LBL 0	
31 LBL 3	Contour subprogram 3: square left island
32 L X+27 Y+50 RL	
33 L Y+58	
34 L X+43	
35 L Y+42	
36 L X+27	
37 LBL 0	
38 LBL 4	Contour subprogram 4: triangular right island
39 L X+65 Y+42 RL	
40 L X+57	
41 L X+65 Y+58	
42 L X+73 Y+42	
43 LBL 0	
44 END PGM C21 MM	



Example: Contour train



0 BEGIN PGM C25 MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-40	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+10	Define the tool
4 TOOL CALL 1 Z S2000	Tool call
5 L Z+250 R0 FMAX	Retract the tool
6 CYCL DEF 14.0 CONTOUR GEOMETRY	Define contour subprogram
7 CYCL DEF 14.1 CONTOUR LABEL 1	
8 CYCL DEF 25.0 CONTOUR TRAIN	Define machining parameters
Q1=-20 ;MILLING DEPTH	
Q3=+0 ;ALLOWANCE FOR SIDE	
Q5=+0 ;SURFACE COORDINATE	
Q7=+250 ;CLEARANCE HEIGHT	
Q10=5 ;INFED DEPTH	
Q11=100 ;FEED RATE FOR PLUNGING	
Q12=200 ;FEED RATE FOR MILLING	
Q15=+1 ;CLIMB OR UP-CUT	
9 CYCL CALL M3	Call the cycle
10 L Z+250 R0 FMAX M2	Retract in the tool axis, end program





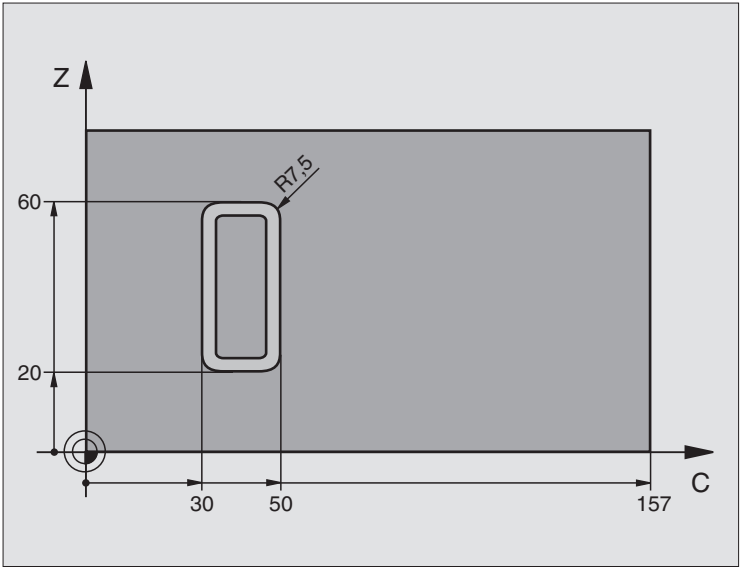
11 LBL 1	Contour subprogram
12 L X+0 Y+15 RL	
13 L X+5 Y+20	
14 CT X+5 Y+75	
15 L Y+95	
16 RND R7.5	
17 L X+50	
18 RND R7.5	
19 L X+100 Y+80	
20 LBL 0	
21 END PGM C25 MM	



Example: Cylinder surface with Cycle 27

Note:

- Cylinder centered on rotary table
- Datum at center of rotary table



0 BEGIN PGM C27 MM	
1 TOOL DEF 1 L+0 R+3.5	Define the tool
2 TOOL CALL 1 Y S2000	Call tool, tool axis is Y
3 L X+250 R0 FMAX	Retract the tool
4 L X+0 R0 FMAX	Position tool on rotary table center
5 CYCL DEF 14.0 CONTOUR GEOMETRY	Define contour subprogram
6 CYCL DEF 14.1 CONTOUR LABEL 1	
7 CYCL DEF 27.0 CYLINDER SURFACE	Define machining parameters
Q1=-7       ;MILLING DEPTH	
Q3=+0       ;ALLOWANCE FOR SIDE	
Q6=2        ;SET-UP CLEARANCE	
Q10=4       ;INFEEED DEPTH	
Q11=100     ;FEED RATE FOR PLUNGING	
Q12=250     ;FEED RATE FOR MILLING	
Q16=25      ;RADIUS	
Q17=1       ;DIMENSION TYPE	
8 L C+0 R0 FMAX M3	Pre-position rotary table
9 CYCL CALL	Call the cycle
10 L Y+250 R0 FMAX M2	Retract in the tool axis, end program



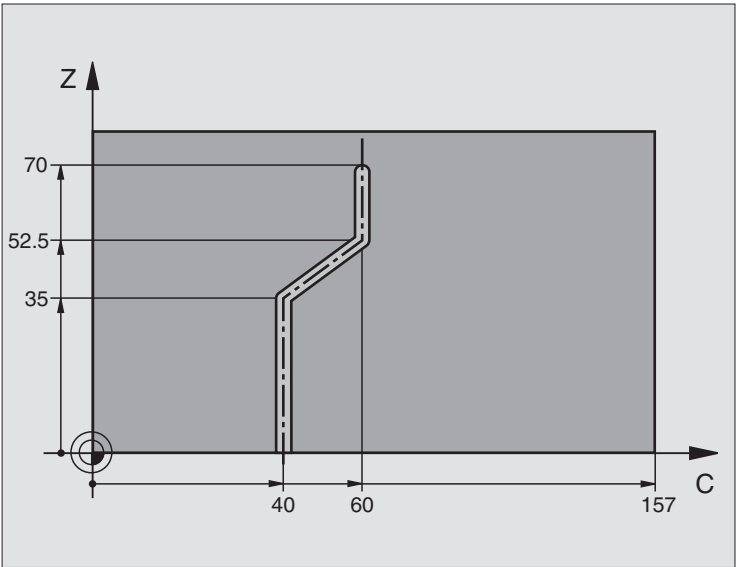
11 LBL 1	Contour subprogram
12 L C+40 Z+20 RL	Data for the rotary axis are entered in mm (Q17=1)
13 L C+50	
14 RND R7.5	
15 L Z+60	
16 RND R7.5	
17 L IC-20	
18 RND R7.5	
19 L Z+20	
20 RND R7.5	
21 L C+40	
22 LBL 0	
23 END PGM C27 MM	



Example: Cylinder surface with Cycle 28

Notes:

- Cylinder centered on rotary table
- Datum at center of rotary table
- Description of the midpoint path in the contour subprogram



0 BEGIN PGM C28 MM	
1 TOOL DEF 1 L+0 R+3.5	Define the tool
2 TOOL CALL 1 Y S2000	Call tool, tool axis is Y
3 L Y+250 R0 FMAX	Retract the tool
4 L X+0 R0 FMAX	Position tool on rotary table center
5 CYCL DEF 14.0 CONTOUR GEOMETRY	Define contour subprogram
6 CYCL DEF 14.1 CONTOUR LABEL 1	
7 CYCL DEF 28.0 CYLINDER SURFACE	Define machining parameters
Q1=-7 ;MILLING DEPTH	
Q3=+0 ;ALLOWANCE FOR SIDE	
Q6=2 ;SET-UP CLEARANCE	
Q10=-4 ;INFEEED DEPTH	
Q11=100 ;FEED RATE FOR PLUNGING	
Q12=250 ;FEED RATE FOR MILLING	
Q16=25 ;RADIUS	
Q17=1 ;DIMENSION TYPE	
Q20=10 ;SLOT WIDTH	
Q21=0.02 ;TOLERANCE	Remachining active
8 L C+0 R0 FMAX M3	Pre-position rotary table
9 CYCL CALL	Call the cycle



10 L Y+250 R0 FMAX M2	Retract in the tool axis, end program
11 LBL 1	Contour subprogram, description of the midpoint path
12 L C+40 Z+0 RL	Data for the rotary axis are entered in mm (Q17=1)
13 L Z+35	
14 L C+60 Z+52.5	
15 L Z+70	
16 LBL 0	
17 END PGM C28 MM	



## 8.7 SL Cycles with Contour Formula

### Fundamentals

SL Cycles and the contour formula enable you to form complex contours by combining subcontours (pockets or islands). You define the individual subcontours (geometry data) as separate programs. In this way, any subcontour can be used any number of times. The TNC calculates the complete contour from the selected subcontours, which you link together through a contour formula.



The memory capacity for programming an SL cycle (all contour description programs) is limited to 32 contours. The number of possible contour elements depends on the type of contour (inside or outside contour) and the number of contour descriptions. For example, you can program up to approx. 1024 line blocks.

The SL Cycles with contour formula presuppose a structured program layout and enable you to save frequently used contours in individual programs. Using the contour formula, you can connect the subcontours to a complete contour and define whether it applies to a pocket or island.

In its present form, the "SL Cycles with contour formula" function requires input from several areas in the TNC's user interface. This function is to serve as a basis for further development.

### Properties of the subcontours

- By default, the TNC assumes that the contour is a pocket. Do not program a radius compensation. In the contour formula you can convert a pocket to an island by making it negative.
- The TNC ignores feed rates F and miscellaneous functions M.
- Coordinate transformations are allowed. If they are programmed within the subcontour they are also effective in the following subprograms, but they need not be reset after the cycle call.
- Although the subprograms can contain coordinates in the spindle axis, such coordinates are ignored.
- The working plane is defined in the first coordinate block of the subprogram. The secondary axes U,V,W are permitted.

### Characteristics of the fixed cycles

- The TNC automatically positions the tool to the set-up clearance before a cycle.
- Each level of infeed depth is milled without interruptions since the cutter traverses around islands instead of over them.
- The radius of "inside corners" can be programmed—the tool keeps moving to prevent surface blemishes at inside corners (this applies for the outermost pass in the Rough-out and Side Finishing cycles).
- The contour is approached on a tangential arc for side finishing.

### Example: Program structure: Machining with SL Cycles and contour formula

```
0 BEGIN PGM CONTOUR MM
...
5 SEL CONTOUR "MODEL"
6 CYCL DEF 20.0 CONTOUR DATA ...
8 CYCL DEF 22.0 ROUGH-OUT...
9 CYCL CALL
...
12 CYCL DEF 23.0 FLOOR FINISHING ...
13 CYCL CALL
...
16 CYCL DEF 24.0 SIDE FINISHING ...
17 CYCL CALL
63 L Z+250 R0 FMAX M2
64 END PGM CONTOUR MM
```

### Example: Program structure: Calculation of the subcontours with contour formula

```
0 BEGIN PGM MODEL MM
1 DECLARE CONTOUR QC1 = "CIRCLE1"
2 DECLARE CONTOUR QC2 = "CIRCLE31XY"
3 DECLARE CONTOUR QC3 = "TRIANGLE"
4 DECLARE CONTOUR QC4 = "SQUARE"
5 QC10 = ( QC1 | QC3 | QC4 ) \ QC2
6 END PGM MODEL MM

0 BEGIN PGM CIRCLE1 MM
1 CC X+75 Y+50
2 LP PR+45 PA+0
3 CP IPA+360 DR+
4 END PGM CIRCLE1 MM

0 BEGIN PGM CIRCLE31XY MM
...
...
```



- For floor finishing, the tool again approaches the workpiece in a tangential arc (for tool axis Z, for example, the arc may be in the Z/X plane).
- The contour is machined throughout in either climb or up-cut milling.



With MP7420 you can determine where the tool is positioned at the end of Cycles 21 to 24.

The machining data (such as milling depth, finishing allowance and set-up clearance) are entered as CONTOUR DATA in Cycle 20.

## Selecting a program with contour definitions

With the **SEL CONTOUR** function you select a program with contour definitions, from which the TNC takes the contour descriptions:

PGM  
CALL

- ▶ To select the functions for program call, press the PGM CALL key.

SELECT  
CONTOUR

- ▶ Press the SELECT KONTUR soft key.
- ▶ Enter the full name of the program with the contour definition and confirm with the END key.



Program a SEL CONTOUR block before the SL cycles. Cycle 14 CONTOUR GEOMETRY is no longer necessary if you use SEL CONTOUR.

## Defining contour descriptions

With the **DECLARE CONTOUR** function you enter in a program the path for programs from which the TNC draws the contour descriptions:

DECLARE

- ▶ Press the DECLARE soft key.

CONTOUR

- ▶ Press the CONTOUR soft key.
- ▶ Enter the number for the contour designator **QC**, and confirm with the ENT key.
- ▶ Enter the full name of the program with the contour description and confirm with the END key.



With the given contour designators QC you can include the various contours in the contour formula.

With the **DECLARE STRING** function you define a text. This function is currently not evaluated.



Entering a contour formula

You can use soft keys to interlink various contours in a mathematical formula.

- ▶ Select a Q parameter function: Press the Q key (in the numerical keypad at right). The Q parameter functions are displayed in a soft-key row.
- ▶ To select the function for entering the contour formula, press the CONTOUR FORMULA soft key. The TNC then shows the following soft keys:

Logic command	Soft key
<b>Intersected with</b> e.g. QC10 = QC1 & QC5	
<b>Joined with</b> e.g. QC25 = QC7   QC18	
<b>Joined without intersection</b> e.g. QC12 = QC5 ^ QC25	
<b>Joined with complement of</b> e.g. QC25 = QC1 \ QC2	
<b>Complement of contour area</b> e.g. Q12 = #Q11	
<b>Opening parenthesis</b> e.g. QC12 = QC1 * (QC2 + QC3)	
<b>Closing parenthesis</b> e.g. QC12 = QC1 * (QC2 + QC3)	
<b>Defining a single contour</b> e.g. QC12 = QC1	





## Overlapping contours

By default, the TNC considers a programmed contour to be a pocket. With the functions of the contour formula, you can convert a contour from a pocket to an island.

Pockets and islands can be overlapped to form a new contour. You can thus enlarge the area of a pocket by another pocket or reduce it by an island.

### Subprograms: Overlapping pockets



The following program examples are contour description programs that are defined in a contour definition program. The contour definition program is called through the **SEL CONTOUR** function in the actual main program.

Pockets A and B overlap.

The TNC calculates the points of intersection S1 and S2 (they do not have to be programmed).

The pockets are programmed as full circles.



## Contour description program 1: Pocket A

```
0 BEGIN PGM POCKET_A MM
1 L X+10 Y+50 R0
2 CC X+35 Y+50
3 C X+10 Y+50 DR-
4 END PGM POCKET_A MM
```

## Contour description program 2: Pocket B

```
0 BEGIN PGM POCKET_B MM
1 L X+90 Y+50 R0
2 CC X+65 Y+50
3 C X+90 Y+50 DR-
4 END PGM POCKET_B MM
```

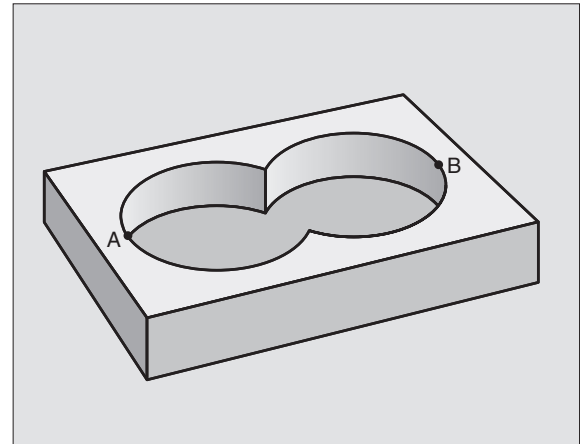
### Area of inclusion

Both surfaces A and B are to be machined, including the overlapping area:

- The surfaces A and B must be programmed in separate programs without radius compensation.
- In the contour formula, the surfaces A and B are processed with the "joined with" function.

Contour definition program:

```
50 ...
51 ...
52 DECLARE CONTOUR QC1 = "POCKET_A.H"
53 DECLARE CONTOUR QC2 = "POCKET_B.H"
54 QC10 = QC1 & QC2
55 ...
56 ...
```



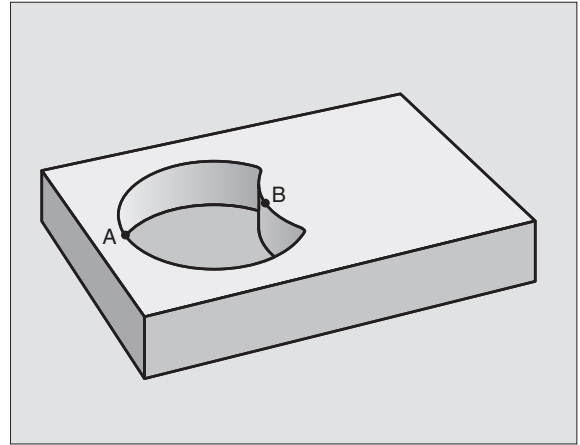
### Area of exclusion

Surface A is to be machined without the portion overlapped by B:

- The surfaces A and B must be entered in separate programs without radius compensation.
- In the contour formula, the surface B is subtracted from the surface A with the "joined with complement of" function.

Contour definition program:

```
50 ...
51 ...
52 DECLARE CONTOUR QC1 = "POCKET_A.H"
53 DECLARE CONTOUR QC2 = "POCKET_B.H"
54 QC10 = QC1 \ QC2
55 ...
56 ...
```



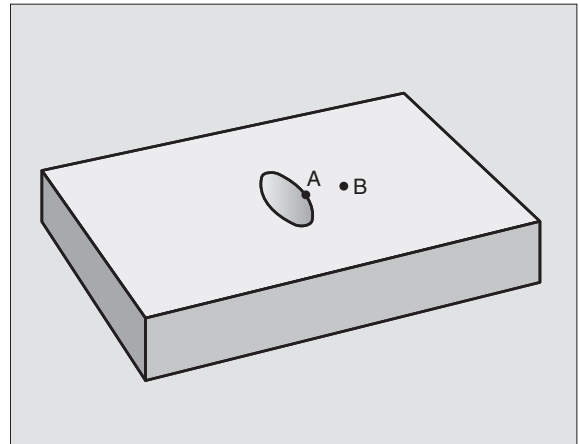
### Area of intersection

Only the area where A and B overlap is to be machined. (The areas covered by A or B alone are to be left unmachined.)

- The surfaces A and B must be entered in separate programs without radius compensation.
- In the contour formula, the surfaces A and B are processed with the "intersected with" function.

Contour definition program:

```
50 ...
51 ...
52 DECLARE CONTOUR QC1 = "POCKET_A.H"
53 DECLARE CONTOUR QC2 = "POCKET_B.H"
54 QC10 = QC1 \ QC2
55 ...
56 ...
```

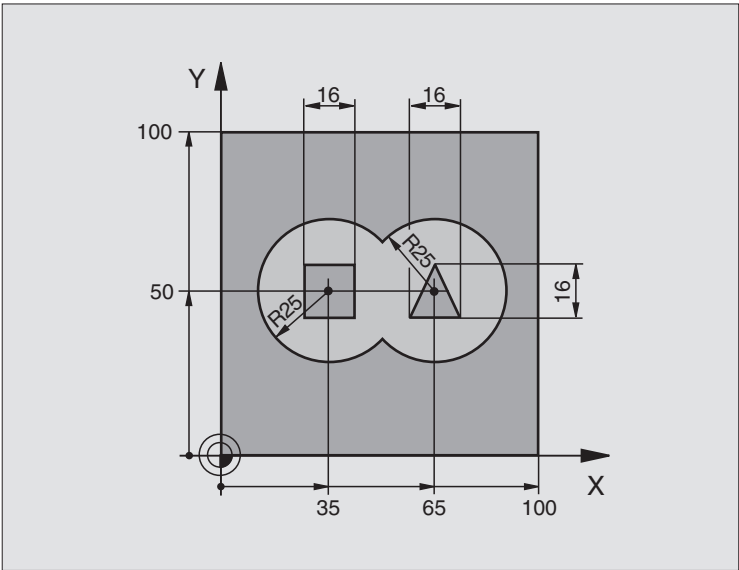


## Contour machining with SL Cycles



The complete contour is machined with the SL Cycles 20 to 24 (see "SL Cycles" on page 368).

### Example: Roughing and finishing superimposed contours with the contour formula



0 BEGIN PGM CONTOUR MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-40	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+2.5	Tool definition of roughing cutter
4 TOOL DEF 2 L+0 R+3	Tool definition of finishing cutter
5 TOOL CALL 1 Z S2500	Tool call of roughing cutter
6 L Z+250 R0 FMAX	Retract the tool
7 SEL CONTOUR "MODEL"	Specify contour definition program
8 CYCL DEF 20.0 CONTOUR DATA	Define general machining parameters
Q1=-20 ;MILLING DEPTH	
Q2=1 ;TOOL PATH OVERLAP	
Q3=+0.5 ;ALLOWANCE FOR SIDE	
Q4=+0.5 ;ALLOWANCE FOR FLOOR	
Q5=+0 ;SURFACE COORDINATE	
Q6=2 ;SET-UP CLEARANCE	
Q7=+100 ;CLEARANCE HEIGHT	
Q8=0.1 ;ROUNDING RADIUS	
Q9=-1 ;DIRECTION OF ROTATION	
9 CYCL DEF 22.0 ROUGH-OUT	Cycle definition: Rough-out
Q10=5 ;INFEED DEPTH	



Q11=100 ;FEED RATE FOR PLUNGING	
Q12=350 ;FEED RATE FOR ROUGHING	
Q18=0 ;COARSE ROUGHING TOOL	
Q19=150 ;RECIPROCATION FEED RATE	
10 CYCL CALL M3	Cycle call: Rough-out
11 TOOL CALL 2 Z S5000	Tool call of finishing cutter
12 CYCL DEF 23.0 FLOOR FINISHING	Cycle definition: Floor finishing
Q11=100 ;FEED RATE FOR PLUNGING	
Q12=200 ;FEED RATE FOR ROUGHING	
13 CYCL CALL M3	Cycle call: Floor finishing
14 CYCL DEF 24.0 SIDE FINISHING	Cycle definition: Side finishing
Q9=+1 ;DIRECTION OF ROTATION	
Q10=5 ;INFEED DEPTH	
Q11=100 ;FEED RATE FOR PLUNGING	
Q12=400 ;FEED RATE FOR ROUGHING	
Q14=+0 ;ALLOWANCE FOR SIDE	
15 CYCL CALL M3	Cycle call: Side finishing
16 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
17 END PGM CONTOUR MM	

Contour definition program with contour formula:

0 BEGIN PGM MODEL MM	Contour definition program
1 DECLARE CONTOUR QC1 = "CIRCLE1"	Definition of the contour designator for the program "CIRCLE1"
2 FN 0: Q1 =+35	Assignment of values for parameters used in PGM "CIRCLE31XY"
3 FN 0: Q2 =+50	
4 FN 0: Q3 =+25	
5 DECLARE CONTOUR QC2 = "CIRCLE31XY"	Definition of the contour designator for the program "CIRCLE31XY"
6 DECLARE CONTOUR QC3 = "TRIANGLE"	Definition of the contour designator for the program "TRIANGLE"
7 DECLARE CONTOUR QC4 = "SQUARE"	Definition of the contour designator for the program "SQUARE"
8 QC10 = ( QC 1   QC 2 ) \ QC 3 \ QC 4	Contour formula
9 END PGM MODEL MM	



Contour description programs:

0 BEGIN PGM CIRCLE1 MM	Contour description program: circle at right
1 CC X+65 Y+50	
2 L PR+25 PA+0 R0	
3 CP IPA+360 DR+	
4 END PGM CIRCLE1 MM	
0 BEGIN PGM CIRCLE31XY MM	Contour description program: circle at left
1 CC X+Q1 Y+Q2	
2 LP PR+Q3 PA+0 R0	
3 CP IPA+360 DR+	
4 END PGM CIRCLE31XY MM	
0 BEGIN PGM TRIANGLE MM	Contour description program: triangle at right
1 L X+73 Y+42 R0	
2 L X+65 Y+58	
3 L X+58 Y+42	
4 L X+73	
5 END PGM TRIANGLE MM	
0 BEGIN PGM SQUARE MM	Contour description program: square at left
1 L X+27 Y+58 R0	
2 L X+43	
3 L Y+42	
4 L X+27	
5 L Y+58	
6 END PGM SQUARE MM	







# 8.8 Cycles for Multipass Milling

## Overview

The TNC offers four cycles for machining surfaces with the following characteristics:

- Created with a CAD/CAM system
- Flat, rectangular surfaces
- Flat, oblique-angled surfaces
- Surfaces that are inclined in any way
- Twisted surfaces

Cycle	Soft key
60 RUN 3-D DATA For multipass milling of 3-D data in several infeeds	
230 MULTIPASS MILLING For flat rectangular surfaces	
231 RULED SURFACE For oblique, inclined or twisted surfaces	
232 FACE MILLING For level rectangular surfaces, with indicated oversizes and multiple infeeds	



## 3-D DATA (Cycle 30)

- 1 From the current position, the TNC positions the tool in rapid traverse FMAX in the tool axis to the set-up clearance above the MAX point that you have programmed in the cycle.
- 2 The tool then moves in FMAX in the working plane to the MIN point you have programmed in the cycle.
- 3 From this point, the tool advances to the first contour point at the feed rate for plunging.
- 4 The TNC subsequently processes all points that are stored in the digitizing data file at the feed rate for milling. If necessary, the TNC retracts the tool between machining operations to set-up clearance if specific areas are to be left unmachined.
- 5 At the end of the cycle, the tool is retracted in FMAX to set-up clearance.



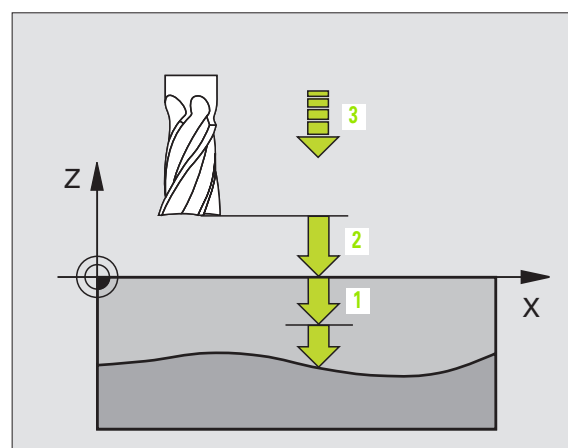
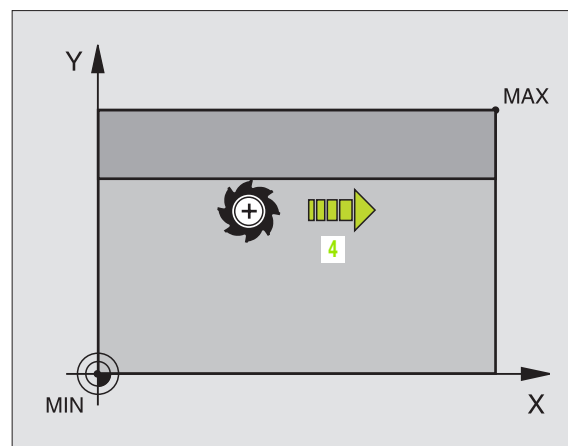
### Before programming, note the following:

You can use Cycle 30 to run conversational programs and PNT files.

If you want to run PNT files in which no tool axis coordinate is programmed, the milling depth is derived from the programmed MIN point in the tool axis.

30  
MILL 3-D  
DATA

- **PGM name 3-D data:** Enter the name of the file in which the data is stored. If the file is not stored in the current directory, enter the complete path.
- **Min. point of range:** Lowest coordinates (X, Y and Z coordinates) in the range to be milled.
- **Max. point of range:** Largest coordinates (X, Y and Z coordinates) in the range to be milled.
- **Set-up clearance 1** (incremental value): Distance between tool tip and workpiece surface for tool movements in rapid traverse.
- **Plunging depth 2** (incremental value): Infeed per cut.
- **Feed rate for plunging 3:** Traversing speed of the tool in mm/min during penetration.
- **Feed rate for milling 4:** Traversing speed of the tool in mm/min while milling.
- **Miscellaneous function M:** Optional entry of a miscellaneous function, for example M13.



### Example: NC blocks

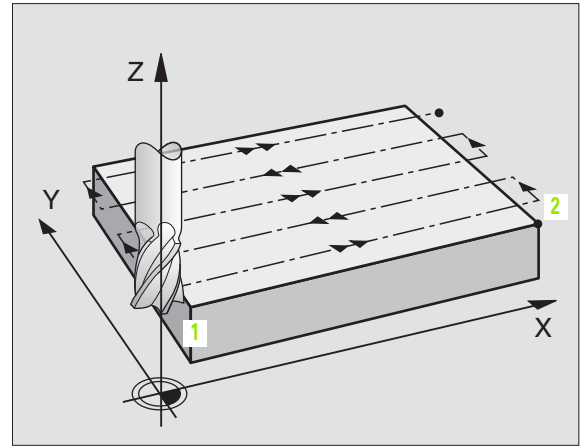
```

64 CYCL DEF 30.0 RUN 3-D DATA
65 CYCL DEF 30.1 PGM DIGIT.: BSP.H
66 CYCL DEF 30.2 X+0 Y+0 Z-20
67 CYCL DEF 30.3 X+100 Y+100 Z+0
68 CYCL DEF 30.4 SETUP 2
69 CYCL DEF 30.5 PECKG +5 F100
70 CYCL DEF 30.6 F350 M8
  
```



## MULTIPASS MILLING (Cycle 230)

- 1 From the current position in the working plane, the TNC positions the tool in rapid traverse FMAX to the starting point **1**; the TNC moves the tool by its radius to the left and upward.
- 2 The tool then moves in FMAX in the tool axis to set-up clearance. From there it approaches the programmed starting position in the tool axis at the feed rate for plunging.
- 3 The tool then moves as the programmed feed rate for milling to the end point **2**. The TNC calculates the end point from the programmed starting point, the program length, and the tool radius.
- 4 The TNC offsets the tool to the starting point in the next pass at the stepover feed rate. The offset is calculated from the programmed width and the number of cuts.
- 5 The tool then returns in the negative direction of the first axis.
- 6 Multipass milling is repeated until the programmed surface has been completed.
- 7 At the end of the cycle, the tool is retracted in FMAX to set-up clearance.



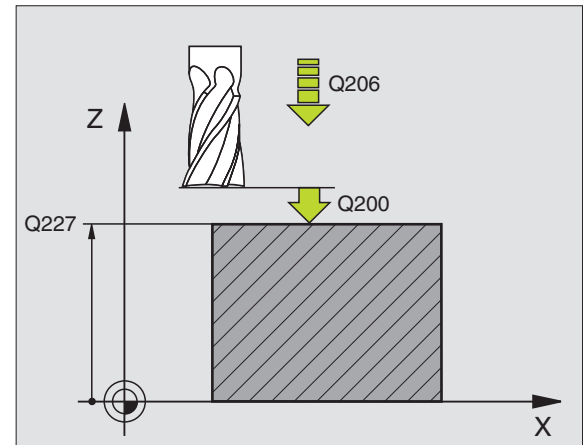
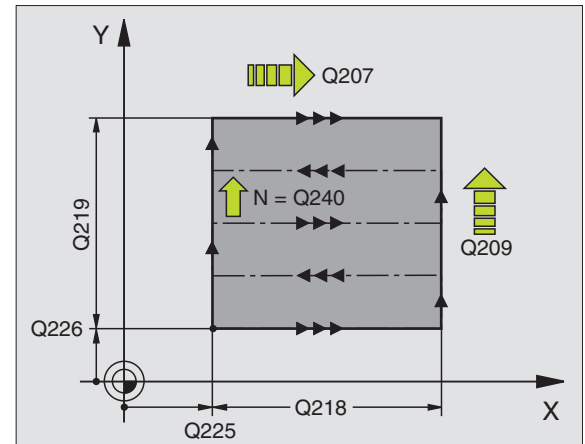
### Before programming, note the following:

From the current position, the TNC positions the tool at the starting point, first in the working plane and then in the spindle axis.

Pre-position the tool in such a way that no collision between tool and clamping devices can occur.



- ▶ **Starting point in 1st axis** Q225 (absolute value): Minimum point coordinate of the surface to be multipass-milled in the reference axis of the working plane.
- ▶ **Starting point in 2nd axis** Q226 (absolute value): Minimum-point coordinate of the surface to be multipass-milled in the minor axis of the working plane.
- ▶ **Starting point in 3rd axis** Q227 (absolute value): Height in the spindle axis at which multipass-milling is carried out.
- ▶ **1st side length** Q218 (incremental value): Length of the surface to be multipass-milled in the reference axis of the working plane, referenced to the starting point in 1st axis.
- ▶ **2nd side length** Q219 (incremental value): Length of the surface to be multipass-milled in the minor axis of the working plane, referenced to the starting point in 1st axis.
- ▶ **Number of cuts** Q240: Number of passes to be made over the width.
- ▶ **Feed rate for plunging** Q206: Traversing speed of the tool in mm/min when moving from set-up clearance to the milling depth.
- ▶ **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling.
- ▶ **Stepover feed rate** Q209: Traversing speed of the tool in mm/min when moving to the next pass. If you are moving the tool transversely in the material, enter Q209 to be smaller than Q207. If you are moving it transversely in the open, Q209 may be greater than Q207.
- ▶ **Set-up clearance** Q200 (incremental value): Distance between tool tip and milling depth for positioning at the start and end of the cycle.



## Example: NC blocks

71 CYCL DEF 230 MULTIPASS MILLING

Q225=+10 ;STARTING PNT 1ST AXIS

Q226=+12 ;STARTING PNT 2ND AXIS

Q227=+2.5 ;STARTING PNT 3RD AXIS

Q218=150 ;1ST SIDE LENGTH

Q219=75 ;2ND SIDE LENGTH

Q240=25 ;NUMBER OF CUTS

Q206=150 ;FEED RATE FOR PLUNGING

Q207=500 ;FEED RATE FOR MILLING

Q209=200 ;STEPOVER FEED RATE

Q200=2 ;SET-UP CLEARANCE

## RULED SURFACE (Cycle 231)

- 1 From the current position, the TNC positions the tool in a linear 3-D movement to the starting point **1**.
- 2 The tool subsequently advances to the stopping point **2** at the feed rate for milling.
- 3 From this point, the tool moves at rapid traverse FMAX by the tool diameter in the positive tool axis direction, and then back to starting point **1**.
- 4 At the starting point **1** the TNC moves the tool back to the last traversed Z value.
- 5 Then the TNC moves the tool in all three axes from point **1** in the direction of point **4** to the next line.
- 6 From this point, the tool moves to the stopping point on this pass. The TNC calculates the end point from point **2** and a movement in the direction of point **3**.
- 7 Multipass milling is repeated until the programmed surface has been completed.
- 8 At the end of the cycle, the tool is positioned above the highest programmed point in the spindle axis, offset by the tool diameter.

### Cutting motion

The starting point, and therefore the milling direction, is selectable because the TNC always moves from point **1** to point **2** and in the total movement from point **1** / **2** to point **3** / **4**. You can program point **1** at any corner of the surface to be machined.

If you are using an end mill for the machining operation, you can optimize the surface finish in the following ways:

- A shaping cut (spindle axis coordinate of point **1** greater than spindle-axis coordinate of point **2**) for slightly inclined surfaces.
- A drawing cut (spindle axis coordinate of point **1** smaller than spindle-axis coordinate of point **2**) for steep surfaces.
- When milling twisted surfaces, program the main cutting direction (from point **1** to point **2**) parallel to the direction of the steeper inclination.

If you are using a spherical cutter for the machining operation, you can optimize the surface finish in the following way:

- When milling twisted surfaces, program the main cutting direction (from point **1** to point **2**) perpendicular to the direction of the steepest inclination.

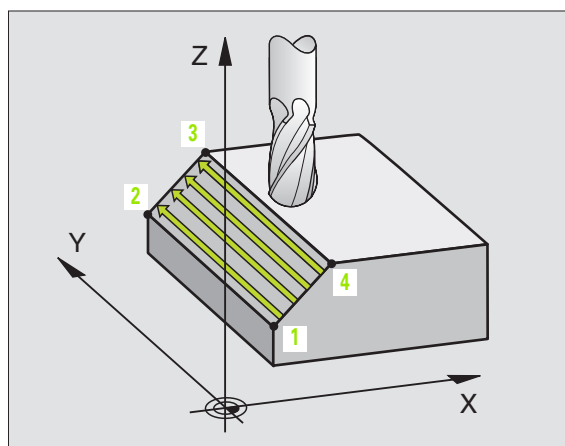
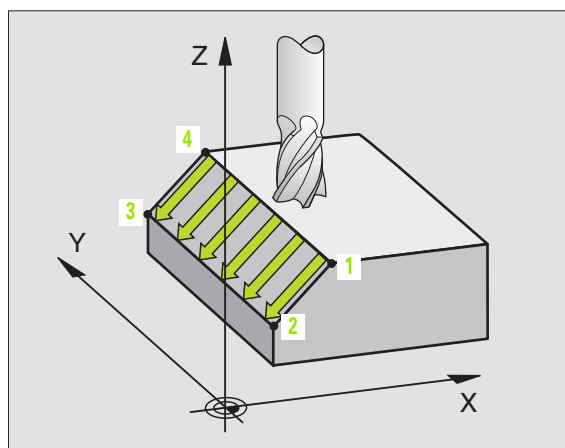
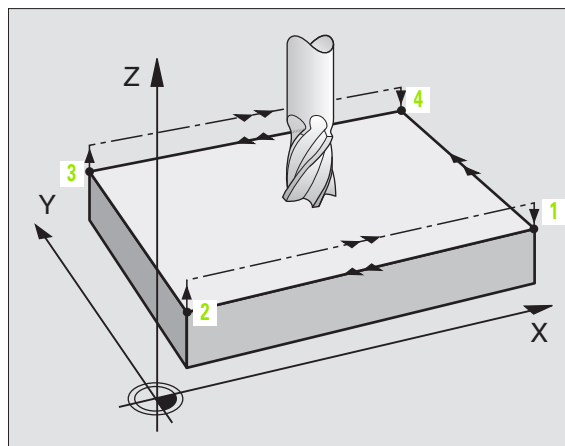


### Before programming, note the following:

The TNC positions the tool from the current position in a linear 3-D movement to the starting point **1**. Pre-position the tool in such a way that no collision between tool and clamping devices can occur.

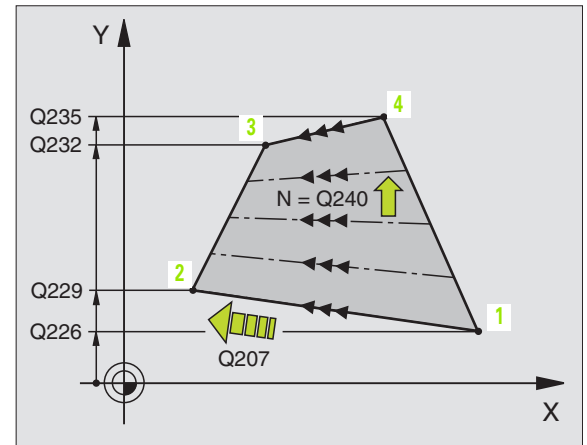
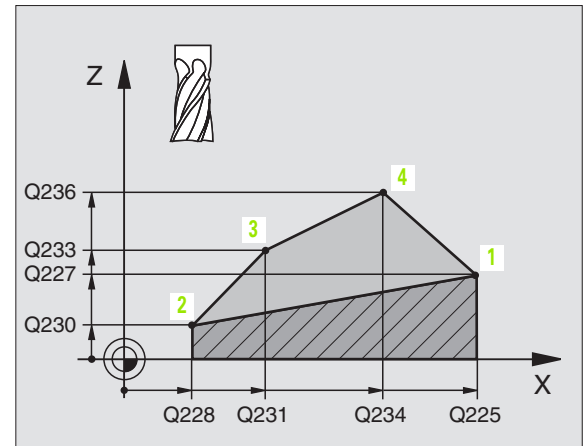
The TNC moves the tool with radius compensation R0 to the programmed positions.

If required, use a center-cut end mill (ISO 1641).





- ▶ **Starting point in 1st axis Q225 (absolute value):**  
Starting point coordinate of the surface to be multipass-milled in the reference axis of the working plane.
- ▶ **Starting point in 2nd axis Q226 (absolute value):**  
Starting point coordinate of the surface to be multipass-milled in the minor axis of the working plane.
- ▶ **Starting point in 3rd axis Q227 (absolute value):**  
Starting point coordinate of the surface to be multipass-milled in the tool axis.
- ▶ **2nd point in 1st axis Q228 (absolute value):**  
Stopping point coordinate of the surface to be multipass milled in the reference axis of the working plane.
- ▶ **2nd point in 2nd axis Q229 (absolute value):**  
Stopping point coordinate of the surface to be multipass milled in the minor axis of the working plane.
- ▶ **2nd point in 3rd axis Q230 (absolute value):**  
Stopping point coordinate of the surface to be multipass milled in the tool axis.
- ▶ **3rd point in 1st axis Q231 (absolute value):**  
Coordinate of point **3** in the reference axis of the working plane.
- ▶ **3rd point in 2nd axis Q232 (absolute value):**  
Coordinate of point **3** in the minor axis of the working plane.
- ▶ **3rd point in 3rd axis Q233 (absolute value):**  
Coordinate of point **3** in the tool axis.



- **4th point in 1st axis** Q234 (absolute value):  
Coordinate of point 4 in the reference axis of the working plane.
- **4th point in 2nd axis** Q235 (absolute value):  
Coordinate of point 4 in the minor axis of the working plane.
- **4th point in 3rd axis** Q236 (absolute value):  
Coordinate of point 4 in the tool axis.
- **Number of cuts** Q240: Number of passes to be made between points 1 and 4, 2 and 3.
- **Feed rate for milling** Q207: Traversing speed of the tool in mm/min while milling. The TNC performs the first step at half the programmed feed rate.

### Example: NC blocks

72 CYCL DEF 231 RULED SURFACE
Q225=+0 ;STARTING PNT 1ST AXIS
Q226=+5 ;STARTING PNT 2ND AXIS
Q227=-2 ;STARTING PNT 3RD AXIS
Q228=+100 ;2ND POINT 1ST AXIS
Q229=+15 ;2ND POINT 2ND AXIS
Q230=+5 ;2ND POINT 3RD AXIS
Q231=+15 ;3RD POINT 1ST AXIS
Q232=+125 ;3RD POINT 2ND AXIS
Q233=+25 ;3RD POINT 3RD AXIS
Q234=+15 ;4TH POINT 1ST AXIS
Q235=+125 ;4TH POINT 2ND AXIS
Q236=+25 ;4TH POINT 3RD AXIS
Q240=40 ;NUMBER OF CUTS
Q207=500 ;FEED RATE FOR MILLING



## FACE MILLING (Cycle 232)

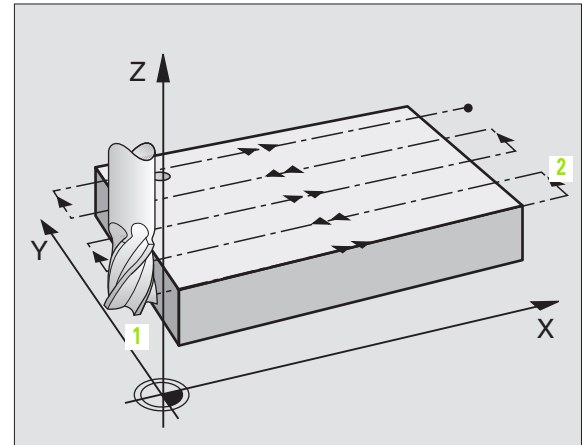
Cycle 232 is used to face mill a level surface in multiple infeeds while taking the finishing allowance into account. Three machining strategies are available:

- **Strategy Q389=0:** Meander machining, stepover outside the surface being machined
- **Strategy Q389=1:** Meander machining, stepover within the surface being machined
- **Strategy Q389=2:** Line-by-line machining, retraction and stepover at the positioning feed rate

- 1 From the current position, the TNC positions the tool at rapid traverse (FMAX) to the starting position using positioning logic **1**. If the current position in the spindle axis is greater than the 2nd set-up clearance, the control positions the tool first in the machining plane and then in the spindle axis. Otherwise it first moves to the 2nd set-up clearance and then in the machining plane. The starting point in the machining plane is offset from the edge of the workpiece by the tool radius and the safety clearance to the side.
- 2 The tool then moves in the spindle axis at the positioning feed rate to the first plunging depth calculated by the control.

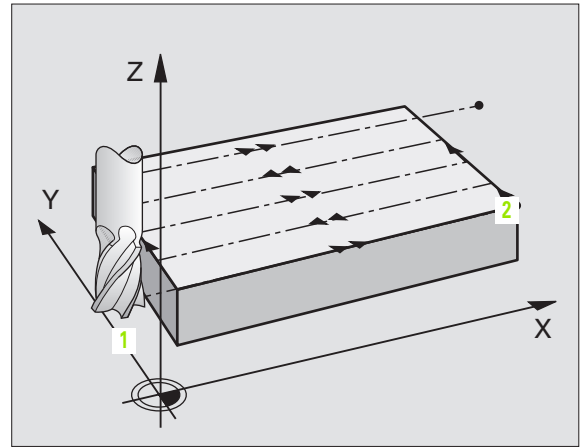
### Strategy Q389=0

- 3 The tool subsequently advances to the stopping point **2** at the feed rate for milling. The end point lies **outside** the surface. The control calculates the end point from the programmed starting point, the programmed length, the programmed safety clearance to the side and the tool radius.
- 4 The TNC offsets the tool to the starting point in the next pass at the pre-positioning feed rate. The offset is calculated from the programmed width, the tool radius and the maximum path overlap factor.
- 5 The tool then moves back in the direction of the starting point **1**.
- 6 The process is repeated until the programmed surface has been completed. At the end of the last pass, the next machining depth is plunged to.
- 7 In order to avoid non-productive motions, the surface is then machined in reverse direction.
- 8 The process is repeated until all infeeds have been machined. In the last infeed, simply the finishing allowance entered is milled at the finishing feed rate.
- 9 At the end of the cycle, the tool is retracted at FMAX to the 2nd set-up clearance.



### Strategy Q389=1

- 3 The tool subsequently advances to the stopping point **2** at the feed rate for milling. The end point lies **within** the surface. The control calculates the end point from the programmed starting point, the programmed length and the tool radius.
- 4 The TNC offsets the tool to the starting point in the next pass at the pre-positioning feed rate. The offset is calculated from the programmed width, the tool radius and the maximum path overlap factor.
- 5 The tool then moves back in the direction of the starting point **1**. The motion to the next line occurs within the workpiece borders.
- 6 The process is repeated until the programmed surface has been completed. At the end of the last pass, the next machining depth is plunged to.
- 7 In order to avoid non-productive motions, the surface is then machined in reverse direction.
- 8 The process is repeated until all infeeds have been machined. In the last infeed, simply the finishing allowance entered is milled at the finishing feed rate.
- 9 At the end of the cycle, the tool is retracted at FMAX to the 2nd set-up clearance.



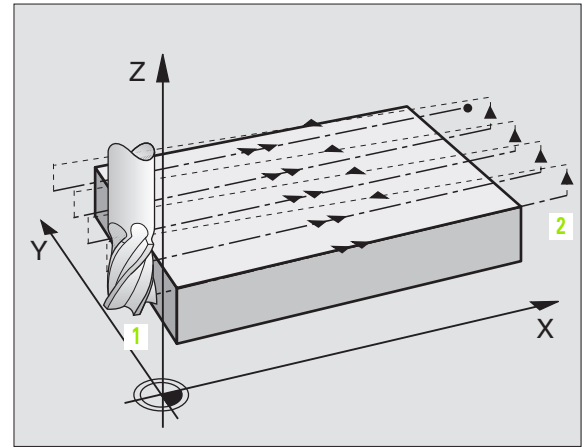
## Strategy Q389=2

- 3 The tool subsequently advances to the stopping point **2** at the feed rate for milling. The end point lies outside the surface. The control calculates the end point from the programmed starting point, the programmed length, the programmed safety clearance to the side and the tool radius.
- 4 The TNC positions the tool in the spindle axis to the set-up clearance over the current infeed depth, and then moves at the pre-positioning feed rate directly back to the starting point in the next line. The TNC calculates the offset from the programmed width, the tool radius and the maximum path overlap factor.
- 5 The tool then returns to the current infeed depth and moves in the direction of the next end point **2**.
- 6 The multipass process is repeated until the programmed surface has been completed. At the end of the last pass, the next machining depth is plunged to.
- 7 In order to avoid non-productive motions, the surface is then machined in reverse direction.
- 8 The process is repeated until all infeeds have been machined. In the last infeed, simply the finishing allowance entered is milled at the finishing feed rate.
- 9 At the end of the cycle, the tool is retracted at FMAX to the 2nd set-up clearance.



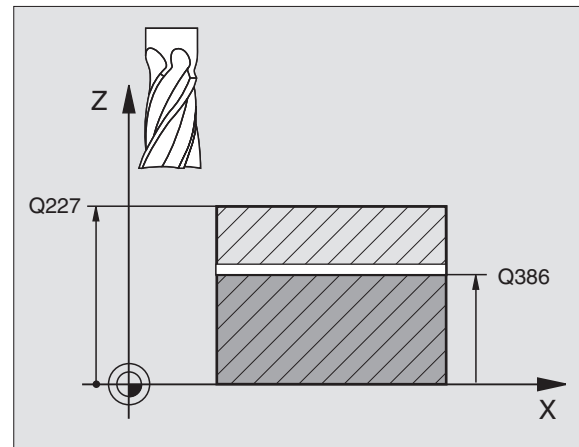
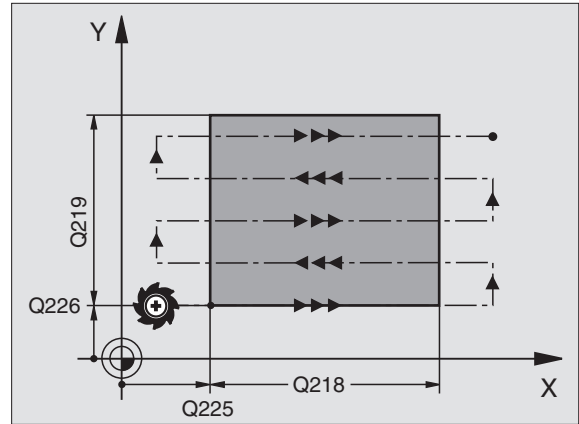
### Before programming, note the following:

Enter the 2nd set-up clearance in Q204 so that no collision between tool and clamping devices can occur.

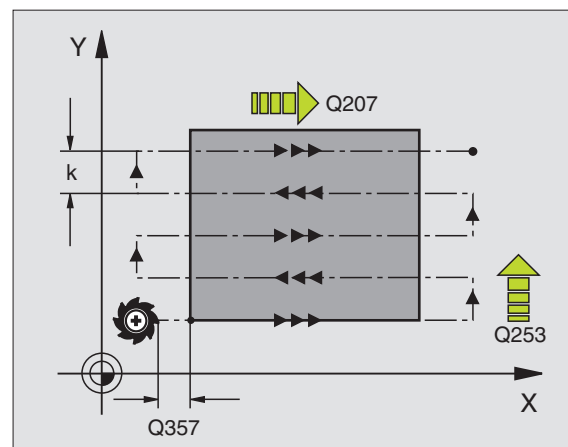
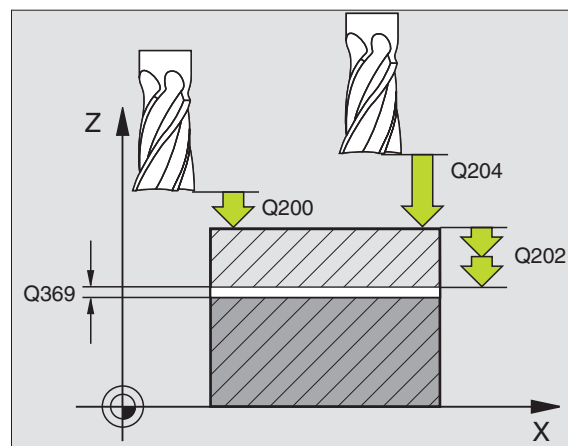




- **Machining strategy (0/1/2) Q389:** Specify how the TNC is to machine the surface:  
**0:** Meander machining, stepover at positioning feed rate outside the surface to be machined  
**1:** Meander machining, stepover at feed rate for milling within the surface to be machined  
**2:** Line-by-line machining, retraction and stepover at the positioning feed rate
- **Starting point in 1st axis Q225 (absolute value):**  
 Starting point coordinate of the surface to be machined in the reference axis of the working plane.
- **Starting point in 2nd axis Q226 (absolute value):**  
 Starting point coordinate of the surface to be multipass-milled in the minor axis of the working plane.
- **Starting point in 3rd axis Q227 (absolute value):**  
 Coordinate of the workpiece surface used to calculate the infeeds.
- **End point in 3rd axis Q386 (absolute value):**  
 Coordinate in the spindle axis to which the surface is to be face milled.
- **1st side length Q218 (incremental value):** Length of the surface to be machined in the reference axis of the working plane. Use the algebraic sign to specify the direction of the first milling path in reference to the **starting point in the 1st axis**.
- **2nd side length Q219 (incremental value):** Length of the surface to be machined in the minor axis of the working plane. Use the algebraic sign to specify the direction of the first stepover in reference to the **starting point in the 2nd axis**.



- ▶ **Maximum plunging depth Q202** (incremental value): **Maximum** amount that the tool is advanced each time. The TNC calculates the actual plunging depth from the difference between the end point and starting point of the tool axis (taking the finishing allowance into account), so that uniform plunging depths are used each time.
- ▶ **Allowance for floor Q369** (incremental value): Distance used for the last infeed.
- ▶ **Max. path overlap factor Q370: Maximum** stepover  $k$ . The TNC calculates the actual stepover from the second side length (Q219) and the tool radius so that a constant stepover is used for machining. If you have entered a radius R2 in the tool table (e.g. tooth radius when using a face-milling cutter), the TNC reduces the stepover accordingly.
- ▶ **Feed rate for milling Q207**: Traversing speed of the tool in mm/min while milling.
- ▶ **Feed rate for finishing Q385**: Traversing speed of the tool in mm/min while milling the last infeed.
- ▶ **Feed rate for pre-positioning Q253**: Traversing speed of the tool in mm/min when approaching the starting position and when moving to the next pass. If you are moving the tool transversely to the material (Q389=1), the TNC moves the tool at the feed rate for milling Q207.

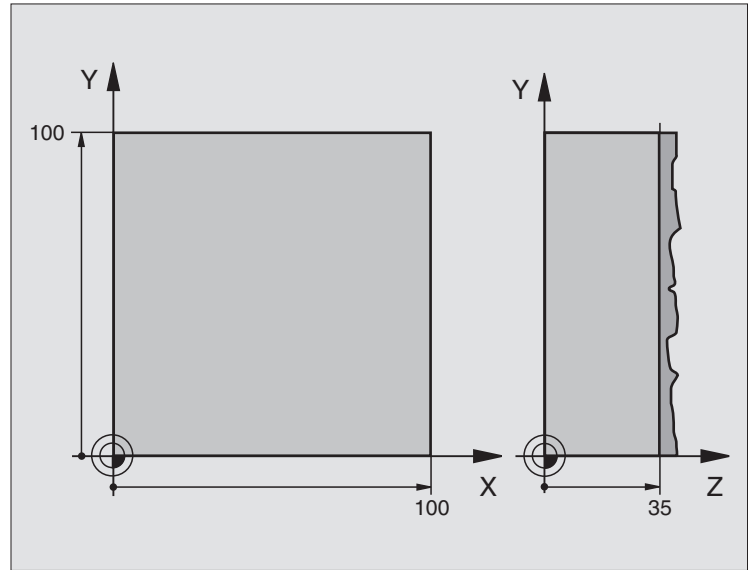


- **Set-up clearance** Q200 (incremental value): Distance between tool tip and the starting position in the tool axis. If you are milling with machining strategy Q389=2, the TNC moves the tool at the set-up clearance over the current plunging depth to the starting point of the next pass.
- **Clearance to side** Q357 (incremental value): Safety clearance to the side of the workpiece when the tool approaches the first plunging depth, and distance at which the stepover occurs if the machining strategy Q389=0 or Q389=2 is used.
- **2nd set-up clearance** Q204 (incremental value): Coordinate in the tool axis at which no collision between tool and workpiece (clamping devices) can occur.

#### Example: NC blocks

71	CYCL DEF 232	FACE MILLING
Q389=2	;STRATEGY	
Q225=+10	;STARTING PNT 1ST AXIS	
Q226=+12	;STARTING PNT 2ND AXIS	
Q227=+2.5	;STARTING PNT 3RD AXIS	
Q386=-3	;END POINT IN 3RD AXIS	
Q218=150	;1ST SIDE LENGTH	
Q219=75	;2ND SIDE LENGTH	
Q202=2	;MAX. PLUNGING DEPTH	
Q369=0.5	;ALLOWANCE FOR FLOOR	
Q370=1	;MAX. TOOL PATH OVERLAP	
Q207=500	;FEED RATE FOR MILLING	
Q385=800	;FEED RATE FOR FINISHING	
Q253=2000	;F PRE-POSITIONING	
Q200=2	;SET-UP CLEARANCE	
Q357=2	;CLEARANCE TO SIDE	
Q204=2	;2ND SET-UP CLEARANCE	

## Example: Multipass milling



0 BEGIN PGM C230 MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z+0	Define the workpiece blank
2 BLK FORM 0.2 X+100 Y+100 Z+40	
3 TOOL DEF 1 L+0 R+5	Define the tool
4 TOOL CALL 1 Z S3500	Tool call
5 L Z+250 R0 FMAX	Retract the tool
6 CYCL DEF 230 MULTIPASS MILLING	Cycle definition: MULTIPASS MILLING
Q225=+0 ;START IN 1ST AXIS	
Q226=+0 ;START IN 2ND AXIS	
Q227=+35 ;START IN 3RD AXIS	
Q218=100 ;1ST SIDE LENGTH	
Q219=100 ;2ND SIDE LENGTH	
Q240=25 ;NUMBER OF CUTS	
Q206=250 ;FEED RATE FOR PLNGNG	
Q207=400 ;FEED RATE FOR MILLING	
Q209=150 ;STEPOVER FEED RATE	
Q200=2 ;SET-UP CLEARANCE	








7 L X+-25 Y+0 R0 FMAX M3	Pre-position near the starting point
8 CYCL CALL	Call the cycle
9 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
10 END PGM C230 MM	



# 8.9 Coordinate Transformation Cycles

## Overview

Once a contour has been programmed, you can position it on the workpiece at various locations and in different sizes through the use of coordinate transformations. The TNC provides the following coordinate transformation cycles:

Cycle	Soft key
7 DATUM SHIFT For shifting contours directly within the program or from datum tables	
247 DATUM SETTING Datum setting during program run	
8 MIRROR IMAGE Mirroring contours	
10 ROTATION For rotating contours in the working plane	
11 SCALING FACTOR For increasing or reducing the size of contours	
26 AXIS-SPECIFIC SCALING FACTOR For increasing or reducing the size of contours with scaling factors for each axis	
19 WORKING PLANE Machining in tilted coordinate system on machines with swivel heads and/or tilting tables	

## Effect of coordinate transformations

Beginning of effect: A coordinate transformation becomes effective as soon as it is defined—it is not called. It remains in effect until it is changed or canceled.

### To cancel coordinate transformations:

- Define cycles for basic behavior with a new value, such as scaling factor 1.0.
- Execute a miscellaneous function M02, M30, or an END PGM block (depending on MP7300).
- Select a new program.
- Program miscellaneous function M142 Erasing modal program information.



## DATUM SHIFT (Cycle 7)

A DATUM SHIFT allows machining operations to be repeated at various locations on the workpiece.

### Effect

When the DATUM SHIFT cycle is defined, all coordinate data is based on the new datum. The TNC displays the datum shift in each axis in the additional status display. Input of rotary axes is also permitted.



► **Datum shift:** Enter the coordinates of the new datum. Absolute values are referenced to the manually set workpiece datum. Incremental values are always referenced to the datum which was last valid—this can be a datum which has already been shifted.

### Cancellation

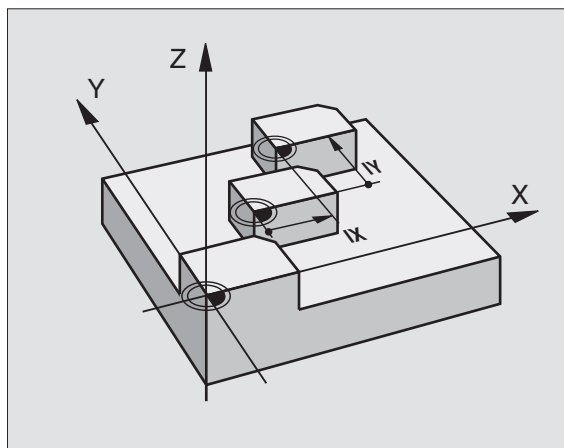
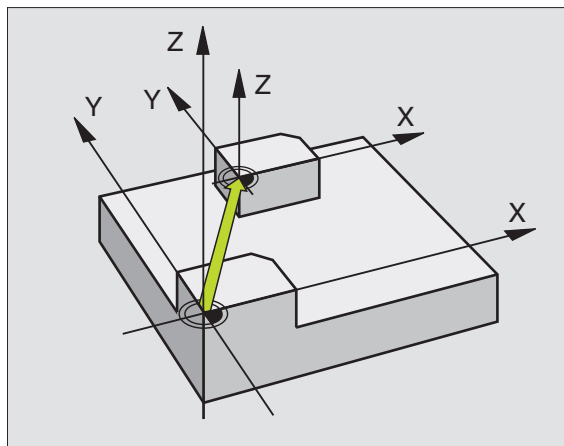
A datum shift is canceled by entering the datum shift coordinates  $X=0$ ,  $Y=0$  and  $Z=0$ .

### Graphics

If you program a new BLK FORM after a datum shift, you can use MP 7310 to determine whether the BLK FORM is referenced to the current datum or to the original datum. Referencing a new BLK FORM to the current datum enables you to display each part in a program in which several pallets are machined.

### Status displays

- The actual position values are referenced to the active (shifted) datum.
- All of the position values shown in the additional status display are referenced to the manually set datum.



### Example: NC blocks

```
13 CYCL DEF 7.0 DATUM SHIFT
```

```
14 CYCL DEF 7.1 X+60
```

```
16 CYCL DEF 7.3 Z-5
```

```
15 CYCL DEF 7.2 Y+40
```

## DATUM SHIFT with datum tables (Cycle 7)



Datums from a datum table are **always and exclusively** referenced to the current datum (preset).

MP7475, which earlier defined whether datums are referenced to the machine datum or the workpiece datum, now serves only as a safety measure. If  $MP7475 = 1$ , the TNC outputs an error message if a datum shift is called from a datum table.

Datum tables from the TNC 4xx whose coordinates are referenced to the machine datum ( $MP7475 = 1$ ) cannot be used in the iTNC 530.



If you are using datum shifts with datum tables, then use the **SEL TABLE** function to activate the desired datum table from the NC program.

If you work without **SEL TABLE**, then you must activate the desired datum table before the test run or the program run. (This applies also to the programming graphics).

- Use the file management to select the desired table for a test run in the **Test Run** operating mode: The table receives the status S.
- Use the file management in a program run mode to select the desired table for a program run: The table receives the status M.

The coordinate values from datum tables are only effective with absolute coordinate values.

New lines can only be inserted at the end of the table.

### Function

Datum tables are used for

- frequently recurring machining sequences at various locations on the workpiece
- frequent use of the same datum shift

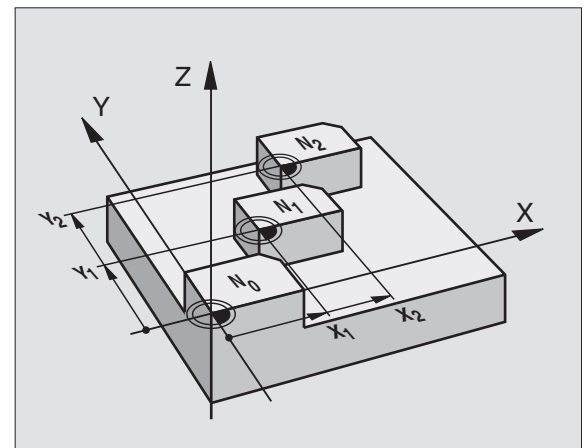
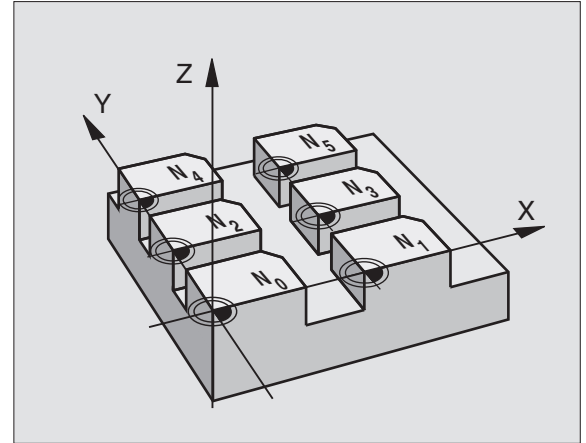
Within a program, you can either program datum points directly in the cycle definition or call them from a datum table.



- **Datum shift:** Enter the number of the datum from the datum table or a Q parameter. If you enter a Q parameter, the TNC activates the datum number entered in the Q parameter.

### Cancellation

- Call a datum shift to the coordinates  $X=0$ ;  $Y=0$  etc. from the datum table.
- Execute a datum shift to the coordinates  $X=0$ ,  $Y=0$  etc. directly with a cycle definition.



### Example: NC blocks

```
77 CYCL DEF 7.0 DATUM SHIFT
```

```
78 CYCL DEF 7.1 #5
```



### Selecting a datum table in the part program

With the **SEL TABLE** function you select the table from which the TNC takes the datums:



- ▶ To select the functions for program call, press the PGM CALL key.



- ▶ Press the DATUM TABLE soft key.
- ▶ Enter the complete path name of the datum table and confirm your entry with the END key.



Program a SEL TABLE block before Cycle 7 Datum Shift.

A datum table selected with SEL TABLE remains active until you select another datum table with SEL TABLE or through PGM MGT.



Edit the datum table in the Programming and Editing mode of operation.



After you have changed a value in a datum table, you must save the change with the ENT key. Otherwise the change may not be included during program run.

Select the datum table in the **Programming and Editing** mode of operation.



- ▶ To call the file manager, press the PGM MGT key, see “File Management: Fundamentals” on page 85.
- ▶ Display the datum tables: Press the soft keys SELECT TYPE and SHOW .D.
- ▶ Select the desired table or enter a new file name.
- ▶ Edit the file. The soft-key row comprises the following functions for editing:

Function	Soft key
Select beginning of table	
Select end of table	
Go to previous page	
Go to next page	
Insert line (only possible at end of table)	
Delete line	
Confirm the entered line and go to the beginning of the next line	
Add the entered number of lines (reference points) to the end of the table	



## Editing a pocket table in a Program Run operating mode

In a program run mode you can select the active datum table. Press the DATUM TABLE soft key. You can then use the same editing functions as in the **Programming and Editing** mode of operation.

## Transferring the actual values into the datum table

You can enter the current tool position or the last probed position in the datum table by pressing the "actual-position-capture" key:

- Place the text box on the line of the column in which you want to enter the position.



- Select the actual-position-capture function: The TNC opens a pop-up window that asks whether you want to enter the current tool position or the last probed values.
- Select the desired function with the arrow keys and confirm your selection with the ENT key.



- To enter the values in all axes, press the ALL VALUES soft key.



- To enter the value in the axis where the text box is located, press the CURRENT VALUE soft key.

## Configuring the datum table

In the second and third soft-key rows you can define for each datum table the axes for which you wish to set the datums. In the standard setting all of the axes are active. If you wish to exclude an axis, set the corresponding soft key to OFF. The TNC then deletes that column from the datum table.

If you do not wish to define a datum table for an active axis, press the NO ENT key. The TNC then enters a dash in that column.

## To leave a datum table

Select a different type of file in file management and choose the desired file.

## Status displays

In the additional status display, the following data from the datum table are shown (see "Coordinate transformations" on page 45):

- Name and path of the active datum table
- Active datum number
- Comment from the DOC column of the active datum number

Manual operation

Datum table editing

Datum shift?

NO	X	Y	Z	B	C
0	+0	+0	+0	+0	+0
1	+25	0.000	+0	+0	+0
2	+0	+0	+0	+0	+0
3	+0	+0	+150	+0	+0
4	+27.25	+12.5	+0	-10	+0
5	+250	+325	+10	+0	+0
6	+250	-240	+15	+0	+0
7	+1200	+0	+0	+0	+0
8	+1700	+0	+0	+0	+0
9	-1700	+0	+0	+0	+0
10	+0	+0	+0	+0	+0
11	+0	+0	+0	+0	+0
12	+0	+0	+0	+0	+0
13	+0	+0	+0	+0	+0

(END)

M

S

T

DIAGNOSIS

BEGIN

END

PAGE

PAGE

INSERT LINE

DELETE LINE

NEXT LINE



DATUM SETTING (Cycle 247)

If you operate the iTNC 530 with the setting PRESET = OFF, Cycle 247 will run as described in the User's Manual for software level 340 420-xx.

With the Cycle DATUM SETTING, you can activate as the new datum a preset defined in a preset table.

Effect

After a DATUM SETTING cycle definition, all of the coordinate inputs and datum shifts (absolute and incremental) are referenced to the new preset.



► **Number for datum?:** Enter the number of the datum to be activated from the preset table



When activating a datum from the preset table, the TNC resets all coordinate transformations that were activated with the following cycles:

- Cycle 7, Datum Shift
- Cycle 8, Mirroring
- Cycle 10, Rotation
- Cycle 11, Scaling
- Cycle 26, Axis-Specific Scaling

However, the coordinate transformation from Cycle 19, Tilted Working Plane, remains active.

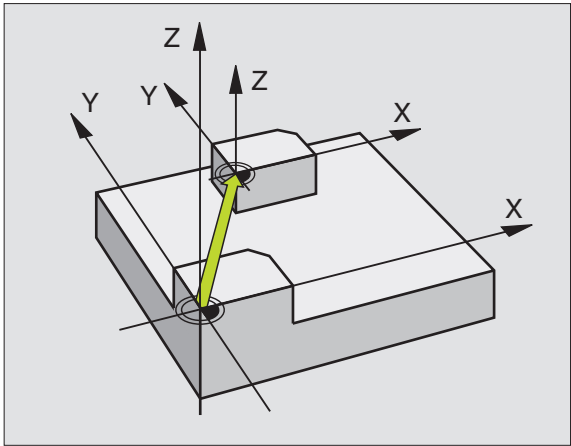
The TNC sets the preset only in the axes that are defined with values in the preset table. The datums of axes marked with–remain unchanged.

If you activate preset number 0 (line 0), then you activate the datum that you last set by hand in a manual operating mode.

Cycle 247 is not functional in Test Run mode.

Status display

In the status display the TNC shows the active preset number behind the datum symbol.



Example: NC blocks

```
13 CYCL DEF 247 DATUM SETTING
Q339=4 ;DATUM NUMBER
```



## MIRROR IMAGE (Cycle 8)

The TNC can machine the mirror image of a contour in the working plane.

### Effect

The mirror image cycle becomes effective as soon as it is defined in the program. It is also effective in the Positioning with MDI mode of operation. The active mirrored axes are shown in the additional status display.

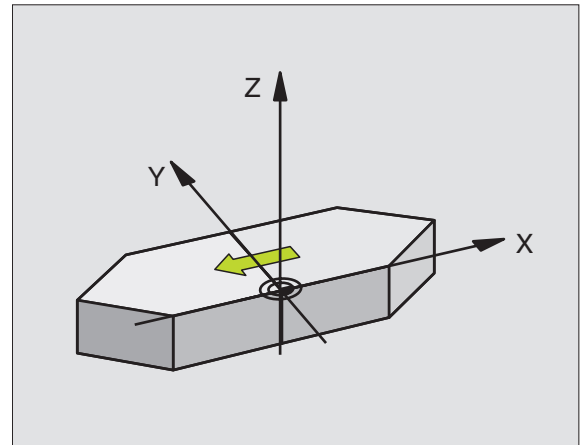
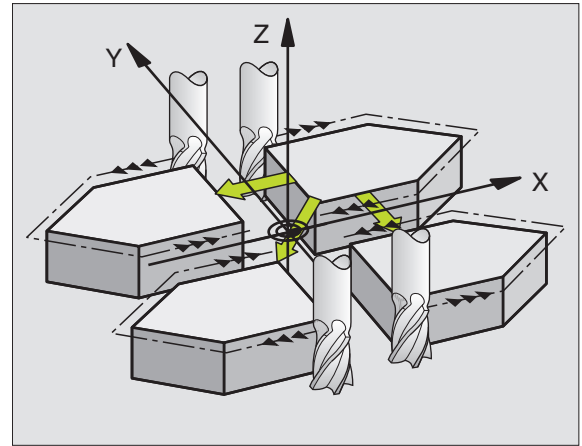
- If you mirror only one axis, the machining direction of the tool is reversed. (except in fixed cycles).
- If you mirror two axes, the machining direction remains the same.

The result of the mirror image depends on the location of the datum:

- If the datum lies on the contour to be mirrored, the element simply flips over.
- If the datum lies outside the contour to be mirrored, the element also "jumps" to another location.



If you mirror only one axis, the machining direction is reversed for the milling cycles (Cycles 2xx).

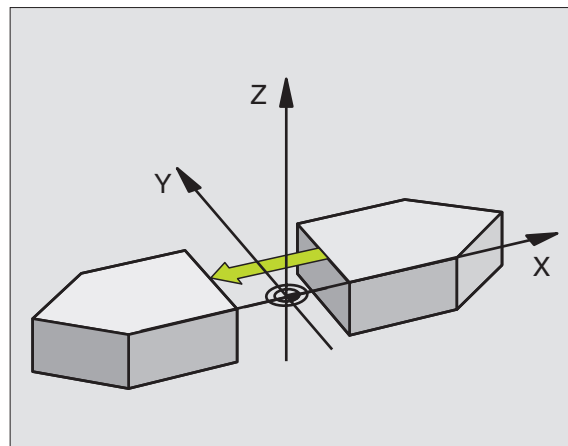




- **Mirrored axis?:** Enter the axis to be mirrored. You can mirror all axes, including rotary axes, except for the spindle axis and its auxiliary axes. You can enter up to three axes.

## Reset

Program the MIRROR IMAGE cycle once again with NO ENT.



## Example: NC blocks

```
79 CYCL DEF 8.0 MIRROR IMAGE
```

```
80 CYCL DEF 8.1 X Y U
```

## ROTATION (Cycle 10)

The TNC can rotate the coordinate system about the active datum in the working plane within a program.

### Effect

The ROTATION cycle becomes effective as soon as it is defined in the program. It is also effective in the Positioning with MDI mode of operation. The active rotation angle is shown in the additional status display.

Reference axis for the rotation angle:

- X/Y plane X axis
- Y/Z plane Y axis
- Z/X plane Z axis



### Before programming, note the following:

An active radius compensation is canceled by defining Cycle 10 and must therefore be reprogrammed, if necessary.

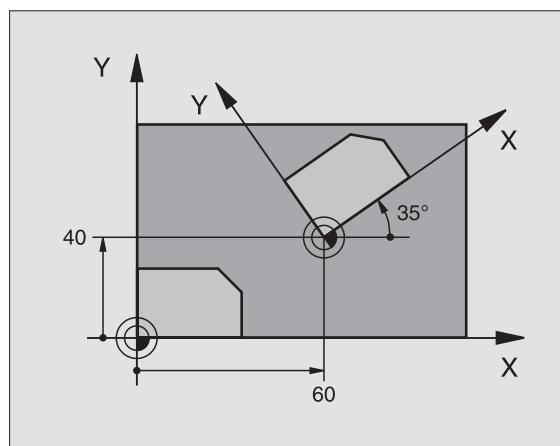
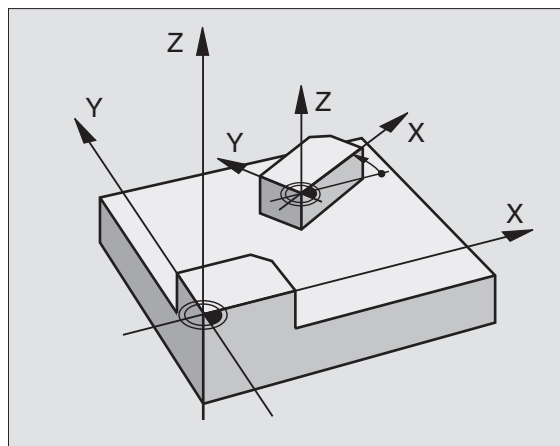
After defining Cycle 10, you must move both axes of the working plane to activate rotation for all axes.



- **Rotation:** Enter the rotation angle in degrees (°). Input range:  $-360^\circ$  to  $+360^\circ$  (absolute or incremental).

### Cancellation

Program the ROTATION cycle once again with a rotation angle of  $0^\circ$ .



### Example: NC blocks

```

12 CALL LBL 1
13 CYCL DEF 7.0 DATUM SHIFT
14 CYCL DEF 7.1 X+60
15 CYCL DEF 7.2 Y+40
16 CYCL DEF 10.0 ROTATION
17 CYCL DEF 10.1 ROT+35
18 CALL LBL 1

```



## SCALING FACTOR (Cycle 11)

The TNC can increase or reduce the size of contours within a program, enabling you to program shrinkage and oversize allowances.

### Effect

The SCALING FACTOR becomes effective as soon as it is defined in the program. It is also effective in the Positioning with MDI mode of operation. The active scaling factor is shown in the additional status display.

The scaling factor has an effect on

- the working plane, or on all three coordinate axes at the same time (depending on MP 7410)
- Dimensions in cycles
- the parallel axes U,V,W

### Prerequisite

It is advisable to set the datum to an edge or a corner of the contour before enlarging or reducing the contour.



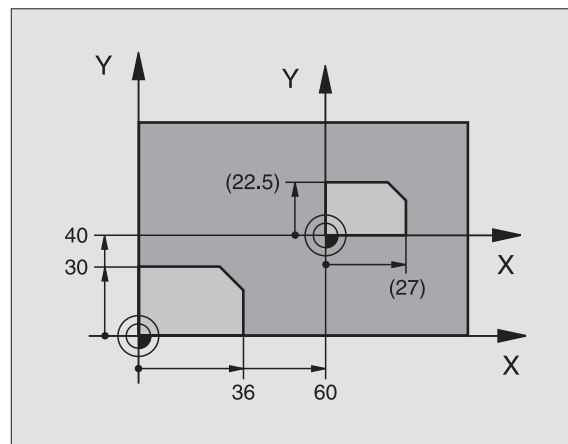
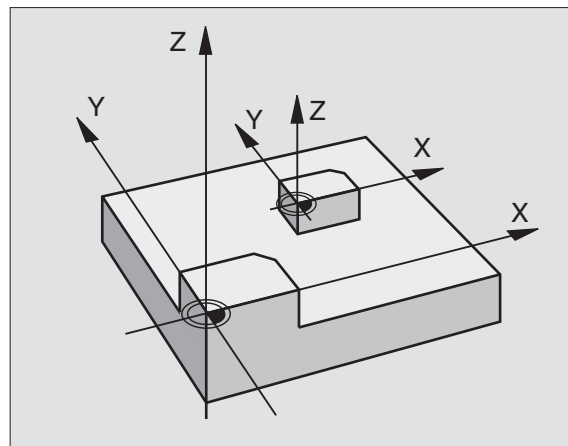
- **Scaling factor ?:** Enter the scaling factor SCL. The TNC multiplies the coordinates and radii by the SCL factor (as described under "Effect" above)

Enlargement: SCL greater than 1 (up to 99.999 999)

Reduction: SCL less than 1 (down to 0.000 001)

### Cancellation

Program the SCALING FACTOR cycle once again with a scaling factor of 1.



### Example: NC blocks

```

11 CALL LBL 1
12 CYCL DEF 7.0 DATUM SHIFT
13 CYCL DEF 7.1 X+60
14 CYCL DEF 7.2 Y+40
15 CYCL DEF 11.0 SCALING
16 CYCL DEF 11.1 SCL 0.75
17 CALL LBL 1

```



## AXIS-SPECIFIC SCALING (Cycle 26)



### Before programming, note the following:

Coordinate axes sharing coordinates for arcs must be enlarged or reduced by the same factor.

You can program each coordinate axis with its own axis-specific scaling factor.

In addition, you can enter the coordinates of a center for all scaling factors.

The size of the contour is enlarged or reduced with reference to the center, and not necessarily (as in Cycle 11 SCALING FACTOR) with reference to the active datum.

### Effect

The SCALING FACTOR becomes effective as soon as it is defined in the program. It is also effective in the Positioning with MDI mode of operation. The active scaling factor is shown in the additional status display.

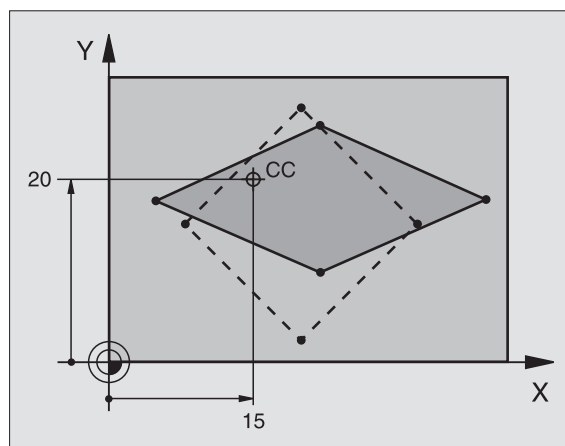
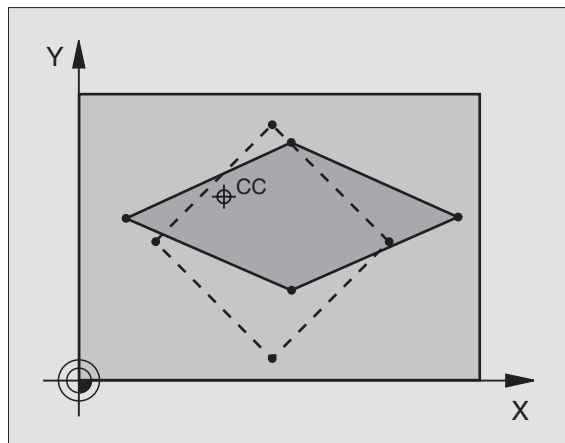


- **Axis and scaling factor:** Enter the coordinate axis/axes as well as the factor(s) involved in enlarging or reducing. Enter a positive value up to 99.999 999.
- **Center coordinates:** Enter the center of the axis-specific enlargement or reduction.

The coordinate axes are selected with soft keys.

### Cancellation

Program the SCALING FACTOR cycle once again with a scaling factor of 1 for the same axis.



### Example: NC blocks

```
25 CALL LBL 1
```

```
26 CYCL DEF 26.0 AXIS-SPECIFIC SCALING
```

```
27 CYCL DEF 26.1 X 1.4 Y 0.6 CCX+15 CCY+20
```

```
28 CALL LBL 1
```



## WORKING PLANE (Cycle 19, software option 1)



The functions for tilting the working plane are interfaced to the TNC and the machine tool by the machine tool builder. With some swivel heads and tilting tables, the machine tool builder determines whether the entered angles are interpreted as coordinates of the rotary axes or as mathematical angles of a tilted plane. Refer to your machine manual.



The working plane is always tilted around the active datum.

For fundamentals, see "Tilting the Working Plane (Software Option 1)" on page 70: Please read this section completely.

### Effect

In Cycle 19 you define the position of the working plane—i.e. the position of the tool axis referenced to the machine coordinate system—by entering tilt angles. There are two ways to determine the position of the working plane:

- Enter the position of the tilting axes directly.
- Describe the position of the working plane using up to 3 rotations (spatial angle) of the **machine-referenced** coordinate system. The required spatial angle can be calculated by cutting a perpendicular line through the tilted working plane and considering it from the axis around which you wish to tilt. With two spatial angles, every tool position in space can be defined exactly.

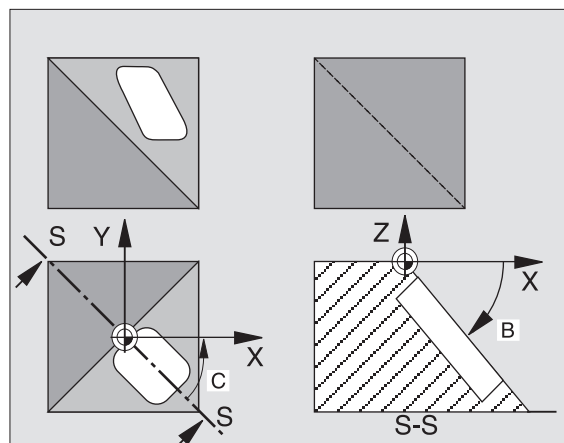
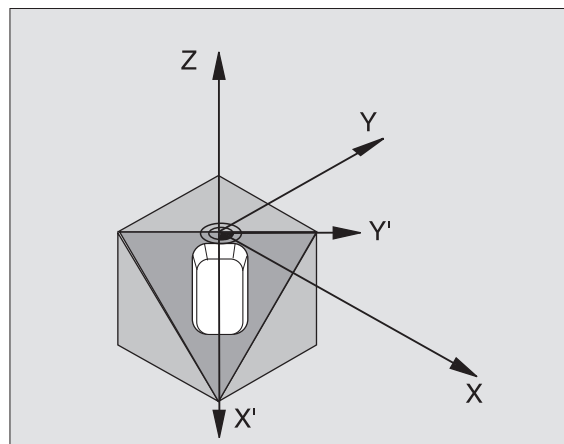
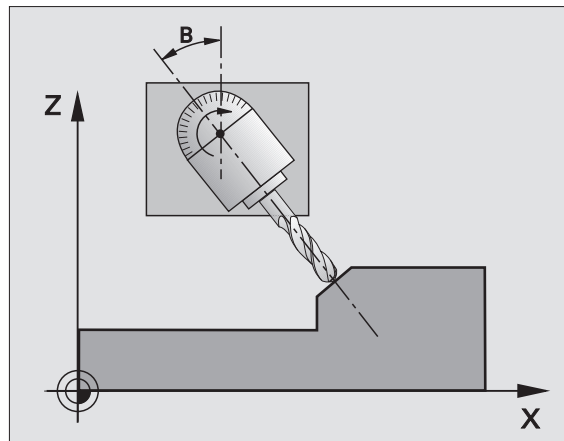


Note that the position of the tilted coordinate system, and therefore also all movements in the tilted system, are dependent on your description of the tilted plane.

If you program the position of the working plane via spatial angles, the TNC will calculate the required angle positions of the tilted axes automatically and will store these in the parameters Q120 (A axis) to Q122 (C axis). If two solutions are possible, the TNC will choose the shorter path from the zero position of the rotary axes.

The axes are always rotated in the same sequence for calculating the tilt of the plane: The TNC first rotates the A axis, then the B axis, and finally the C axis.

Cycle 19 becomes effective as soon as it is defined in the program. As soon as you move an axis in the tilted system, the compensation for this specific axis is activated. You must move all axes to activate compensation for all axes.



If you set the function **Tilting program run** to **Active** in the Manual Operation mode (see “Tilting the Working Plane (Software Option 1)” on page 70), the angular value entered in this menu is overwritten by Cycle 19 WORKING PLANE.



- **Tilt axis and tilt angle?:** Enter the axes of rotation together with the associated tilt angles. The rotary axes A, B and C are programmed using soft keys.



Because nonprogrammed rotary axis values are interpreted as unchanged, you should always define all three spatial angles, even if one or more angles are at zero.

If the TNC automatically positions the rotary axes, you can enter the following parameters:

- **Feed rate ? F=:** Traverse speed of the rotary axis during automatic positioning.
- **Set-up clearance?** (incremental value): The TNC positions the tilting head so that the position that results from the extension of the tool by the set-up clearance does not change relative to the workpiece.

### Cancellation

To cancel the tilt angle, redefine the WORKING PLANE cycle and enter an angular value of 0° for all axes of rotation. You must then program the WORKING PLANE cycle once again by answering the dialog question with the NO ENT key to disable the function.



Position the axis of rotation



The machine tool builder determines whether Cycle 19 positions the axes of rotation automatically or whether they must be pre-positioned in the program. Refer to your machine manual.

If the rotary axes are positioned automatically in Cycle 19:

- The TNC can position only controlled axes
- In order for the tilted axes to be positioned, you must enter a feed rate and a set-up clearance in addition to the tilting angles, during cycle definition.
- You can use only preset tools (with the full tool length defined in the TOOL DEF block or in the tool table).
- The position of the tool tip as referenced to the workpiece surface remains nearly unchanged after tilting
- The TNC tilts the working plane at the last programmed feed rate. The maximum feed rate that can be reached depends on the complexity of the swivel head or tilting table.

If the axes are not positioned automatically in Cycle 19, position them before defining the cycle, for example with an L block.

Example NC blocks:

10 L Z+100 R0 FMAX	
11 L X+25 Y+10 R0 FMAX	
12 L B+15 R0 F1000	Position the axis of rotation
13 CYCL DEF 19.0 WORKING PLANE	Define the angle for calculation of the compensation
14 CYCL DEF 19.1 B+15	
15 L Z+80 R0 FMAX	Activate compensation for the tool axis
16 L X-8.5 Y-10 R0 FMAX	Activate compensation for the working plane



### Position display in the tilted system

On activation of Cycle 19, the displayed positions (**ACTL** and **NOML**) and the datum indicated in the additional status display are referenced to the tilted coordinate system. The positions displayed immediately after cycle definition might not be the same as the coordinates of the last programmed position before Cycle 19.

### Workspace monitoring

The TNC monitors only those axes in the tilted coordinate system that are moved. If necessary, the TNC outputs an error message.

### Positioning in a tilted coordinate system

With the miscellaneous function M130 you can move the tool, while the coordinate system is tilted, to positions that are referenced to the non-tilted coordinate system (see "Miscellaneous Functions for Coordinate Data" on page 232).

Positioning movements with straight lines that are referenced to the machine coordinate system (blocks with M91 or M92) can also be executed in a tilted working plane. Constraints:

- Positioning is without length compensation.
- Positioning is without machine geometry compensation.
- Tool radius compensation is not permitted.

### Combining coordinate transformation cycles

When combining coordinate transformation cycles, always make sure the working plane is swiveled around the active datum. You can program a datum shift before activating Cycle 19. In this case, you are shifting the machine-based coordinate system.

If you program a datum shift after having activated Cycle 19, you are shifting the tilted coordinate system.

Important: When resetting the cycles, use the reverse sequence used for defining them:

- 1st Activate the datum shift.
- 2nd Activate tilting function
- 3rd Activate rotation
- ...
- Machining
- ...
- 1st Reset the rotation
- 2nd Reset the tilting function
- 3rd Reset the datum shift

### Automatic workpiece measurement in the tilted system

The TNC measuring cycles enable you to have the TNC measure a workpiece in a tilted system automatically. The TNC stores the measured data in Q parameters for further processing (for example, for printout).



## Procedure for working with Cycle 19 WORKING PLANE

### 1 Write the program

- ▶ Define the tool (not required if TOOL.T is active), and enter the full tool length.
- ▶ Call the tool
- ▶ Retract the tool in the tool axis to a position where there is no danger of collision with the workpiece (clamping devices) during tilting.
- ▶ If required, position the rotary axis or axes with an L block to the appropriate angular value(s) (depending on a machine parameter).
- ▶ Activate datum shift if required.
- ▶ Define Cycle 19 WORKING PLANE; enter the angular values for the tilt axes.
- ▶ Traverse all main axes (X, Y, Z) to activate compensation.
- ▶ Write the program as if the machining process were to be executed in a non-tilted plane.
- ▶ If required, define Cycle 19 WORKING PLANE with other angular values to execute machining in a different axis position. In this case, it is not necessary to reset Cycle 19. You can define the new angular values directly.
- ▶ Reset Cycle 19 WORKING PLANE; program 0° for all tilt axes.
- ▶ Disable the WORKING PLANE function; redefine Cycle 19 and answer the dialog question with NO ENT.
- ▶ Reset datum shift if required.
- ▶ Position the rotary axes to the 0° position, if required.

### 2 Clamp the workpiece

### 3 Preparations in the operating mode

#### Positioning with Manual Data Input (MDI)

Pre-position the rotary axis/axes to the corresponding angular value(s) for setting the datum. The angular value depends on the selected reference plane on the workpiece.

### 4 Preparations in the operating mode

#### Manual Operation

Use the 3D-ROT soft key to set the function TILT WORKING PLANE to ACTIVE in the Manual Operation mode. Enter the angular values for the rotary axes into the menu if the axes are not controlled.

If the axes are not controlled, the angular values entered in the menu must correspond to the actual position(s) of the rotary axis or axes, respectively. The TNC will otherwise calculate a wrong datum.

**5 Set the datum**

- Manually by touching the workpiece with the tool in the untilted coordinate system (see "Datum Setting (Without a 3-D Touch Probe)" on page 62).
- Controlled with a HEIDENHAIN 3-D touch probe (see the Touch Probe Cycles Manual, chapter 2).
- Automatically by using a HEIDENHAIN 3-D touch probe (see the Touch Probe Cycles Manual, chapter 3).

**6 Start the part program in the operating mode Program Run, Full Sequence****7 Manual Operation mode**

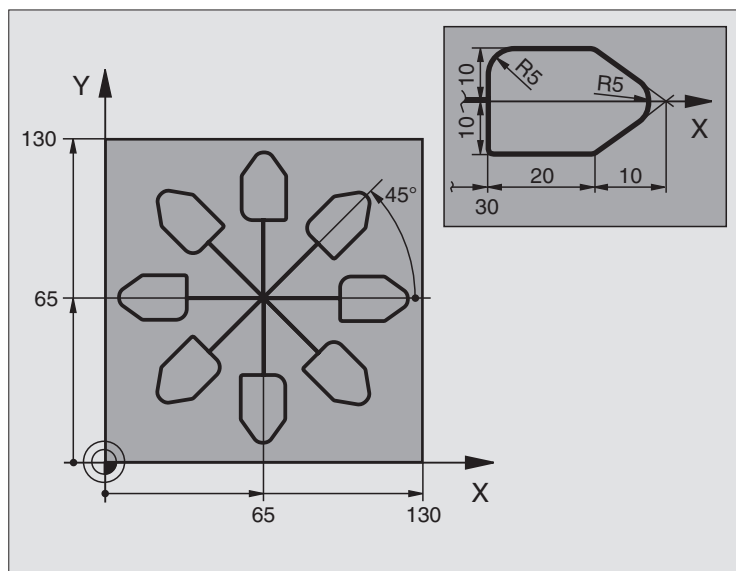
Use the 3-D ROT soft key to set the TILT WORKING PLANE function to INACTIVE. Enter an angular value of 0° for each axis in the menu (see "Activating manual tilting" on page 74).



## Example: Coordinate transformation cycles

### Program sequence

- Program the coordinate transformations in the main program
- For subprograms within a subprogram, see "Subprograms" on page 487.



0 BEGIN PGM KOUMR MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
2 BLK FORM 0.2 X+130 Y+130 Z+0	
3 TOOL DEF 1 L+0 R+1	Define the tool
4 TOOL CALL 1 Z S4500	Tool call
5 L Z+250 R0 FMAX	Retract the tool
6 CYCL DEF 7.0 DATUM SHIFT	Shift datum to center
7 CYCL DEF 7.1 X+65	
8 CYCL DEF 7.2 Y+65	
9 CALL LBL 1	Call milling operation
10 LBL 10	Set label for program section repeat
11 CYCL DEF 10.0 ROTATION	Rotate by 45° (incremental)
12 CYCL DEF 10.1 IROT+45	
13 CALL LBL 1	Call milling operation
14 CALL LBL 10 REP 6/6	Return jump to LBL 10; repeat the milling operation six times
15 CYCL DEF 10.0 ROTATION	Reset the rotation
16 CYCL DEF 10.1 ROT+0	
17 CYCL DEF 7.0 DATUM SHIFT	Reset the datum shift
18 CYCL DEF 7.1 X+0	
19 CYCL DEF 7.2 Y+0	



20 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
21 LBL 1	Subprogram 1
22 L X+0 Y+0 R0 FMAX	Define milling operation
23 L Z+2 R0 FMAX M3	
24 L Z-5 R0 F200	
25 L X+30 RL	
26 L IY+10	
27 RND R5	
28 L IX+20	
29 L IX+10 IY-10	
30 RND R5	
31 L IX-10 IY-10	
32 L IX-20	
33 L IY+10	
34 L X+0 Y+0 R0 F5000	
35 L Z+20 R0 FMAX	
36 LBL 0	
37 END PGM KOUMR MM	



## 8.10 Special Cycles

### DWELL TIME (Cycle 9)

This causes the execution of the next block within a running program to be delayed by the programmed dwell time. A dwell time can be used for such purposes as chip breaking.

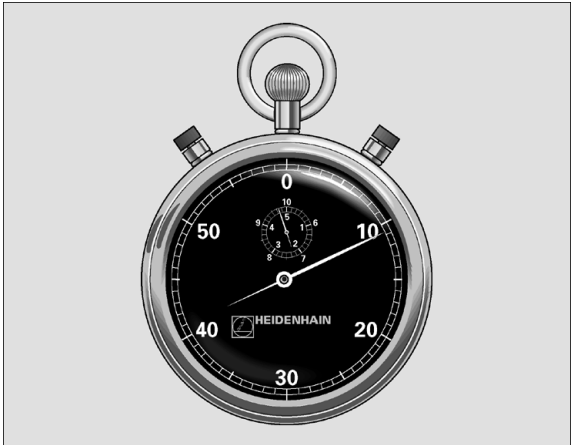
#### Effect

The cycle becomes effective as soon as it is defined in the program. Modal conditions such as spindle rotation are not affected.



► **Dwell time in seconds:** Enter the dwell time in seconds.

Input range: 0 to 3600 s (1 hour) in steps of 0.001 seconds



#### Example: NC blocks

```
89 CYCL DEF 9.0 DWELL TIME
```

```
90 CYCL DEF 9.1 DWELL 1.5
```



## PROGRAM CALL (Cycle 12)

Routines that you have programmed (such as special drilling cycles or geometrical modules) can be written as main programs and then called like fixed cycles.



### Before programming, note the following:

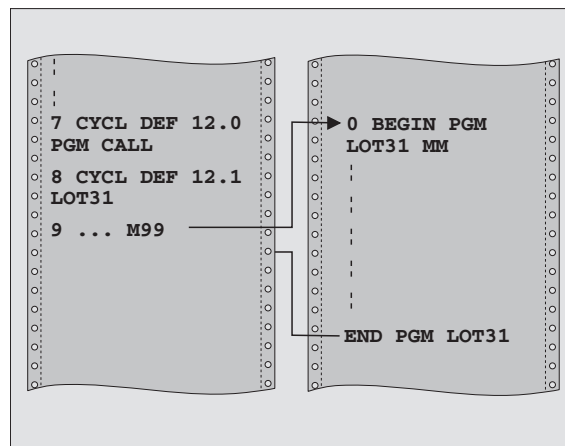
The program you are calling must be stored on the hard disk of your TNC.

If the program you are defining to be a cycle is located in the same directory as the program you are calling it from, you only need to enter the program name.

If the program you are defining to be a cycle is not located in the same directory as the program you are calling it from, you must enter the complete path (for example TNC:\KLAR35\FK1\50.H).

If you want to define an ISO program to be a cycle, enter the file type .I behind the program name.

As a rule, Q parameters are globally effective when called with Cycle 12. So please note that changes to Q parameters in the called program can also influence the calling program.



### Example: NC blocks

```
55 CYCL DEF 12.0 PGM CALL
```

```
56 CYCL DEF 12.1 PGM TNC:\KLAR35\FK1\50.H
```

```
57 L X+20 Y+50 FMAX M99
```

12  
PGM  
CALL

- **Program name:** Enter the name of the program you want to call and, if necessary, the directory it is located in.

Call the program with

- CYCL CALL (separate block) or
- M99 (blockwise) or
- M89 (executed after every positioning block)

### Example: Program call

A callable program 50 is to be called into a program via a cycle call.



## ORIENTED SPINDLE STOP (Cycle 13)



Machine and control must be specially prepared by the machine tool builder for use of this cycle.



Cycle 13 is used internally for machining cycles 202, 204 and 209. Please note that, if required, you must program Cycle 13 again in your NC program after one of the machining cycles mentioned above.

The control can control the machine tool spindle and rotate it to a given angular position.

Oriented spindle stops are required for

- Tool changing systems with a defined tool change position
- Orientation of the transmitter/receiver window of HEIDENHAIN 3-D touch probes with infrared transmission

### Effect

The angle of orientation defined in the cycle is positioned to by entering M19 or M20 (depending on the machine).

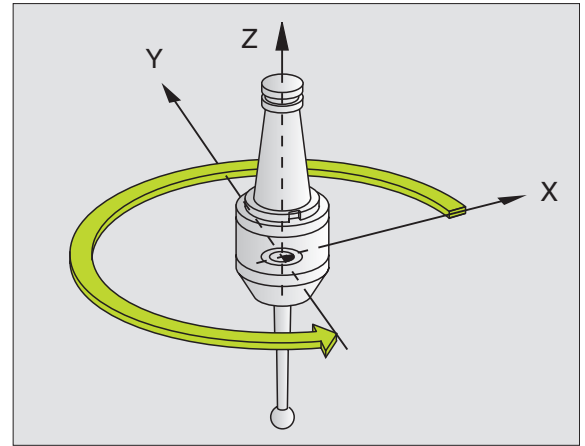
If you program M19 or M20 without having defined Cycle 13, the TNC positions the machine tool spindle to an angle that has been set by the machine manufacturer (see your machine manual).



- **Angle of orientation:** Enter the angle according to the reference axis of the working plane.

Input range: 0 to 360°

Input resolution: 0.1°



### Example: NC blocks

```
93 CYCL DEF 13.0 ORIENTATION
```

```
94 CYCL DEF 13.1 ANGLE 180
```

## TOLERANCE (Cycle 32, software option 2)



Machine and control must be specially prepared by the machine tool builder for use of this cycle.

The TNC automatically smoothes the contour between two path elements (whether compensated or not). The tool has constant contact with the workpiece surface. If necessary, the TNC automatically reduces the programmed feed rate so that the program can be machined at the fastest possible speed without short pauses for computing time. As a result the surface quality is improved and the machine is protected.

A contour deviation results from the smoothing. The size of this deviation (**tolerance value**) is set in a machine parameter by the machine manufacturer. With Cycle **32**, you can change the pre-set tolerance value and select different filter settings.



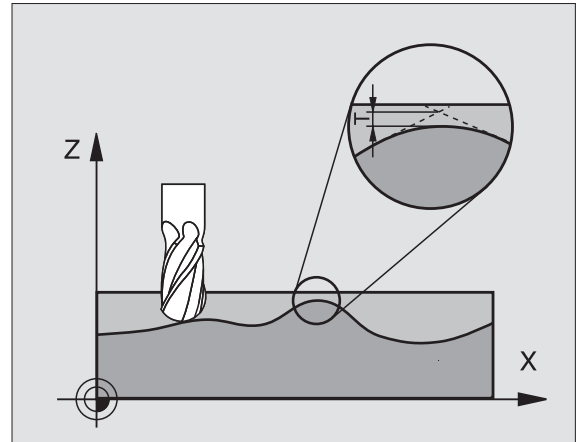
### Before programming, note the following:

Cycle 32 is DEF active which means that it becomes effective as soon as it is defined in the part program.

You can reset Cycle 32 by defining it again and confirming the dialog question after the **tolerance value** with NO ENT. Resetting reactivates the pre-set tolerance.

In a program with millimeters set as unit of measure, the TNC interprets the entered tolerance value in millimeters. In an inch program it interprets them as inches.

If you transfer a program with Cycle 32 that contains only the cycle parameter **Tolerance value T**, the TNC inserts the two remaining parameters with the value 0 if required.





- ▶ **Tolerance value:** Permissible contour deviation in mm (or inches with inch programming)
- ▶ **Finishing=0, Roughing=1:** Activate filter:
  - Input value 0:  
**Milling with increased contour accuracy.** The TNC uses the filter settings that your machine tool builder has defined for finishing operations.
  - Input value 1:  
**Milling at an increased feed rate.** The TNC uses the filter settings that your machine tool builder has defined for roughing operations.
- ▶ **Tolerance for rotary axes:** Permissible position error of rotary axes in degrees when M128 is active. The TNC always reduces the feed rate in such a way that—if more than one axis is traversed—the slowest axis moves at its maximum feed rate. Rotary axes are usually much slower than linear axes. You can significantly reduce the machining time for programs for more than one axis by entering a large tolerance value (e.g. 10°), since the TNC does not always have to move the rotary axis to the given nominal position. The contour will not be damaged by entering a tolerance value. Only the position of the rotary axis with respect to the workpiece surface will change.

Example: NC blocks

95	CYCL	DEF	32.0	TOLERANCE
96	CYCL	DEF	32.1	T0.05
97	CYCL	DEF	32.2	HSC MODE:1 TA5





# 9

**Programming:  
Special Functions**



# 9.1 The PLANE Function: Tilting the Working Plane (Software Option 1)

## Introduction



The machine manufacturer must enable the functions for tilting the working plane!

You can only use the PLANE function on machines which have at least two tilting axes (head and/or table).

The PLANE function is a powerful function for defining tilted working planes in various manners.

All **PLANE** functions available on the TNC describe the desired working plane independently of the rotary axes actually present on your machine. The following possibilities are available:

Function	Required parameters	Soft key
SPATIAL	Three space angles: <b>SPA</b> , <b>SPB</b> , and <b>SPC</b>	
PROJECTED	Two projection angles: <b>PROPR</b> and <b>PROMIN</b> and a rotation angle <b>ROT</b>	
EULER	Three Euler angles: precession ( <b>EULPR</b> ), nutation ( <b>EULNU</b> ) and rotation ( <b>EULROT</b> )	
VECTOR	Norm vector for defining the plane and base vector for defining the direction of the tilted X axis	
POINTS	Coordinates of any three points in the plane to be tilted	
RELATIVE	Single, incrementally effective spatial angle	
RESET	Reset the PLANE function	



Use the **PLANE SPATIAL** function if your machine features Cartesian rotary axes. **SPA** stands for rotation of the A axis, **SPB** the B axis and **SPC** the C axis. Because you always have to enter all three angles, define the angle to be 0 in any axes that are not available on your machine.





In order to make the differences between each definition possibility more clear even before selecting the function, you can start an animated sequence via soft key.



The parameter definition of the **PLANE** function is separated 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 (see "Specifying the Positioning Behavior of the PLANE Function" on page 468).



The actual-position-capture function is not possible with an active tilted working plane.



Define the PLANE function



- ▶ Show the soft-key row with special functions
- ▶ Select special TNC functions: Press the SPECIAL TNC FUNCTIONS soft key.
- ▶ Select the **PLANE** function: Press the TILT MACHINING PLANE soft key: The TNC displays the available definition possibilities in the soft-key row.

Selecting the function while animation is active

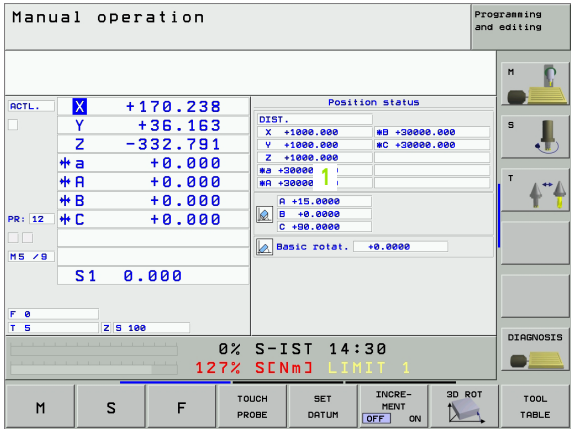
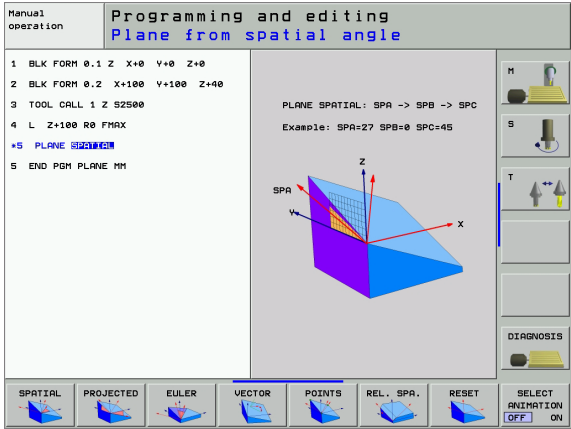
- ▶ Activate animation: Set the SELECT ANIMATION ON/OFF soft key to ON.
- ▶ Start an animation for one of the definition possibilities: Press one of the available soft keys. The TNC highlights the soft key with a different color and begins the appropriate animation.
- ▶ To assume the currently active function: Press the ENT key or press the soft key of the active function again. The TNC continues the dialog and requests the required parameters.

Selecting the function while animation is inactive

- ▶ Select the desired function directly via soft key. The TNC continues the dialog and requests the required parameters.

Position display

As soon as a **PLANE** function is active, the TNC shows the calculated spatial angle in the additional status display (see 1 in figure at lower right). As a rule, the TNC internally always calculates with spatial angles, independent of which **PLANE** function is active.



## Reset the PLANE function



- Show the soft-key row with special functions



- Select special TNC functions: Press the SPECIAL TNC FUNCTIONS soft key.



- Select the PLANE function: Press the TILT MACHINING PLANE soft key: The TNC displays the available definition possibilities in the soft-key row.



- Select the Reset function. This internally resets the **PLANE** function, but does not change the current axis positions.



- Specify whether the TNC should automatically move the rotary axes to the default setting (**MOVE**) or not (**STAY**) (see “Automatic positioning: MOVE/TURN/STAY (entry is mandatory)” on page 469).



- To terminate entry, press the END key.



The **PLANE RESET** function resets the current **PLANE** function—or an active Cycle 19—completely (angles = 0 and function is inactive). It does not need to be defined more than once.

### Example: NC block

```
25 PLANE RESET MOVE SET UP 50 F1000
```



## 9.2 Defining the Machining Plane with Space Angles: PLANE SPATIAL

### Function

Spatial angles define a machining plane through up to three **rotations around the fixed machine coordinate system**. The sequence of rotations is firmly specified: first around the A axis, then B, and then C (the function corresponds to Cycle 19, if the entries in Cycle 19 are set to space angles).

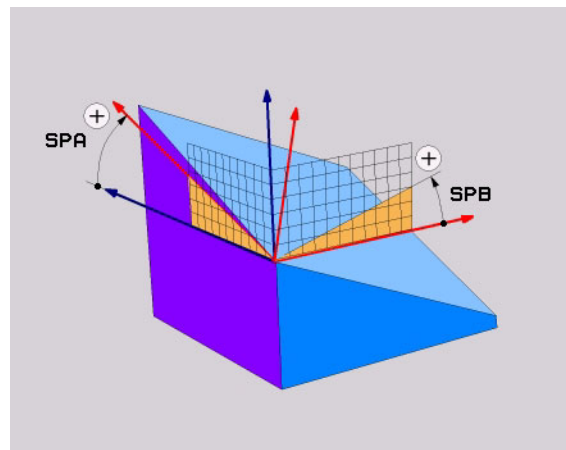


#### Before programming, note the following:

You must always define the three space angles **SPA**, **SPB**, and **SPC**, even if one of them = 0.

The sequence of the rotations described above is independent of the active tool axis.

Parameter description for the positioning behavior: See "Specifying the Positioning Behavior of the PLANE Function," page 468.



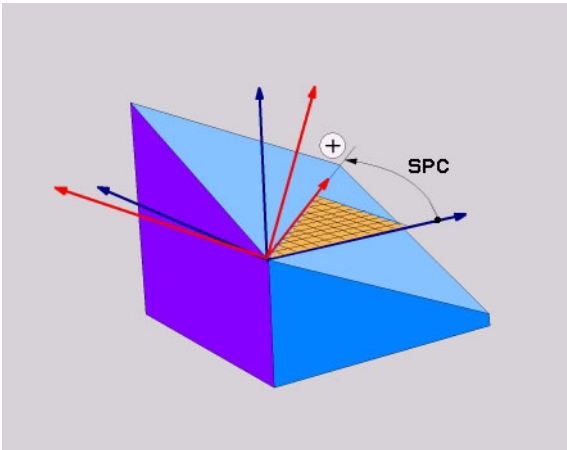
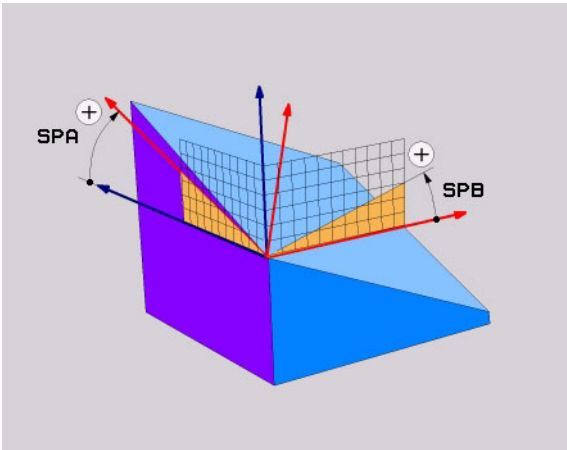
# Input parameters



- **Space angle A?:** Rotational angle **SPA** around the fixed machine axis X (see figure at top right). Input range: from  $-359.9999^\circ$  to  $+359.9999^\circ$
- **Spatial angle B?:** Rotational angle **SPB** around the fixed machine axis Y (see figure at top right). Input range: from  $-359.9999^\circ$  to  $+359.9999^\circ$
- **Spatial angle C?:** Rotational angle **SPC** around the fixed machine axis Z (see figure at center right). Input range: from  $-359.9999^\circ$  to  $+359.9999^\circ$
- Continue with the positioning properties (see "Specifying the Positioning Behavior of the PLANE Function" on page 468).

## Abbreviations used

Abbreviation	Meaning
SPATIAL	<b>spatial</b> = in space
SPA	<b>spatial A:</b> rotation about the X axis
SPB	<b>spatial B:</b> rotation about the Y axis
SPC	<b>spatial C:</b> rotation about the Z axis



Example: NC block

```
5 PLANE SPATIAL SPA+27 SPB+0 SPC+45 .....
```



## 9.3 Defining the Machining Plane with Projection Angles: PROJECTED PLANE

### Function

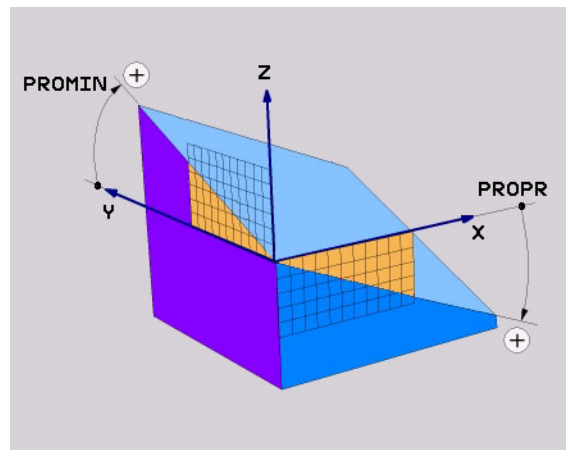
Projection angles define a machining plane through the entry of two angles that you determine by projecting the first coordinate plane (Z/X plane with tool axis Z) and the second coordinate plane (Y/Z with tool axis Z) onto the machining plane to be defined.



#### Before programming, note the following:

You can only use projection angles if a rectangular cuboid is to be machined. Otherwise distortions could occur on the workpiece.

Parameter description for the positioning behavior: See "Specifying the Positioning Behavior of the PLANE Function," page 468.



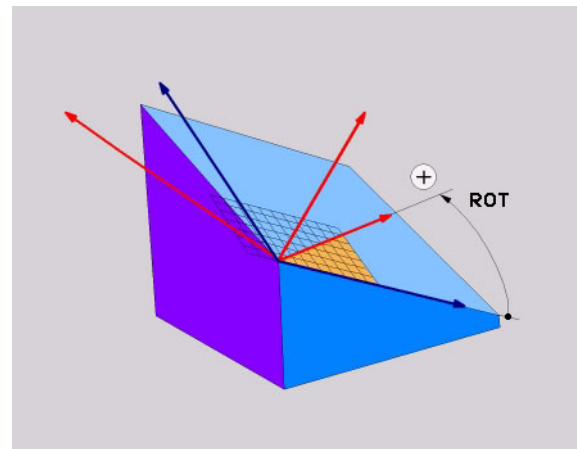
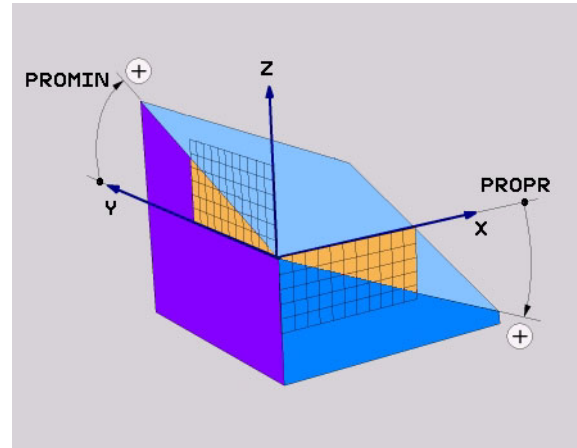
## Input parameters



- **Proj. angle 1st coordinate plane?:** Projected angle of the tilted machining plane in the 1st coordinate plane of the fixed machine coordinate system (Z/X for tool axis Z, see figure at top right). Input range: from  $-89.9999^\circ$  to  $+89.9999^\circ$ . The  $0^\circ$  axis is the principal axis of the active machining plane (X for tool axis Z. See figure at top right for positive direction).
- **Proj. angle 2nd coordinate plane?:** Projected angle in the 2nd coordinate plane of the fixed machine coordinate system (Y/Z for tool axis Z, see figure at top right). Input range: from  $-89.9999^\circ$  to  $+89.9999^\circ$ . The  $0^\circ$  axis is the minor axis of the active machining plane (Y for tool axis Z).
- **ROT angle of the tilted plane?:** Rotation of the tilted coordinate system around the tilted tool axis (corresponds to a rotation with Cycle 10 ROTATION). The rotation angle is used to simply specify the direction of the principal axis of the machining plane (X for tool axis Z, Z for tool axis Y; see figure at bottom right). Input range: from  $0^\circ$  to  $+360^\circ$ .
- Continue with the positioning properties (see "Specifying the Positioning Behavior of the PLANE Function" on page 468).

### Abbreviations used

Abbreviation	Meaning
PROJECTED	<b>p</b> rojected
PROPR	<b>p</b> rincipal plane
PROMIN	<b>m</b> inor plane
PROROT	<b>r</b> otation



Example: NC block

```
5 PLANE PROJECTED PROPR+24 PROMIN+24 PROROT
+30 .....
```



## 9.4 Defining the Machining Plane with Euler Angles: EULER PLANE

### Function

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. When applied to the machine coordinate system, they have the following meanings:

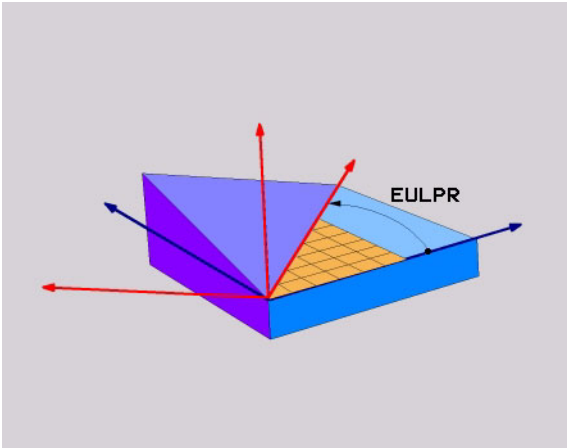
Precession angle <b>EULPR</b>	Rotation of the coordinate system around the Z axis
Nutation angle <b>EULNU</b>	Rotation of the coordinate system around the X axis already shifted by the precession angle
Rotation angle <b>EULROT</b>	Rotation of the tilted machining plane around the tilted Z axis



#### Before programming, note the following:

The sequence of the rotations described above is independent of the active tool axis.

Parameter description for the positioning behavior: See "Specifying the Positioning Behavior of the PLANE Function," page 468.





# Input parameters



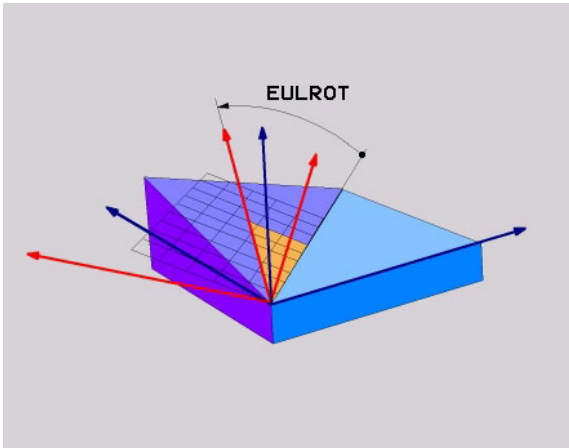
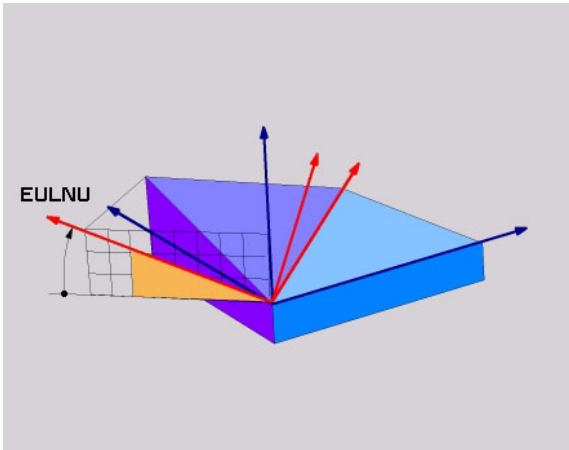
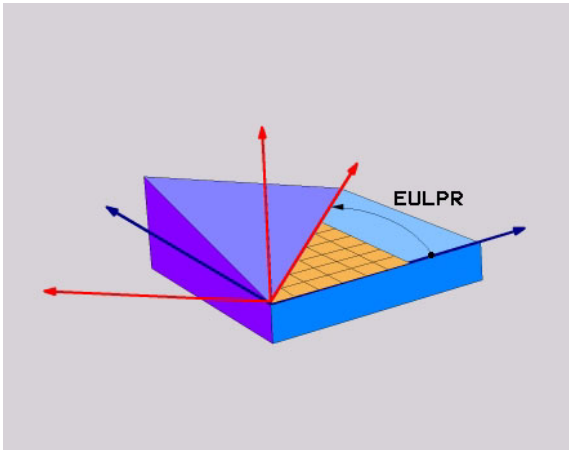
- ▶ **Rot. angle main coordinate plane?:** Rotary angle **EULPR** around the Z axis (see figure at top right). Note:
  - Input range:  $-180.0000^{\circ}$  to  $180.0000^{\circ}$
  - The  $0^{\circ}$  axis is the X axis.
- ▶ **Tilting angle tool axis?:** Tilting angle **EULNUT** of the coordinate system around the X axis shifted by the precession angle (see figure at center right). Note:
  - Input range: from  $0^{\circ}$  to  $180.0000^{\circ}$
  - The  $0^{\circ}$  axis is the Z axis.
- ▶ **ROT angle of the tilted plane?:** Rotation **EULROT** of the tilted coordinate system around the tilted Z axis (corresponds to a rotation with Cycle 10 ROTATION). Use the rotation angle to simply define the direction of the X axis in the tilted machining plane (see figure at bottom right). Note:
  - Input range: from  $0^{\circ}$  to  $360.0000^{\circ}$
  - The  $0^{\circ}$  axis is the X axis.
- ▶ Continue with the positioning properties (see "Specifying the Positioning Behavior of the PLANE Function" on page 468).

## NC block

```
5 PLANE EULER EULPR45 EULNU20 EULROT22 .....
```

## Abbreviations used

Abbreviation	Meaning
EULER	Swiss mathematician who defined these angles
EULPR	<b>P</b> recession angle: angle describing the rotation of the coordinate system around the Z axis
EULNU	<b>N</b> utation angle: angle describing the rotation of the coordinate system around the X axis shifted by the precession angle
EULROT	<b>R</b> otation angle: angle describing the rotation of the tilted machining plane around the tilted Z axis



## 9.5 Defining the Machining Plane with Two Vectors: VECTOR PLANE

### Function

You can use the definition of a machining plane via **two vectors** if your CAD system can calculate the base vector and normal vector of the tilted machining plane. A normalize input is not necessary. The TNC calculates the normal, so you can enter values between  $-99.999999$  and  $+99.999999$ .

The base vector required for the definition of the machining plane is defined by the components **BX**, **BY** and **BZ** (see figure at right). The normal vector is defined by the components **NX**, **NY** and **NZ**.

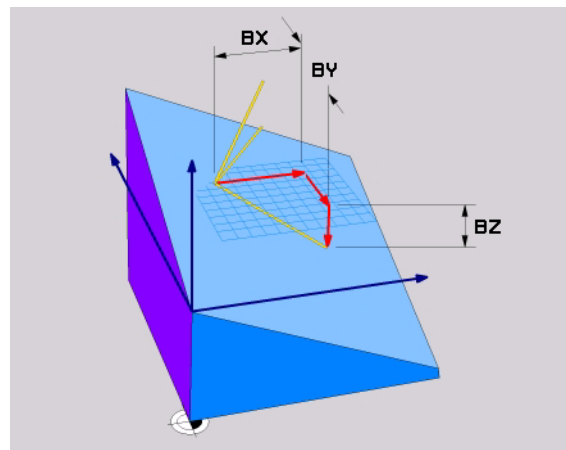
The base vector defines the direction of the X axis in the tilted machining plane, and the normal vector determines the direction of the machining plane, and at the same time is perpendicular to it.



#### Before programming, note the following:

The TNC calculates standardized vectors from the values you enter.

Parameter description for the positioning behavior: See "Specifying the Positioning Behavior of the PLANE Function," page 468.



# Input parameters



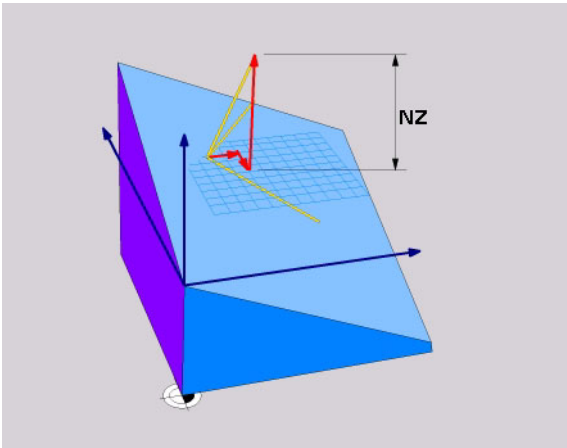
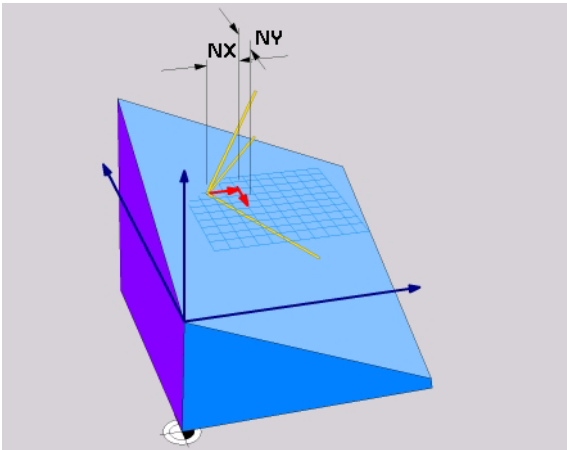
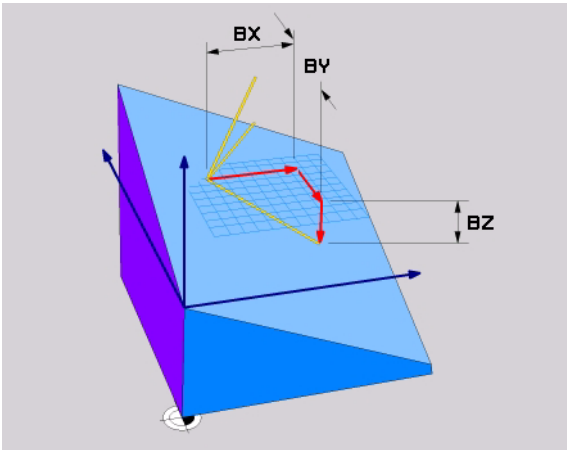
- **X component of base vector?:** X component **BX** of the base vector B (see figure at top right). Input range: -9.9999999 to +9.9999999
- **Y component of base vector?:** Y component **BY** of the base vector B (see figure at top right). Input range: -9.9999999 to +9.9999999
- **Z component of base vector?:** Z component **BZ** of the base vector B (see figure at top right). Input range: -9.9999999 to +9.9999999
- **X component of normal vector?:** X component **NX** of the normal vector N (see figure at center right). Input range: -99.9999999 to +99.9999999
- **Y component of normal vector?:** Y component **NY** of the normal vector N (see figure at center right). Input range: -99.9999999 to +99.9999999
- **Z component of normal vector?:** Z component **NZ** of the normal vector N (see figure at lower right). Input range: -99.9999999 to +99.9999999
- Continue with the positioning properties (see "Specifying the Positioning Behavior of the PLANE Function" on page 468).

## NC block

```
5 PLANE VECTOR BX0.8 BY-0.4 BZ-
0.4472 NX0.2 NY0.2 NZ0.9592 .....
```

## Abbreviations used

Abbreviation	Meaning
VECTOR	Vector
BX, BY, BZ	Base vector: X, Y and Z components
NX, NY, NZ	Normal vector: X, Y and Z components



## 9.6 Defining the Machining Plane via Three Points: POINTS PLANE

### Function

A machining plane can be uniquely defined by entering **any three points P1 to P3 in this plane**. This possibility is realized in the **POINTS PLANE** function.



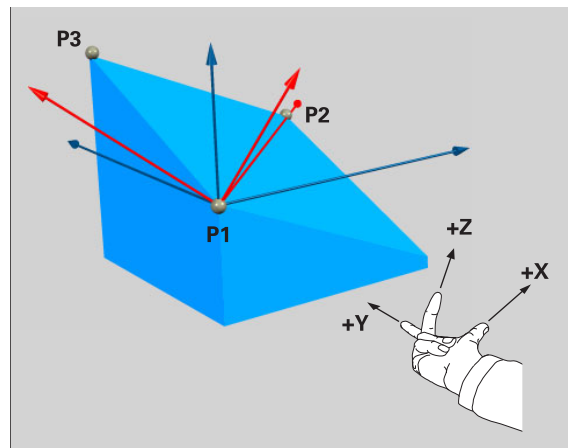
#### Before programming, note the following:

The connection from Point 1 to Point 2 determines the direction of the tilted principal axis (X for tool axis Z).

The direction of the tilted tool axis is determined by the position of Point 3 relative to the connecting line between Point 1 and Point 2. Use the right-hand rule (thumb = X axis, index finger = Y axis, middle finger = Z axis (see figure at right)) to remember: thumb (X axis) points from Point 1 to Point 2, index finger (Y axis) points parallel to the tilted Y axis in the direction of Point 3. Then the middle finger points in the direction of the tilted tool axis.

The three points define the slope of the plane. The position of the active datum is not changed by the TNC.

Parameter description for the positioning behavior: See "Specifying the Positioning Behavior of the PLANE Function," page 468.



# Input parameters



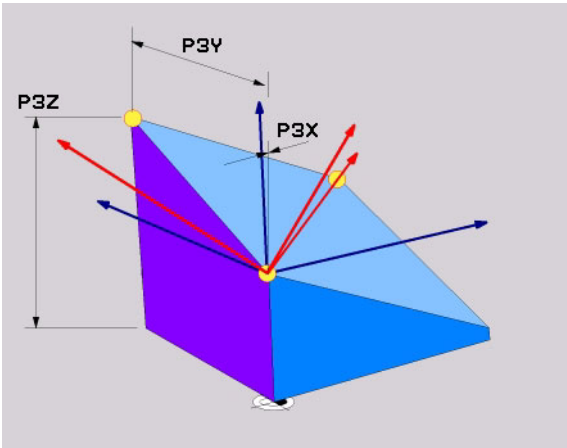
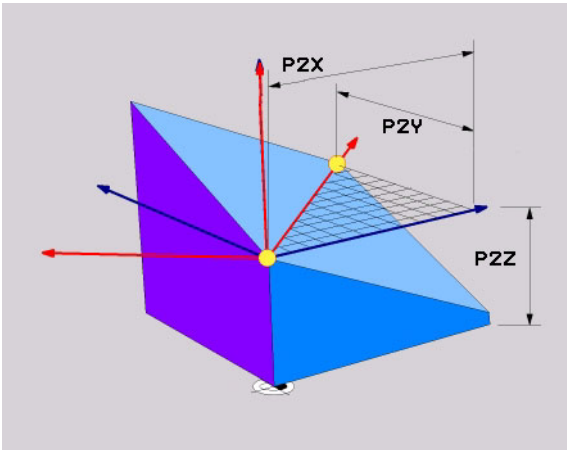
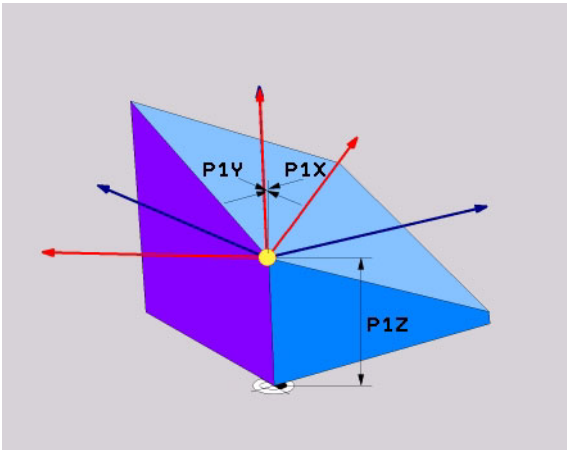
- **X coordinate of 1st plane point?:** X coordinate **P1X** of the 1st plane point (see figure at top right).
- **Y coordinate of 1st plane point?:** Y coordinate **P1Y** of the 1st plane point (see figure at top right).
- **Z coordinate of 1st plane point?:** Z coordinate **P1Z** of the 1st plane point (see figure at top right).
- **X coordinate of 2nd plane point?:** X coordinate **P2X** of the 2nd plane point (see figure at center right).
- **Y coordinate of 2nd plane point?:** Y coordinate **P2Y** of the 2nd plane point (see figure at center right).
- **Z coordinate of 2nd plane point?:** Z coordinate **P2Z** of the 2nd plane point (see figure at center right).
- **X coordinate of 3rd plane point?:** X coordinate **P3X** of the 3rd plane point (see figure at bottom right).
- **Y coordinate of 3rd plane point?:** Y coordinate **P3Y** of the 3rd plane point (see figure at bottom right).
- **Z coordinate of 3rd plane point?:** Z coordinate **P3Z** of the 3rd plane point (see figure at bottom right).
- Continue with the positioning properties (see "Specifying the Positioning Behavior of the PLANE Function" on page 468).

## NC block

```
5 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



## 9.7 Defining the Machining Plane with a Single, Incremental Space Angle: PLANE RELATIVE

### Function

Use the incremental space angle when an already active tilted machining plane is to be tilted by **another rotation**. Example: machining a 45° chamfer on a tilted plane.



#### Before programming, note the following:

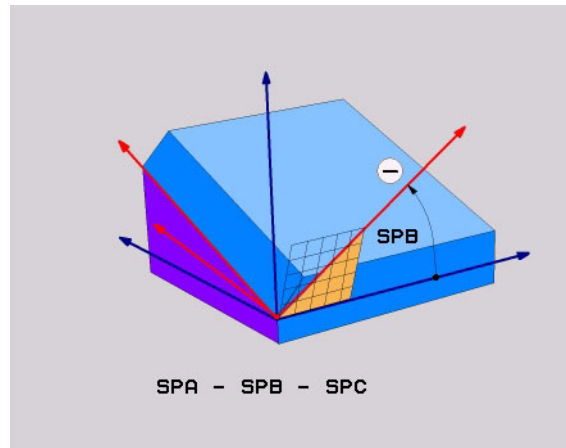
The defined angle always applies to the active machining plane, no matter which function you used to activate it.

You can program any number of **PLANE RELATIVE** functions in a row.

If you want to return to the machining plane that was active before the **PLANE RELATIVE** function, define the **PLANE RELATIVE** function again with the same angle but with the opposite algebraic sign.

If you use the **PLANE RELATIVE** function on an untilted machining plane, then you simply rotate the untilted plane about the space angle defined in the **PLANE** function.

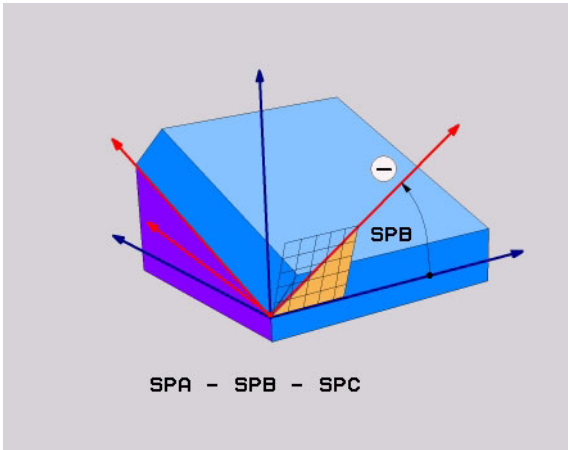
Parameter description for the positioning behavior: See "Specifying the Positioning Behavior of the PLANE Function," page 468.



# Input parameters



- **Incremental angle?:** Spatial angle about which the active machining plane is to be rotated additionally (see figure at right). Use a soft key to select the axis to be rotated about. Input range:  $-359.9999^{\circ}$  to  $+359.9999^{\circ}$
- Continue with the positioning properties (see "Specifying the Positioning Behavior of the PLANE Function" on page 468).



Example: NC block

```
5 PLANE RELATIV SPB-45 .....
```

## Abbreviations used

Abbreviation	Meaning
RELATIV	Relative



## 9.8 Specifying 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
- Selection of alternate tilting possibilities
- Selection of the type of transformation



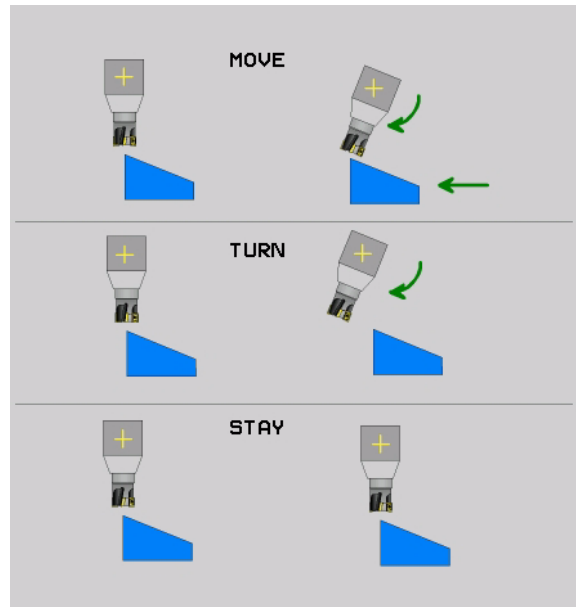


## Automatic positioning: MOVE/TURN/STAY (entry is mandatory)

After you have entered all parameters for the plane definition, you must specify how the rotary axes will be positioned to the calculated axis values:

- |  |   |
|--|---|
| <div style="border: 1px solid black; background-color: #cccccc; padding: 2px; text-align: center; width: 50px; margin-bottom: 10px;">MOVE</div> <div style="border: 1px solid black; background-color: #cccccc; padding: 2px; text-align: center; width: 50px; margin-bottom: 10px;">TURN</div> <div style="border: 1px solid black; background-color: #cccccc; padding: 2px; text-align: center; width: 50px;">STAY</div> | <ul style="list-style-type: none"><li>▶ The PLANE function is to automatically position the rotary axes to the calculated position values. The position of the tool relative to the workpiece is to remain the same. The TNC carries out a compensating motion in the linear axes.</li><li>▶ The PLANE function is to automatically position the rotary axes to the calculated position values, but only the rotary axes are positioned. The TNC does <b>not</b> carry out a compensating motion in the linear axes.</li><li>▶ You will position the rotary axes later in a separate positioning block.</li></ul> |
|--|---|

If you have selected the **MOVE** option (**PLANE** function is to position the axes automatically), the following two parameters must still be defined: **Dist. tool tip – center of rot.** and **Feed rate? F=**. If you have selected the **TURN** option (**PLANE** function is to position the axes automatically without any compensating movement), the following parameter must still be defined: **Feed rate? F=**.



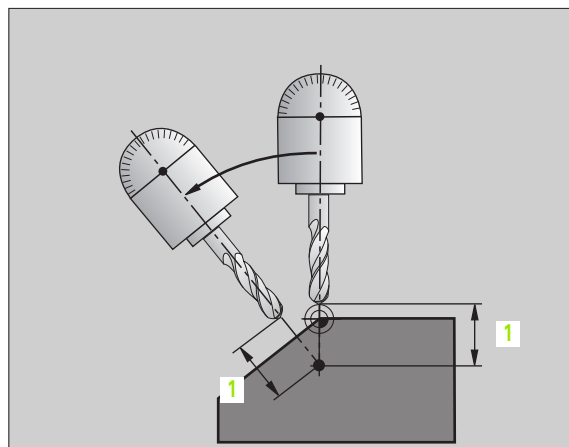
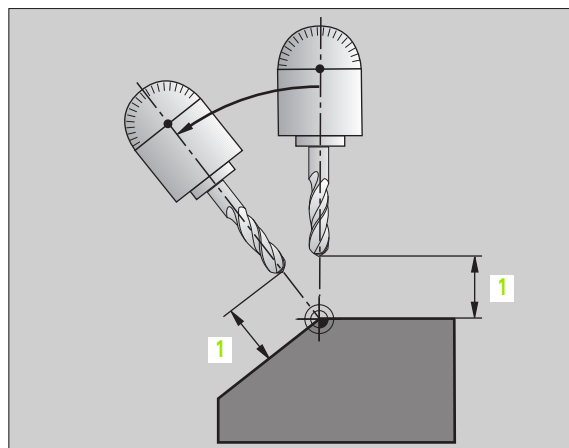
- **Dist. tool tip – center of rot.** (incremental): The TNC tilts the tool (or table) relative to the tool tip. The **SETUP** parameter shifts the center of rotation of the positioning movement relative to the current position of the tool tip.



## Note:


- If the tool is already at the given distance to the workpiece before positioning, then relatively speaking the tool is at the same position after positioning (see figure at center right, **1** = SET UP).
- If the tool is not at the given distance to the workpiece before positioning, then relatively speaking the tool is offset from the original position after positioning (see figure at bottom right, **1** = SET UP).

- **Feed rate ? F=:** Contour speed at which the tool should be positioned.



Positioning the rotary axes in a separate block

Proceed as follows if you want to position the rotary axes in a separate positioning block (option **STAY** selected):

-  Pre-position the tool to a position where there is no danger of collision with the workpiece (clamping devices) during positioning.
- ▶ Select any **PLANE** function, and define automatic positioning with the **STAY** option. During program execution the TNC 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 TNC.

NC example blocks: Position a machine with a C rotary table and an A tilting table to a space angle of B+45°.

...	
12 L Z+250 R0 FMAX	Position at clearance height
13 PLANE SPATIAL SPA+0 SPB+45 SPC+0 STAY	Define and activate the PLANE function
14 L A+Q120 C+Q122 F2000	Position the rotary axis with the values calculated by the TNC
...	Define machining in the tilted working plane



Selection of alternate tilting possibilities:  
SEQ +/- (entry optional)

The position you define for the machining plane is used by the TNC to calculate the appropriate positioning of the rotary axes present on the machine. In general there are always two solution possibilities.

Use the **SEQ** switch to specify which possibility the TNC should use:

- **SEQ+** positions the master axis so that it assumes a positive angle.  
The master axis is the 2nd rotary axis from the table, or the 1st axis from the tool (depending on the machine configuration (see figure at top right)).
- **SEQ-** positions the master axis so that it assumes a negative angle.

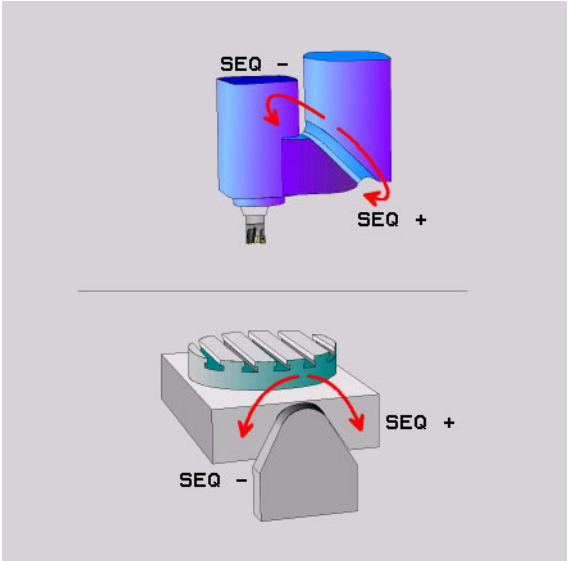
If the solution you chose with **SEQ** is not within the machine's range of traverse, the TNC displays the **Entered angle not permitted** error message.

If you do not define **SEQ**, the TNC determines the solution as follows:

- 1 The TNC first checks whether both solution possibilities are within the traverse range of the rotary axes.
- 2 If they are, then the TNC selects the shortest possible solution.
- 3 If only one solution is within the traverse range, the TNC selects this solution.
- 4 If neither solution is within the traverse range, the TNC displays the **Entered angle not permitted** error message.

Example for a machine with a C rotary table and an A tilting table.  
Programmed function: **PLANE SPATIAL SPA+0 SPB+45 SPC+0**

Limit switch	Starting position	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
None	A+0, C-135	+	A+45, C+90



## Selecting the type of transformation (entry optional)

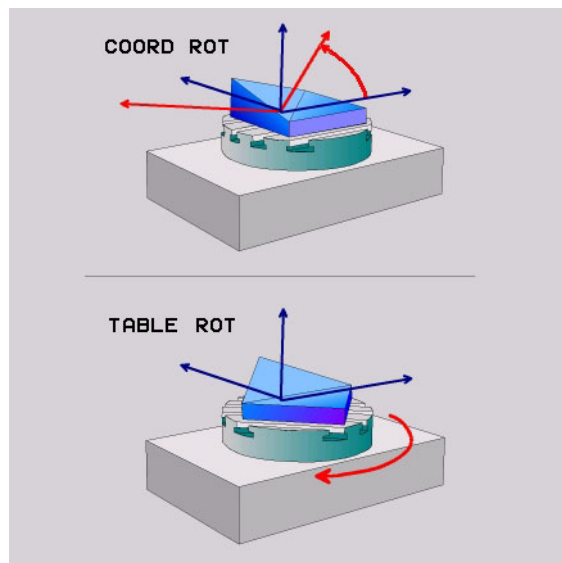
On machines with C-rotary tables, a function is available for specifying the type of transformation:



- **COORD ROT** specifies that the PLANE function should only rotate the coordinate system to the defined tilting angle. The rotary table is not moved; the compensation is purely mathematical.



- **TABLE ROT** specifies that the PLANE function should position the rotary table to the defined tilting angle. Compensation results from rotating the workpiece.



## 9.9 Inclined-Tool Machining in the Tilted Plane

### Function

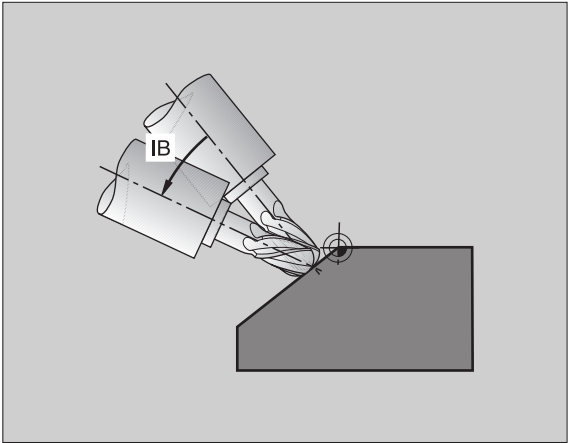
In combination with M128 and the new **PLANE** functions, **inclined-tool machining** in a tilted machining plane is now possible. Two possibilities are available for definition:

- Inclined-tool machining via incremental traverse of a rotary axis
- Inclined-tool machining via normal vectors



Inclined-tool machining in a tilted machining plane only functions with spherical cutters.

With 45° swivel heads and tilting tables you can also define the incline angle as a space angle. Use the **TCPM FUNCTION**. (see "TCPM FUNCTION (Software Option 2)" on page 476)



### Inclined-tool machining via incremental traverse of a rotary axis

- ▶ Retract the tool
- ▶ Activate M128
- ▶ Define any PLANE function; consider the positioning behavior
- ▶ Via an L block, traverse to the desired incline angle in the appropriate axis incrementally

#### Example NC blocks:

...	
12 L Z+50 R0 FMAX M128	Position at clearance height, activate M128
13 PLANE SPATIAL SPA+0 SPB-45 SPC+0 MOVE SET UP50 F1000	Define and activate the PLANE function
14 L IB-17 F1000	Set the incline angle
...	Define machining in the tilted working plane



## Inclined-tool machining via normal vectors



Only one directional vector can be defined in an LN block. This vector defines the incline angle (normal vector **NX**, **NY**, **NZ**, or tool direction vector **TX**, **TY**, **TZ**).

- ▶ Retract the tool
- ▶ Activate M128
- ▶ Define any PLANE function; consider the positioning behavior
- ▶ Execute program with LN block in which the tool direction is defined by a vector

### Example NC blocks:

...	
12 L Z+50 R0 FMAX M128	Position at clearance height, activate M128
13 PLANE SPATIAL SPA+0 SPB+45 SPC+0 MOVE SET UP50 F1000	Define and activate the PLANE function
14 LN X+31.737 Y+21.954 Z+33.165 NX+0.3 NY+0 NZ+0.9539 F1000 M3	Set the incline angle with the normal vector
...	Define machining in the tilted working plane



## 9.10 TCPM FUNCTION (Software Option 2)

### Function



The machine geometry must be entered in machine parameters or in kinematic tables.



#### For tilted axes with Hirth coupling:


Only change the position of the tilted axis after retracting the tool. Otherwise you might damage the contour.



Before positioning with **M91** or **M92** and before a **TOOL CALL**:  
Reset **TCPM FUNCTION**

To avoid contour gouging you must use only spherical cutters with **TCPM FUNCTION**.

The tool length must refer to the spherical center of the tool tip.

If **TCPM FUNCTION** is active, the TNC shows the symbol  in the status display.

**TCPM FUNCTION** is an improvement on the **M128** function, with which you can define the behavior of the TNC when positioning the rotary axes. In contrast to **M128**, with **TCPM FUNCTION** you can define the mode of action of various functions:

- Mode of action of the programmed feed rate: **F TCP / F CONT**
- Interpretation if the rotary axis coordinates programmed in the NC program: **AXIS POS / AXIS SPAT**
- Type of interpolation between start and target position:  
**PATHCTRL AXIS / PATHCTRL VECTOR**

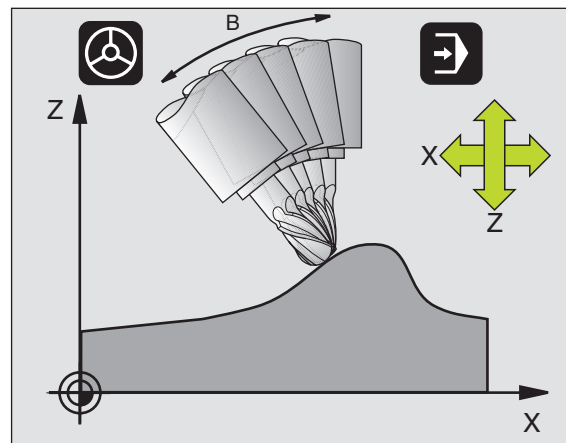
### Define TCPM FUNCTION

SPEC  
FCT

- Show the soft-key row with special functions

FUNCTION

- Select TCPM FUNCTION function





### Mode of action of the programmed feed rate

The TNC provides two functions for defining the mode of action of the programmed feed rate:



► **F TCP** determines that the programmed feed rate is interpreted as the actual relative velocity between the tool point (**t**ool **c**enter **p**oint) and the workpiece.



► **F CONTOUR** determines that the programmed feed rate is interpreted as the contouring feed rate of the axis programmed in the respective NC block.

**Example NC blocks:**

...	
13 FUNCTION TCPM F TCP ...	Feed rate refers to the tool point.
14 FUNCTION TCPM F CONTOUR ...	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 specially written programs with normal vectors (LN blocks).

The TNC now provides the following function:



- ▶ **AXIS POS** determines that the TNC interprets the programmed coordinates of rotary axes as the nominal position of the respective axis.



- ▶ **AXIS SPAT** determines that the TNC interprets the programmed coordinates of rotary axes as the spatial angle.



**AXIS POS** should only be used if your machine is equipped with equipped with Cartesian rotary axes. With 45° swivel heads/tilting tables, **AXIS POS** may also result in incorrect axis positions.

**AXIS SPAT:** The rotary axis coordinates entered in the positioning block are spatial angles that are given with respect to the currently active (perhaps tilted) coordinate system (incremental spatial angle).

After you switch on **FUNCTION TCPM** with **AXIS SPAT**, in the first positioning block you should always program all three spatial angles in the inclination angle definition. This also applies if one or more spatial angles are 0°.

Example NC blocks:

...	
13 FUNCTION TCPM F TCP AXIS POS ...	Rotary axis coordinates are axis angle
...	
18 FUNCTION TCPM F TCP AXIS SPAT ...	Rotary axis coordinates are spatial angle
20 L A+0 B+45 C+0 F MAX	Set tool orientation to B+45 degrees (spatial angle). Define spatial angle A and C with 0.
...	



## Interpolation type between the starting and end position

The TNC provides two functions for defining the type of interpolation between the starting and end position:

- PATH  
CONTROL  
AXIS

► **PATHCTRL AXIS** determines that the tool point between the starting and end position of the respective NC block moves on a straight line (**Face Milling**). The direction of the tool axis at the starting and end position corresponds to the respective programmed values, but the tool circumference does not describe a defined path between starting and end position. The surface produced by milling with the tool circumference (**Peripheral Milling**), depends on the machine geometry.
- PATH  
CONTROL  
VECTOR

► **PATHCTRL VECTOR** determines that the tool point between the starting and end position of the respective NC block moves on a straight line and also that the direction of the tool axis between starting and end position is interpolated so that a plane results from machining at the tool circumference (**Peripheral Milling**)



### With PATHCTRL VECTOR, remember:

Any defined tool orientation is generally accessible through two different tilting angle positions. The TNC uses the solution over the shortest available path—starting from the current position. Therefore, with 5-axis machining it may happen that the TNC moves in the rotary axes to end positions that are not programmed.

To attain the most continuous multiaxis movement possible, define Cycle 32 with a **Tolerance for rotary axes** (see “TOLERANCE (Cycle 32, software option 2)” on page 449). The tolerance of the rotary axes should be about the same as the tolerance of the contouring deviation that is also defined in Cycle 32. The greater the tolerance for the rotary axes is defined, the greater are the contour deviations during peripheral milling.

### Example NC blocks:

...	
13 FUNCTION TCPM F TCP AXIS SPAT PATHCTRL AXIS	Tool tip moves along a straight line
14 FUNCTION TCPM F TCP AXIS POS PATHCTRL VECTOR	Tool tip and tool directional vector move in one plane
...	



Reset TCPM FUNCTION



► **FUNCTION RESET TCPM** is to be used if you want to purposely reset the function within a program .

Example NC block:

...	
25 <b>FUNCTION RESET TCPM</b>	Reset FUNCTION TCPM
...	



The TNC automatically resets **FUNCTION TCPM** if you select a new program in a program run mode.

You can reset the **TCPM FUNCTION** only if the **PLANE** function is inactive. If required, run **PLANE RESET** before **FUNCTION RESET TCPM**.



## 9.11 Generate Backward Program

### Function

With this TNC function you can reverse the machining direction of a contour.



If you wish to generate a backward program, select the PROGRAM + GRAPHICS screen layout ((see “Programming and editing” on page 41)).

Note that the TNC may need many times more free memory space on the hard disk than the size of the program file to be converted.



► Select the third soft-key row.



► Select the soft-key row with functions for converting programs.



► Generate Forward and Backward Program



The name of the file created by the TNC consists of the old file name and the extension **\_rev**. Example:

- File name of the program whose machining direction is to be reversed: **CONT1.H**
- File name of the backwardprogram to be generated by the TNC: **CONT1\_rev.h**

To be able to generate a backward program, the TNC must first generate a linearized forward program, i.e. a program in which all contour elements are resolved. This program is also executable and has the file name extension **\_fwd.h**.



## Prerequisites for the program to be converted

The TNC reverses the sequence of all **positioning blocks** in the program. The following functions are not taken into the **backward program**.

- Define the workpiece blank
- Tool calls
- Coordinate transformation cycles
- Fixed cycles and probing cycles
- Cycle calls **CYCL CALL**, **CYCL CALL PAT**, **CYCL CALL POS**
- Miscellaneous **(M)** functions

HEIDENHAIN therefore recommends converting only programs containing a pure contour description. All path functions available on the TNC are permitted, including FK blocks. **RND** and **CHF** blocks are moved by the TNC so that they can be executed again at the correct position on the contour.

The TNC also calculates the radius compensation for the other direction.



If the program included contour approach and departure functions (**APPR/DEP/RND**), check the backward program with the programming graphics. Certain geometric conditions might result in incorrect contours.

Application example

The contour **CONT1.H** is to be milled in several infeeds. The TNC generates the forward file **CONT1\_fwd.h** and the backward file **CONT1\_rev.h**.

NC blocks

...	
5 T00L CALL 12 Z S6000	Tool call
6 L Z+100 R0 FMAX	Retract in the tool axis
7 L X-15 Y-15 R0 F MAX M3	Pre-position in the plane, spindle on
8 L Z+0 R0 F MAX	Approach the starting point in the tool axis
9 LBL 1	Set a mark
10 L IZ-2.5 F1000	Infeed depth in incremental values
11 CALL PGM CONT1_FWD.H	Call the forward program
12 L IZ-2.5 F1000	Infeed depth in incremental values
13 CALL PGM CONT1_FWD.H	Call backward program
14 CALL LBL 1 REP3	Repeat pgm part three times starting with block 9
15 L Z+100 R0 F MAX M2	Retract tool, end of program









# 10

**Programming:  
Subprograms and Program  
Section Repeats**



## 10.1 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 desired.

### Labels

The beginnings of subprograms and program section repeats are marked in a part program by labels.

A label is identified by a number between 1 and 999 or by a name you define. Each LABEL number or LABEL name can be set only once in the program with LABEL SET. The number of label names you can enter is only limited by the internal memory.



If a LABEL name or number is set more than once, the TNC sends an error message at the end of the LBL SET block. With very long programs, you can limit the number of blocks to be checked for repeated labels with MP7229.

LABEL 0 (LBL 0) is used exclusively to mark the end of a subprogram and can therefore be used as often as desired.

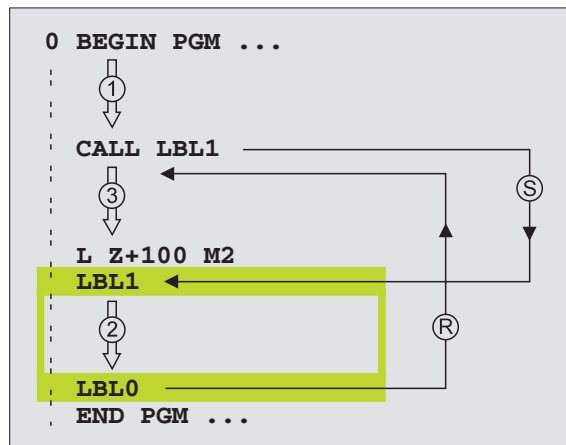
## 10.2 Subprograms

### Operating sequence

- 1 The TNC executes the part program up to the block in which a subprogram is called with CALL LBL.
- 2 The subprogram is then executed from beginning to end. The subprogram end is marked with LBL 0.
- 3 The TNC then resumes the part program from the block after the subprogram call.

### Programming notes

- A main program can contain up to 254 subprograms.
- You can call subprograms in any sequence and as often as desired.
- A subprogram cannot call itself.
- Write subprograms at the end of the main program (behind the block with M02 or M30).
- If subprograms are located before the block with M02 or M30, they will be executed at least once even if they are not called.



### Programming a subprogram

LBL  
SET

- ▶ To mark the beginning, press the LBL SET key.
- ▶ Enter the subprogram number.
- ▶ To mark the end, press the LBL SET key and enter the label number "0".

### Calling a subprogram

LBL  
CALL

- ▶ To call a subprogram, press the LBL CALL key.
- ▶ **Label number:** Enter the label number of the subprogram you wish to call. If you want to use a label name, press the key " " to switch to text entry.
- ▶ **Repeat REP:** Ignore the dialog question with the NO ENT key. Repeat REP is used only for program section repeats.



CALL LBL 0 is not permitted (Label 0 is only used to mark the end of a subprogram).

## 10.3 Program Section Repeats

### Label LBL

The beginning of a program section repeat is marked by the label LBL. The end of a program section repeat is identified by CALL LBL /REP.

### Operating sequence

- 1 The TNC executes the part program up to the end of the program section (CALL LBL /REP).
- 2 Then the program section between the called LBL and the label call CALL LBL /REP is repeated the number of times entered after REP.
- 3 The TNC then resumes the part 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.

### Programming a program section repeat

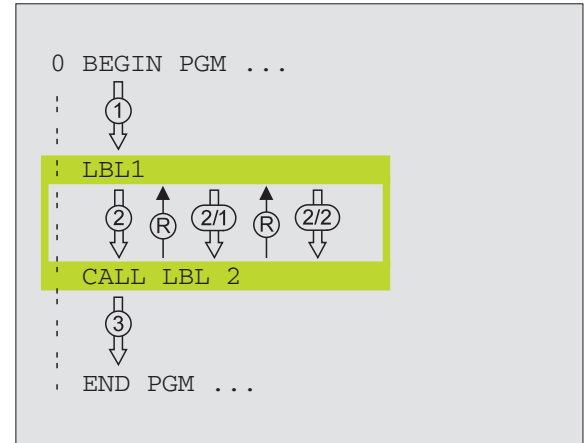


- To mark the beginning, press the LBL SET key and enter a LABEL NUMBER for the program section you wish to repeat. If you want to use a label name, press the key " " to switch to text entry.
- Enter the program section.

### Calling a program section repeat



- Press the LBL CALL key and enter the label number of the program section you want to repeat as well as the number of repeats (with Repeat REP).



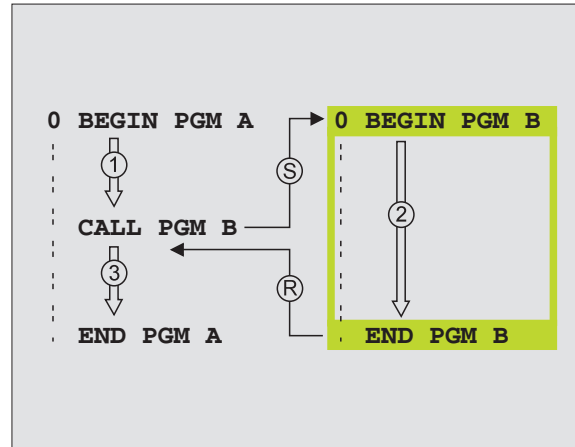
## 10.4 Separate Program as Subprogram

### Operating sequence

- 1 The TNC executes the part program up to the block in which another program is called with **CALL PGM**.
- 2 Then the other program is run from beginning to end.
- 3 The TNC then resumes the first (calling) part program with the block behind the program call.

### Programming notes

- No labels are needed to call any program as a subprogram.
- The called program must not contain the miscellaneous functions M02 or M30.
- The called program must not contain a **CALL PGM** call into the calling program, otherwise an infinite loop will result.



## Calling any program as a subprogram



- ▶ To select the functions for program call, press the PGM CALL key.
- ▶ Press the PROGRAMM soft key.
- ▶ Enter the complete path name of the program you want to call and confirm your entry with the END key.



The program you are calling must be stored on the hard disk of your TNC.

You need only enter the program name if the program you want to call is located in the same directory as the program you are calling it from.

If the called program is not located in the same directory as the program you are calling it from, you must enter the complete path, e.g. **TNC:\ZW35\SCHRUPP\PGM1.H**

If you want to call an ISO program, enter the file type .I after the program name.

You can also call a program with **CYCLE 12 PGM CALL**.

As a rule, Q parameters are effective globally with a **PGM CALL**. So please note that changes to Q parameters in the called program can also influence the calling program.

# 10.5 Nesting

## Types of nesting

- Subprograms within a subprogram
- Program section repeats within a program section repeat
- Subprograms repeated
- Program section repeats within a subprogram

## Nesting depth

The nesting depth is the number of successive levels in which program sections or subprograms can call further program sections or subprograms.

- Maximum nesting depth for subprograms: 8
- Maximum nesting depth for main program calls: 6, where a CYCL CALL acts like a main program call.
- You can nest program section repeats as often as desired.

## Subprogram within a subprogram

### Example NC blocks

0 BEGIN PGM UPGMS MM	
...	
17 CALL LBL "SP1"	Call the subprogram marked with LBL SP1
...	
35 L Z+100 R0 FMAX M2	Last program block of the
	Main program (with M02)
36 LBL "SP1"	Beginning of subprogram SP2
...	
39 CALL LBL 2	Call the subprogram marked with LBL 2
...	
45 LBL 0	End of subprogram 1
46 LBL 2	Beginning of subprogram 2
...	
62 LBL 0	End of subprogram 2
63 END PGM UPGMS MM	



Program execution

- 1 Main program UPGMS is executed up to block 17.
- 2 Subprogram 1 is called, and executed up to block 39.
- 3 Subprogram 2 is called, and executed up to block 62. End of subprogram 2 and return jump to the subprogram from which it was called.
- 4 Subprogram 1 is executed from block 40 up to block 45. End of subprogram 1 and return jump to the main program SUBPGMS.
- 5 Main program UPGMS is executed from block 18 up to block 35. Return jump to block 1 and end of program.

Repeating program section repeats

Example NC blocks

0 BEGIN PGM REPS MM	
...	
15 LBL 1	Beginning of program section repeat 1
...	
20 LBL 2	Beginning of program section repeat 2
...	
27 CALL LBL 2 REP 2/2	The program section between this block and LBL 2
...	(block 20) is repeated twice
35 CALL LBL 1 REP 1/1	The program section between this block and LBL 1
...	(block 15) is repeated once
50 END PGM REPS MM	

Program execution

- 1 Main program REPS is executed up to block 27.
- 2 Program section between block 27 and block 20 is repeated twice.
- 3 Main program REPS is executed from block 28 to block 35.
- 4 Program section between block 35 and block 15 is repeated once (including the program section repeat between 20 and block 27).
- 5 Main program REPS is executed from block 36 to block 50 (end of program).





## Repeating a subprogram

### Example NC blocks

0 BEGIN PGM UPGREP MM	
...	
10 LBL 1	Beginning of program section repeat 1
11 CALL LBL 2	Subprogram call.
12 CALL LBL 1 REP 2/2	The program section between this block and LBL1
...	(block 10) is repeated twice
19 L Z+100 R0 FMAX M2	Last block of the main program with M2
20 LBL 2	Beginning of subprogram
...	
28 LBL 0	End of subprogram
29 END PGM UPGREP MM	

### Program execution

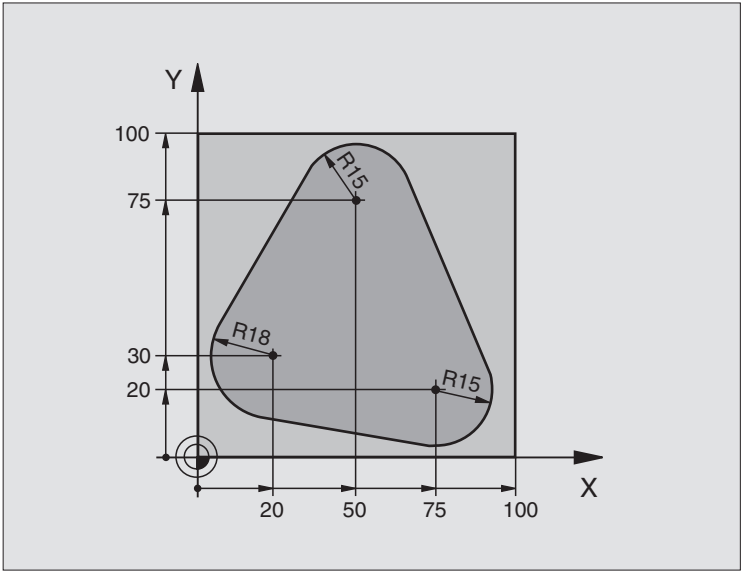
- 1 Main program UPGREP is executed up to block 11.
- 2 Subprogram 2 is called and executed.
- 3 Program section between block 12 and block 10 is repeated twice. This means that subprogram 2 is repeated twice.
- 4 Main program UPGREP is executed from block 13 to block 19. End of program.



Example: Milling a contour in several infeeds

Program sequence

- Pre-position the tool to the workpiece surface
- Enter the infeed depth in incremental values
- Contour milling
- Repeat downfeed and contour-milling



0 BEGIN PGM PGMWDH MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-40	
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+10	Define the tool
4 TOOL CALL 1 Z S500	Tool call
5 L Z+250 R0 FMAX	Retract the tool
6 L X-20 Y+30 R0 FMAX	Pre-position in the working plane
7 L Z+0 R0 FMAX M3	Pre-position to the workpiece surface



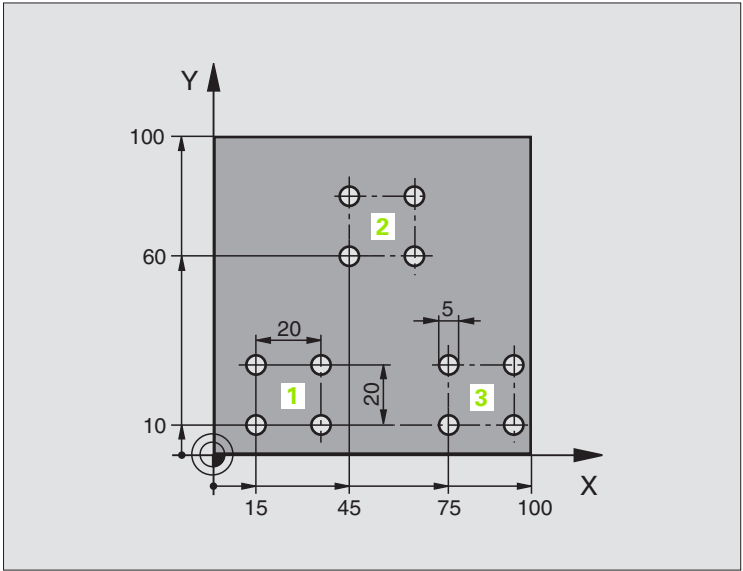
8 LBL 1	Set label for program section repeat
9 L IZ-4 R0 FMAX	Infeed depth in incremental values (in space)
10 APPR CT X+2 Y+30 CCA90 R+5 RL F250	Approach to the contour.
11 FC DR- R18 CLSD+ CCX+20 CCY+30	Contour
12 FLT	
13 FCT DR- R15 CCX+50 CCY+75	
14 FLT	
15 FCT DR- R15 CCX+75 CCY+20	
16 FLT	
17 FC DR- R18 CLSD+ CCX+20 CCY+30	
18 DEP CT CCA90 R+5 F1000	Contour, departing
19 L X-20 Y+0 R0 FMAX	Retract tool
20 CALL LBL 1 REP 4/4	Return jump to LBL 1; section is repeated a total of 4 times.
21 L Z+250 R0 FMAX M2	Retract in the tool axis, end program
22 END PGM PGMWDH MM	



Example: Groups of holes

Program sequence

- Approach the groups of holes in the main program
- Call the group of holes (subprogram 1)
- Program the group of holes only once in subprogram 1



0 BEGIN PGM SP1 MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+2.5	Define the tool
4 TOOL CALL 1 Z S5000	Tool call
5 L Z+250 R0 FMAX	Retract the tool
6 CYCL DEF 200 DRILLING	Cycle definition: drilling
Q200=2 ;SET-UP CLEARANCE	
Q201=-10 ;DEPTH	
Q206=250 ;FEED RATE FOR PLNGNG	
Q202=5 ;INFED DEPTH	
Q210=0 ;DWELL TIME AT TOP	
Q203=+0 ;SURFACE COORDINATE	
Q204=10 ;2ND SET-UP CLEARANCE	
Q211=0.25 ;DWELL TIME AT DEPTH	



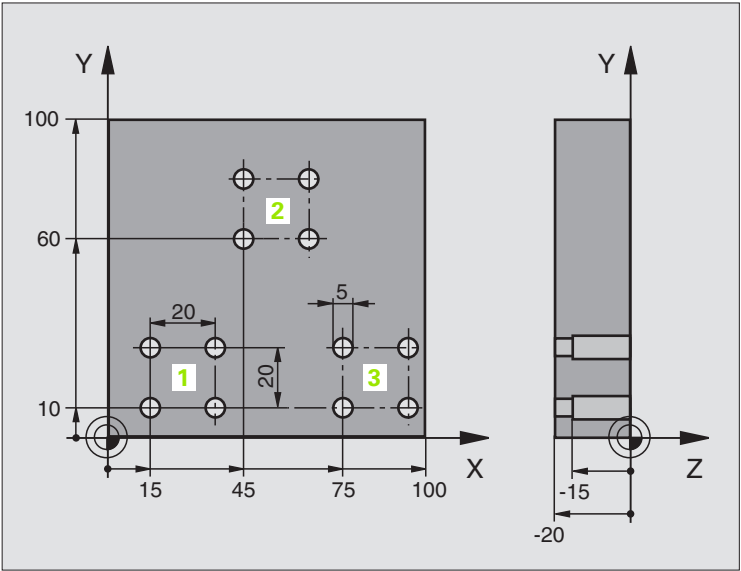
7 L X+15 Y+10 R0 FMAX M3	Move to starting point for group 1
8 CALL LBL 1	Call the subprogram for the group
9 L X+45 Y+60 R0 FMAX	Move to starting point for group 2
10 CALL LBL 1	Call the subprogram for the group
11 L X+75 Y+10 R0 FMAX	Move to starting point for group 3
12 CALL LBL 1	Call the subprogram for the group
13 L Z+250 R0 FMAX M2	End of main program
14 LBL 1	Beginning of subprogram 1: Group of holes
15 CYCL CALL	Hole 1
16 L IX.20 R0 FMAX M99	Move to 2nd hole, call cycle
17 L IY+20 R0 FMAX M99	Move to 3rd hole, call cycle
18 L IX-20 R0 FMAX M99	Move to 4th hole, call cycle
19 LBL 0	End of subprogram 1
20 END PGM SP1 MM	



Example: Group of holes with several tools

Program sequence

- Program the fixed cycles in the main program
- Call the entire hole pattern (subprogram 1)
- Approach the groups of holes in subprogram 1, call group of holes (subprogram 2)
- Program the group of holes only once in subprogram 2



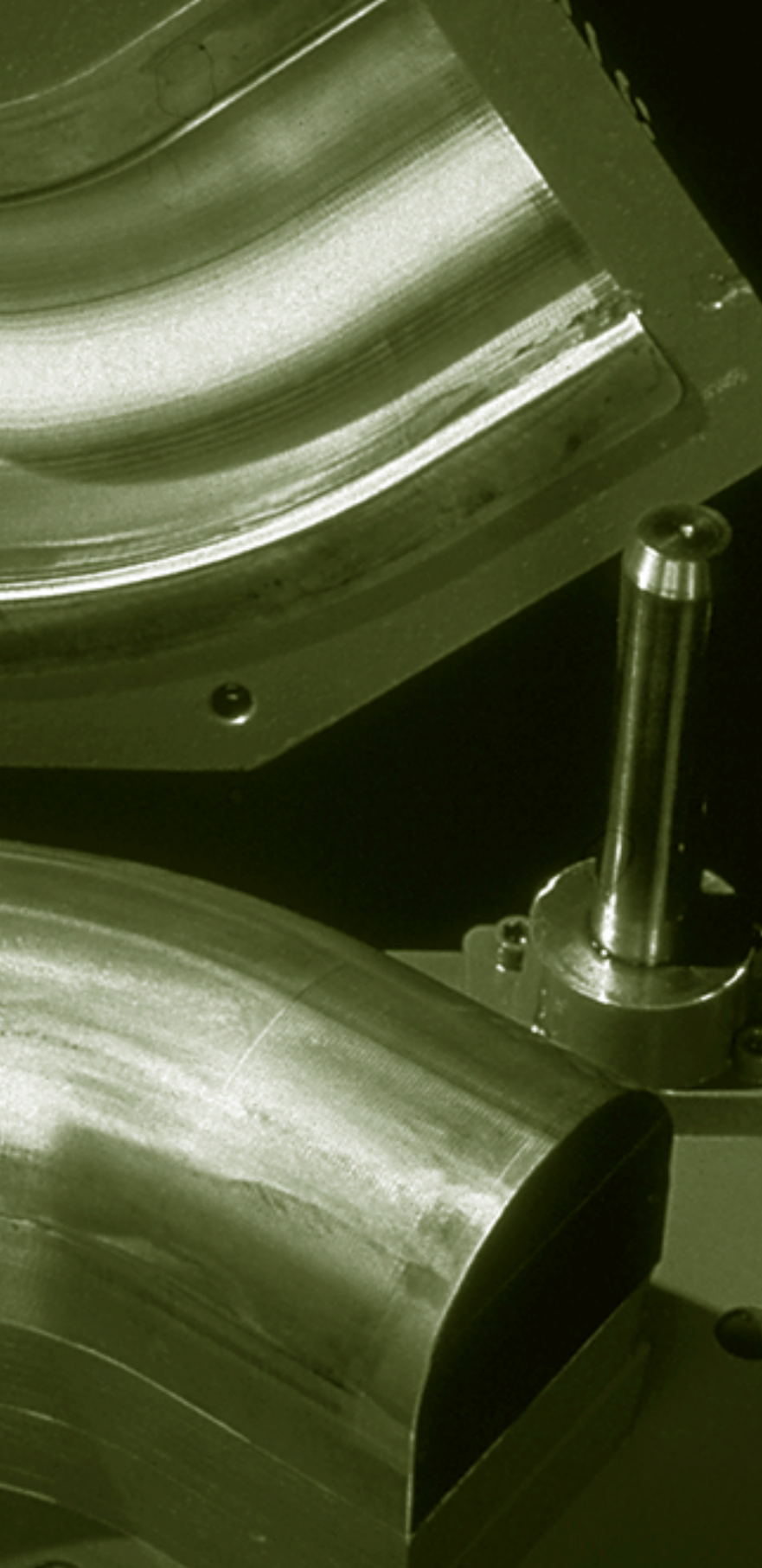
0 BEGIN PGM SP2 MM	
1 BLK FORM 0.1 Z X+0 Y+0 Z-20	
2 BLK FORM 0.2 X+100 Y+100 Z+0	
3 TOOL DEF 1 L+0 R+4	Define tool: center drill
4 TOOL DEF 2 L+0 R+3	Define tool: drill
5 TOOL DEF 2 L+0 R+3.5	Define tool: reamer
6 TOOL CALL 1 Z S5000	Call tool: center drill
7 L Z+250 R0 FMAX	Retract the tool
8 CYCL DEF 200 DRILLING	Cycle definition: Centering
Q200=2 ;SET-UP CLEARANCE	
Q202=-3 ;DEPTH	
Q206=250 ;FEED RATE FOR PLNGNG	
Q202=3 ;INFED DEPTH	
Q210=0 ;DWELL TIME AT TOP	
Q203=+0 ;SURFACE COORDINATE	
Q204=10 ;2ND SET-UP CLEARANCE	
Q211=0.25 ;DWELL TIME AT DEPTH	
9 CALL LBL 1	Call subprogram 1 for the entire hole pattern



10 L Z+250 R0 FMAX M6	Tool change
11 TOOL CALL 2 Z S4000	Call toll: drill
12 FN 0: Q201 = -25	New depth for drilling
13 FN 0: Q202 = +5	New plunging depth for drilling
14 CALL LBL 1	Call subprogram 1 for the entire hole pattern
15 L Z+250 R0 FMAX M6	Tool change
16 TOOL CALL 3 Z S500	Call tool: reamer
17 CYCL DEF 201 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	
18 CALL LBL 1	Call subprogram 1 for the entire hole pattern
19 L Z+250 R0 FMAX M2	End of main program
20 LBL 1	Beginning of subprogram 1: Entire hole pattern
21 L X+15 Y+10 R0 FMAX M3	Move to starting point for group 1
22 CALL LBL 2	Call subprogram 2 for the group
23 L X+45 Y+60 R0 FMAX	Move to starting point for group 2
24 CALL LBL 2	Call subprogram 2 for the group
25 L X+75 Y+10 R0 FMAX	Move to starting point for group 3
26 CALL LBL 2	Call subprogram 2 for the group
27 LBL 0	End of subprogram 1
28 LBL 2	Beginning of subprogram 2: Group of holes
29 CYCL CALL	1st hole with active fixed cycle
30 L 9X+20 R0 FMAX M99	Move to 2nd hole, call cycle
31 L IY+20 R0 FMAX M99	Move to 3rd hole, call cycle
32 L IX-20 R0 FMAX M99	Move to 4th hole, call cycle
33 LBL 0	End of subprogram 2
34 END PGM SP2 MM	







# 11

**Programming: Q Parameters**



# 11.1 Principle and Overview

You can program an entire family of parts in a single part program. You do this by entering variables called Q parameters instead of fixed numerical values.

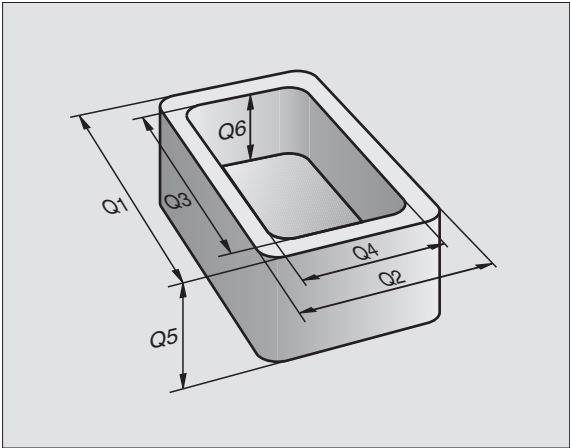
Q parameters can represent information such as:

- Coordinate values
- Feed rates
- Spindle speeds
- Cycle data

Q parameters also enable you to program contours that are defined with mathematical functions. You can also use Q parameters to make the execution of machining steps depend on logical conditions. In conjunction with FK programming you can also combine contours that do not have NC-compatible dimensions with Q parameters.

Q parameters are designated by the letter Q and a number between 0 and 1999. They are grouped according to various ranges:


Meaning	Range
Freely applicable parameters, globally effective for all programs stored in the TNC memory	Q1600 to Q1999
Freely applicable parameters, as long as no overlapping with SL cycles can occur, globally effective for all programs stored in the TNC memory	Q0 to Q99
Parameters for special TNC functions	Q100 to Q199
Parameters that are primarily used for cycles, globally effective for all programs that are stored in the TNC memory	Q200 to Q1399
Parameters that are primarily used for call-active OEM cycles, globally effective for all programs that are stored in the TNC memory	Q1400 to Q1499
Parameters that are primarily used for def-active OEM cycles, globally effective for all programs that are stored in the TNC memory	Q1500 to Q1599



## Programming notes

You can mix Q parameters and fixed numerical values within a program.

Q parameters can be assigned numerical values between –99 999.9999 and +99 999.9999. Internally, the TNC can calculate up to a width of 57 bits before and 7 bits after the decimal point (32-bit data width corresponds to a decimal value of 4 294 967 296).



Some Q parameters are always assigned the same data by the TNC. For example, Q108 is always assigned the current tool radius (see “Preassigned Q Parameters” on page 535).

If you are using the parameters Q60 to Q99 in encoded OEM cycles, define via MP7251 whether the parameters are only to be used locally in the OEM cycles (.CYC file), or may be used globally.

## Calling Q parameter functions

When you are writing a part program, press the “Q” key (in the numeric keypad for numerical input and axis selection, below the +/- key). The TNC then displays the following soft keys:

Function group	Soft key
Basic arithmetic (assign, add, subtract, multiply, divide, square root)	BASIC ARITHM.
Trigonometric functions	TRIGO-NOMETRY
Function for calculating circles	CIRCLE CALCULATION
If/then conditions, jumps	JUMP
Other functions	DIVERSE FUNCTION
Entering formulas directly	FORMULA
Function for machining complex contours	CONTOUR FORMULA



## 11.2 Part Families—Q Parameters in Place of Numerical Values

The Q parameter function FN0: ASSIGN assigns numerical values to Q parameters. This enables you to use variables in the program instead of fixed numerical values.

### Example NC blocks

15 FN0: Q10=25	Assign
...	Q10 is assigned the value 25
25 L X +Q10	Means L X +25

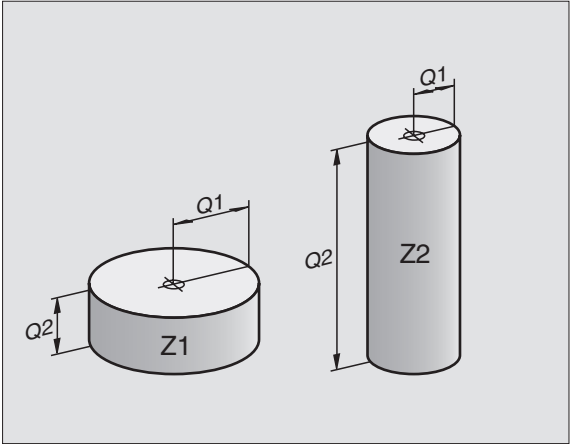
You need write only one program for a whole family of parts, entering the characteristic dimensions as Q parameters.

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









# 11.3 Describing Contours through Mathematical Operations

## Function

The Q parameters listed below enable you to program basic mathematical functions in a part program:

- ▶ Select a Q parameter function: Press the Q key (in the numerical keypad at right). The Q parameter functions are displayed in a soft-key row.
- ▶ To select the mathematical functions, press the BASIC ARITHMETIC soft key. The TNC then displays the following soft keys:

## Overview

Function	Soft key
<b>FN0: ASSIGN</b> Example: <b>FN0: Q5 = +60</b> Assigns a numerical value.	
<b>FN1: ADDITION</b> Example: <b>FN1: Q1 = -Q2 + -5</b> Calculates and assigns the sum of two values.	
<b>FN2: SUBTRACTION</b> Example: <b>FN2: Q1 = +10 - +5</b> Calculates and assigns the difference of two values.	
<b>FN3: MULTIPLICATION</b> Example: <b>FN3: Q2 = +3 * +3</b> Calculates and assigns the product of two values.	
<b>FN4: DIVISION</b> Example: <b>FN4: Q4 = +8 DIV +Q2</b> Calculates and assigns the quotient of two values. <b>Not permitted:</b> Division by 0	
<b>FN5: SQUARE ROOT</b> Example: <b>FN5: Q20 = SQRT 4</b> Calculates and assigns the square root of a number. <b>Not permitted:</b> Square root of a negative number	

To the right of the “=” character you can enter the following:

- 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:

**Q** Call the Q parameter functions by pressing the Q key.

**BASIC ARITHM.** To select the mathematical functions, press the BASIC ARITHMETIC soft key.

**FN0 X = Y** To select the Q parameter function ASSIGN, press the FN0 X = Y soft key.

PARAMETER NO. FOR RESULT?

5 **ENT** Enter the number of the Q parameter, e.g. 5.

1ST VALUE OR PARAMETER?

10 **ENT** Assign the value 10 to Q5.

**Q** Call the Q parameter functions by pressing the Q key.

**BASIC ARITHM.** To select the mathematical functions, press the BASIC ARITHMETIC soft key.

**FN3 X \* Y** To select the Q parameter function MULTIPLICATION, press the FN3 X \* Y soft key.

PARAMETER NO. FOR RESULT?

12 **ENT** Enter the number of the Q parameter, e.g. 12.

1ST VALUE OR PARAMETER?

Q5 **ENT** Enter Q5 for the first value.

2ND VALUE OR PARAMETER?

7 **ENT** Enter 7 for the second value.

Example: Program blocks in the TNC

```
16 FN0: Q5 = +10
17 FN3: Q12 = +Q5 * +7
```



# 11.4 Trigonometric Functions

## Definitions

Sine, cosine and tangent are terms designating the ratios of sides of right triangles. In this case:

**Sine:**  $\sin \alpha = a / c$

**Cosine:**  $\cos \alpha = b / c$

**Tangent:**  $\tan \alpha = a / b = \sin \alpha / \cos \alpha$

where

- c is the side opposite the right angle
- a is the side opposite the angle  $\alpha$
- b is the third side.

The TNC can find the angle from the tangent:

$$\alpha = \arctan (a / b) = \arctan (\sin \alpha / \cos \alpha)$$

### Example:

$$a = 25 \text{ mm}$$

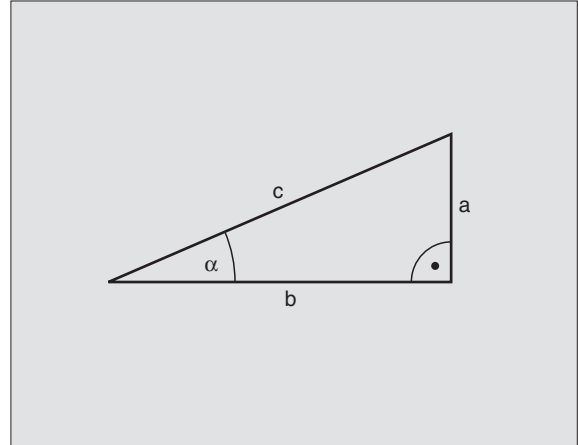
$$b = 50 \text{ mm}$$

$$\alpha = \arctan (a / b) = \arctan 0.5 = 26.57^\circ$$

Furthermore:

$$a^2 + b^2 = c^2 \text{ (where } a^2 = a \times a \text{)}$$

$$c = \sqrt{(a^2 + b^2)}$$



Programming trigonometric functions

Press the ANGLE FUNCTION soft key to call the angle functions. The TNC then displays the following soft keys:

Programming: Compare "Example: Programming fundamental operations."

Function	Soft key
<b>FN6: SINE</b> Example: <b>FN6: Q20 = SIN-Q5</b> Calculates the sine of an angle in degrees (°) and assigns it to a parameter.	<div>FN6 SIN(X)</div>
<b>FN7: COSINE</b> Example: <b>FN7: Q21 = COS-Q5</b> Calculate the cosine of an angle in degrees (°) and assign it to a parameter.	<div>FN7 COS(X)</div>
<b>FN8: ROOT SUM OF SQUARES</b> Example: <b>FN8: Q10 = +5 LEN +4</b> Calculate and assign length from two values.	<div>FN8 X LEN Y</div>
<b>FN13: ANGLE</b> Example: <b>FN13: Q20 = +25 ANG-Q1</b> Calculates the angle from the arc tangent of two sides or from the sine and cosine of the angle (0 < angle < 360°) and assigns it to a parameter.	<div>FN13 X ANG Y</div>





# 11.5 Calculating Circles

## Function

The TNC 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 if you wish to determine the location and size of a bore hole or a pitch circle using the programmable probing function.

Function	Soft key
FN23: Determining the CIRCLE DATA from three points Example: <b>FN23: Q20 = CDATA Q30</b>	<div>FN23 3 POINTS OF CIRCLE</div>


The coordinate pairs for three points of the circle must be stored in Parameter Q30 and in the following five parameters, i.e. to Q35.

The TNC then stores the circle center of the reference axis (X with spindle axis Z) in Parameter Q20, the circle center of the minor axis (Y with spindle axis Z) in Parameter Q21 and the circle radius in Parameter Q22.

Function	Soft key
FN24: Determining the CIRCLE DATA from four points Example: <b>FN24: Q20 = CDATA Q30</b>	<div>FN24 4 POINTS OF CIRCLE</div>

The coordinate pairs for four points of the circle must be stored in Parameter Q30 and in the following seven parameters, i.e. to Q37.

The TNC then stores the circle center of the reference axis (X with spindle axis Z) in Parameter Q20, the circle center of the minor axis (Y with spindle axis Z) in Parameter Q21 and the circle radius in Parameter Q22.



Note that FN23 and FN24 automatically overwrite the resulting parameter and the two following parameters.



# 11.6 If-Then Decisions with Q Parameters

## Function

The TNC can make logical If-Then decisions by comparing a Q parameter with another Q parameter or with a numerical value. If the condition is fulfilled, the TNC continues the program at the label that is programmed after the condition (for information on labels, see "Labeling Subprograms and Program Section Repeats" on page 486). If it is not fulfilled, the TNC continues with the next block.

To call another program as a subprogram, enter PGM CALL after the block with the target label.

## Unconditional jumps

An unconditional jump is programmed by entering a conditional jump whose condition is always true. Example:

FN9: IF+10 EQU+10 GOTO LBL1

## Programming If-Then decisions

Press the JUMP soft key to call the If-Then conditions. The TNC then displays the following soft keys:

Function	Soft key
<b>FN9: IF EQUAL, JUMP</b> Example: <b>FN9: IF +Q1 EQU +Q3 GOTO LBL "UPCAN25"</b> If the two values or parameters are equal, jump to the given label.	<div>FN9 IF X EQ Y GOTO</div>
<b>FN10: IF NOT EQUAL, JUMP</b> Example: <b>FN10: IF +10 NE -Q5 GOTO LBL 10</b> If the two values or parameters are not equal, jump to the given label.	<div>FN10 IF X NE Y GOTO</div>
<b>FN11: IF GREATER THAN, JUMP</b> Example: <b>FN11: IF+Q1 GT+10 GOTO LBL 5</b> If the first parameter or value is greater than the second value or parameter, jump to the given label.	<div>FN11 IF X GT Y GOTO</div>
<b>FN12: IF LESS THAN, JUMP</b> Example: <b>FN12: IF+Q5 LT+0 GOTO LBL "ANYNAME"</b> If the first value or parameter is less than the second value or parameter, jump to the given label.	<div>FN12 IF X LT Y GOTO</div>



## Abbreviations used:

<b>IF</b>	:	If
<b>EQU</b>	:	Equals
<b>NE</b>	:	Not equal
<b>GT</b>	:	Greater than
<b>LT</b>	:	Less than
<b>GOTO</b>	:	Go to



## 11.7 Checking and Changing Q Parameters

### Procedure

You can check and edit Q parameters when writing, testing and running programs in the Programming and Editing, Test Run, Program Run Full Sequence, and Program Run Single Block modes.

- ▶ If you are in a program run, interrupt it if required (for example, by pressing the machine STOP button and the INTERNAL STOP soft key). If you are in a test run, interrupt it.



- ▶ To call Q parameter functions: Press the Q key or the Q INFO soft key in the Programming and Editing mode of operation.
- ▶ The TNC lists all parameters and their current values. With the arrow keys or the soft keys, go pagewise to the desired parameters.
- ▶ If you would like to change the value, enter a new value and confirm with the ENT key.
- ▶ To leave the value unchanged, press the PRESENT VALUE soft key or end the dialog with the END key.



The parameters used by the TNC are provided with comments.



# 11.8 Additional Functions

## Overview

Press the DIVERSE FUNCTION soft key to call the additional functions. The TNC then displays the following soft keys:

Function	Soft key
<b>FN14:ERROR</b> Output error messages	FN14 ERROR=
<b>FN15:PRINT</b> Unformatted output of texts or Q parameter values	FN15 PRINT
<b>FN16:F-PRINT</b> Formatted output of texts or Q parameter values	FN16 F-PRINT
<b>FN18:SYS-DATUM READ</b> Read system data	FN18 SYS-DATUM READ
<b>FN19:PLC</b> Transfer values to the PLC	FN19 PLC=
<b>FN20:WAIT FOR</b> Synchronize NC and PLC	FN20 WAIT FOR
<b>FN25:PRESET</b> Set datum during program run	FN25 SET DATUM
<b>FN26:TABOPEN</b> Open a freely definable table	FN26 OPEN TABLE
<b>FN27:TABWRITE</b> Write to a freely definable table	FN27 WRITE TO TABLE
<b>FN28:TABREAD</b> Read from a freely definable table	FN28 READ FROM TABLE



FN14: ERROR: Displaying error messages

With the function FN14: ERROR you can call messages under program control. The messages were programmed by the machine tool builder or by HEIDENHAIN. Whenever the TNC comes to a block with FN 14 in the Program Run or Test Run mode, it interrupts the program run and displays a message. The program must then be restarted. The error numbers are listed in the table below.

Range of error numbers	Standard dialog text
0 ... 299	FN 14: Error code 0 .... 299
300 ... 999	Machine-dependent dialog
1000 ... 1099	Internal error messages (see table at right)

Example NC block

The TNC is to display the text stored under error number 254.

```
180 FN14: ERROR = 254
```

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	MIRRORING not permitted
1009	Datum shift not permitted
1010	Feed rate is missing
1011	Entry value incorrect
1012	Wrong sign programmed
1013	Entered angle not permitted
1014	Touch point inaccessible
1015	Too many points
1016	Contradictory entry
1017	CYCL incomplete
1018	Plane wrongly defined
1019	Wrong axis programmed
1020	Wrong RPM
1021	Radius comp. undefined
1022	Rounding-off undefined
1023	Rounding radius too large
1024	Program start undefined
1025	Excessive subprogramming
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	Enter Q218 greater than Q219
1033	CYCL 210 not permitted
1034	CYCL 211 not permitted
1035	Q220 too large
1036	Enter Q222 greater than Q223
1037	Q244 must be greater than 0
1038	Q245 must not equal Q246
1039	Angle range must be < 360°
1040	Enter Q223 greater than Q222
1041	Q214: 0 not permitted



Error number	Text
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
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 0
1067	Enter Q247 greater than 5
1068	Datum table?
1069	Enter direction Q351 unequal 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 a negative value
1078	Q303 not defined in measuring cycle
1079	Tool axis not allowed
1080	Calculated values incorrect
1081	Contradictory measuring points
1082	Clearance height entered incorrectly
1083	Contradictory type of plunging
1084	Machining cycle not permitted
1085	Line is write-protected
1086	No point angle defined



FN15: PRINT: Output of texts or Q parameter values



Setting the data interface: In the menu option PRINT or PRINT-TEST, you must enter the path for storing the texts or Q parameters. See “Assign,” page 578.

FN15 cannot transfer data over the Ethernet interface.

The function FN15: PRINT transfers Q parameter values and error messages through the data interface, for example to a printer. When you save the data in the TNC memory or transfer them to a PC, the TNC stores the data in the file %FN 15RUN.A (output in program run mode) or in the file %FN15SIM.A (output in test run mode).

The data are transmitted from a buffer. Data output begins at the latest by program end or when you stop the program. In the Single Block mode of operation, data transfer begins at block end.

To output dialog texts and error messages with FN 15: PRINT “numerical value”

Numerical values from 0 to 99: Dialog texts for OEM cycles

Numerical values 100 and above: PLC error messages

Example: Output of dialog text 20

67 FN15: PRINT 20

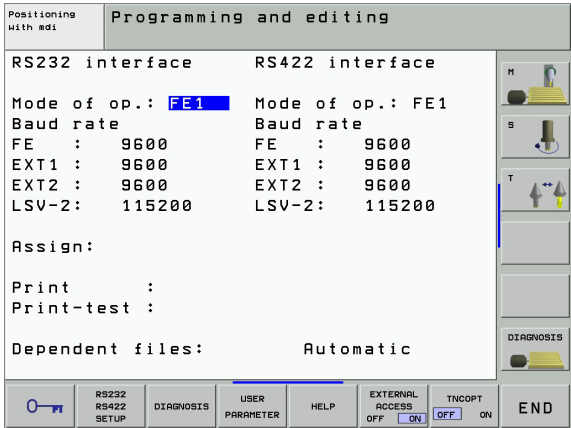
Outputting dialog texts and Q parameters with FN15: PRINT “Q parameter”

Application example: Recording workpiece measurement.

You can transfer up to six Q parameters and numerical values simultaneously. The TNC separates them with slashes.

Example: Output of dialog text 1 and numerical value for Q1

70 FN15: PRINT1/Q1





## FN16: F-PRINT: Formatted output of texts or Q parameter values



Setting the data interface: In the menu option PRINT or PRINT-TEST, you must enter the path for storing the text file. See "Assign," page 578.

FN16 cannot transfer data over the Ethernet interface.

With FN16, you can also output to the screen any messages from the NC program. Such messages are displayed by the TNC in a pop-up window.

The function FN16: F-PRINT transfers Q parameter values and texts in a selectable format through the data interface, for example to a printer. If you save the values internally or send them to a computer, the TNC saves the data in the file that you defined in the FN 16 block.

To output the formatted texts and Q parameter values, create a text file with the TNC's text editor. In this file you then define the output format and Q parameters you want to output.

Example of a text file to define the output format:

"TEST RECORD IMPELLER CENTER OF GRAVITY";

"DATE: %2d-%2d-%4d", DAY, MONTH, YEAR4;

"TIME: %2d:%2d:%2d", HOUR, MIN, SEC; "

"\_\_\_\_\_"

"NO. OF MEASURED VALUES : = 1";

"\*\*\*\*\*";#

"X1 = %9.3LF", Q31;

"Y1 = %9.3LF", Q32;

"Z1 = %9.3LF", Q33;

"\*\*\*\*\*";



When you create a text file, use the following formatting functions:

Special character	Function
"....."	Define the output format for texts and variables between the quotation marks.
%9.3LF	Define format for Q parameter: 9 places in total (with decimal point), three of which are decimal places, long, floating (decimal number)
%S	Format for text variable
,	Separation character between output format and parameter
;	End of block character

The following functions allow you to include the following additional information in the protocol log file:

Code word	Function
CALL_PATH	Gives the path for the NC program where you will find the FN16 function. Example: "Measuring program: %S",CALL_PATH;
M_CLOSE	Closes the file to which you are writing with FN16. Example: M_CLOSE;
L_ENGLISH	Display the text only in English conversational language
L_GERMAN	Display the text only in German conversational language
L_CZECH	Display text only in Czech conversational language
L_FRENCH	Display text only in French conversational language
L_ITALIAN	Display text only in Italian conversational language
L_SPANISH	Display text only in Spanish conversational language
L_SWEDISH	Output text only in Swedish conversational language
L_DANISH	Display text only in Danish conversational language
L_FINNISH	Display text only in Finnish conversational language
L_DUTCH	Display the text only in Dutch conversational language
L_POLISH	Display text only in Polish conversational language
L_HUNGARIA	Display text only in Hungarian conversational language



Code word	Function
L_ALL	Display the text independent of the conversational language
HOURL	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
YEAR4	Four-digit year from the real-time clock

In the part program, program **FN 16: F-PRINT**, to activate the output:

```
96 FN16: F-PRINT TNC:\MASKE\MASKE1.A /
RS232:\PROT1.TXT
```

The TNC then outputs the file PROT1.TXT through the serial interface:

**CALIBRAT. CHART IMPELLER CENTER GRAVITY**

**DATE: 27:11:2001**

**TIME: 8:56:34**

**NO. OF MEASURED VALUES : = 1**


\*\*\*\*\*

**X1 = 149.360**

**Y1 = 25.509**

**Z1 = 37.000**

\*\*\*\*\*



If you use FN 16 several times in the program, the TNC saves all texts in the file that you have defined with the first FN 16 function. The file is not output until the TNC reads the END PGM block, or you press the NC stop button, or you close the file with M\_CLOSE.

In the FN16 block, program the format file and the log file with their respective extensions.

If you enter only the file name for the path of the log file, the TNC saves the log file in the directory in which the NC program with the FN16 function is located.



## Displaying messages on the TNC screen

You can also use the function FN16 to display any messages from the NC program in a pop-up window on the TNC screen. This makes it easily possible to display explanatory texts, including long texts, at any point in the program in a way that the user has to react to it. You can also display Q-parameter contents if the protocol description file contains such instructions.

For the message to appear on the TNC screen, you need only enter **SCREEN:** as the name of the protocol file.

```
96 FN16: F-PRINT 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.

To close the pop-up window, press the CE key.



All the previously described conventions apply for the protocol description file.

If you output to the screen more than one text in the program, the TNC appends all texts to the end of the text already displayed. To display each text individually on the screen, program the function M\_CLOSE at the end of the protocol description file.

## FN18: SYS-DATUM READ Read system data

With the function FN 18: SYS-DATUM READ you can read system data and store them in Q parameters. You select the system data through a group number (ID number), and additionally through a number and an index.

Group name, ID No.	Number	Index	Meaning
Program information, 10	1	-	MM/inch condition
	2	-	Overlap factor for pocket milling
	3	-	Number of active fixed cycle
Machine status, 20	1	-	Active tool number
	2	-	Prepared tool number
	3	-	Active tool axis 0=X, 1=Y, 2=Z, 6=U, 7=V, 8=W
	4	-	Programmed spindle rpm
	5	-	Active spindle status: -1=undefined, 0=M3 active, 1=M4 active, 2=M5 after M3, 3=M5 after M4
	8	-	Coolant status: 0=off, 1=on
	9	-	Active feed rate
	10	-	Index of the prepared tool
	11	-	Index of the active tool
	1	-	Set-up clearance of active fixed cycle
	2	-	Drilling depth / milling depth of active fixed cycle
Cycle parameter, 30	3	-	Plunging depth of active fixed cycle
	4	-	Feed rate for pecking in active fixed cycle
	5	-	1st side length for rectangular pocket cycle
	6	-	2nd side length for rectangular pocket cycle
	7	-	1st side length for slot cycle
	8	-	2nd side length for slot cycle
	9	-	Radius for circular pocket cycle
	10	-	Feed rate for milling in active fixed cycle
	11	-	Direction of rotation for active fixed cycle
	12	-	Dwell time for active fixed cycle
	13	-	Thread pitch for Cycles 17, 18



Group name, ID No.	Number	Index	Meaning
	14	-	Milling allowance for active fixed cycle
	15	-	Direction angle for rough out in active fixed cycle
Data from the tool table, 50	1	Tool no.	Tool length
	2	Tool no.	Tool radius
	3	Tool no.	Tool radius R2
	4	Tool no.	Oversize for tool length DL
	5	Tool no.	Oversize for tool radius DR
	6	Tool no.	Oversize for tool radius DR2
	7	Tool no.	Tool inhibited (0 or 1)
	8	Tool no.	Number of replacement tool
	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 teeth CUT
	16	Tool no.	TT: Wear tolerance for length LTOL
	17	Tool no.	TT: Wear tolerance for radius RTOL
	18	Tool no.	TT: Rotational direction DIRECT (0=positive/-1=negative)
	19	Tool no.	TT: Offset for radius R-OFFS
	20	Tool no.	TT: Offset for length L-OFFS
	21	Tool no.	TT: Breakage tolerance in length LBREAK
	22	Tool no.	TT: Breakage tolerance in radius RBREAK
No index: Data of the currently active tool			
Pocket table data, 51	1	Pocket number	Tool number
	2	Pocket number	Special tool: 0=no, 1=yes
	3	Pocket number	Fixed pocket: 0=no, 1=yes

Group name, ID No.	Number	Index	Meaning
	4	Pocket number	Locked pocket: 0=no, 1=yes
	5	Pocket number	PLC status
Pocket number of a tool in the tool-pocket table, 52	1	Tool no.	Pocket number
Immediately after TOOL CALL programmed position, 70	1	-	Position valid / invalid (1/0)
	2	1	X axis
	2	2	Y axis
	2	3	Z axis
	3	-	Programmed feed rate (-1: no feed rate programmed)
Active tool compensation, 200	1	-	Tool radius (including delta values)
	2	-	Tool length (including delta values)
Active transformations, 210	1	-	Basic rotation in MANUAL OPERATION mode
	2	-	Programmed rotation with Cycle 10
	3	-	Active mirror axis
			0: mirroring not active
			+1: X axis mirrored
			+2: Y axis mirrored
			+4: Z axis mirrored
			+64: U axis mirrored
			+128: V axis mirrored
			+256: W axis mirrored
			Combinations = sum of individual axes
	4	1	Active scaling factor in X axis
	4	2	Active scaling factor in Y axis
	4	3	Active scaling factor in Z axis
	4	7	Active scaling factor in U axis
	4	8	Active scaling factor in V axis
	4	9	Active scaling factor in W axis



Group name, ID No.	Number	Index	Meaning
	5	1	3-D ROT A axis
	5	2	3-D ROT B axis
	5	3	3-D ROT C axis
	6	-	Tilted working plane active / inactive (-1/0) in a Program Run operating mode
	7	-	Tilted working plane active / inactive (-1/0) in a Manual operating mode
Active datum shift, 220	2	1	X axis
		2	Y axis
		3	Z axis
		4	A axis
		5	B axis
		6	C axis
		7	U axis
		8	V axis
		9	W axis
Traverse range, 230	2	1 to 9	Negative software limit switch in axes 1 to 9
	3	1 to 9	Positive software limit switch in axes 1 to 9
Nominal position in the REF system, 240	1	1	X axis
		2	Y axis
		3	Z axis
		4	A axis
		5	B axis
		6	C axis
		7	U axis
		8	V axis
		9	W axis
Current position in the active coordinate system, 270	1	1	X axis
		2	Y axis





Group name, ID No.	Number	Index	Meaning
		3	Z axis
		4	A axis
		5	B axis
		6	C axis
		7	U axis
		8	V axis
		9	W axis
Status of M128, 280	1	-	0: M128 inactive, -1: M128 active
	2	-	Feed rate that was programmed with M128
Triggering touch probe, 350	10	-	Touch probe axis
	11	-	Effective ball radius
	12	-	Effective length
	13	-	Radius setting ring
	14	1	Center misalignment in reference axis
		2	Center misalignment in minor axis
	15	-	Direction of center misalignment compared with 0° position
TT 130 Tool Touch Probe	20	1	Center point X axis (REF system)
		2	Center point Y axis (REF system)
		3	Center point Z axis (REF system)
	21	-	Probe contact radius
Measuring touch probe, 350	30	-	Calibrated stylus length
	31	-	Stylus radius 1
	32	-	Stylus radius 2
	33	-	Setting ring diameter
	34	1	Center misalignment in reference axis
		2	Center misalignment in minor axis
	35	1	Compensation factor for 1st axis
		2	Compensation factor for 2nd axis
		3	Compensation factor for 3rd axis



Group name, ID No.	Number	Index	Meaning
	36	1	Power ratio for 1st axis
		2	Power ratio for 2nd axis
		3	Power ratio for 3rd axis
Last touch point in TCH PROBE Cycle 0 or last touch point from manual operating mode, 360	1	1 to 9	Position in the active coordinate system in axes 1 to 9
	2	1 to 9	Position in the REF system in axes 1 to 9
Value from the active datum table in the active coordinate system, 500	Datum number	1 to 9	X axis to W axis
REF value from the active datum table, 501	Datum number	1 to 9	X axis to W axis
Datum table selected, 505	1	-	Return code = 0: No datum table active Return code = 1: Datum table active
Data from the active pallet table, 510	1	-	Active line
	2	-	Palette number from PAL/PGM field
Existence of machine parameter, 1010	MP number	MP index	Return value = 0: MP does not exist Return code = 1: MP exists

**Example: Assign the value of the active scaling factor for the Z axis to Q25**

```
55 FN18: SYSREAD Q25 = ID210 NR4 IDX3
```

**FN19: PLC: Transferring values to the PLC**

The function FN 19: PLC transfers up to two numerical values or Q parameters to the PLC.


Increments and units: 0.1 µm or 0.0001°

**Example: Transfer the numerical value 10 (which means 1 µm or 0.001°) to the PLC**

```
56 FN19: PLC=+10/+Q3
```



# FN20: WAIT FOR: NC and PLC synchronization



This function may only be used with the permission of your machine tool builder.

With function FN 20: WAIT FOR you can synchronize the NC and PLC with each other during a program run. The NC stops machining until the condition that you have programmed in the FN 20 block is fulfilled. With FN10 the TNC can check the following operands:

PLC operand	Abbreviation	Address range
Marker	M	0 to 4999
Input	I	0 to 31, 128 to 152 64 to 126 (first PL 401 B) 192 to 254 (second PL 401 B)
Output	O	0 to 30 32 to 62 (first PL 401 B) 64 to 94 (second PL 401 B)
Counter	C	48 to 79
Timer	T	0 to 95
Byte	B	0 to 4095
Word	W	0 to 2047
Double word	D	2048 to 4095

The following conditions are permitted in the FN 20 block:

Condition	Abbreviation
Equals	==
Less than	<
Greater than	>
Less than or equal	<=
Greater than or equal	>=

**Example: Stop program run until the PLC sets marker 4095 to 1**

```
32 FN20: WAIT FOR M4095==1
```



## FN 25: PRESET: Setting a new datum



This function can only be programmed if you have entered the code number 555343 (see “Code Numbers” on page 575).

With the function FN 25: PRESET, it is possible to set a new datum in an axis of choice during program run.

- ▶ Select a Q parameter function: Press the Q key (in the numerical keypad at right). The Q parameter functions are displayed in a soft-key row.
- ▶ To select the additional functions, press the DIVERSE FUNCTIONS soft key.
- ▶ Select FN25: Switch the soft-key row to the second level, press the FN25 DATUM SET soft key.
- ▶ **Axis?:** Enter the axis where you wish to set the new datum and confirm with ENT.
- ▶ **Value to be calculated?:** Enter the coordinate for the new datum point in the active coordinate system.
- ▶ **New datum?:** Enter the coordinate that the value to be converted should have in the new coordinate system.

**Example: Set a new datum at the current coordinate X+100**

56 FN25: PRESET = X/+100/+0

**Example: The current coordinate Z+50 will have the value –20 in the new coordinate system**

56 FN25: PRESET = Z/+50/-20



With the miscellaneous function M104 you can reactivate the datum that was last set in the Manual Operation mode (see “Activating the most recently entered datum: M104” on page 234).

## FN26:TABOPEN: Opening a freely definable table

With FN 26: TABOPEN you can define a table to be written with FN27, or to be read from with FN28.



Only one table can be open in an NC program. A new block with TABOPEN automatically closes the last opened table.

The table to be opened must have the file name extension .TAB.

**Example: Open the table TAB1.TAB, which is saved in the directory TNC:DIR1.**

```
56 FN26: TABOPEN TNC:\DIR1\TAB1.TAB
```

## FN27: TABWRITE: Writing to a freely definable table

After you have opened a table with FN 26 TABOPEN, you can use function FN 27: TABWRITE to write to it.

You can define and write up to 8 column names in a TABWRITE block. The column names must be written between quotation marks and separated by a comma. You define the values that the TNC is to write to the respective column with Q parameters.



You can write only to numerical table fields.

If you wish to write to more than one column in a block, you must save the values under successive Q parameter numbers.

### 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 must be saved in the Q parameters Q5, Q6 and Q7.

```
53 FN0: Q5 = 3,75
```

```
54 FN0: Q6 = -5
```

```
55 FN0: Q7 = 7,5
```

```
56 FN27: TABWRITE 5/"RADIUS,DEPTH,D" = Q5
```



## FN28:TABREAD: Reading a freely definable table

After you have opened a table with FN 26 TABOPEN, you can use function FN 28: TABREAD to read from it.

You can define, i.e. read, up to 8 column names in a TABREAD block. The column names must be written between quotation marks and separated by a comma. In the FN 28 block you can define the Q parameter number in which the TNC is to write the value that is first read.



You can read only numerical table fields.

If you wish to read from more than one column in a block, the TNC will save the values under successive Q parameter numbers.

### Example:

You wish to read the values of the columns "Radius," "Depth" and "D" from line 6 of the presently opened table. Save the first value in Q parameter Q10 (second value in Q11, third value in Q12).














```
56 FN28: TABREAD Q10 = 6/"RADIUS,DEPTH,D"
```

# 11.9 Entering Formulas Directly

## Entering formulas

You can enter mathematical formulas that include several operations directly into the part program by soft key.

Press the FORMULA soft key to call the formula functions. The TNC displays the following soft keys in several soft-key rows:

Logic command	Soft key
<b>Addition</b> Example: $Q10 = Q1 + Q5$	
<b>Subtraction</b> Example: $Q25 = Q7 - Q108$	
<b>Multiplication</b> Example: $Q12 = 5 * Q5$	
<b>Division</b> Example: $Q25 = Q1 / Q2$	
<b>Opening parenthesis</b> Example: $Q12 = Q1 * (Q2 + Q3)$	
<b>Closing parenthesis</b> Example: $Q12 = Q1 * (Q2 + Q3)$	
<b>Square of a value</b> Example: $Q15 = SQ\ 5$	
<b>Square root</b> Example: $Q22 = SQRT\ 25$	
<b>Sine of an angle</b> Example: $Q44 = SIN\ 45$	
<b>Cosine of an angle</b> Example: $Q45 = COS\ 45$	
<b>Tangent of an angle</b> Example: $Q46 = TAN\ 45$	
<b>Arc sine</b> Inverse of the sine. Determine the angle from the ratio of the opposite side to the hypotenuse. Example: $Q10 = ASIN\ 0.75$	
<b>Arc cosine</b> Inverse of the cosine. Determine the angle from the ratio of the adjacent side to the hypotenuse. Example: $Q11 = ACOS\ Q40$	



Logic command	Soft key
<b>Arc tangent</b> Inverse of the tangent. Determine the angle from the ratio of the opposite to the adjacent side. Example: Q12 = ATAN Q50	ATAN
<b>Powers of values</b> Example: Q15 = 3^3	^
<b>Constant "pi" (3.14159)</b> Example: Q15 = PI	PI
<b>Natural logarithm (LN) of a number</b> Base 2.7183 Example: Q15 = LN Q11	LN
<b>Logarithm of a number, base 10</b> Example: Q33 = LOG Q22	LOG
<b>Exponential function, 2.7183 to the power of n</b> Example: Q1 = EXP Q12	EXP
<b>Negate (multiplication by -1)</b> Example: Q2 = NEG Q1	NEG
<b>Truncate decimal places</b> Form an integer Example: Q3 = INT Q42	INT
<b>Absolute value of a number</b> Example: Q4 = ABS Q22	ABS
<b>Truncate places before the decimal point</b> Form a fraction Example: Q5 = FRAC Q23	FRAC
<b>Check algebraic sign of a number</b> Example: Q12 = SGN Q50 If result for Q12 = 1, then Q50 >= 0 If result for Q12 = -1, then Q50 < 0	SGN
<b>Calculate modulo value</b> Example: Q12 = 400 % 360 Result: Q12 = 40	%





## Rules for formulas

Mathematical formulas are programmed according to the following rules:

### Higher-level operations are performed first

**12**  $Q1 = 5 * 3 + 2 * 10 = 35$

**1st** calculation step  $5 * 3 = 15$

**2nd** calculation step  $2 * 10 = 20$

**3rd** calculation step  $15 + 20 = 35$

or

**13**  $Q2 = SQ 10 - 3^3 = 73$

**1st** calculation step  $10^2 = 100$

**2nd** calculation step  $3^3 = 27$

**3rd** calculation step  $100 - 27 = 73$

### Distributive law

for calculating with parentheses

$$a * (b + c) = a * b + a * c$$



## Programming example

Calculate an angle with the arc tangent from the opposite side (Q12) and adjacent side (Q13); then store in Q25.

**Q** **FORMULA** To select the formula entering function, press the Q key and FORMULA soft key.

PARAMETER NO. FOR RESULT?

**ENT** 25 Enter the parameter number.

**▷** **ATAN** Shift the soft-key row and select the arc tangent function.

**◁** **⌈** Shift the soft-key row and open the parentheses.

**Q** 12 Enter Q parameter number 12.

**/** Select division.

**Q** 13 Enter Q parameter number 13.

**⌋** **END** Close parentheses and conclude formula entry.

### Example NC block

37 Q25 = ATAN (Q12/Q13)



# 11.10 Preassigned Q Parameters

The Q parameters Q100 to Q122 are assigned values by the TNC. These values include:

- Values from the PLC
- Tool and spindle data
- Data on operating status, etc.

## Values from the PLC: Q100 to Q107

The TNC uses the parameters Q100 to Q107 to transfer values from the PLC to 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 TOOL DEF block)
- Delta value DR from the tool table
- Delta value DR from the TOOL CALL block

## Tool axis: Q109

The value of Q109 depends on the current tool axis:

Tool axis	Parameter value
No tool axis defined	Q109 = -1
X axis	Q109 = 0
Y axis	Q109 = 1
Z axis	Q109 = 2
U axis	Q109 = 6
V axis	Q109 = 7
W axis	Q109 = 8



Spindle status: Q110

The value of Q110 depends on which M function was last programmed for the spindle:

M Function	Parameter value
No spindle status defined	Q110 = -1
M03: Spindle ON, clockwise	Q110 = 0
M04: Spindle ON, counterclockwise	Q110 = 1
M05 after M03	Q110 = 2
M05 after M04	Q110 = 3

Coolant on/off: Q111

M Function	Parameter value
M08: Coolant ON	Q111 = 1
M09: Coolant OFF	Q111 = 0

Overlap factor: Q112

The overlap factor for pocket milling (MP7430) is assigned to Q112.

Unit of measurement for dimensions in the program: Q113

The value of parameter Q113 specifies whether the highest-level NC program (for nesting with PGM CALL) is programmed in millimeters or inches.

Dimensions of the main program	Parameter value
Metric system (mm)	Q113 = 0
Inch system (inches)	Q113 = 1

Tool length: Q114

The current value for the tool length is assigned to Q114.



## Coordinates after probing during program run

The parameters Q115 to Q119 contain the coordinates of the spindle position at the moment of contact during programmed measurement with the 3-D touch probe. The coordinates are referenced to the datum that is currently active in the Manual operating mode.

The length and radius of the probe tip are not compensated in these coordinates.

Coordinate axis	Parameter value
X axis	Q115
Y axis	Q116
Z axis	Q117
IVth axis dependent on MP100	Q118
Vth axis dependent on MP100	Q119

## Deviation between actual value and nominal value during automatic tool measurement with the TT 130

Actual-nominal deviation	Parameter value
Tool length	Q115
Tool radius	Q116

## Tilting the working plane with mathematical angles: Rotary axis coordinates calculated by the TNC

coordinates	Parameter value
A axis	Q120
B axis	Q121
C axis	Q122



Measurement results from touch probe cycles  
(see also User’s Manual for Touch Probe Cycles)

Measured actual values	Parameter value
Angle of a straight line	Q150
Center in reference axis	Q151
Center in minor axis	Q152
Diameter	Q153
Length of pocket	Q154
Width of pocket	Q155
Length in the axis selected in the cycle	Q156
Position of the center line	Q157
Angle of the A axis	Q158
Angle of the B axis	Q159
Coordinate of the axis selected in the cycle	Q160

Determined deviation	Parameter value
Center in reference axis	Q161
Center in minor axis	Q162
Diameter	Q163
Length of pocket	Q164
Width of pocket	Q165
Measured length	Q166
Position of the center line	Q167

Determined solid angles	Parameter value
Rotation about the A axis	Q170
Rotation about the B axis	Q171
Rotation about the C axis	Q172



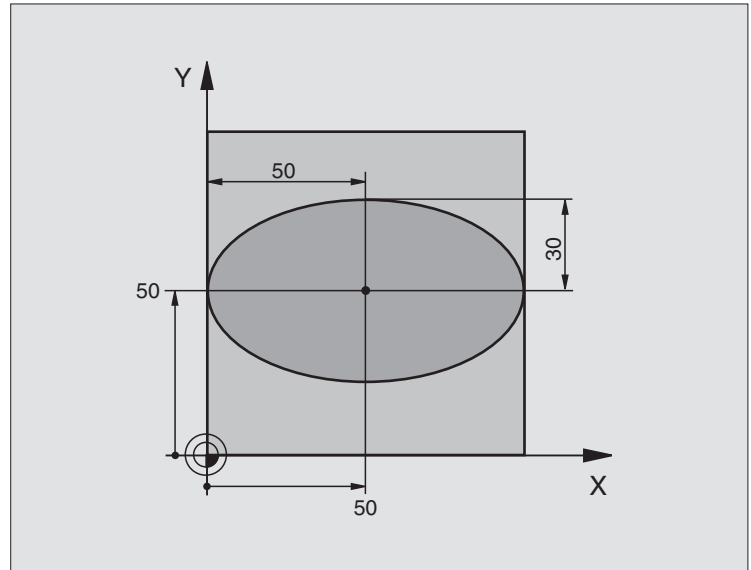
Workpiece status	Parameter value
Good	Q180
Re-work	Q181
Scrap	Q182
Measured deviation with cycle 440	Parameter value
X axis	Q185
Y axis	Q186
Z axis	Q187
Reserved for internal use	Parameter value
Markers for cycles (point patterns)	Q197
Number of the last active measuring cycle	Q198
Status during tool measurement with TT	Parameter value
Tool within tolerance	Q199 = 0,0
Tool is worn (LTOL/RTOL exceeded)	Q199 = 1,0
Tool is broken (LBREAK/RBREAK exceeded)	Q199 = 2,0



## Example: Ellipse

Program sequence

- The contour of the ellipse is approximated by many short lines (defined in Q7). The more calculation steps you define for the lines, the smoother the curve becomes.
- The machining direction can be altered by changing the entries for the starting and end angles in the plane:  
Clockwise machining direction:  
starting angle > end angle  
Counterclockwise machining direction:  
starting angle < end angle
- The tool radius is not taken into account.



0 BEGIN PGM ELLIPSE MM	
1 FN 0: Q1 = +50	Center in X axis
2 FN 0: Q2 =+50	Center in Y axis
3 FN 0: Q3 = +50	Semixaxis in X
4 FN 0: Q4 = +30	Semixaxis in Y
5 FN 0: Q5 = +0	Starting angle in the plane
6 FN 0: Q6 = +360	End angle in the plane
7 FN 0: Q7 = +40	Number of calculation steps
8 FN 0: Q8 = +0	Rotational position of the ellipse
9 FN 0: Q9 = +5	Milling depth
10 FN 0: Q10 = +100	Feed rate for plunging
11 FN 0: Q11 = +350	Feed rate for milling
12 FN 0: Q12 = +2	Set-up clearance for pre-positioning
13 BLK FORM 0.1 Z X+0 Y+0 Z-20	Define the workpiece blank
14 BLK FORM 0.2 X+100 Y+100 Z+0	
15 TOOL DEF 1 L+0 R+2.5	Define the tool
16 TOOL CALL 1 Z S4000	Tool call
17 L Z+250 R0 FMAX	Retract the tool
18 CALL LBL 10	Call machining operation
19 L Z+100 R0 FMAX M2	Retract in the tool axis, end program



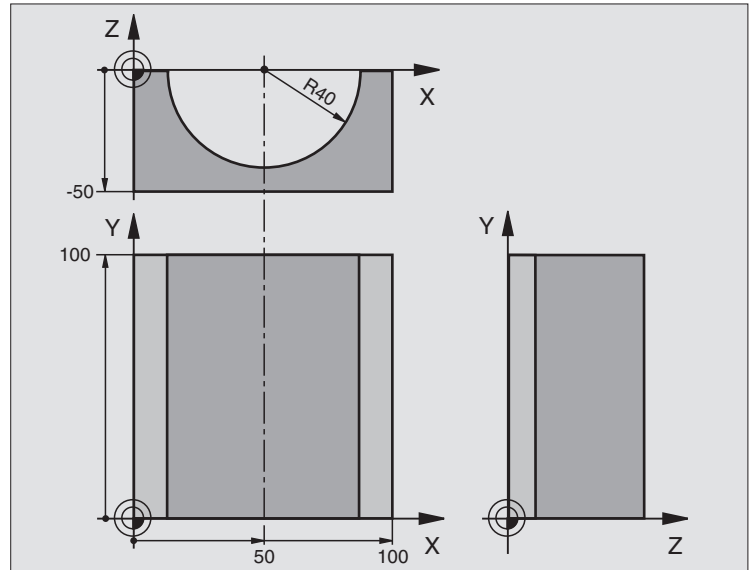
20 LBL 10	Subprogram 10: Machining operation
21 CYCL DEF 7.0 DATUM SHIFT	Shift datum to center of ellipse
22 CYCL DEF 7.1 X+Q1	
23 CYCL DEF 7.2 Y+Q2	
24 CYCL DEF 10.0 ROTATION	Account for rotational position in the plane
25 CYCL DEF 10.1 ROT+Q8	
26 Q35 = (Q6 - Q5) / Q7	Calculate angle increment
27 Q36 = Q5	Copy starting angle
28 Q37 = 0	Set counter
29 Q21 = Q3 * COS Q36	Calculate X coordinate for starting point
30 Q22 = Q4 * SIN Q36	Calculate Y coordinate for starting point
31 L X+Q21 Y+Q22 R0 FMAX M3	Move to starting point in the plane
32 L Z+Q12 R0 FMAX	Pre-position in tool axis to set-up clearance
33 L Z-Q9 R0 FQ10	Move to working depth
34 LBL 1	
35 Q36 = Q36 + Q35	Update the angle
36 Q37 = Q37 + 1	Update the counter
37 Q21 = Q3 * COS Q36	Calculate the current X coordinate
38 Q22 = Q4 * SIN Q36	Calculate the current Y coordinate
39 L X+Q21 Y+Q22 R0 FQ11	Move to next point
40 FN 12: IF +Q37 LT +Q7 GOTO LBL 1	Unfinished? If not finished, return to LBL 1
41 CYCL DEF 10.0 ROTATION	Reset the rotation
42 CYCL DEF 10.1 ROT+0	
43 CYCL DEF 7.0 DATUM SHIFT	Reset the datum shift
44 CYCL DEF 7.1 X+0	
45 CYCL DEF 7.2 Y+0	
46 L Z+Q12 F0 FMAX	Move to set-up clearance
47 LBL 0	End of subprogram
48 END PGM ELLIPSE MM	



## Example: Concave cylinder machined with spherical cutter

Program sequence

- Program functions only with a spherical cutter. The tool length refers to 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 curve becomes.
- The cylinder is milled in longitudinal cuts (here: parallel to the Y axis).
- The machining direction can be altered by changing the entries for the starting and end angles in space:  
Clockwise machining direction:  
starting angle > end angle  
Counterclockwise machining direction:  
starting angle < end angle
- The tool radius is compensated automatically.



0 BEGIN PGM CYLIN MM	
1 FN 0: Q1 = +50	Center in X axis
2 FN 0: Q2 =+0	Center in Y axis
3 FN 0: Q3 = +0	Center in Z axis
4 FN 0: Q4 = +90	Starting angle in space (Z/X plane)
5 FN 0: Q5 = +270	End angle in space (Z/X plane)
6 FN 0: Q6 = +40	Radius of the cylinder
7 FN 0: Q7 = +100	Length of the cylinder
8 FN 0: Q8 = +0	Rotational position in the X/Y plane
9 FN 0: Q10 = +5	Allowance for cylinder radius
10 FN 0: Q11 = +250	Feed rate for plunging
11 FN 0: Q12 = +400	Feed rate for milling
12 FN 0: Q13 = +90	Number of cuts
13 BLK FORM 0.1 Z X+0 Y+0 Z-50	Define the workpiece blank
15 BLK FORM 0.2 X+100 Y+100 Z+0	
15 TOOL DEF 1 L+0 R+3	Define the tool
16 TOOL CALL 1 Z S4000	Tool call
17 L Z+250 R0 FMAX	Retract the tool
18 CALL LBL 10	Call machining operation
19 FN 0: Q10 = +0	Reset allowance

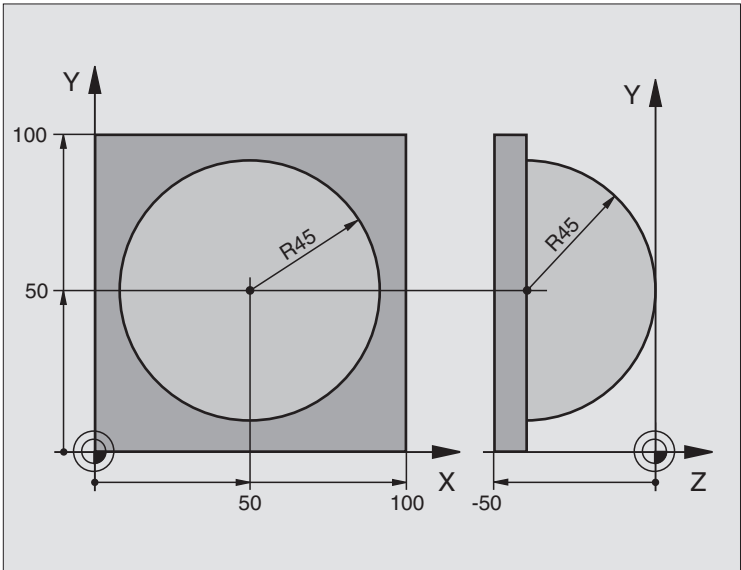
20 CALL LBL 10	Call machining operation
21 L Z+100 R0 FMAX M2	Retract in the tool axis, end program
22 LBL 10	Subprogram 10: Machining operation
23 Q16 = Q6 - Q10 - Q108	Account for allowance and tool, based on the cylinder radius
24 FN 0: Q20 = +1	Set counter
25 FN 0: Q24 = +Q4	Copy starting angle in space (Z/X plane)
26 Q25 = (Q5 - Q4) / Q13	Calculate angle increment
27 CYCL DEF 7.0 DATUM SHIFT	Shift datum to center of cylinder (X axis)
28 CYCL DEF 7.1 X+Q1	
29 CYCL DEF 7.2 Y+Q2	
30 CYCL DEF 7.3 Z+Q3	
31 CYCL DEF 10.0 ROTATION	Account for rotational position in the plane
32 CYCL DEF 10.1 ROT+Q8	
33 L X+0 Y+0 R0 FMAX	Pre-position in the plane to the cylinder center
34 L Z+5 R0 F1000 M3	Pre-position in the tool axis
35 LBL 1	
36 CC Z+0 X+0	Set pole in the Z/X plane
37 LP PR+Q16 PA+Q24 FQ11	Move to starting position on cylinder, plunge-cutting obliquely into the material
38 L Y+Q7 R0 FQ12	Longitudinal cut in Y+ direction
39 FN 1: Q20 = +Q20 + +1	Update the counter
40 FN 1: Q24 = +Q24 + +Q25	Update solid angle
41 FN 11: IF +Q20 GT +Q13 GOTO LBL 99	Finished? If finished, jump to end
42 LP PR+Q16 PA+Q24 FQ11	Move in an approximated "arc" for the next longitudinal cut
43 L Y+0 R0 FQ12	Longitudinal cut in Y- direction
44 FN 1: Q20 = +Q20 + +1	Update the counter
45 FN 1: Q24 = +Q24 + +Q25	Update solid angle
46 FN 12: IF +Q20 LT +Q13 GOTO LBL 1	Unfinished? If not finished, return to LBL 1
47 LBL 99	
48 CYCL DEF 10.0 ROTATION	Reset the rotation
49 CYCL DEF 10.1 ROT+0	
50 CYCL DEF 7.0 DATUM SHIFT	Reset the datum shift
51 CYCL DEF 7.1 X+0	
52 CYCL DEF 7.2 Y+0	
53 CYCL DEF 7.3 Z+0	
54 LBL 0	End of subprogram
55 END PGM CYLIN	



Example: Convex sphere machined with end mill

Program sequence

- This program requires an end mill.
- The contour of the sphere is approximated by many short lines (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.



0 BEGIN PGM SPHERE MM	
1 FN 0: Q1 = +50	Center in X axis
2 FN 0: Q2 =+50	Center in Y axis
3 FN 0: Q4 = +90	Starting angle in space (Z/X plane)
4 FN 0: Q5 = +0	End angle in space (Z/X plane)
5 FN 0: Q14 = +5	Angle increment in space
6 FN 0: Q6 = +45	Radius of the sphere
7 FN 0: Q8 = +0	Starting angle of rotational position in the X/Y plane
8 FN 0: Q9 = +360	End angle of rotational position in the X/Y plane
9 FN 0: Q18 = +10	Angle increment in the X/Y plane for roughing
10 FN 0: Q10 = +5	Allowance in sphere radius for roughing
11 FN 0: Q11 = +2	Set-up clearance for pre-positioning in the tool axis
12 FN 0: Q12 = +350	Feed rate for milling
13 BLK FORM 0.1 Z X+0 Y+0 Z-50	Define the workpiece blank
14 BLK FORM 0.2 X+100 Y+100 Z+0	
15 TOOL DEF 1 L+0 R+7.5	Define the tool
16 TOOL CALL 1 Z S4000	Tool call
17 L Z+250 R0 FMAX	Retract the tool



18 CALL LBL 10	Call machining operation
19 FN 0: Q10 = +0	Reset allowance
20 FN 0: Q18 = +5	Angle increment in the X/Y plane for finishing
21 CALL LBL 10	Call machining operation
22 L Z+100 R0 FMAX M2	Retract in the tool axis, end program
23 LBL 10	Subprogram 10: Machining operation
24 FN 1: Q23 = +Q11 + +Q6	Calculate Z coordinate for pre-positioning
25 FN 0: Q24 = +Q4	Copy starting angle in space (Z/X plane)
26 FN 1: Q26 = +Q6 + +Q108	Compensate sphere radius for pre-positioning
27 FN 0: Q28 = +Q8	Copy rotational position in the plane
28 FN 1: Q16 = +Q6 + -Q10	Account for allowance in the sphere radius
29 CYCL DEF 7.0 DATUM SHIFT	Shift datum to center of sphere
30 CYCL DEF 7.1 X+Q1	
31 CYCL DEF 7.2 Y+Q2	
32 CYCL DEF 7.3 Z-Q16	
33 CYCL DEF 10.0 ROTATION	Account for starting angle of rotational position in the plane
34 CYCL DEF 10.1 ROT+Q8	
35 LBL 1	Pre-position in the tool axis
36 CC X+0 Y+0	Set pole in the X/Y plane for pre-positioning
37 LP PR+Q26 PA+Q8 R0 FQ12	Pre-position in the plane
38 CC Z+0 X+Q108	Set pole in the Z/X plane, offset by the tool radius
39 L Y+0 Z+0 FQ12	Move to working depth

40 LBL 2	
41 LP PR+Q6 PA+Q24 R9 FQ12	Move upward in an approximated "arc"
42 FN 2: Q24 = +Q24 - +Q14	Update solid angle
43 FN 11: IF +Q24 GT +Q5 GOTO LBL 2	Inquire whether an arc is finished. If not finished, return to LBL 2.
44 LP PR+Q6 PA+Q5	Move to the end angle in space
45 L Z+Q23 R0 F1000	Retract in the tool axis
46 L X+Q26 R0 FMAX	Pre-position for next arc
47 FN 1: Q28 = +Q28 + +Q18	Update rotational position in the plane
48 FN 0: Q24 = +Q4	Reset solid angle
49 CYCL DEF 10.0 ROTATION	Activate new rotational position
50 CYCL DEF 10.0 ROT+Q28	
51 FN 12: IF +Q28 LT +Q9 GOTO LBL 1	
52 FN 9: IF +Q28 EQU +Q9 GOTO LBL 1	Unfinished? If not finished, return to label 1
53 CYCL DEF 10.0 ROTATION	Reset the rotation
54 CYCL DEF 10.1 ROT+0	
55 CYCL DEF 7.0 DATUM SHIFT	Reset the datum shift
56 CYCL DEF 7.1 X+0	
57 CYCL DEF 7.2 Y+0	
58 CYCL DEF 7.3 Z+0	
59 LBL 0	End of subprogram
60 END PGM SPHERE MM	



# 12

**Test Run and Program Run**



## 12.1 Graphics

### Function

In the program run modes of operation as well as in the Test Run mode, the TNC provides the following three display modes: Using soft keys, select whether you desire:

- Plan view
- Projection in 3 planes
- 3-D view

The TNC graphic depicts the workpiece as if it were being machined with a cylindrical end mill. If a tool table is active, you can also simulate the machining operation with a spherical cutter. For this purpose, enter  $R2 = R$  in the tool table.

The TNC will not show a graphic if

- the current program has no valid blank form definition
- no program is selected

With MPs 7315 to 7317 you can have the TNC display a graphic even if no tool axis is defined or moved.




Using the new 3-D graphics you can now also graphically display machining operations in the tilted working plane as well as multi-sided machining operations, provided that you have already simulated the program in another view. The MC 422 B hardware is required in order to be able to use this function. In order to increase the speed of the test graphics on older hardware versions, bit 5 of MP7310 should be set to 1. This deactivates functions which were implemented specifically for the 3-D graphics.

The TNC graphic does not show a radius oversize DR that has been programmed in the TOOL CALL block.







Setting the speed of the test run



You can set the speed of the test run only if the “Display of machining time” function is active (see “Activating the stopwatch function” on page 556). The TNC otherwise always performs the test run at the maximum possible speed.

The most recently set speed remains active, even after a restart, until you change it.

After you have started a program, the TNC displays the following soft keys with which you can set the simulation speed.

Function	Soft key
Execute test run at the same speed at which the program will be executed (programmed feed rates are taken into account).	
Increase the test speed incrementally.	
Decrease the test speed incrementally.	
Test run at the maximum possible speed (default setting).	



Overview of display modes

The control displays the following soft keys in the Program Run and Test Run modes of operation:

Display mode	Soft key
Plan view	
Projection in 3 planes	
3-D view	

Limitations during program run

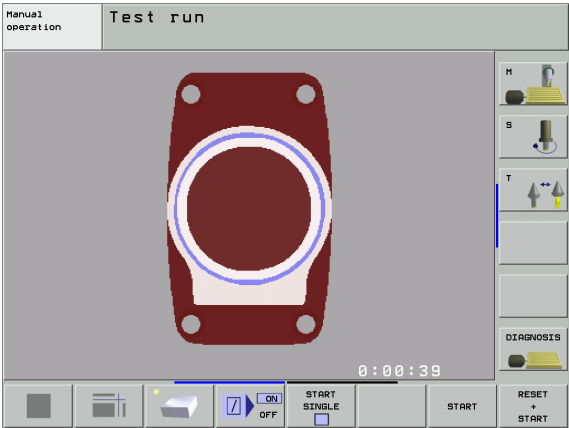
A graphical representation of a running program is not possible if the microprocessor of the TNC is already occupied with complicated machining tasks or if large areas are being machined. Example: Multipass milling over the entire blank form with a large tool. The TNC interrupts the graphics and displays the text **ERROR** in the graphics window. The machining process is continued, however.

Plan view

This is the fastest of the three graphic display modes.



- ▶ Press the soft key for plan view.
- ▶ Regarding depth display, remember:  
The deeper the surface, the darker the shade.









# Projection in 3 planes

Similar to a workpiece drawing, the part is displayed with a plan view and two sectional planes. A symbol to the lower left indicates whether the display is in first angle or third angle projection according to ISO 6433 (selected with MP7310).

Details can be isolated in this display mode for magnification (see “Magnifying details” on page 554).

In addition, you can shift the sectional planes with the corresponding soft keys:

- ▶ Select the soft key for projection in three planes.
- ▶ Shift the soft-key row and select the soft key for sectional planes.
- ▶ The TNC then displays the following soft keys:

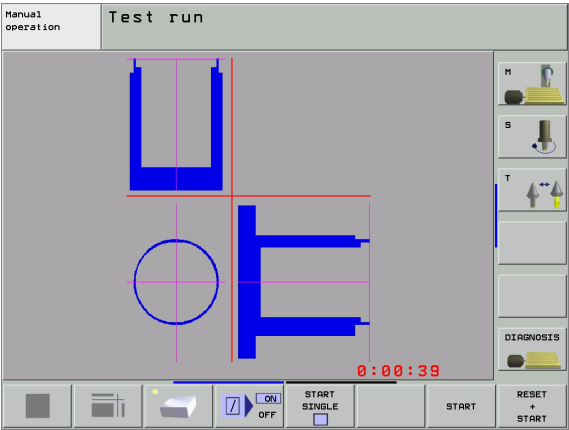
Function	Soft keys	
Shift the vertical sectional plane to the right or left		
Shift the vertical sectional plane forward or backward		
Shift the horizontal sectional plane upwards or downwards		

The positions of the sectional planes are visible during shifting.

The default setting of the sectional plane is selected such that it lies in the working plane in the workpiece center and in the tool axis on the top surface.

## Coordinates of the line of intersection

At the bottom of the graphics window, the TNC displays the coordinates of the line of intersection, referenced to the workpiece datum. Only the coordinates of the working plane are shown. This function is activated with MP7310.



## 3-D view

The workpiece is displayed in three dimensions, and can be rotated about the vertical axis. If you have the appropriate hardware, then with its high-resolution 3-D graphics the TNC can also display machining operations in the tilted working plane as well as multi-sided machining operations.

You can rotate the 3-D display about the vertical and horizontal axes. The shape of the workpiece blank can be depicted by a frame overlay at the beginning of the graphic simulation.

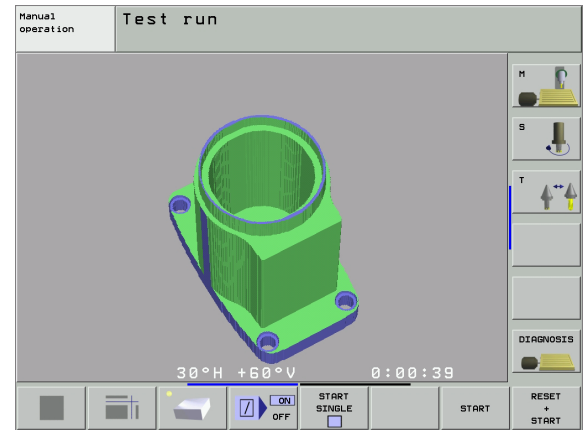
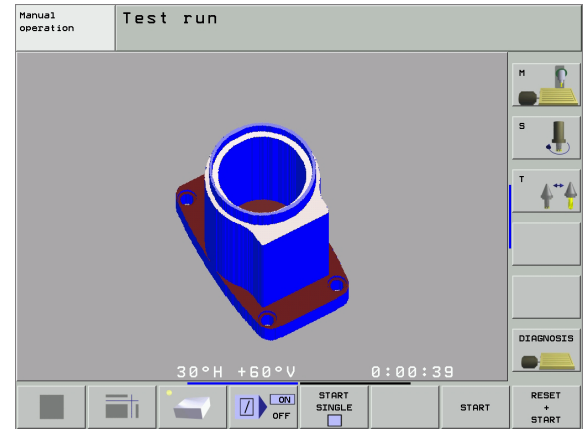
In the Test Run mode of operation you can isolate details for magnification, see "Magnifying details" on page 554.



- Press the soft key for 3-D view. Press the soft key twice to switch to the high-resolution 3-D graphics. This switch is only possible once the simulation has finished. The high-resolution graphics also display machining operations in the tilted working plane.



The speed of the high-resolution 3-D graphics depends on the tooth length (LCUTS column in the tool table). If LCUTS is defined as 0 (basic setting), the simulation calculates an infinitely long tooth length, which leads to a long processing time. If you do not want to define LCUTS, then set MP7312 to a value between 5 and 10. This way the TNC internally limits the tooth length to a value which is calculated from MP7312 times the tool diameter.



Rotating and magnifying/reducing the 3-D view

- Shift the soft-key row until the soft key for the rotating and magnification/reduction appears.



- Select functions for rotating and magnifying/reducing:

Function	Soft keys	
Rotate in 5° steps about the vertical axis		
Rotate in 5° steps about the horizontal axis		
Magnify the graphic stepwise. If the view is magnified, the TNC shows the letter <b>Z</b> in the footer of the graphic window.		
Reduce the graphic stepwise. . If the view is magnified, the TNC shows the letter <b>Z</b> in the footer of the graphic window.		
Reset image to programmed size		

Switch the frame overlay display for the workpiece blank on/off:

- Shift the soft-key row until the soft key for the rotating and magnification/reduction appears.



- Select functions for rotating and magnifying/reducing:
- Show the frame for the BLK FORM: Set the highlight in the soft key to SHOW
- Hide the frame for the BLK FORM: Set the highlight in the soft key to OMIT



Magnifying details

You can magnify details in all display modes in the Test Run mode and a program run mode.

The graphic simulation or the program run, respectively, must first have been stopped. A detail magnification is always effective in all display modes.

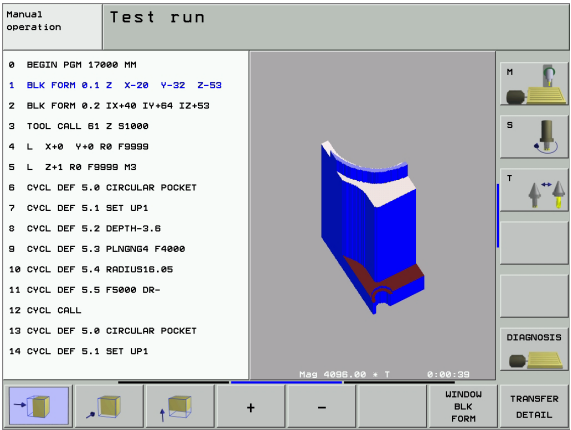
Changing the detail magnification

The soft keys are listed in the table.

- ▶ Interrupt the graphic simulation, if necessary.
- ▶ Shift the soft-key row in the Test Run mode, or in a program run mode, respectively, until the soft key for detail enlargement appears.



- ▶ Select the functions for section magnification.
- ▶ Press the corresponding soft key to select the workpiece surface (see table below).
- ▶ To reduce or magnify the blank form, press and hold the MINUS or PLUS soft key, respectively.
- ▶ Restart the test run or program run by pressing the START soft key (RESET + START returns the workpiece blank to its original state).



Function	Soft keys	
Select the left/right workpiece surface		
Select the front/back workpiece surface		
Select the top/bottom workpiece surface		
Shift the sectional plane to reduce or magnify the blank form		
Select the isolated detail		



Cursor position during detail magnification

During detail magnification, the TNC displays the coordinates of the axis that is currently being isolated. The coordinates describe the area determined for magnification. To the left of the slash is the smallest coordinate of the detail (MIN point), to the left is the largest (MAX point).

If a graphic display is magnified, this is indicated with **MAGN** at the lower right of the graphics window.

If the workpiece blank cannot be further enlarged or reduced, the TNC displays an error message in the graphics window. To clear the error message, reduce or enlarge the workpiece blank.

Repeating graphic simulation

A part program can be graphically simulated as often as desired, either with the complete workpiece or with a detail of it.

Function	Soft key
Restore workpiece blank to the detail magnification in which it was last shown.	<div>RESET BLK FORM</div>
Reset detail magnification so that the machined workpiece or workpiece blank is displayed as it was programmed with BLK FORM.	<div>WINDOW BLK FORM</div>



With the WINDOW BLK FORM soft key, you return the displayed workpiece blank to its originally programmed dimensions, even after isolating a detail—without TRANSFER DETAIL.



# Measuring the machining time

## Program Run modes of operation





The timer counts and displays the time from program start to program end. The timer stops whenever machining is interrupted.

### Test run

The timer displays the time that the TNC calculates from the duration of tool movements. The time calculated by the TNC can only conditionally be used for calculating the production time because the TNC does not account for the duration of machine-dependent interruptions, such as tool change. If you have switched the "find machining time" function on, you can generate a file listing the usage times of all tools used in the program (see "Dependent files" on page 589).

### Activating the stopwatch function

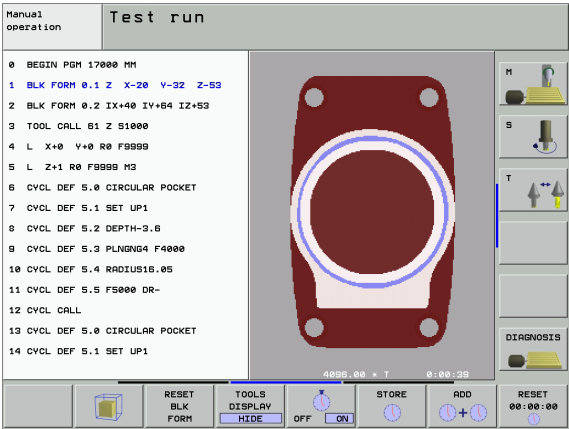
Shift the soft-key rows until the TNC displays the following soft keys with the stopwatch functions:

Stopwatch functions	Soft key
Enable (ON) or disable (OFF) the "measure the machining time" function.	
Store displayed time	
Display the sum of stored time and displayed time	
Clear displayed time	



The soft keys available to the left of the stopwatch functions depend on the selected screen layout.

During the Test Run, the TNC resets the machining time as soon as a new **BLK FORM** is evaluated.



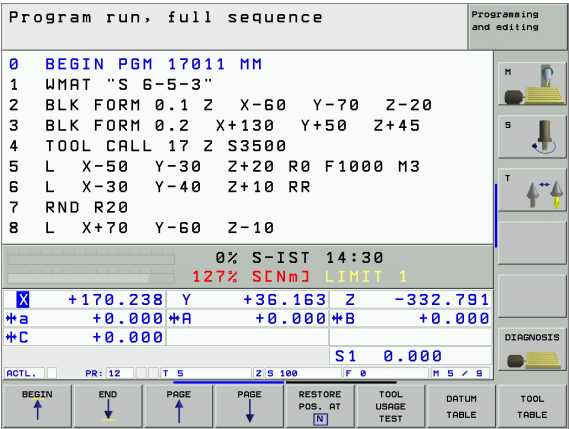


# 12.2 Functions for Program Display

## Overview

In the Program Run modes of operation as well as in the Test Run mode, the TNC provides the following soft keys for displaying a part program in pages:

Function	Soft key
Go back in the program by one screen	<div>PAGE</div> <div>↑</div>
Go forward in the program by one screen	<div>PAGE</div> <div>↓</div>
Go to beginning of program	<div>BEGIN</div> <div>↑</div>
Go to end of program	<div>END</div> <div>↓</div>



## 12.3 Test Run

### Function

In the Test Run mode of operation you can simulate programs and program sections to prevent errors from occurring during program run. The TNC checks the programs for the following:

- Geometrical incompatibilities
- Missing data
- Impossible jumps
- Violation of the machine's working space

The following functions are also available:

- Blockwise test run
- Interrupt test at any block
- Optional Block Skip
- Functions for graphic simulation
- Measuring the machining time
- Additional status display



### Running a program test





If the central tool file is active, a tool table must be active (status S) to run a program test. Select a tool table via the file manager (PGM MGT) in the Test Run mode of operation.

With the MOD function BLANK IN WORK SPACE, you can activate work space monitoring for the test run (see “Showing the Workpiece in the Working Space” on page 592).



- ▶ Select the Test Run operating mode
- ▶ Call the file manager with the PGM MGT key and select the file you wish to test, or
- ▶ Go to the program beginning: Select line “0” with the GOTO key and confirm your entry with the ENT key.

The TNC then displays the following soft keys:

Function	Soft key
Test the entire program	
Test each program block individually	
Show the blank form and test the entire program	
Interrupt the test run	

You can interrupt the program test and continue it again at any point—even within a machining cycle. In order to continue the test, the following actions must not be performed:

- Selecting another block with the GOTO key
- Making changes to the program
- Switching the operating mode
- Selecting a new program



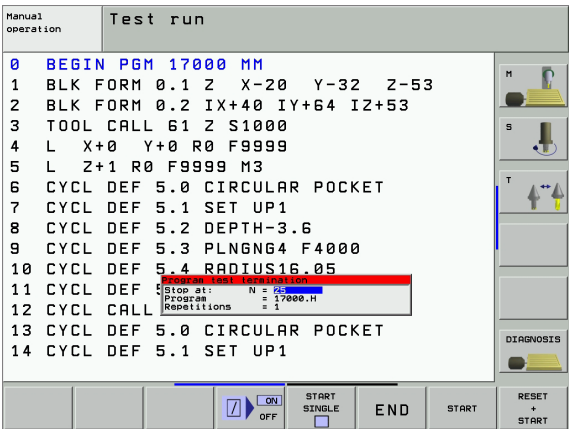
## Run a program test up to a certain block

With the STOP AT N function the TNC does a test run up to the block with block number N.

- Go to the beginning of program in the Test Run mode of operation.
- To run a program test up to a specific block, press the STOP AT N soft key.



- **Stop at N:** Enter the block number at which you wish the test to stop.
- **Program:** Enter the name of the program that contains the block with the selected block number. The TNC displays the name of the selected program. If the test run is to be interrupted in a program that was called with PGM CALL, you must enter this name.
- **Repetitions:** If N is located in a program section repeat, enter the number of repeats that you want to run.
- To test a program section, press the START soft key. The TNC will test the program up to the entered block.



## 12.4 Program Run

### Function

In the Program Run, Full Sequence mode of operation the TNC executes a part program continuously to its end or up to a program stop.

In the Program Run, Single Block mode of operation you must start each block separately by pressing the machine START button.

The following TNC functions can be used in the program run modes of operation:

- Interrupt program run
- Start program run from a certain block
- Optional block skip
- Editing the tool table TOOL.T
- Check and change Q parameters
- Superimpose handwheel positioning
- Functions for graphic simulation
- Additional status display

### Run a part program

#### Preparation

- 1 Clamp the workpiece to the machine table.
- 2 Datum setting
- 3 Select the necessary tables and pallet files (status M).
- 4 Select the part program (status M).



You can adjust the feed rate and spindle speed with the override knobs.

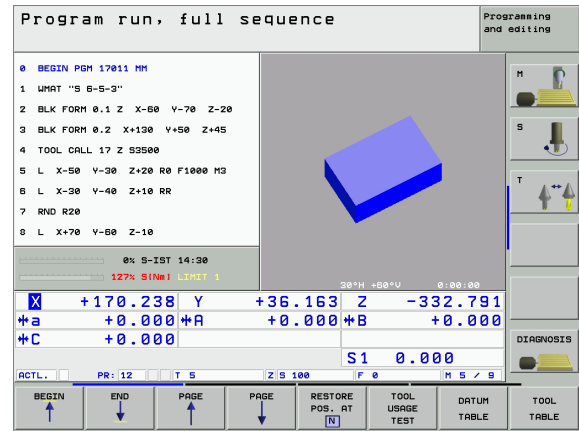
It is possible to reduce the rapid traverse speed when starting the NC program using the FMAX soft key. The entered value remains in effect even after the machine has been turned off and on again. In order to re-establish the original rapid traverse speed, you need to re-enter the corresponding value.

#### Program Run, Full Sequence

- ▶ Start the part program with the machine START button.

#### Program Run, Single Block

- ▶ Start each block of the part program individually with the machine START button.



## Interrupting machining

There are several ways to interrupt a program run:

- Programmed interruptions
- Pressing the machine STOP button
- Switching to Program Run, Single Block

If the TNC registers an error during program run, it automatically interrupts the machining process.

### Programmed interruptions

You can program interruptions directly in the part program. The TNC interrupts the program run at a block containing one of the following entries:

- STOP (with and without a miscellaneous function)
- Miscellaneous function M0, M2 or M30
- Miscellaneous function M6 (determined by the machine tool builder)

### Interrupting the machining process with the machine STOP button

- ▶ Press the machine STOP button: The block which the TNC is currently executing is not completed. The asterisk in the status display blinks.
- ▶ If you do not wish to continue the machining process, you can reset the TNC with the INTERNAL STOP soft key. The asterisk in the status display goes out. In this case, the program must be restarted from the program beginning.

### Interrupting the machining process by switching to the Program Run, Single Block mode of operation

You can interrupt a program that is being run in the Program Run, Full Sequence mode of operation by switching to the Program Run, Single Block mode. The TNC interrupts the machining process at the end of the current block.

## Moving the machine axes during an interruption

You can move the machine axes during an interruption in the same way as in the Manual Operation mode.



### **Danger of collision!**

If you interrupt program run while the working plane is tilted, you can change from a tilted to a non-tilted coordinate system, and vice versa, by pressing the 3-D ON/OFF soft key.

The functions of the axis direction buttons, the electronic handwheel and the positioning logic for returning to the contour are then evaluated by the TNC. When retracting the tool make sure the correct coordinate system is active and the angular values of the tilt axes are entered in the 3-D ROT menu.

### **Application example:**

#### **Retracting the spindle after tool breakage**

- ▶ Interrupt machining.
- ▶ Enable the external direction keys: Press the MANUAL OPERATION soft key.
- ▶ Move the axes with the machine axis direction buttons.



On some machines you may have to press the machine START button after the MANUAL OPERATION soft key to enable the axis direction buttons. Refer to your machine manual.



## Resuming program run after an interruption



If a program run is interrupted during a fixed cycle, the program must be resumed from the beginning of the cycle. This means that some machining operations will be repeated.

If you interrupt a program run during execution of a subprogram or program section repeat, use the RESTORE POS AT N function to return to the position at which the program run was interrupted.

When a program run is interrupted, the TNC stores:

- The data of the last defined tool
- Active coordinate transformations (e.g. datum shift, rotation, mirroring)
- The coordinates of the circle center that was last defined



Note that the stored data remain active until they are reset (e.g. if you select a new program).

The stored data are used for returning the tool to the contour after manual machine axis positioning during an interruption (RESTORE POSITION soft key).

### Resuming program run with the START button

You can resume program run by pressing the machine START button if the program was interrupted in one of the following ways:

- The machine STOP button was pressed.
- An interruption was programmed.

### Resuming program run after an error

If the error message is not blinking:

- ▶ Remove the cause of the error.
- ▶ To clear the error message from the screen, press the CE key.
- ▶ Restart the program, or resume program run where it was interrupted.

If the error message is blinking:

- ▶ Press and hold the END key for two seconds. This induces a TNC system restart.
- ▶ Remove the cause of the error.
- ▶ Start again.

If you cannot correct the error, write down the error message and contact your repair service agency.



## Mid-program startup (block scan)



The RESTORE POS AT N feature must be enabled and adapted by the machine tool builder. Refer to your machine manual.

With the RESTORE POS AT N feature (block scan) you can start a part program at any block you desire. The TNC scans the program blocks up to that point. Machining can be graphically simulated.

If you have interrupted a part program with an INTERNAL STOP, the TNC automatically offers the interrupted block N for mid-program startup.

If the program was interrupted by one of the conditions described below, the TNC saves the point of interruption.

- EMERGENCY STOP
- Power interruption
- Control software crash

After you have called the mid-program startup function, you can press the soft key SELECT LAST N to reactivate the point of interruption and approach it with an NC start. After switch-on the TNC then shows the message **NC program was interrupted.**



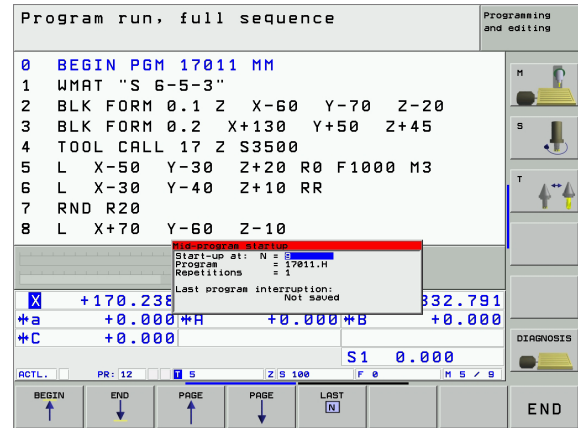
Mid-program startup must not begin in a subprogram.

All necessary programs, tables and pallet files must be selected in a Program Run mode of operation (status M).

If the program contains a programmed interruption before the startup block, the block scan is interrupted. Press the machine START button to continue the block scan.

After a block scan, return the tool to the calculated position with RESTORE POSITION.

Tool length compensation does not take effect until after the tool call and a following positioning block. This applies if you have only changed the tool length.





If you are working with nested programs, you can use MP7680 to define whether the block scan is to begin at block 0 of the main program or at block 0 of the last interrupted program.

If the working plane is tilted, you can use the 3-D ON/OFF soft key to define whether the TNC is to return to the contour in a tilted or in a non-tilted coordinate system.

If you want to use the block scan feature in a pallet table, select the program in which a mid-program startup is to be performed from the pallet table by using the arrow keys. Then press the RESTORE POS AT N soft key.

The TNC skips all touch probe cycles in a mid-program startup. Result parameters that are written to from these cycles might therefore remain empty.



If you execute mid-program startup in a program containing M128, the TNC performs compensating movements as necessary. The compensating movements are superposed over the approach movement.



- ▶ To go to the first block of the current program to start a block scan, enter GOTO "0".

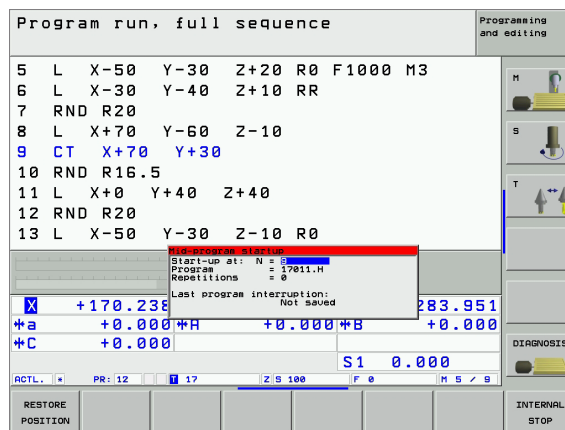


- ▶ To select mid-program startup, press the RESTORE POS AT N soft key.
- ▶ **Start-up at N:** Enter the block number N at which the block scan should end.
- ▶ **Program:** Enter the name of the program containing block N.
- ▶ **Repetitions:** If block N is located in a program section repeat, enter the number of repetitions to be calculated in the block scan.
- ▶ To start the block scan, press the machine START button.
- ▶ Contour approach (see following section)

## Returning to the contour

With the RESTORE POSITION function, the TNC returns to the workpiece contour in the following situations:

- Return to the contour after the machine axes were moved during a program interruption that was not performed with the INTERNAL STOP function.
- Return to the contour after a block scan with RESTORE POS AT N, for example after an interruption with INTERNAL STOP.
- Depending on the machine, if the position of an axis has changed after the control loop has been opened during a program interruption.
- ▶ To select a return to contour, press the RESTORE POSITION soft key.
- ▶ Restore machine status, if required.
- ▶ To move the axes in the sequence that the TNC suggests on the screen, press the machine START button.
- ▶ To move the axes in any sequence, press the soft keys RESTORE X, RESTORE Z, etc., and activate each axis with the machine START key.
- ▶ To resume machining, press the machine START key.



# 12.5 Automatic Program Start

## Function

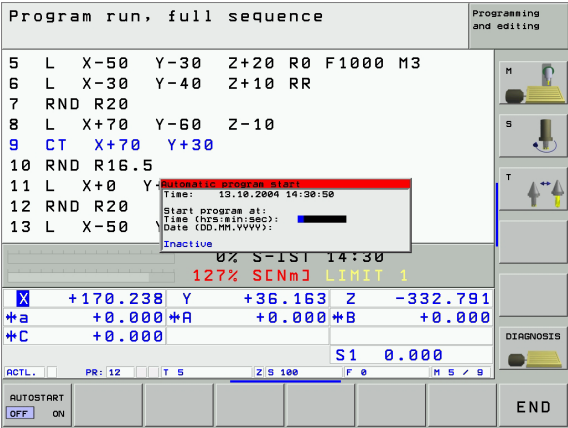
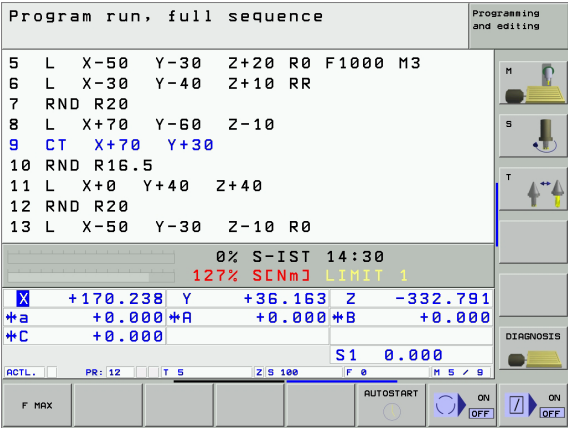


The TNC must be specially prepared by the machine tool builder for use of the automatic program start function. Refer to your machine manual.

In a Program Run operating mode, you can use the soft key AUTOSTART (see figure at upper right) to define a specific time at which the program that is currently active in this operating mode is to be started:



- Show the window for entering the starting time (see figure at center right).
- **Time (h:min:sec):** Time of day at which the program is to be started.
- **Date (DD.MM.YYYY):** Date at which the program is to be started.
- To activate the start, set the AUTOSTART soft key to ON.



## 12.6 Optional Block Skip

### Function

In a test run or program run, the TNC can skip over blocks that begin with a slash “/”:



- ▶ To run or test the program without the blocks preceded by a slash, set the soft key to ON.



- ▶ To run or test the program with the blocks preceded by a slash, set the soft key to OFF.



This function does not work for TOOL DEF blocks.

After a power interruption the control returns to the most recently selected setting.

### Erasing the “/” character

- ▶ In the **Programming and Editing** mode you select the block in which the character is to be erased.



- ▶ Erase the “/” character.

## 12.7 Optional Program-Run Interruption

### Function

The TNC optionally interrupts the program run or test run at blocks containing M01. If you use M01 in the Program Run mode, the TNC does not switch off the spindle or coolant.



- ▶ Do not interrupt Program Run or Test Run at blocks containing M01: Set soft key to OFF.



- ▶ Interrupt Program Run or Test Run at blocks containing M01: Set soft key to ON.



# 13

**MOD Functions**



## 13.1 MOD Function

The MOD functions provide additional input possibilities and displays. The available MOD functions depend on the selected operating mode.

### Selecting the MOD functions

Call the operating mode in which you wish to change the MOD functions.

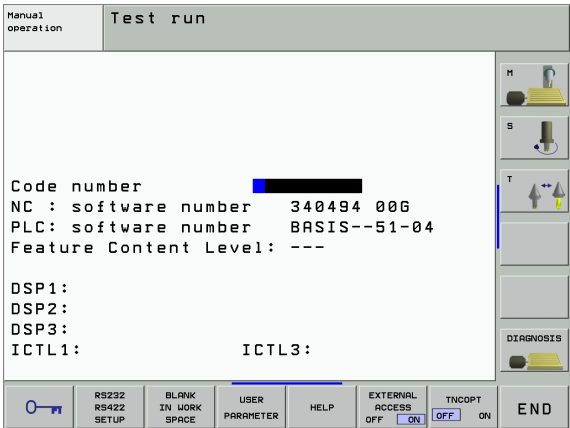
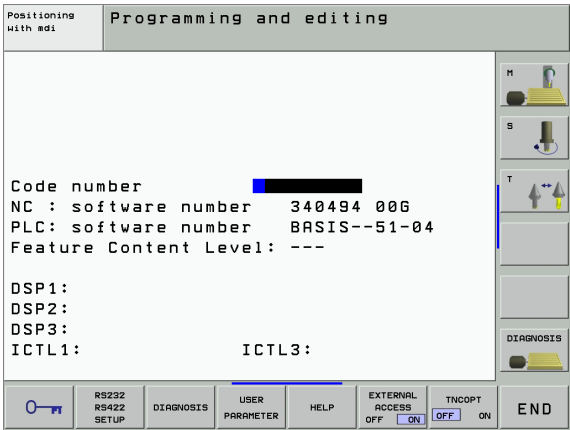
- ▶ To select the MOD functions, press the MOD key. The figures at right show typical screen menus in Programming and Editing (figure at upper right), Test Run (figure at lower right) and in a machine operating mode (see figure on next page).

### Changing the settings

- ▶ Select the desired MOD function in the displayed menu with the arrow keys.
- There are three possibilities for changing a setting, depending on the function selected:
- Enter a numerical value directly, e.g. when determining traverse range limit.
  - Change a setting by pressing the ENT key, e.g. when setting program input.
  - Change a setting via a selection window. If more than one possibility is available for a particular setting, you can superimpose a window listing all of the given possibilities by pressing the GOTO key. Select the desired setting directly by pressing the corresponding numerical key (to the left of the colon), or by using the arrow keys and then confirming with ENT. If you don't want to change the setting, close the window again with END.

### Exiting the MOD functions

- ▶ Close the MOD functions with the END key or soft key.





## Overview of MOD functions

Depending on the selected mode of operation, you can make the following changes:

Programming and Editing:

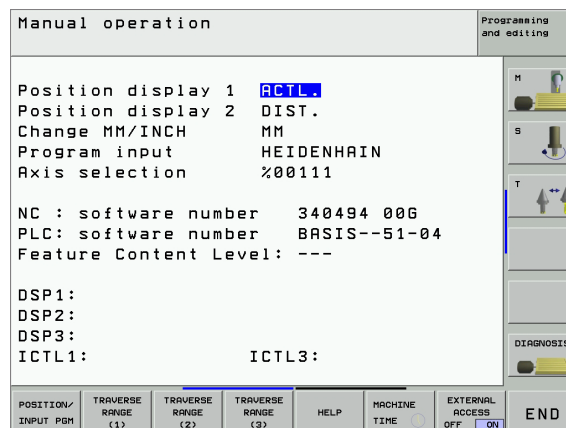
- Display software numbers
- Enter code number
- Set data interface
- Machine-specific user parameters (if provided)
- HELP files (if provided)
- Loading service packs

Test Run:

- Display software numbers
- Enter code number
- Setting the data interface
- Showing the Workpiece in the Working Space
- Machine-specific user parameters (if provided)
- Displaying HELP files (if provided)

In all other modes:

- Display software numbers
- Display code digits for installed options
- Select position display
- Unit of measurement (mm/inches)
- Programming language for MDI
- Select the axes for actual position capture
- Set the axis traverse limits
- Display reference points
- Display operating times
- HELP files (if provided)



## 13.2 Software Numbers and Option Numbers

### Function

The following software numbers are displayed on the TNC screen after the MOD functions have been selected:

- **NC:** Number of the NC software (managed by HEIDENHAIN)
- **PLC:** Number and name of the PLC software (managed by your machine tool builder)
- **Development level:** Development level of the software installed on the control
- **DSP1** to **DSP3:** Number of the speed controller software (managed by HEIDENHAIN)
- **ICTL1** and **ICTL3:** Number of the current controller software (managed by HEIDENHAIN)

In addition, coded numbers for the options available on your control are displayed after the abbreviation **OPT:**

No options active	%0000000000000000
Bit 0 to bit 7: Additional control loops	%00000000 <b>00000011</b>
Bit 8 to bit 15: Software options	% <b>00000011</b> 00000011



# 13.3 Code Numbers

## Function

The TNC requires a code number for the following functions:

Function	Code number
Select user parameters	123
Configure an Ethernet card (not iTNC 530 with Windows 2000)	NET123
Enable special functions for Q-parameter programming	555343

In addition, you can use the keyword **version** to create a file containing all current software numbers of your control:

- ▶ Enter the keyword **version** and confirm with the ENT key.
- ▶ The TNC displays all current software numbers on the screen.
- ▶ To terminate the version overview, press the END key.



If necessary, you can output the file **version.a** saved in the directory TNC:, and send it to your machine manufacturer or HEIDENHAIN for diagnostic purposes.



## 13.4 Loading Service Packs

### Function



We strongly recommend contacting your machine tool builder before you install a service pack.

The TNC restarts the system after the installation procedure is completed. Before loading the service pack, put the machine in the EMERGENCY STOP condition.

Connect the network drive from which you want to import the service pack (if not already done).

This function provides a simple way of updating the software of your TNC.

- ▶ Select the **Programming and Editing** mode of operation.
- ▶ Press the MOD key.
- ▶ To start the software update, press the “Load Service Pack” soft key. The TNC then displays a superimposed window for selecting the update file.
- ▶ Use the arrow keys to select the directory in which the service pack is stored. The respective subdirectories can be shown by pressing the ENT key.
- ▶ To select the file: Press the ENT key twice on the selected directory. The TNC switches from the directory window to the file window.
- ▶ To start the updating process, press the ENT key to select the file. The TNC unpacks all required files and then restarts the control. This process may take several minutes.

# 13.5 Setting the Data Interfaces

## Function

To set up the data interfaces, press the RS-232 / RS-422 SETUP soft key to call a menu for setting the data interfaces:


## Setting the RS-232 interface

The mode of operation and baud rates for the RS-232 interface are entered in the upper left of the screen.

## Setting the RS-422 interface

The mode of operation and baud rates for the RS-422 interface are entered in the upper right of the screen.






## Setting the OPERATING MODE of the external device

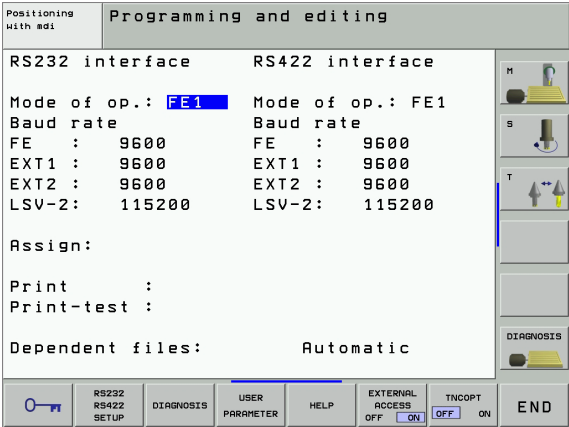


The functions “Transfer all files,” “Transfer selected file,” and “Transfer directory” are not available in the operating modes FE2 and EXT.

## Setting the BAUD RATE

You can set the BAUD RATE (data transfer speed) from 110 to 115 200 baud.

External device	Operating mode	Symbol
PC with HEIDENHAIN software TNCremo for remote operation of the TNC	LSV2	
PC with HEIDENHAIN data transfer software TNCremo	FE1	
HEIDENHAIN floppy disk units FE 401 B FE 401 from prog. no. 230 626 03	FE1 FE1	
HEIDENHAIN floppy disk unit FE 401 up to prog. no. 230 626 02	FE2	
Non-HEIDENHAIN devices such as punchers, PC without TNCremo	EXT1, EXT2	



Assign

This function sets the destination for the transferred data.

Applications:

- Transferring values with Q parameter function FN15
- Transferring values with Q parameter function FN16

The TNC mode of operation determines whether the PRINT or PRINT TEST function is used:

TNC mode of operation	Transfer function
Program Run, Single Block	PRINT
Program Run, Full Sequence	PRINT
Test run	PRINT TEST

You can set PRINT and PRINT TEST as follows:

Function	Path
Output data via RS-232	RS232:\...
Output data via RS-422	RS422:\...
Save data to the TNC's hard disk	TNC:\...
Save the data in the same directory as the program with FN15/FN16.	- vacant -

File names

Data	Operating mode	File name
Values with FN15	Program run	%FN15RUN.A
Values with FN15	Test run	%FN15SIM.A
Values with FN16	Program run	%FN16RUN.A
Values with FN16	Test run	%FN16SIM.A



## Software for data transfer

For transfer of files to and from the TNC, we recommend using the HEIDENHAIN TNCremoNT data transfer software. With TNCremoNT, data transfer is possible with all HEIDENHAIN controls via the serial interface or the Ethernet interface.



You can download the current version of TNCremoNT free of charge from the HEIDENHAIN Filebase ([www.heidenhain.de](http://www.heidenhain.de), <service>, <download area>, <TNCremo NT>).

System requirements for TNCremoNT:

- PC with 486 processor or higher
- Operating system Windows 95, Windows 98, Windows NT 4.0, Windows 2000
- 16 MB RAM
- 5 MB free memory space on your hard disk
- An available serial interface or connection to the TCP/IP network

### Installation under Windows

- ▶ Start the SETUP.EXE installation program with the File Manager (Explorer).
- ▶ Follow the setup program instructions.

### Starting TNCremoNT under Windows

- ▶ Click <Start>, <Programs>, <HEIDENHAIN Applications>, <TNCremoNT>

When you start TNCremoNT for the first time, TNCremoNT automatically tries to set up a connection with the TNC.



## Data transfer between the TNC and TNCremoNT

Check whether the TNC is connected to the correct serial port on your PC or to the network, respectively.

Once you have started TNCremoNT, you will see a list of all files that are stored in the active directory in the upper section of the main window **1**. Using the menu items <File> and <Change directory>, you can change the active directory or select another directory on your PC.

If you want to control data transfer from the PC, establish the connection with your PC in the following manner:

- Select <File>, <Setup connection>. TNCremoNT now receives the file and directory structure from the TNC and displays this at the bottom left of the main window **2**.
- To transfer a file from the TNC to the PC, select the file in the TNC window with a mouse click and drag and drop the highlighted file into the PC window **1**.
- To transfer a file from the PC to the TNC, select the file in the PC window with a mouse click and drag and drop the highlighted file into the TNC window **2**.

If you want to control data transfer from the TNC, establish the connection with your PC in the following way:

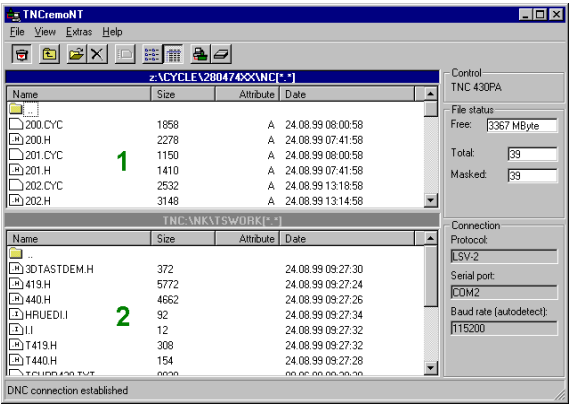
- Select <Extras>, <TNCserver>. TNCremoNT is now in server mode. It can receive data from the TNC and send data to the TNC.
- You can now call the file management functions on the TNC by pressing the key PGM MGT (see "Data transfer to or from an external data medium" on page 97) and transfer the desired files.

### End TNCremoNT

Select the menu items <File>, <Exit>.



Refer also to the TNCremoNT context-sensitive help texts where all of the functions are explained in more detail. The help texts must be called with the F1 key.





## 13.6 Ethernet Interface

### Introduction

The TNC is shipped with a standard Ethernet card to connect the control as a client in your network. The TNC transmits data via the Ethernet card with

- the **smb** protocol (**s**erver **m**essage **b**lock) for Windows operating systems, or
- the **TCP/IP** protocol family (Transmission Control Protocol/Internet Protocol) and with support from the NFS (Network File System).

### Connection possibilities

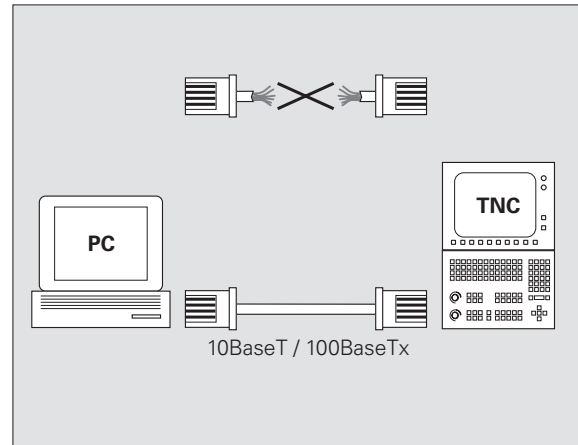
You can connect the Ethernet card in your TNC to your network through the RJ45 connection (X26, 100BaseTX or 10BaseT), or directly to a PC. The connection is metallically isolated from the control electronics.

For a 100BaseTX or 10BaseT connection you need a Twisted Pair cable to connect the TNC to your network.



The maximum cable length between TNC and a node depends on the quality grade of the cable, the sheathing and the type of network (100BaseTX or 10BaseT).

If you connect the TNC directly with a PC you must use a transposed cable.



Connecting the iTNC directly with a Windows PC

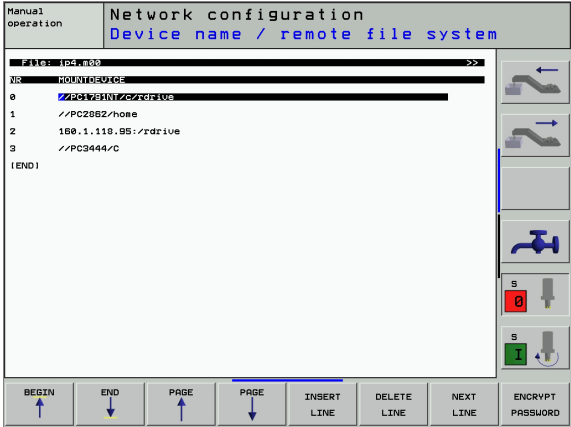
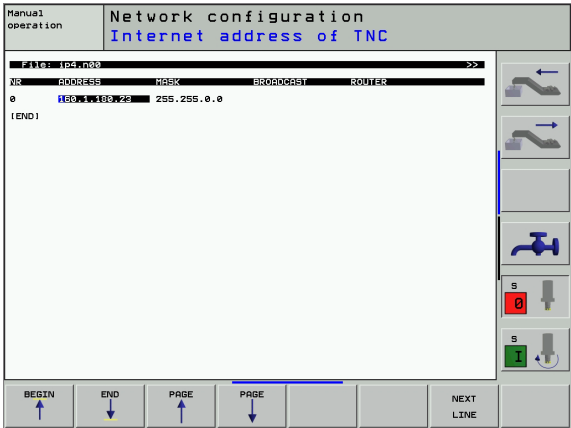
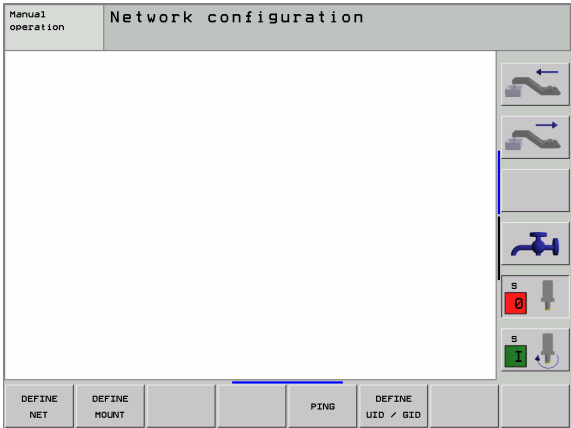
You don't need any large effort or special networking knowledge to attach the iTNC 530 directly to a PC that has an Ethernet card. You simply have to make some settings on the TNC and the corresponding settings on the PC.

Settings on the iTNC

- ▶ Connect the iTNC (connection X26) and the PC with a crossed Ethernet cable (trade names: crossed patch cable or STP cable).
- ▶ In the Programming and Editing mode of operation, press the MOD key. Enter the keyword NET123. The iTNC will then display the main screen for network configuration (see figure at top right).
- ▶ Press the DEFINE NET soft key to enter the network setting for a specific device (see figure at center right).
- ▶ Enter any network address. Network addresses consist of four numbers separated by periods, e.g. **160.1.180.23**
- ▶ Press the right arrow key to select the next column, and enter the subnet mask. The subnet mask also consists of four numbers separated by periods, e.g. **255.255.0.0**
- ▶ Press the END key to leave the network configuration screen.
- ▶ Press the DEFINE MOUNT soft key to enter the network settings for a specific PC (see figure at bottom right).
- ▶ Define the PC name and drive that you want to access, beginning with two slashes, e.g. **//PC3444/C**
- ▶ Press the right arrow key to select the next column, and enter the name that the iTNC's file manager uses to display the PC, e.g. **PC3444**:
- ▶ Press the right arrow key to select the next column, and enter the file system type **smb**
- ▶ Press the right arrow key to select the next column and enter the following information (depending on the PC operating system):  
**ip=160.1.180.1,username=abcd,workgroup=SALES,password=uvwx**
- ▶ To exit the network configuration, press the END key twice. The iTNC restarts automatically.



The parameters **username**, **workgroup** and **password** do not need to be entered in all Windows operating systems.



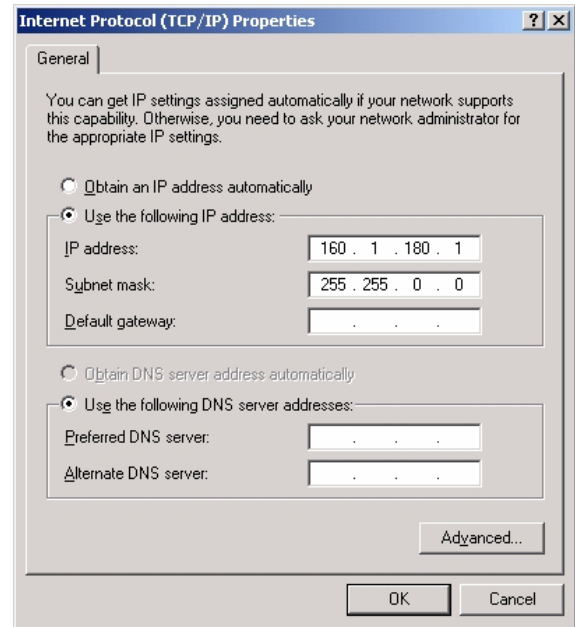
## Settings on a PC with Windows 2000

**Prerequisite:**

The network card must already be installed on the PC and ready for operation.

If the PC that you want to connect the iTNC to is already integrated in your company network, then keep the PC's network address and adapt the iTNC's network address accordingly.

- ▶ To open Network Connections, click <Start>, <Control Panel>, <Network and Dial-up Connections>, and then Network Connections.
- ▶ Right-click the <LAN connection> symbol, and then <Properties> in the menu that appears.
- ▶ Double-click <Internet Protocol (TCP/IP)> to change the IP settings (see figure at top right).
- ▶ If it is not yet active, select the <Use the following IP address> option.
- ▶ In the <IP address> input field, enter the same IP address that you entered for the PC network settings on the iTNC, e.g. 160.1.180.1
- ▶ Enter 255.255.0.0 in the <Subnet mask> input field.
- ▶ Confirm the settings with <OK>.
- ▶ Save the network configuration with <OK>. You may have to restart Windows now.



Configuring the TNC



To configure the dual-processor version: See “Network Settings,” page 641.

Make sure that the person configuring your TNC is a network specialist.

- ▶ In the Programming and Editing mode of operation, press the MOD key. Enter the keyword NET123. The TNC will then display the main screen for network configuration.

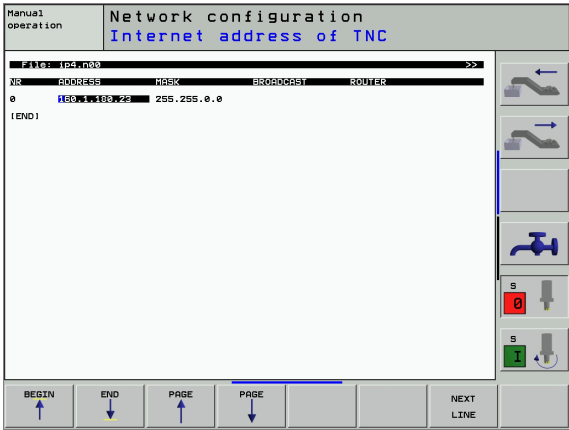
General network settings

- ▶ Press the DEFINE NET soft key to enter the general network settings and enter the following information:

Setting	Meaning
ADDRESS	Address that your network specialist must assign to the TNC. Input: four numerical values separated by points, e.g. 160.1.180.20
MASK	The SUBNET MASK serves to differentiate between the network ID and the host ID in the network. Input: four numerical values separated by points. Ask your network specialist for the values, e.g. 255.255.0.0
BROADCAST	The broadcast address of the control is required only if it differs from the standard setting. The standard setting is formed from the network ID and the host ID, for which all bits are set to 1, e.g. 160.1.255.255
ROUTER	Internet address of your default router. Enter the Internet address only if your network consists of several parts. Input: four numerical values separated by points. Ask your network specialist for the values, e.g. 160.1.0.2
HOST	Name under which the TNC identifies itself in the network
DOMAIN	Domain name of the control (is not evaluated until later)
NAMESERVER	Network address of the domain server (is not evaluated until later)



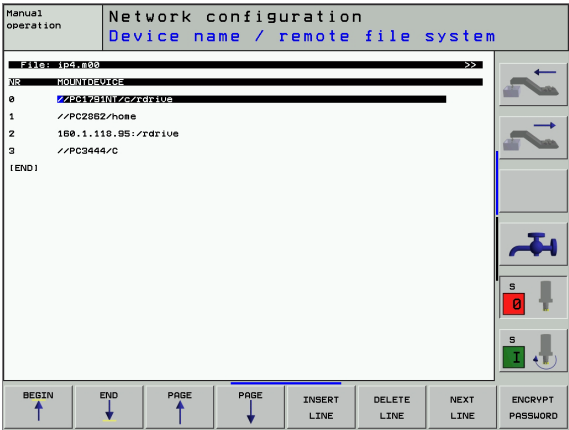
You do not need to indicate the protocol with the iTNC 530. It uses the transmission protocol according to RFC 894.



Network settings specific to the device

► Press the soft key DEFINE MOUNT to enter the network settings for a specific device. You can define any number of network settings, but you can manage only seven at one time.

Setting	Meaning
MOUNTDEVICE	<div> <div></div> <div> <p>Connection via NFS:</p> <p>Name of the directory that is to be logged on. This is formed by the network address of the server, a colon and the name of the directory to be mounted. Input: four numerical values separated by points. Ask your network specialist for the values, e.g. 160.1.13.4.</p> <p>Directory of the NFS server that you wish to connect to the TNC. Be sure to differentiate between small and capital letters when entering the path.</p> </div> </div> <div> <div></div> <div> <p>Connection via smb:</p> <p>Enter the network name and the share name of the computer, e.g. //PC1791NT/C</p> </div> </div>
MOUNTPOINT	<p>Name that the TNC shows in the file manager for a connected device. Remember that the name must end with a colon.</p>
FILESYSTEM-TYPE	<p>File system type.</p> <p><b>nfs:</b> Network File System</p> <p><b>smb:</b> Server Message Block (Windows protocol)</p>
OPTIONS for FILESYSTEM-TYPE=nfs	<p>Data without spaces, separated by commas, and written in sequence. Switch between upper and lower case letters.</p> <p><b>rsize=:</b> Packet size in bytes for data reception. Input range: 512 to 8192</p> <p><b>wsiz=:</b> Packet size in bytes for data transmission. Input range: 512 to 8192</p> <p><b>time0=:</b> Time, in tenths of a second, after which the TNC repeats a Remote Procedure Call. Input range: 0 to 100 000. If there is no entry, the standard value 7 is used. Use higher values only if the TNC must communicate with the server through several routers. Ask your network specialist for the proper value.</p> <p><b>soft=:</b> Definition of whether the TNC should repeat the Remote Procedure Call until the NFS server answers.</p> <p>“soft” entered: Do not repeat the Remote Procedure Call.</p> <p>“soft” not entered: Always repeat the Remote Procedure Call.</p>



Setting	Meaning
OPTIONS for FILESYSTEM- TYPE=smb for direct connection to Windows networks	Data without spaces, separated by commas, and written in sequence. Switch between upper and lower case letters. <b>ip=:</b> IP address of PC to which the TNC is to be connected <b>username=:</b> User name under which the TNC is to log on <b>workgroup=:</b> Work group under which the TNC is to log on <b>password=:</b> Password that the TNC is to use for logon (up to 80 characters)
AM	Definition of whether the TNC upon switch-on should automatically connect with the network drive. 0: Do not automatically connect 1: Connect automatically



The entries **username**, **workgroup** and **password** in the  
OPTIONS column may not be necessary in Windows 95  
and Windows 98 networks.

With the ENCODE PASSWORD soft key, you can encode  
the password defined under OPTIONS.

Defining a network identification

► Press the soft key DEFINE UID / GID to enter the network  
identification.

Setting	Meaning
TNC USER ID	Definition of the User Identification under which the end user accesses files in the network. Ask your network specialist for the proper value.
OEM USER ID	Definition of the User Identification under which the machine manufacturer accesses files in the network. Ask your network specialist for the proper value.
TNC GROUP ID	Definition of the group identification with which you access files in the network. Ask your network specialist for the proper value. The group identification is the same for end users and machine manufacturers.
UID for mount	Defines the user identification (UID) for the log-on procedure. <b>USER:</b> The user logs on with the USER identification. <b>ROOT:</b> The user logs on with the ID of the ROOT user, value = 0.

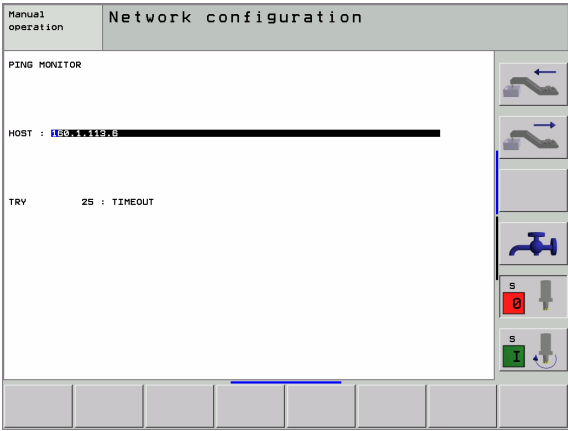


**Test network connection**

- ▶ Press the PING soft key.
- ▶ In the **HOST** line, enter then internet address of the computer for which you want to check the network connection.
- ▶ Confirm your entry with the ENT key. The TNC transmits data packets until you exit the test monitor by pressing the END key.

In the **TRY** line the TNC shows the number of data packets that were transmitted to the previously defined addressee. Behind the number of transmitted data packets the TNC shows the status:

Status display	Meaning
HOST RESPOND	Data packet was received again, connection is OK.
TIMEOUT	Data packet was not received, check the connection.
CAN NOT ROUTE	Data packet could not be transmitted. Check the Internet address of the server and of the router to the TNC.



## 13.7 Configuring PGM MGT

### Function

Use the MOD functions to specify which directories or files are to be displayed by the TNC:

- **PGM MGT** setting: Simple file management (directories are not displayed) or enhanced file management (directories are displayed).
- **Dependent files** setting: Specify whether dependent files are displayed.



Please note: See “Working with the File Manager,” page 87.

### Changing the PGM MGT setting

- ▶ To select the file manager in the Programming and Editing mode of operation, press the PGM MGT key
- ▶ To select the MOD function, press the MOD key.
- ▶ To select the PGM MGT setting: Using the arrow keys, move the highlight onto the **PGM MGT** setting and use the ENT key to switch between **STANDARD** and **ENHANCED**.



## Dependent files

In addition to the file extension, dependent files also have the extension **.SEC.DEP** (**SEC**tion, **DEP**endent). The following different types are available:

- **.H.SEC.DEP**  
The TNC creates files with the **.SEC.DEP** extension if you work with the structure function. The file contains information needed by the TNC to rapidly jump from one structure point to the next.
- **.T.SEC.DEP**: Tool usage file for individual conversational-format programs  
The TNC creates files with the **.T.DEP** extension if
  - bit 2 of the machine parameter 7246=1 is set
  - the machining timer is active in the **Test Run** operating mode
  - a plain language program is being run in the **Test run** mode
- **.P.T.SEC.DEP**: Tool usage file for a complete pallet  
The TNC creates files with the **.P.T.DEP** ending if, in a program run mode, you run the tool usage test (see “Tool usage test” on page 590) for a pallet entry of the active pallet file. This file then lists the sum of all tool usage times of all tools that you use within a pallet.

In a tool usage file, the TNC saves the following information:

Column	Meaning
TOKEN	<ul style="list-style-type: none"> <li>■ <b>TOOL</b>: Tool usage time per <b>TOOL CALL</b>. The entries are listed in chronological order.</li> <li>■ <b>TTOTAL</b>: Total usage time of a tool</li> <li>■ <b>STOTAL</b>: Call of a subprogram (including cycles). The entries are listed in chronological order.</li> </ul>
TNR	Tool number (–1: No tool inserted yet)
IDX	Tool index
NAME	Tool name from the tool table
TIME	Tool usage time in seconds
RAD	<b>Tool radius R + Oversize of tool radius DR</b> from the tool table. The unit is 0.1 µm
BLOCK	Block number in which the <b>TOOL CALL</b> block was programmed
PATH	<ul style="list-style-type: none"> <li>■ <b>TOKEN = TOOL</b>: Path name of the active main program or subprogram</li> <li>■ <b>TOKEN = STOTAL</b>: Path name of the subprogram</li> </ul>



## Tool usage test

With the TOOL USAGE TEST soft key, you can check before starting a program in a Program Run operating mode whether the tool being used has enough service life remaining. Here the TNC compares the actual values for service life in the tool table with the nominal values from the tool requirement file.

The TNC can show a tool's remaining service life in a pop-up window.

There are two ways to run a tool usage test for a pallet file:

- The highlight is on a pallet entry in the pallet file:  
The TNC runs the tool usage test for the entire pallet.
- The highlight is on a program entry in the pallet file:  
The TNC runs the tool usage test for the selected program.

## Changing the MOD setting for dependent files

- To select the file manager in the Programming and Editing mode of operation, press the PGM MGT key
- To select the MOD function, press the MOD key.
- To select the Dependent files setting: Using the arrow keys, move the highlight onto the **Dependent files** setting and use the ENT key to switch between **AUTOMATIC** and **MANUAL**.



Dependent files are only visible in the file manager if you selected the MANUAL setting.

If dependent files exist for a file, then the TNC displays a + character in the status column of the file manager (only if **Dependent files** is set to **AUTOMATIC**).



## 13.8 Machine-Specific User Parameters

### Function

To enable you to set machine-specific functions, your machine tool builder can define up to 16 machine parameters as user parameters.



This function is not available on all TNCs. Refer to your machine manual.



# 13.9 Showing the Workpiece in the Working Space

## Function

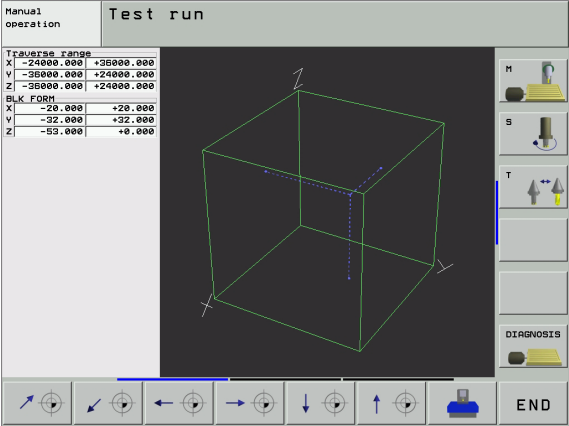
This MOD function enables you to graphically check the position of the workpiece blank in the machine's working space and to activate work space monitoring in the Test Run mode of operation.

The TNC displays a transparent cuboid for the working space. Its dimensions are shown in the **Traverse range** table (standard color is green). The TNC takes the dimensions for the working space from the machine parameters for the active traverse range. Since the traverse range is defined in the reference system of the machine, the datum of the cuboid is also the machine datum. You can see the position of the machine datum in the cuboid by pressing the soft key M91 in the 2nd soft-key row.

another transparent cuboid represents the workpiece blank. Its dimensions are shown in the **BLK FORM** table (standard color is blue). The TNC takes the dimensions from the workpiece blank definition of the selected program. The workpiece cuboid defines the coordinate system for input. Its datum lies within the traverse-range cuboid. You can view the position of the active datum within the traverse range by pressing the "Show tool datum" soft-key (2nd soft-key row).







For a test run it normally does not matter where the workpiece blank is located within the working space. However, if you test programs that contain movements with M91 or M92, you must graphically shift the workpiece blank to prevent contour damage. Use the soft keys shown in the following table.

You can also activate the working-space monitor for the Test Run mode in order to test the program with the current datum and the active traverse ranges (see table below, last line).







Function	Soft key
Move workpiece blank to the left	
Move workpiece blank to the right	
Move workpiece blank forward	
Move workpiece blank backward	
Move workpiece blank upward	
Move workpiece blank downward	



Function	Soft key
Show workpiece blank referenced to the set datum	
Show the entire traversing range referenced to the displayed workpiece blank	
Show the machine datum in the working space	
Show a position determined by the machine tool builder (e.g. tool change position) in the working space	
Show the workpiece datum in the working space	
Enable (ON) or disable (OFF) working-space monitoring	

### Rotate the entire image

The third soft-key row provided functions with which you can rotate and tilt the entire image:

Function	Soft keys
Rotate the image about the vertical axis	 
Tilt the image about the horizontal axis	 



## 13.10 Position Display Types

### Function

In the Manual Operation mode and in the Program Run modes of operation, you can select the type of coordinates to be displayed.

The figure at right shows the different tool positions:

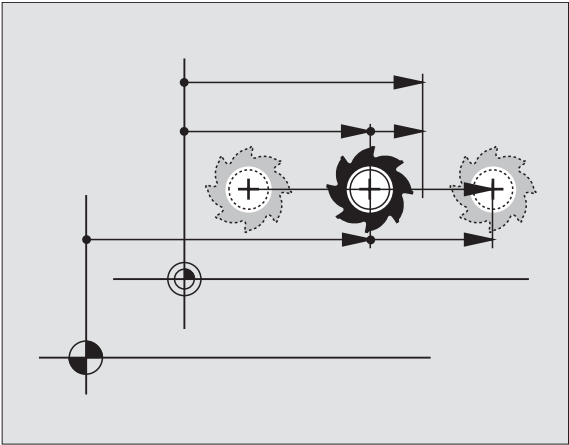
- Starting position
- Target position of the tool
- Workpiece datum
- Machine datum

The TNC position displays can show the following coordinates:

Function	Display
Nominal position: the value presently commanded by the TNC	NOML.
Actual position; current tool position	ACTL.
Reference position; the actual position relative to the machine datum	REF
Distance remaining to the programmed position; difference between actual and target positions	DIST.
Servo lag: difference between nominal and actual positions (following error)	LAG
Deflection of the measuring touch probe	DEFL.
Traverses that were carried out with handwheel superpositioning (M118) (only Position display 2)	M118

With the MOD function Position display 1, you can select the position display in the status display.

With Position display 2, you can select the position display in the additional status display.



## 13.11 Unit of Measurement

### Function

This MOD function determines whether the coordinates are displayed in millimeters (metric system) or inches.

- To select the metric system (e.g. X = 15.789 mm) set the Change mm/inches function to mm. The value is displayed to 3 decimal places.
- To select the inch system (e.g. X = 0.6216 inches) set the Change mm/inches function to inches. The value is displayed to 4 decimal places.

If you would like to activate the inch display, the TNC shows the feed rate in inch/min. In an inch program you must enter the feed rate larger by a factor of 10.



## 13.12 Select the Programming Language for \$MDI

### Function

The Program input MOD function lets you decide whether to program the \$MDI file in HEIDENHAIN conversational dialog or in ISO format.

- To program the \$MDI.H file in conversational dialog, set the Program input function to HEIDENHAIN
- To program the \$MDI.I file according to ISO, set the Program input function to ISO





## 13.13 Selecting the Axes for Generating L Blocks

### Function

The axis selection input field enables you to define the current tool position coordinates that are transferred to an L block. To generate a separate L block, press the ACTUAL-POSITION-CAPTURE soft key. The axes are selected by bit-oriented definition similar to programming the machine parameters:

Axis selection %11111: Transfer the X, Y, Z, IV, and V axes

Axis selection %01111: X, Y, Z, IV. Transfer the axis

Axis selection %00111: Transfer the X, Y and Z axes

Axis selection %00011: Transfer the X and Y axes

Axis selection %00001: Transfer the X axis



## 13.14 Enter the Axis Traverse Limits, Datum Display

### Function

The AXIS LIMIT MOD function allows you to set limits to axis traverse within the machine's actual working envelope.

Possible application: Protecting an indexing fixture against tool collision.

The maximum range of traverse of the machine tool is defined by software limit switches. This range can be additionally limited through the TRAVERSE RANGE MOD function. With this function, you can enter the maximum and minimum traverse positions for each axis, referenced to the machine datum. If several traverse ranges are possible on your machine, you can set the limits for each range separately using the soft keys TRAVERSE RANGE (1) to TRAVERSE RANGE (3).

### Working without additional traverse limits

To allow a machine axis to use its full range of traverse, enter the maximum traverse of the TNC (+/- 99 999 mm) as the TRAVERSE RANGE.

### Find and enter the maximum traverse

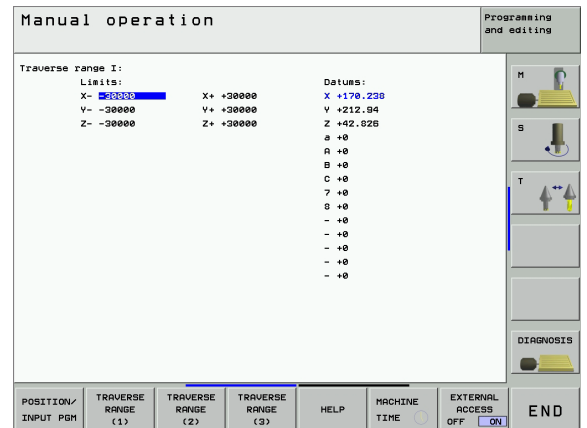
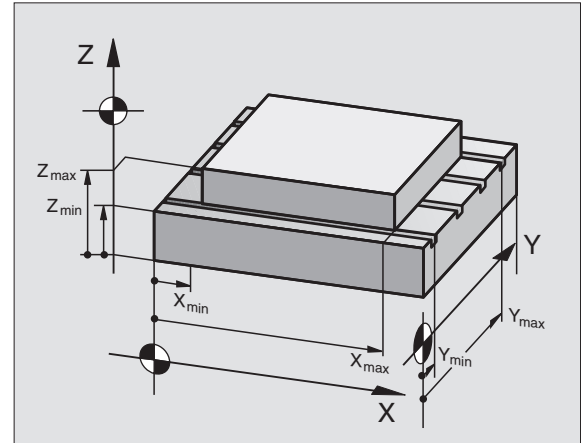
- ▶ Set the Position display mod function to REF.
- ▶ Move the spindle to the positive and negative end positions of the X, Y and Z axes.
- ▶ Write down the values, including the algebraic sign.
- ▶ To select the MOD functions, press the MOD key.
- ▶ Enter the limits for axis traverse: Press the TRAVERSE RANGE soft key and enter the values that you wrote down as limits in the corresponding axes
- ▶ To exit the MOD function, press the END soft key.

TRAVERSE  
RANGE



Active tool radius compensations are not taken into account in the axis traverse limit values.

The traverse range limits and software limit switches become active as soon as the reference points are traversed.



## Datum display

The values shown at the top right of the screen define the currently active datum. The datum can have been set manually or can have been activated from the preset table. The datum cannot be changed in the screen menu.



The displayed values depend on your machine configuration. Refer to the notes in Chapter 2 (see “Explanation of values saved in the preset table” on page 66).



## 13.15 Displaying HELP Files

### Function

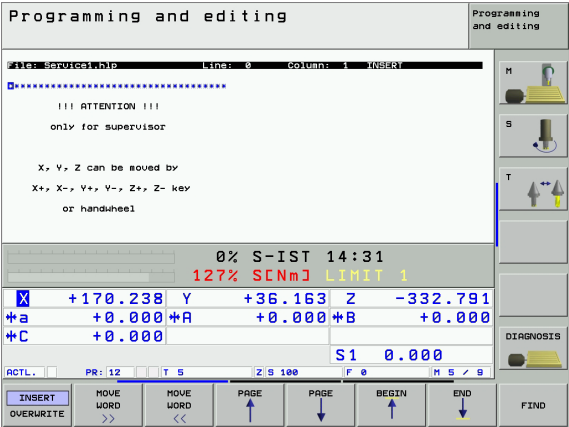
Help files can aid you in situations in which you need clear instructions before you can continue (for example, to retract the tool after an interruption of power). The miscellaneous functions may also be explained in a help file. The figure at right shows the screen display of a help file.



HELP files are not provided on every machine. Your machine tool builder can provide you with further information on this feature.


### Selecting HELP files

- ▶ Press the MOD key to select the MOD function.
  - ▶ To select the last active HELP file, press the HELP soft key.
  - ▶ Call the file manager (PGM MGT key) and select a different help file, if necessary.



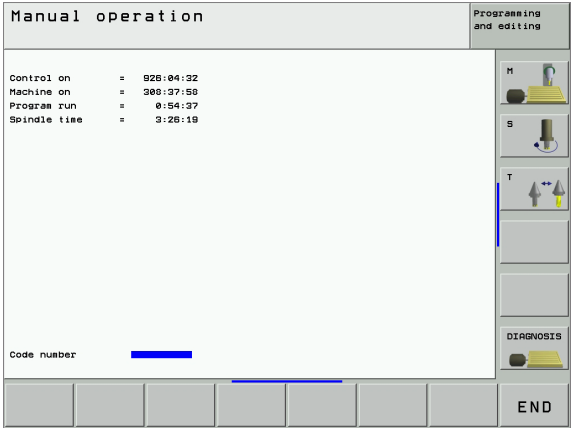
# 13.16 Display Operating Times

## Function

 The machine tool builder can provide further operating time displays. The machine tool manual provides further information.

The MACHINE TIME soft key enables you to show different operating time displays:

Operating time	Meaning
Control ON	Operating time of the control since commissioning
Machine ON	Operating time of the machine tool since commissioning
Program run	Duration of controlled operation since commissioning



## 13.17 TeleService

### Function



The TeleService functions are enabled and adapted by the machine tool builder. The machine tool manual provides further information.

The TNC provides two soft keys for teleservice, making it possible to configure two different service agencies.

The TNC allows you to carry out teleservice. To be able to use this feature, your TNC should be equipped with an Ethernet card which achieves a higher data transfer rate than the serial RS232-C interface.

With the HEIDENHAIN TeleService software, your machine tool builder can then establish a connection to the TNC via an ISDN modem and carry out diagnostics. The following functions are available:

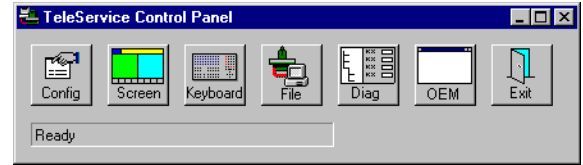
- On-line screen transfer
- Polling of machine states
- Data transfer
- Remote control of the TNC

### Calling/exiting teleservice

- ▶ Select any machine mode of operation.
- ▶ To select the MOD function, press the MOD key.




- ▶ Establish a connection to the service agency: Set the SERVICE or SUPPORT soft key to ON. The TNC breaks the connection automatically if no new data is transferred for a time set by the machine tool builder (default: 15 min).
- ▶ To break the connection to the service agency: Set the SERVICE or SUPPORT soft key to OFF. The TNC terminates the connection after approx. one minute.



# 13.18 External Access


## Function



The machine tool builder can configure teleservice settings with the LSV-2 interface. The machine tool manual provides further information.

The soft key SERVICE can be used to grant or restrict access through the LSV-2 interface.

With an entry in the configuration file TNC.SYS you can protect a directory and its subdirectories with a password. The password is requested when data from this directory is accessed from the LSV-2 interface. Enter the path and password for external access in the configuration file TNC.SYS.



The TNC.SYS file must be stored in the root directory TNC:\.

If you only supply one entry for the password, then the entire drive TNC:\ is protected.


You should use the updated versions of the HEIDENHAIN software TNCremo or TNCremoNT to transfer the data.

Entries in TNC.SYS	Meaning
REMOTE.TNCPASSWORD=	Password for LSV-2 access
REMOTE.TNCPRIVATEPATH=	Path to be protected

### Example of TNC.SYS

```
REMOTE.TNCPASSWORD=KR1402
REMOTE.TNCPRIVATEPATH=TNC:\RK
```

### Permitting/Restricting external access

- ▶ Select any machine mode of operation.
- ▶ To select the MOD function, press the MOD key.
- 

  - ▶ Permit a connection to the TNC: Set the EXTERNAL ACCESS soft key to ON. The TNC will then permit data access through the LSV-2 interface. The password is requested when a directory that was entered in the configuration file TNC.SYS is accessed.
  - ▶ Block connections to the TNC: Set the EXTERNAL ACCESS soft key to OFF. The TNC will then block access through the LSV-2 interface.







NAME = KONTUR.

TNC: \BHB530\\*.\*

Datei-Name		Byte	S
DOKU_BOHRPL	.A	0	
MOVE	.D	1276	
125852	.H	22	
REIECK	.H	90	
KONTUR	.H	472	S E
REIS1	.H	76	
REIS31XY	.H	76	
DEL	.H	416	
ADRAT	.H	90	
10	.I	22	
WAHL	.PNT	16	

Datei(en) 3716000 kbyte frei

EN KOPIEREN TYP



# 14

Tables and Overviews



## 14.1 General User Parameters

General user parameters are machine parameters affecting TNC settings that the user may want to change in accordance with his requirements.

Some examples of user parameters are:

- Dialog language
- Interface behavior
- Traversing speeds
- Sequence of machining
- Effect of overrides

### Input possibilities for machine parameters

Machine parameters can be programmed as

- **Decimal numbers**  
Enter only the number
- **Pure binary numbers**  
Enter a percent sign (%) before the number
- **Hexadecimal numbers**  
Enter a dollar sign (\$) before the number

#### Example:

Instead of the decimal number 27 you can also enter the binary number %11011 or the hexadecimal number \$1B.

The individual machine parameters can be entered in the different number systems.

Some machine parameters have more than one function. The input value for these machine parameters is the sum of the individual values. For these machine parameters the individual values are preceded by a plus sign.

### Selecting general user parameters

General user parameters are selected with code number 123 in the MOD functions.



The MOD functions also include machine-specific user parameters.

External data transfer	
Integrating TNC interfaces EXT1 (5020.0) and EXT2 (5020.1) to an external device	<p><b>MP5020.x</b> 7 data bits (ASCII code, 8th bit = parity): <b>+0</b> 8 data bits (ASCII code, 9th bit = parity): <b>+1</b></p> <p>Block Check Character (BCC) any: <b>+0</b> Block Check Character (BCC) control character not permitted: <b>+2</b></p> <p>Transmission stop through RTS active: <b>+4</b> Transmission stop through RTS inactive: <b>+0</b></p> <p>Transmission stop through DC3 active: <b>+8</b> Transmission stop through DC3 inactive: <b>+0</b></p> <p>Character parity even: <b>+0</b> Character parity odd: <b>+16</b></p> <p>Character parity not desired: <b>+0</b> Character parity desired: <b>+32</b></p> <p>Number of stop bits that are transmitted at the end of a character: 1 stop bit: <b>+0</b> 2 stop bits: <b>+64</b> 1 stop bit: <b>+128</b> 1 stop bit: <b>+192</b></p> <p>Example: Use the following setting to adjust the TNC interface EXT2 (MP 5020.1) to an external non-HEIDENHAIN device: 8 data bits, any BCC, transmission stop through DC3, even character parity, character parity desired, 2 stop bits Input for <b>MP 5020.1</b>: 1+0+8+0+32+64 = <b>105</b></p>
Interface type for EXT1 (5030.0) and EXT2 (5030.1)	<p><b>MP5030.x</b> Standard transmission: <b>0</b> Interface for blockwise transfer: <b>1</b></p>

3-D touch probes	
Select signal transmission	<p><b>MP6010</b> Touch probe with cable transmission: <b>0</b> Touch probe with infrared transmission: <b>1</b></p>
Probing feed rate for triggering touch probes	<p><b>MP6120</b> <b>1 to 3 000</b> [mm/min]</p>
Maximum traverse to first probe point	<p><b>MP6130</b> <b>0.001 to 99 999.9999</b> [mm]</p>
Safety clearance to probing point during automatic measurement	<p><b>MP6140</b> <b>0.001 to 99 999.9999</b> [mm]</p>
Rapid traverse for triggering touch probes	<p><b>MP6150</b> <b>1 to 300 000</b> [mm/min]</p>



3-D touch probes	
Measure center misalignment of the stylus when calibrating a triggering touch probe	<b>MP6160</b> No 180° rotation of the 3-D touch probe during calibration: <b>0</b> M function for 180° rotation of the touch probe during calibration: <b>1 to 999</b>
M function for orienting the infrared sensor before each measuring cycle	<b>MP6161</b> Function inactive: <b>0</b> Orientation directly through the NC: <b>-1</b> M function for orienting the touch probe: <b>1 to 999</b>
Angle of orientation for the infrared sensor	<b>MP6162</b> <b>0 to 359.9999</b> [°]
Difference between the current angle of orientation and the angle of orientation set in MP 6162; when the entered difference is reached, an oriented spindle stop is to be carried out.	<b>MP6163</b> <b>0 to 3.0000</b> [°]
Automatically orient the infrared sensor before probing to the programmed probing direction	<b>MP6165</b> Function inactive: <b>0</b> Orient infrared sensor: <b>1</b>
Multiple measurement for programmable probe function	<b>MP6170</b> <b>1 to 3</b>
Confidence range for multiple measurement	<b>MP6171</b> <b>0.001 to 0.999</b> [mm]
Automatic calibration cycle: Center of the calibration ring in the X axis referenced to the machine datum	<b>MP6180.0 (traverse range 1) to MP6180.2 (traverse range3)</b> <b>0 to 99 999.9999</b> [mm]
Automatic calibration cycle: Center of the calibration ring in the Y axis referenced to the machine datum	<b>MP6181.x (traverse range 1) to MP6181.2 (traverse range3)</b> <b>0 to 99 999.9999</b> [mm]
Automatic calibration cycle: Upper edge of the calibration ring in the Z axis referenced to the machine datum	<b>MP6182.x (traverse range 1) to MP6182.2 (traverse range3)</b> <b>0 to 99 999.9999</b> [mm]
Automatic calibration cycle: Distance below the upper edge of the ring where the calibration is carried out by the TNC	<b>MP6185.x (traverse range 1) to MP6185.2 (traverse range 3)</b> <b>0.1 to 99 999.9999</b> [mm]
Radius measurement with the TT 130 touch probe: Probing direction	<b>MP6505.0 (traverse range 1) to 6505.2 (traverse range 3)</b> Positive probing direction in the angle reference axis (0° axis): <b>0</b> Positive probing direction in the +90° axis: <b>1</b> Negative probing direction in the angle reference axis (0° axis): <b>2</b> Negative probing direction in the +90° axis: <b>3</b>
Probing feed rate for second measurement with TT 120, stylus shape, corrections in TOOL.T	<b>MP6507</b> Calculate feed rate for second measurement with TT 130, with constant tolerance: <b>+0</b> Calculate feed rate for second measurement with TT 130, with variable tolerance: <b>+1</b> Constant feed rate for second measurement with TT 130: <b>+2</b>

3-D touch probes	
<b>Maximum permissible measuring error with TT 130 during measurement with rotating tool</b>  Required for calculating the probing feed rate in connection with MP6570	<b>MP6510.0</b> <b>0.001 to 0.999</b> [mm] (recommended input value: 0.005 mm)  <b>MP6510.1</b> <b>0.001 to 0.999</b> [mm] (recommended input value: 0.01 mm)
<b>Feed rate for probing a stationary tool with the TT 130</b>	<b>MP6520</b> <b>1 to 3000</b> [mm/min]
<b>Radius measurement with the TT 130: Distance from lower edge of tool to upper edge of stylus</b>	<b>MP6530.0 (traverse range 1) to MP6530.2 (traverse range 3)</b> <b>0.001 to 99.9999</b> [mm]
<b>Set-up clearance in the tool axis above the stylus of the TT 130 for pre-positioning</b>	<b>MP6540.0</b> <b>0.001 to 30 000.000</b> [mm]
<b>Clearance zone in the machining plane around the stylus of the TT 130 for pre-positioning</b>	<b>MP6540.1</b> <b>0.001 to 30 000.000</b> [mm]
<b>Rapid traverse for TT 130 in the probe cycle</b>	<b>MP6550</b> <b>10 to 10 000</b> [mm/min]
<b>M function for spindle orientation when measuring individual teeth</b>	<b>MP6560</b> <b>0 to 999</b>
<b>Measuring rotating tools: Permissible rotational speed at the circumference of the milling tool</b>  Required for calculating rpm and probe feed rate	<b>MP6570</b> <b>1.000 to 120.000</b> [m/min]
<b>Measuring rotating tools: Permissible rotational rpm</b>	<b>MP6572</b> <b>0.000 to 1000.000</b> [rpm] If you enter 0, the speed is limited to 1000 rpm



3-D touch probes	
Coordinates of the TT 120 stylus center relative to the machine datum	<b>MP6580.0 (traverse range 1)</b> X axis
	<b>MP6580.1 (traverse range 1)</b> Y axis
	<b>MP6580.2 (traverse range 1)</b> Z axis
	<b>MP6581.0 (traverse range 2)</b> X axis
	<b>MP6581.1 (traverse range 2)</b> Y axis
	<b>MP6581.2 (traverse range 2)</b> Z axis
	<b>MP6582.0 (traverse range 3)</b> X axis
	<b>MP6582.1 (traverse range 3)</b> Y axis
	<b>MP6582.2 (traverse range 3)</b> Z axis
Monitoring the position of rotary axes and parallel axes	<b>MP6585</b> Function inactive: <b>0</b> Function active: <b>1</b>
Defining the rotary axes and parallel axes to be monitored	<b>MP6586.0</b> Do not monitor the position of the A axis: <b>0</b> Monitor the position of the A axis: <b>1</b> <b>MP6586.1</b> Do not monitor the position of the B axis: <b>0</b> Monitor the position of the B axis: <b>1</b> <b>MP6586.2</b> Do not monitor the position of the C axis: <b>0</b> Monitor the position of the C axis: <b>1</b> <b>MP6586.3</b> Do not monitor the position of the U axis: <b>0</b> Monitor the position of the U axis: <b>1</b> <b>MP6586.4</b> Do not monitor the position of the V axis: <b>0</b> Monitor the position of the V axis: <b>1</b> <b>MP6586.5</b> Do not monitor the position of the W axis: <b>0</b> Monitor the position of the W axis: <b>1</b>



TNC displays, TNC editor	
<b>Cycles 17, 18 and 207: Oriented spindle stop at beginning of cycle</b>	<b>MP7160</b> Oriented spindle stop: <b>0</b> No oriented spindle stop: <b>1</b>
<b>Programming station</b>	<b>MP7210</b> TNC with machine: <b>0</b> TNC as programming station with active PLC: <b>1</b> TNC as programming station with inactive PLC: <b>2</b>
<b>Acknowledgment of POWER INTERRUPTED after switch-on</b>	<b>MP7212</b> Acknowledge with key: <b>0</b> Acknowledge automatically: <b>1</b>
<b>ISO programming: Set the block number increment</b>	<b>MP7220</b> <b>0 to 150</b>
<b>Disabling the selection of file types</b>	<b>MP7224.0</b> All file types selectable via soft key: <b>+0</b> Disable selection of HEIDENHAIN programs (soft key SHOW .H): <b>+1</b> Disable selection of ISO programs (soft key SHOW .I): <b>+2</b> Disable selection of tool tables (soft key SHOW .T): <b>+4</b> Disable selection of datum tables (soft key SHOW .D): <b>+8</b> Disable selection of pallet tables (soft key SHOW .P): <b>+16</b> Disable selection of text files (soft key SHOW .A): <b>+32</b> Disable selection of point tables (soft key SHOW .PNT): <b>+64</b>
<b>Disabling the editor for certain file types</b>  <b>Note:</b>  If a particular file type is inhibited, the TNC will erase all files of this type.	<b>MP7224.1</b> Do not disable editor: <b>+0</b> Disable editor for  ■ HEIDENHAIN programs: <b>+1</b> ■ ISO programs: <b>+2</b> ■ Tool tables: <b>+4</b> ■ Datum tables: <b>+8</b> ■ Pallet tables: <b>+16</b> ■ Text files: <b>+32</b> ■ Point tables: <b>+64</b>
<b>Configure pallet files</b>	<b>MP7226.0</b> Pallet table inactive: <b>0</b> Number of pallets per pallet table: <b>1 to 255</b>
<b>Configure datum files</b>	<b>MP7226.1</b> Datum table inactive: <b>0</b> Number of datums per datum table: <b>1 to 255</b>
<b>Program length for program check</b>	<b>MP7229.0</b> Blocks <b>100 to 9999</b>
<b>Program length up to which FK blocks are permitted</b>	<b>MP7229.1</b> Blocks <b>100 to 9999</b>



TNC displays, TNC editor	
Dialog language	<b>MP7230</b> English: <b>0</b> German: <b>1</b> Czech: <b>2</b> French: <b>3</b> Italian: <b>4</b> Spanish: <b>5</b> Portuguese: <b>6</b> Swedish: <b>7</b> Danish: <b>8</b> Finnish: <b>9</b> Dutch: <b>10</b> Polish: <b>11</b> Hungarian: <b>12</b> Reserved: <b>13</b> Russian (Cyrillic character set): <b>14</b> (only on the MC 422 B) Chinese (simplified): <b>15</b> (only on the MC 422 B) Chinese (traditional): <b>16</b> (only on the MC 422 B)
Internal clock of the TNC	<b>MP7235</b> Universal time (Greenwich time): <b>0</b> Central European Time (CET): <b>1</b> Central European Summer Time: <b>2</b> Time difference to universal time: <b>-23</b> to <b>+23</b> [hours]
Configure tool tables	<b>MP7260</b> Inactive: <b>0</b> Number of tools generated by the TNC when a new tool table is opened: <b>1</b> to <b>254</b> If you require more than 254 tools, you can expand the tool table with the function APPEND N LINES see "Tool Data" on page 144
Configure pocket tables	<b>MP7261.0 (magazine 1)</b> <b>MP7261.1 (magazine 2)</b> <b>MP7261.2 (magazine 3)</b> <b>MP7261.3 (magazine 4)</b> Inactive: <b>0</b> Number of pockets in the tool magazine: <b>1</b> to <b>254</b> If the value 0 is entered in MP7261.1 to MP7261.3, only one tool magazine will be used.
Index tool numbers in order to be able to assign different compensation data to one tool number	<b>MP7262</b> Do not index: <b>0</b> Number of permissible indices: <b>1</b> to <b>9</b>
Soft key for pocket tables	<b>MP7263</b> Show the POCKET TABLE soft key in the tool table: <b>0</b> Do not show the POCKET TABLE soft key in the tool table: <b>1</b>





## TNC displays, TNC editor

**Configure tool table  
(To omit from the  
table: enter 0); Column  
number in the tool  
table for**

### **MP7266.0**

Tool name – NAME: **0** to **32**; column width: 16 characters

### **MP7266.1**

Tool length – L: **0** to **32**; column width: 11 characters

### **MP7266.2**

Tool radius – R: **0** to **32**; column width: 11 characters

### **MP7266.3**

Tool radius 2 – R2: **0** to **32**; column width: 11 characters

### **MP7266.4**

Oversize length – DL: **0** to **32**; column width: 8 characters

### **MP7266.5**

Oversize radius – DR: **0** to **32**; column width: 8 characters

### **MP7266.6**

Oversize radius 2 – DR2: **0** to **32**; column width: 8 characters

### **MP7266.7**

Tool locked – TL: **0** to **32**; column width: 2 characters

### **MP7266.8**

Replacement tool – RT: **0** to **32**; column width: 3 characters

### **MP7266.9**

Maximum tool life – TIME1: **0** to **32**; column width: 5 characters

### **MP7266.10**

Maximum tool life for TOOL CALL – TIME2: **0** to **32**; column width: 5 characters

### **MP7266.11**

Current tool life – CUR. TIME: **0** to **32**; column width: 8 characters

### **MP7266.12**

Tool comment – DOC: **0** to **32**; column width: 16 characters

### **MP7266.13**

Number of teeth – CUT.: **0** to **32**; column width: 4 characters

### **MP7266.14**

Tolerance for wear detection in tool length – LTOL: **0** to **32**; column width: 6 characters

### **MP7266.15**

Tolerance for wear detection in tool radius – RTOL: **0** to **32**; column width: 6 characters



TNC displays, TNC editor

Configure tool table  
(To omit from the  
table: enter 0); Column  
number in the tool  
table for

- MP7266.16**  
Cutting direction – DIRECT.: **0** to **32**; column width: 7 characters
- MP7266.17**  
PLC status – PLC: **0** to **32**; column width: 9 characters
- MP7266.18**  
Offset of the tool in the tool axis in addition to MP6530 – TT:L-OFFS: **0** to **32**  
column width: 11 characters
- MP7266.19**  
Offset of the tool between stylus center and tool center – TT:R-OFFS: **0** to **32**  
column width: 11 characters
- MP7266.20**  
Tolerance for break detection in tool length – LBREAK: **0** to **32**; column width: 6 characters
- MP7266.21**  
Tolerance for break detection in tool radius – RBREAK: **0** to **32**; column width: 6 characters
- MP7266.22**  
Tooth length (Cycle 22) – LCUTS: **0** to **32**; column width: 11 characters
- MP7266.23**  
Maximum plunge angle (Cycle 22) – ANGLE.: **0** to **32**; column width: 7 characters
- MP7266.24**  
Tool type –TYP: **0** to **32**; column width: 5 characters
- MP7266.25**  
Tool material – TMAT: **0** to **32**; column width: 16 characters
- MP7266.26**  
Cutting data table – CDT: **0** to **32**; column width: 16 characters
- MP7266.27**  
PLC value – PLC-VAL: **0** to **32**; column width: 11 characters
- MP7266.28**  
Center misalignment in reference axis – CAL-OFF1: **0** to **32**; column width: 11 characters
- MP7266.29**  
Center misalignment in minor axis – CAL-OFF2: **0** to **32**; column width: 11 characters
- MP7266.30**  
Spindle angle for calibration – CALL-ANG: **0** to **32**; column width: 11 characters
- MP7266.31**  
Tool type for the pocket table–PTYP: **0** to **32**; column width: 2 characters
- MP7266.32**  
Limitation of spindle speed – NMAX: – to **999999**; Column width: 6 characters
- MP7266.33**  
Retraction at NC stop – LIFTOFF: **Y / N**; column width is 1 character
- MP7266.34**  
Machine-dependent function – P1: **–99999.9999** to **+99999.9999**; column width: 10 characters
- MP7266.35**  
Machine-dependent function – P2: **–99999.9999** to **+99999.9999**; column width: 10 characters
- MP7266.36**  
Machine-dependent function – P3: **–99999.9999** to **+99999.9999**; column width: 10 characters
- MP7266.37**  
Tool-specific kinematics description – KINEMATIC: **Name of the kinematics description**;  
column width: 16 characters
- MP7266.38**  
Point angle – T\_ANGLE: **0** to **180**; column width: 9 characters
- MP7266.39**  
Thread pitch PITCH: **0** to **99999.9999**; column width: 10 characters



TNC displays, TNC editor	
Configure tool pocket table (to omit from the table: enter 0); Column number in the pocket table for	<p><b>MP7267.0</b> Tool number – T: <b>0</b> to <b>7</b></p> <p><b>MP7267.1</b> Special tool – ST: <b>0</b> to <b>7</b></p> <p><b>MP7267.2</b> Fixed pocket – F: <b>0</b> to <b>7</b></p> <p><b>MP7267.3</b> Pocket locked – L: <b>0</b> to <b>7</b></p> <p><b>MP7267.4</b> PLC status – PLC: <b>0</b> to <b>7</b></p> <p><b>MP7267.5</b> Tool name from tool table – TNAME: <b>0</b> to <b>7</b></p> <p><b>MP7267.6</b> Comment from tool table – DOC: <b>0</b> to <b>77</b></p> <p><b>MP7267.7</b> Tool type – PTP: <b>0</b> to <b>99</b></p> <p><b>MP7267.8</b> Value for PLC – P1: <b>-99999.9999</b> to <b>+99999.9999</b></p> <p><b>MP7267.9</b> Value for PLC – P2: <b>-99999.9999</b> to <b>+99999.9999</b></p> <p><b>MP7267.10</b> Value for PLC – P3: <b>-99999.9999</b> to <b>+99999.9999</b></p> <p><b>MP7267.11</b> Value for PLC – P4: <b>-99999.9999</b> to <b>+99999.9999</b></p> <p><b>MP7267.12</b> Value for PLC – P5: <b>-99999.9999</b> to <b>+99999.9999</b></p> <p><b>MP7267.13</b> Reserved pocket – RSV: <b>0</b> to <b>1</b></p> <p><b>MP7267.14</b> Pocket above locked – LOCKED_ABOVE: <b>0</b> to <b>65535</b></p> <p><b>MP7267.15</b> Pocket below locked – LOCKED_BELOW: <b>0</b> to <b>65535</b></p> <p><b>MP7267.16</b> Pocket at left locked – LOCKED_LEFT: <b>0</b> to <b>65535</b></p> <p><b>MP7267.17</b> Pocket at right locked – LOCKED_RIGHT: <b>0</b> to <b>65535</b></p>
Manual Operation mode: Display of feed rate	<p><b>MP7270</b> Display feed rate F only if an axis direction button is pressed: <b>0</b> Display feed rate F even if no axis direction button is pressed (feed rate defined via soft key F or feed rate of the “slowest” axis): <b>1</b></p>
Decimal character	<p><b>MP7280</b> The decimal character is a comma: <b>0</b> The decimal character is a point: <b>1</b></p>
Position display in the tool axis	<p><b>MP7285</b> Display is referenced to the tool datum: <b>0</b> Display in the tool axis is referenced to the tool face: <b>1</b></p>



TNC displays, TNC editor	
Display step for the spindle position	<b>MP7289</b> 0.1 °: <b>0</b> 0.05 °: <b>1</b> 0.01 °: <b>2</b> 0.005 °: <b>3</b> 0.001 °: <b>4</b> 0.0005 °: <b>5</b> 0.0001 °: <b>6</b>
Display step	<b>MP7290.0 (X axis) to MP7290.13 (14th axis)</b> 0.1 mm: <b>0</b> 0.05 mm: <b>1</b> 0.01 mm: <b>2</b> 0.005 mm: <b>3</b> 0.001 mm: <b>4</b> 0.0005 mm: <b>5</b> 0.0001 mm: <b>6</b>
Disable datum setting in the preset table	<b>MP7294</b> Do not disable datum setting: <b>+0</b> Disable datum setting in the X axis: <b>+1</b> Disable datum setting in the Y axis: <b>+2</b> Disable datum setting in the Z axis: <b>+4</b> Disable datum setting in the IVth axis: <b>+8</b> Disable datum setting in the Vth axis: <b>+16</b> Disable datum setting in the 6th axis: <b>+32</b> Disable datum setting in the 7th axis: <b>+64</b> Disable datum setting in the 8th axis: <b>+128</b> Disable datum setting in the 9th axis: <b>+256</b> Disable datum setting in the 10th axis: <b>+512</b> Disable datum setting in the 11th axis: <b>+1024</b> Disable datum setting in the 12th axis: <b>2048</b> Disable datum setting in the 13th axis: <b>+4096</b> Disable datum setting in the 14th axis: <b>+8192</b>
Disable datum setting	<b>MP7295</b> Do not disable datum setting: <b>+0</b> Disable datum setting in the X axis: <b>+1</b> Disable datum setting in the Y axis: <b>+2</b> Disable datum setting in the Z axis: <b>+4</b> Disable datum setting in the IVth axis: <b>+8</b> Disable datum setting in the Vth axis: <b>+16</b> Disable datum setting in the 6th axis: <b>+32</b> Disable datum setting in the 7th axis: <b>+64</b> Disable datum setting in the 8th axis: <b>+128</b> Disable datum setting in the 9th axis: <b>+256</b> Disable datum setting in the 10th axis: <b>+512</b> Disable datum setting in the 11th axis: <b>+1024</b> Disable datum setting in the 12th axis: <b>2048</b> Disable datum setting in the 13th axis: <b>+4096</b> Disable datum setting in the 14th axis: <b>+8192</b>
Disable datum setting with the orange axis keys	<b>MP7296</b> Do not disable datum setting: <b>0</b> Disable datum setting with the orange axis keys: <b>1</b>



TNC displays, TNC editor	
<b>Reset status display, Q parameters, tool data and machining time</b>	<b>MP7300</b> Reset all when a program is selected: <b>0</b> Reset all when a program is selected and with M02, M30, END PGM: <b>1</b> Reset only status display and tool data when a program is selected: <b>2</b> Reset only status display, machining time and tool data when a program is selected and with M02, M30, END PGM: <b>3</b> Reset status display, machining time and Q parameters when a program is selected: <b>4</b> Reset status display, machining time, and Q parameters when a program is selected and with M02, M30, END PGM: <b>5</b> Reset status display and machining time when a program is selected: <b>6</b> Reset status display and machining time when a program is selected and with M02, M30, END PGM: <b>7</b>
<b>Graphic display mode</b>	<b>MP7310</b> Projection in three planes according to ISO 6433, projection method 1: <b>+1</b> Projection in three planes according to ISO 6433, projection method 2: <b>+1</b> Do not rotate coordinate for graphic display: <b>+0</b> Rotate coordinate system for graphic display by 90°: <b>+2</b> Display new BLK FORM in Cycle 7 DATUM SHIFT referenced to the old datum: <b>+0</b> Display new BLK FORM in Cycle 7 DATUM SHIFT referenced to the new datum: <b>+4</b> Do not show cursor position during projection in three planes: <b>+0</b> Show cursor position during projection in three planes: <b>+8</b> Software functions of the new 3-D graphics active: <b>+0</b> Software functions of the new 3-D graphics inactive: <b>+16</b>
<b>Limitation of a tool's tooth length to be simulated. Only effective if LCUTS is not defined.</b>	<b>MP7312</b> <b>0 to 99 999.9999</b> [mm] Factor by which the tool diameter is multiplied in order to increase the simulation speed. If 0 is entered, the TNC assumes an infinitely long tooth length, which increases the simulation speed.
<b>Graphic simulation without programmed tool axis: Tool radius</b>	<b>MP7315</b> <b>0 to 99 999.9999</b> [mm]
<b>Graphic simulation without programmed tool axis: Penetration depth</b>	<b>MP7316</b> <b>0 to 99 999.9999</b> [mm]
<b>Graphic simulation without programmed tool axis: M function for start</b>	<b>MP7317.0</b> <b>0 to 88</b> (0: function inactive)
<b>Graphic simulation without programmed tool axis: M function for end</b>	<b>MP7317.1</b> <b>0 to 88</b> (0: function inactive)
<b>Screen saver</b> Enter the time after which the TNC should start the screen saver	<b>MP7392</b> <b>0 to 99</b> [min] (0: function inactive)



Machining and program run	
Effect of Cycle 11 SCALING FACTOR	<b>MP7410</b> SCALING FACTOR effective in 3 axes: <b>0</b> SCALING FACTOR effective in the working plane only: <b>1</b>
Manage tool data/calibration data	<b>MP7411</b> The TNC saves the calibrated data for the 3-D touch probe internally: <b>+0</b> The TNC uses the compensation values for the touch probe from the tool table as calibration data for the 3-D touch probe: <b>+1</b>
SL Cycles	<b>MP7420</b> Mill channel around the contour - clockwise for islands and counterclockwise for pockets: <b>+0</b> Mill channel around the contour - clockwise for pockets and counterclockwise for islands: <b>+1</b> First mill the channel, then rough out the contour: <b>+0</b> First rough out the contour, then mill the channel: <b>+2</b> Combine compensated contours: <b>+0</b> Combine uncompensated contours: <b>+4</b> Complete one process for all infeeds before switching to the other process: <b>+0</b> Mill channel and rough-out for each infeed depth before continuing to the next depth: <b>+8</b>  The following note applies to the Cycles 6, 15, 16, 21, 22, 23, and 24: At the end of the cycle, move the tool to the position that was last programmed before the cycle call: <b>+0</b> At the end of the cycle, retract the tool in the tool axis only: <b>+16</b>
Cycle 4 POCKET MILLING, Cycle 5 CIRCULAR POCKET MILLING, and Cycle 6 ROUGH OUT: Overlap factor	<b>MP7430</b> <b>0.1 to 1.414</b>
Permissible deviation of circle radius between circle end point and circle starting point	<b>MP7431</b> <b>0.0001 to 0.016</b> [mm]
Operation of various miscellaneous functions M  Note:  The $k_V$ factors for position loop gain are set by the machine tool builder. Refer to your machine manual.	<b>MP7440</b> Program stop with M06: <b>+0</b> No program stop with M06: <b>+1</b> No cycle call with M89: <b>+0</b> Cycle call with M89: <b>+2</b> Program stop with M functions: <b>+0</b> No program stop with M functions: <b>+4</b> $k_V$ factors cannot be switched through M105 and M106: <b>+0</b> $k_V$ factors switchable through M105 and M106: <b>+8</b> Reduce the feed rate in the tool axis with M103 F.. Function inactive: <b>+0</b> Reduce the feed rate in the tool axis with M103 F.. Function active: <b>+16</b> Exact stop for positioning with rotary axes inactive: <b>+0</b> Exact stop for positioning with rotary axes active: <b>+64</b>



Machining and program run	
Error message during cycle call	<b>MP7441</b> Error message when M3/M4 not active: <b>0</b> Suppress error message when M3/M4 not active: <b>+1</b> Reserved: <b>+2</b> Suppress error message when positive depth programmed: <b>+0</b> Output error message when negative depth programmed: <b>+4</b>
M function for spindle orientation in the fixed cycles	<b>MP7442</b> Function inactive: <b>0</b> Orientation directly through the NC: <b>-1</b> M function for orienting the spindle: <b>1</b> to <b>999</b>
Maximum contouring speed at feed rate override setting of 100% in the Program Run modes	<b>MP7470</b> <b>0</b> to <b>99 999</b> [mm/min]
Feed rate for rotary-axis compensation movements	<b>MP7471</b> <b>0</b> to <b>99 999</b> [mm/min]
Compatibility machine parameters for datum tables	<b>MP7475</b> Datum shifts are referenced to the workpiece datum: <b>0</b> If the value <b>1</b> was entered in older TNC controls or in controls with software 340 420-xx, datum shifts were referenced to the machine datum. This function is no longer available. You must now use the preset table instead of datum tables referenced to REF (see "Datum management with the preset table" on page 64).



# 14.2 Pin Layout and Connecting Cable for the Data Interfaces

## RS-232-C/V.24 interface for HEIDENHAIN devices



The interface complies with the requirements of EN 50 178 for “low voltage electrical separation.”

When using the 25-pin adapter block:

TNC		Connecting cable 365 725-xx			Adapter block 310 085-01		Connecting cable 274 545-xx		
Male	Assignment	Female	Color	Female	Male	Female	Male	Color	Female
1	Do not assign	1		1	1	1	1	WH/BN	1
2	RXD	2	Yellow	3	3	3	3	Yellow	2
3	TXD	3	Green	2	2	2	2	Green	3
4	DTR	4	Brown	20	20	20	20	Brown	8
5	Signal GND	5	Red	7	7	7	7	Red	7
6	DSR	6	Blue	6	6	6	6		6
7	RTS	7	Gray	4	4	4	4	Gray	5
8	CTR	8	Pink	5	5	5	5	Pink	4
9	Do not assign	9					8	Violet	20
Hsg.	Ext. shield	Hsg.	Ext. shield	Hsg.	Hsg.	Hsg.	Hsg.	Ext. shield	Hsg.

When using the 9-pin adapter block:

TNC		Connecting cable 355 484-xx			Adapter block 363 987-02		Connecting cable 366 964-xx		
Male	Assignment	Female	Color	Male	Female	Male	Female	Color	Female
1	Do not assign	1	Red	1	1	1	1	Red	1
2	RXD	2	Yellow	2	2	2	2	Yellow	3
3	TXD	3	White	3	3	3	3	White	2
4	DTR	4	Brown	4	4	4	4	Brown	6
5	Signal GND	5	Black	5	5	5	5	Black	5
6	DSR	6	Violet	6	6	6	6	Violet	4
7	RTS	7	Gray	7	7	7	7	Gray	8
8	CTR	8	WH/GN	8	8	8	8	WH/GN	7
9	Do not assign	9	Green	9	9	9	9	Green	9
Hsg.	Ext. shield	Hsg.	Ext. shield	Hsg.	Hsg.	Hsg.	Hsg.	Ext. shield	Hsg.





Non-HEIDENHAIN devices

The connector pin layout of a non-HEIDENHAIN device may differ considerably from that on a HEIDENHAIN device.

This often depends on the unit and type of data transfer. The table below shows the connector pin layout on the adapter block.

Adapter block 363 987-02		Connecting cable 366 964-xx		
Female	Male	Female	Color	Female
1	1	1	Red	1
2	2	2	Yellow	3
3	3	3	White	2
4	4	4	Brown	6
5	5	5	Black	5
6	6	6	Violet	4
7	7	7	Gray	8
8	8	8	WH/GN	7
9	9	9	Green	9
Hsg.	Hsg.	Hsg.	Ext. shield	Hsg.



RS-422/V.11 interface

Only non-HEIDENHAIN devices are connected to the RS-422 interface.



The interface complies with the requirements of EN 50 178 for “low voltage electrical separation.”

The pin layouts on the TNC logic unit (X28) and on the adapter block are identical.

TNC		Connecting cable 355 484-xx			Adapter block 363 987-01	
Female	Assignment	Male	Color	Female	Male	Female
1	RTS	1	Red	1	1	1
2	DTR	2	Yellow	2	2	2
3	RXD	3	White	3	3	3
4	TXD	4	Brown	4	4	4
5	Signal GND	5	Black	5	5	5
6	CTS	6	Violet	6	6	6
7	DSR	7	Gray	7	7	7
8	RXD	8	WH/GN	8	8	8
9	TXD	9	Green	9	9	9
Hsg.	Ext. shield	Hsg.	Ext. shield	Hsg.	Hsg.	Hsg.

Ethernet interface RJ45 socket

Maximum cable length:

- Unshielded: 100 m
- Shielded: 400 m

Pin	Signal	Description
1	TX+	Transmit Data
2	TX–	Transmit Data
3	REC+	Receive Data
4	Vacant	
5	Vacant	
6	REC–	Receive Data
7	Vacant	
8	Vacant	



## 14.3 Technical Information

### Explanation of symbols

- Standard
- Axis option
- Software option 1
- Software option 2

User functions	
<b>Description</b>	<ul style="list-style-type: none"> <li>■ Basic version: 3 axes plus spindle</li> <li>● Fourth NC axis plus auxiliary axis or</li> <li>● 8 additional axes or 7 additional axes plus 2nd spindle</li> <li>■ Digital current and speed control</li> </ul>
<b>Programming</b>	HEIDENHAIN conversational format, with smarT.NC and as per ISO
<b>Position entry</b>	<ul style="list-style-type: none"> <li>■ Nominal positions for line segments and arcs in Cartesian or polar coordinates</li> <li>■ Absolute or incremental dimensions</li> <li>■ Display and entry in mm or inches</li> <li>■ Display of the handwheel path during machining with handwheel superimposition</li> </ul>
<b>Tool compensations</b>	<ul style="list-style-type: none"> <li>■ Tool radius in the working plane and tool length</li> <li>■ Calculating the radius-compensated contour up to 99 blocks in advance (M120)</li> <li>■ Three-dimensional tool-radius compensation for subsequent changing of tool data without having to recalculate the program</li> </ul>
<b>Tool tables</b>	Multiple tool tables with any number of tools
<b>Cutting data tables</b>	Cutting data tables for automatic calculation of spindle speed and feed rate from tool-specific data (cutting speed, feed per tooth)
<b>Constant cutting speed</b>	<ul style="list-style-type: none"> <li>■ With respect to the path of the tool center</li> <li>■ With respect to the cutting edge</li> </ul>
<b>Background programming</b>	Create one program with graphical support while another program is running.
<b>3-D machining (software option 2)</b>	<ul style="list-style-type: none"> <li>□ Motion control with minimum jerk</li> <li>□ 3-D compensation through surface normal vectors</li> <li>□ Using the electronic handwheel to change the angle of the swivel head during program run without affecting the position of the tool point (TCPM = Tool Center Point Management)</li> <li>□ Keeping the tool normal to the contour</li> <li>□ Tool radius compensation normal to the direction of traverse and the tool direction</li> <li>□ Spline interpolation</li> </ul>
<b>Rotary table machining (software option 1)</b>	<ul style="list-style-type: none"> <li>○ Programming of cylindrical contours as if in two axes</li> <li>○ Feed rate in length per minute</li> </ul>



User functions	
<b>Contour elements</b>	<ul style="list-style-type: none"> <li>■ Straight line</li> <li>■ Chamfer</li> <li>■ Circular path</li> <li>■ Circle center</li> <li>■ Circle radius</li> <li>■ Tangentially connecting circle</li> <li>■ Corner rounding</li> </ul>
<b>Contour approach and departure</b>	<ul style="list-style-type: none"> <li>■ Via straight line: tangential or perpendicular</li> <li>■ Via circular arc</li> </ul>
<b>FK free contour programming</b>	■ FK free contour programming in HEIDENHAIN conversational format with graphic support for workpiece drawings not dimensioned for NC
<b>Program jumps</b>	<ul style="list-style-type: none"> <li>■ Subprograms</li> <li>■ Program section repeat</li> <li>■ Program as subprogram</li> </ul>
<b>Fixed cycles</b>	<ul style="list-style-type: none"> <li>■ Drilling cycles for drilling, pecking, reaming, boring, tapping with a floating tap holder, rigid tapping</li> <li>■ Cycles for milling internal and external threads</li> <li>■ Milling and finishing rectangular and circular pockets</li> <li>■ Cycles for multipass milling of flat and twisted surfaces</li> <li>■ Cycles for milling linear and circular slots</li> <li>■ Linear and circular point patterns</li> <li>■ Contour pockets—also with contour-parallel machining</li> <li>■ Contour train</li> <li>■ OEM cycles (special cycles developed by the machine tool builder) can also be integrated</li> </ul>
<b>Coordinate transformation</b>	<ul style="list-style-type: none"> <li>■ Datum shift, rotation, mirroring</li> <li>■ Axis-specific scaling</li> <li>○ Tilting the working plane (software option 1)</li> </ul>
<b>Q parameters</b> Programming with variables	<ul style="list-style-type: none"> <li>■ Mathematic functions =, +, −, *, /, <math>\sin \alpha</math>, <math>\cos \alpha</math>  <math>\sqrt{a^2 + b^2}</math>    <math>\sqrt{a}</math></li> <li>■ Logical comparisons (=, ≠, &lt;, &gt;)</li> <li>■ Calculating with parentheses</li> <li>■ <math>\tan \alpha</math>, arc sin, arc cos, arc tan, <math>a^n</math>, <math>e^n</math>, ln, log, absolute value of a number, the constant <math>\pi</math>, negation, truncation of digits before or after the decimal point</li> <li>■ Functions for calculating circles</li> </ul>
<b>Programming support</b>	<ul style="list-style-type: none"> <li>■ Calculator</li> <li>■ Context-sensitive help function for error messages</li> <li>■ Graphical support during programming of cycles</li> <li>■ Comment blocks in the NC program</li> </ul>
<b>Actual position capture</b>	■ Actual positions can be transferred directly into the NC program

User functions	
<b>Test Run graphics</b> Display modes	Graphic simulation before a program run, even while another program is being run <ul style="list-style-type: none"> <li>■ Plan view / projection in 3 planes / 3-D view</li> <li>■ Magnification of details</li> </ul>
<b>Interactive programming graphics</b>	<ul style="list-style-type: none"> <li>■ In the Programming and Editing mode, the contour of the NC blocks is drawn on screen while they are being entered (2-D pencil-trace graphics), even while another program is running</li> </ul>
<b>Program Run graphics</b> Display modes	<ul style="list-style-type: none"> <li>■ Graphic simulation of real-time machining in plan view / projection in 3 planes / 3-D view</li> </ul>
<b>Machining time</b>	<ul style="list-style-type: none"> <li>■ Calculating the machining time in the Test Run mode of operation</li> <li>■ Display of the current machining time in the Program Run modes</li> </ul>
<b>Returning to the contour</b>	<ul style="list-style-type: none"> <li>■ Mid-program startup in any block in the program, returning the tool to the calculated nominal position to continue machining</li> <li>■ Program interruption, contour departure and reapproach</li> </ul>
<b>Datum tables</b>	<ul style="list-style-type: none"> <li>■ Several datum tables</li> </ul>
<b>Pallet tables</b>	<ul style="list-style-type: none"> <li>■ Pallet tables (with as many entries as desired for the selection of pallets, NC programs and datums) can be machined workpiece by workpiece or tool by tool</li> </ul>
<b>Touch probe cycles</b>	<ul style="list-style-type: none"> <li>■ Calibrating a touch probe</li> <li>■ Compensation of workpiece misalignment, manual or automatic</li> <li>■ Datum setting, manual or automatic</li> <li>■ Automatic workpiece measurement</li> <li>■ Cycles for automatic tool measurement</li> </ul>
Specifications	
<b>Components</b>	<ul style="list-style-type: none"> <li>■ MC 422 B main computer</li> <li>■ CC 422 or CC 424 controller unit</li> <li>■ Operating panel</li> <li>■ 15.1" TFT color flat-panel display with soft keys</li> </ul>
<b>Program memory</b>	<ul style="list-style-type: none"> <li>■ Hard disk with at least 36 GB for NC programs</li> </ul>
<b>Input resolution and display step</b>	<ul style="list-style-type: none"> <li>■ To 0.1 <math>\mu\text{m}</math> for linear axes</li> <li>■ To 0.0001° for angular axes</li> </ul>
<b>Input range</b>	<ul style="list-style-type: none"> <li>■ Maximum 99 999.999 mm (3.937 in.) or 99 999.999°</li> </ul>



Specifications	
Interpolation	<div><div>■</div>Line in 4 axes</div> <div><div>□</div>Line in 5 axes (subject to export permit) (software option 1)</div> <div><div>■</div>Arc in 2 axes</div> <div><div>○</div>Arc in 3 axes with tilted working plane (software option 1)</div> <div><div>■</div>Helix: Combination of circular and linear motion</div> <div><div>■</div>Spline: Execution of splines (3rd degree polynomials)</div>
Block processing time 3-D straight line without radius compensation	<div><div>■</div>3.6 ms</div> <div><div>□</div>0.5 ms (software option 2)</div>
Axis feedback control	<div><div>■</div>Position loop resolution: Signal period of the position encoder/1024</div> <div><div>■</div>Cycle time of position controller: 1.8 ms</div> <div><div>■</div>Cycle time of speed controller: 600 µs</div> <div><div>■</div>Cycle time of current controller: minimum 100 µs</div>
Traverse range	<div><div>■</div>Maximum 100 m (3973 inches)</div>
Spindle speed	<div><div>■</div>Maximum 40 000 rpm (with 2 pole pairs)</div>
Error compensation	<div><div>■</div>Linear and nonlinear axis error, backlash, reversal spikes during circular movements, thermal expansion</div> <div><div>■</div>Stick-slip friction</div>
Data interfaces	<div><div>■</div>One each RS-232-C / V.24 and RS-422 / V.11 max. 115 kilobaud</div> <div><div>■</div>Expanded data interface with LSV-2 protocol for remote operation of the TNC through the data interface with the HEIDENHAIN software TNCremo</div> <div><div>■</div>Ethernet interface 100 Base T approx. 2 to 5 megabaud (depending on file type and network load)</div> <div><div>■</div>USB 2.0 interface For connection of pointing devices (mouse)</div>
Ambient temperature	<div><div>■</div>Operation: 0 °C to +45 °C (32 °F to 113 °F)</div> <div><div>■</div>Storage: -30 °C to +70 °C (-22 °F to 158 °F)</div>
Accessories	
Electronic handwheels	<div><div>■</div>One <b>HR 420</b> portable handwheel with display or</div> <div><div>■</div>One <b>HR 410</b> portable handwheel or</div> <div><div>■</div>One <b>HR 130</b> panel-mounted handwheel or</div> <div><div>■</div>Up to three <b>HR 150</b> panel-mounted handwheels via HRA 110 handwheel adapter</div>
Touch probes	<div><div>■</div><b>TS 220</b>: 3-D touch trigger probe with cable connection, or</div> <div><div>■</div><b>TS 640</b>: 3-D touch trigger probe with infrared transmission</div> <div><div>■</div><b>TT 130</b>: 3-D touch trigger probe for workpiece measurement</div>



Software option 1	
Rotary table machining	<input type="radio"/> Programming of cylindrical contours as if in two axes <input type="checkbox"/> Feed rate in length per minute
Coordinate transformations	<input type="radio"/> Tilting the working plane
Interpolation	<input type="radio"/> Circle in 3 axes (with tilted working plane)
Software option 2	
3-D machining	<input type="checkbox"/> Motion control with minimum jerk <input type="checkbox"/> 3-D compensation through surface normal vectors <input type="checkbox"/> Using the electronic handwheel to change the angle of the swivel head during program run without affecting the position of the tool point (TCPM = Tool Center Point Management) <input type="checkbox"/> Keeping the tool normal to the contour <input type="checkbox"/> Tool radius compensation normal to the direction of traverse and the tool direction <input type="checkbox"/> Spline interpolation
Interpolation	<input type="checkbox"/> Line in 5 axes (subject to export permit)
Block processing time	<input type="checkbox"/> 0.5 ms



Input format and unit of TNC functions	
Positions, coordinates, circle radii, chamfer lengths	-99 999.9999 to +99 999.9999 (5,4: places before decimal point, places after decimal point) [mm]
Tool numbers	0 to 32 767.9 (5,1)
Tool names	16 characters, enclosed by quotation marks with TOOL CALL. Permitted special characters: #, \$, %, &, -
Delta values for tool compensation	-99.9999 to +99.9999 (2,4) [mm]
Spindle speeds	0 to 99 999.999 (5,3) [rpm]
Feed rates	0 to 99 999.999 (5,3) [mm/min] or [mm/tooth] or [mm/rev]
Dwell time in Cycle 9	0 to 3600.000 (4,3) [s]
Thread pitch in various cycles	-99.9999 to +99.9999 (2,4) [mm]
Angle of spindle orientation	0 to 360.0000 (3,4) [°]
Angle for polar coordinates, rotation, tilting the working plane	-360.0000 to 360.0000 (3,4) [°]
Polar coordinate angle for helical interpolation (CP)	-5400.0000 to 5400.0000 (4,4) [°]
Datum numbers in Cycle 7	0 to 2999 (4,0)
Scaling factor in Cycles 11 and 26	0.000 001 to 99.999 999 (2,6)
Miscellaneous Functions M	0 to 999 (3,0)
Q parameter numbers	0 to 1999 (4,0)
Q parameter values	-99 999.9999 to +99 999.9999 (5,4)
Labels (LBL) for program jumps	0 to 999 (3,0)
Labels (LBL) for program jumps	Any text string in quotes (" ")
Number of program section repeats REP	1 to 65 534 (5,0)
Error number with Q parameter function FN14	0 to 1 099 (4,0)
Spline parameter K	-9.999 999 99 to +9.999 999 99 (1,8)
Exponent for spline parameter	-255 to 255 (3,0)
Surface-normal vectors N and T with 3-D compensation	-9.999 999 99 to +9.999 999 99 (1,8)





## 14.4 Exchanging the Buffer Battery

A buffer battery supplies the TNC with current to prevent the data in RAM memory from being lost when the TNC is switched off.

If the TNC displays the error message **Exchange buffer battery**, then you must replace the batteries:

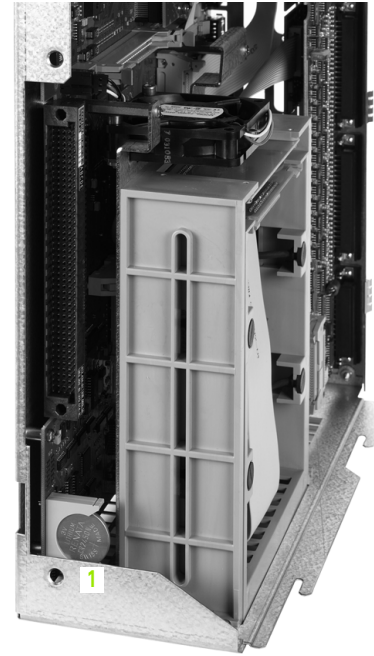


To exchange the buffer battery, first switch off the TNC.

The buffer battery must be exchanged only by trained service personnel.

Battery type: 1 Lithium battery, type CR 2450N (Renata)  
ID Nr. 315 878-01

- 1 The buffer battery is at the back of the MC 422 422 B (see **1**, figure at right)
- 2 Exchange the battery. The new battery can only be inserted the right way around.







# 15

**iTNC 530 with Windows 2000  
(Option)**



## 15.1 Introduction

### End User License Agreement (EULA) for Windows 2000

You have purchased Microsoft software together with the TNC. The Microsoft software was licensed to HEIDENHAIN by Microsoft Licensing Inc. or its affiliates (**MS**). Those installed software products of MS origin, as well as associated media, printed materials and "online" or electronic documentation ("**SOFTWARE**") are protected both by international intellectual property laws and treaties. This **SOFTWARE** is licensed, not sold. All rights reserved.



If you do not agree to this End User License Agreement (EULA), you are not permitted to use the TNC or copy the **SOFTWAREPRODUCT**. Instead, promptly contact HEIDENHAIN for instructions on the return of the unused TNC. Any use of this **SOFTWARE**, including but not limited to its use on the TNC, will constitute your agreement to this EULA (or ratification of any previous consent).

### Grant of software license

You may use the **SOFTWARE** only on the TNC. This EULA grants you the following license:

#### Not tolerant

The **SOFTWARE** is not fault tolerant. HEIDENHAIN has independently determined how to use the **SOFTWARE** in the TNC, and MS has relied upon HEIDENHAIN to conduct sufficient testing to determine that the **SOFTWARE** is suitable for such use.

#### No warranties for the software

The **SOFTWARE** is provided "as is" and with all faults. The entire risk as to satisfactory quality, performance, accuracy and effort (including lack of negligence) is with you. Also, there is no warranty against interference with your enjoyment of the software or against infringement. If you have received any warranties regarding the TNC or the **SOFTWARE** those warranties do not originate from and are not binding on MS.

**Note on Java Support**

The **SOFTWARE** may contain support for programs written in Java. Java technology is not fault tolerant and is not designed, manufactured or intended for use or resale as online control software in hazardous environments requiring fail-safe performance, such as in the operation of nuclear facilities, aircraft navigation or communication systems, air traffic control, direct life support machines, or weapons systems, in which the failure of Java technology could lead directly to death, personal injury or severe physical or environmental damage. Sun Microsystems, Inc. has contractually obligated MS to make this disclaimer.

**No liability for Certain Damages**

Except as prohibited by law, MS shall have no liability for any indirect, special, consequential or incidental damages arising from or in connection with the use or performance of the **SOFTWARE**. This limitation shall apply even if any remedy fails of its essential purpose. In no event shall MS be liable for any amount in excess of U.S. two hundred fifty dollars (U.S. \$250.00).

**Limitations on Reverse Engineering, Decompilation, and Disassembly**

You may not reverse engineer, decompile or disassemble the **SOFTWARE**, except and only to the extent that such activity is expressly permitted by applicable law notwithstanding this limitation..

**Software transfer allowed but with restrictions**

You may permanently transfer rights under this EULA only as part of a permanent sale or transfer of the TNC, and only if the recipient agrees to this EULA. If the **SOFTWARE** is an upgrade, any transfer must include all prior versions of the **SOFTWARE**.

**Export restrictions**

You acknowledge that **SOFTWARE** is subject to U.S. export jurisdiction. You agree to comply with all applicable international and national laws that apply to the **SOFTWARE**, including the U.S. Export Administration Regulations, as well as end user, end use, and destination restrictions issued by U.S. and other governments. You will find more information under <http://www.microsoft.com/exporting/>.



## General information



The special features of the iTNC 530 with Windows 2000 are described in this chapter. For the Windows 2000 system functions, please refer to the Windows documentation.

The TNC controls from HEIDENHAIN have always been user-friendly: Simple programming in HEIDENHAIN conversational format, field-proven cycles, unambiguous function keys and clearly structured graphic functions make them extremely popular shop-floor programmable controls.

The standard Windows operating system is now also provided as a user interface. The new and highly efficient HEIDENHAIN hardware with two processors is the basis for the iTNC 530 with Windows 2000.

The first processor handles real-time jobs and the HEIDENHAIN operating system, whereas the second processor is available only to the standard Windows operating system and thus provides the user access to the world of information technology.

Again, ease of operation has been given top priority:

- A complete PC keyboard with touch pad is integrated in the operating panel.
- The 15-inch high-resolution color flat-panel monitor displays both the iTNC interface and the Windows applications.
- Standard PC equipment such as a mouse or drives can easily be connected to the control through USB interfaces.

# Specifications

Specifications	iTNC 530 with Windows 2000
Version	<p>Dual-processor control with</p> <ul style="list-style-type: none"> <li>■ HEROS real-time operating system for controlling the machine</li> <li>■ Windows 2000 PC operating system as user interface</li> </ul>
Memory	<ul style="list-style-type: none"> <li>■ Random access memory (RAM) <ul style="list-style-type: none"> <li>■ 64 MB for control applications</li> <li>■ 128 MB for Windows applications</li> </ul> </li> <li>■ Hard disk <ul style="list-style-type: none"> <li>■ 2.63 GB for TNC files</li> <li>■ 9 GB for Windows files, of which approx. 7.7 GB are available for applications</li> </ul> </li> </ul>
Data interfaces	<ul style="list-style-type: none"> <li>■ Ethernet 10/100 BaseT (up to 100 Mbps depending on network utilization)</li> <li>■ RS-232-C/V.24 (max. 115 200 bps)</li> <li>■ RS-422/V.11 (max. 115 200 bps)</li> <li>■ 2 x USB</li> <li>■ 2 x PS/2</li> </ul>



## 15.2 Starting an iTNC 530 Application

### Logging on to Windows

After you have switched on the power supply, the iTNC 530 starts booting automatically. When the input dialog for logging on to Windows appears, there are two possibilities for logging in:

- Logging on as a TNC user
- Logging on as a local administrator

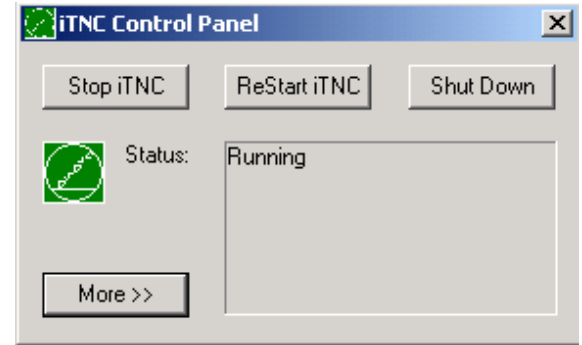
### Logging on as a TNC user

- Enter the user name "TNC" in the **User name** input box. Leave the **Password** input box blank and press the OK button.
- The TNC software is automatically started. The status message **Starting, please wait...** appears in the iTNC Control Panel.



Do not open or use any other Windows programs as long as the iTNC Control Panel is displayed (see figure at right). When the iTNC software has successfully started, the Control Panel minimizes itself to a HEIDENHAIN symbol on the task bar.

This user identification permits very limited access to the Windows operating system. You are neither allowed to change the network settings, nor are you allowed to install new software.





## Logging on as a local administrator



Please contact your machine tool builder for the user name and the password.

As a local administrator, you are allowed to install software and change the network settings.



HEIDENHAIN does not assist you in installing Windows applications and offers no guarantee for the function of the applications you installed.

HEIDENHAIN is not liable for faulty hard disk contents caused by installing updates to third-party software or additional application software.

If HEIDENHAIN is required to render service after programs or data have been changed, HEIDENHAIN will charge you for the service costs incurred.

In order to guarantee the trouble-free function of the iTNC application, the Windows 2000 system must at all times have sufficient

- CPU performance
- free hard disk memory on the C drive
- RAM
- bandwidth for the hard drive interface

available.

By sufficiently buffering the TNC data, the control can compensate brief interruptions (up to one second at a block cycle time of 0.5 ms) to the data transfer from the Windows PC. However, if the data transfer from the Windows PC is interrupted for a longer time period, problems can occur with the feed rate during program run, resulting in damage to the workpiece.



### Keep in mind the following requirements for software installations:

The program to be installed must not overburden the computing power of the Windows PC (128 MB RAM, 266 MHz clock frequency).

Programs executed under Windows with the priority levels **above normal**, **high** or **real time** (e.g. games), must not be installed.



## 15.3 Switching Off the iTNC 530

### Fundamentals

To prevent data from being lost at switch-off, you must shut down the iTNC 530 properly. The following sections describe the various possibilities for doing so.



Inappropriate switch-off of the iTNC 530 can lead to data loss.

Exit the iTNC 530 application before exiting Windows.

### Logging a user off

You can log a user off of Windows at any time without adversely influencing the iTNC software. However, the iTNC screen is not visible during the log-off process, and you cannot make any entries during this time.



Note that machine-specific keys (such as NC Start or the axis direction keys) remain active.

After a new user has logged on, the iTNC screen reappears.

## Exiting the iTNC application



### Caution!

Before you exit the iTNC application, you absolutely must press the Emergency Stop key. Otherwise you could lose data or the machine could become damaged.

There are two possibilities for exiting the iTNC application:

- Internal exiting via the Manual operating mode; simultaneously exits Windows
- External exiting via the iTNC Control Panel; only exits the iTNC application

### Internal exiting via the Manual operating mode

- ▶ Select the Manual operating mode
- ▶ Shift the soft-key row until the soft key for shutting down the iTNC application appears.



- ▶ Select the function for shutting down and confirm the following dialog prompt again with the YES soft key.
- ▶ When the message **It is now safe to turn off your computer.** appears on the iTNC screen, you may switch off the power supply to the iTNC 530.

### External exiting via the iTNC Control Panel

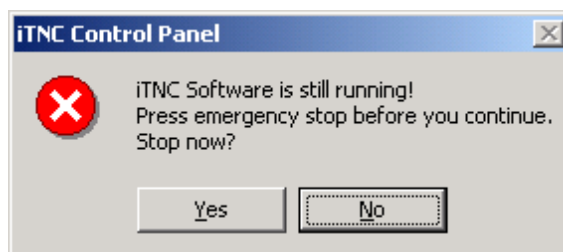
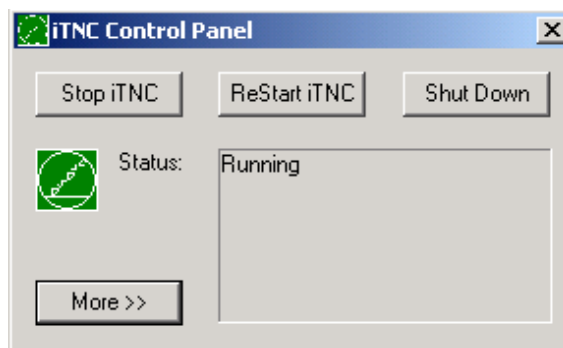
- ▶ Press the Windows key on the ASCII keyboard to minimize the iTNC application and display the Task Bar.
- ▶ Double-click the green HEIDENHAIN symbol to the lower right in the Task Bar for the iTNC Control Panel to appear (see figure at upper right).



- ▶ Select the function for exiting the iTNC 530 application: Press the **Stop iTNC** button.
- ▶ After you have pressed the Emergency Stop button, acknowledge the iTNC message with the **Yes** screen button. The iTNC application is stopped.
- ▶ The iTNC Control Panel remains active. To restart the iTNC 530, press the **Restart iTNC** button.

To exit Windows, select

- ▶ the **Start** button
- ▶ the menu item **Shut down...**
- ▶ again the menu item **Shut down...**
- ▶ and confirm with **OK**



## Shutting down Windows

If you try to shut down Windows while the iTNC software is still active, the control displays a warning (see figure at top right).



### Caution!

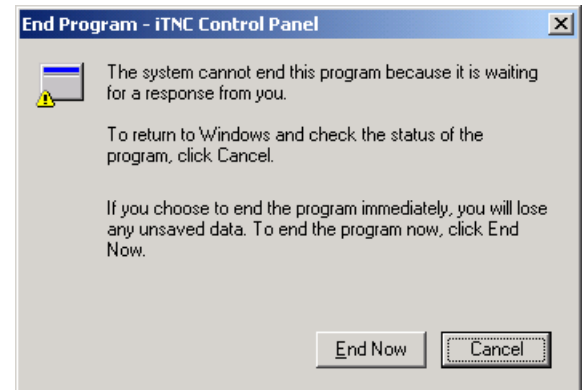
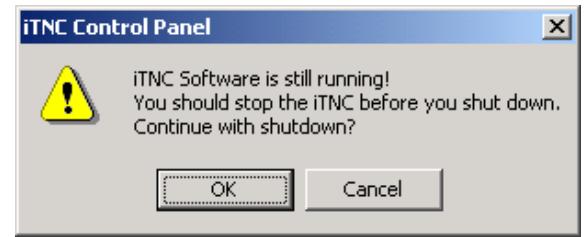
Before you confirm with OK, you absolutely must press the Emergency Stop button. Otherwise you could lose data or the machine could become damaged.

If you confirm with OK, the iTNC software is exited and Windows is shut down.



### Caution!

After several seconds Windows displays its own warning, covering the iTNC warning (see figure at center right). Never confirm the warning with End Now, since you could lose data or the machine could become damaged.



# 15.4 Network Settings

## Prerequisite



You must log on as a local administrator to be able to change the network settings. Please contact your machine tool builder for the required user name and password.

The network should be configured only by network specialists.

## Adjusting the network settings

The iTNC 530 is shipped with two network connections: The **Local Area Connection** and the **iTNC Internal Connection** (see figure at right).

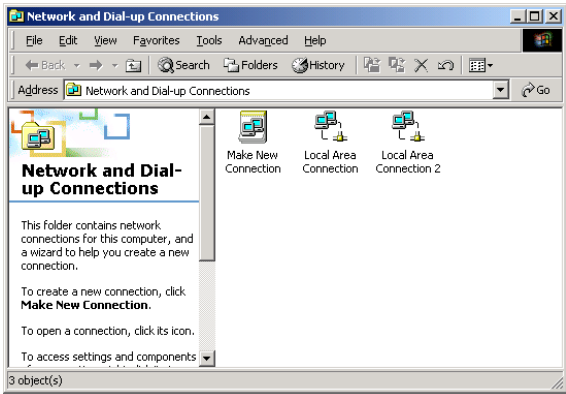
The **Local Area Connection** is the iTNC's connection to its network. You may adjust all familiar Windows 2000 settings to your network (also see the Windows 2000 network description).



The **iTNC Internal Connection** is exactly that: an internal iTNC connection. The configuration of this connection must not be changed. Changes might cause the iTNC to stop functioning.

This internal network address has a default setting of **192.168.254.253** and must not collide with your company network, meaning that the subnet **192.168.254.xxx** cannot already exist in your network.

The option **Obtain IP address automatically** must be inactive.



### Controlling access

Administrators have access to the TNC drives D, E and F. Please note that some of the data in these partitions is binary encoded, and write-accesses might lead to undefined behavior of the iTNC.

The partitions D, E and F have access rights for the user groups **SYSTEM** and **Administrators**. The group **SYSTEM** ensures that the Windows service that starts the control has access. The group **Administrators** ensures that the real-time processor of the iTNC receives a network connection via the **iTNC Internal Connection**.



You may not restrict access by these groups, nor may you add groups and prohibit certain accesses by these groups (in Windows, access restrictions have priority over access rights).

## 15.5 Specifics About File Management

### The iTNC drive

When you call the iTNC file manager, the left window shows all available drives. For example:

- **C:\**: Windows partition of the built-in hard disk
- **RS232:\**: Serial interface 1
- **RS422:\**: Serial interface 2
- **TNC:\**: Data partition of the iTNC

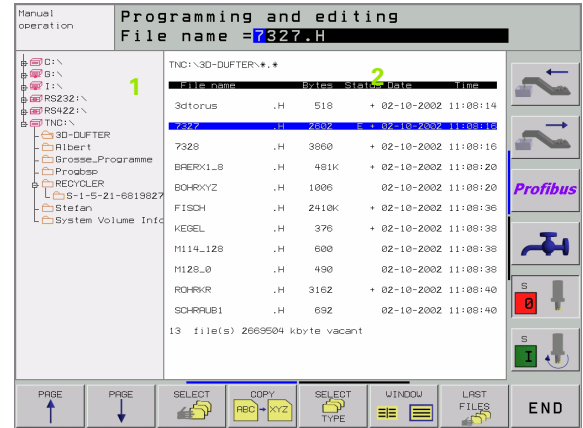
There might also be other networks available if you have connected them with Windows Explorer.



Please note that the data drive of the iTNC appears in the file manager with the name **TNC:\**. In Windows Explorer, this drive (partition) appears with the letter **D**.

Subdirectories on the TNC drive (e.g. **RECYCLER** and **System Volume Identifier**) are created by Windows 2000 and may not be deleted.

With machine parameter 7225 you can define letters of drives that should not be shown in the file management of the TNC.



If you connect a new network drive with Windows Explorer, you may have to update the iTNC's display of available drives:

- ▶ To call the File Manager, press the PGM MGT key.
- ▶ Move the highlight to the drive window at left.
- ▶ Switch to the second level of the soft-key row.
- ▶ To update the drive overview, press the UPDATE TREE soft key.



## Data transfer to the iTNC 530



Before you can initiate a data transfer on the iTNC, the network drive must have been connected with Windows Explorer. Access to UNC network names (e.g. \\PC0815\\DIR1) is not possible.

### TNC-specific files

After integrating the iTNC 530 into your network, you can access any computer and transfer files to it from the iTNC. However, certain file types may only be transferred if the data transfer was initiated by the iTNC. The reason is that these files must be converted into binary format during the data transfer to the iTNC.



Simply copying the file types listed below to the D drive using Windows Explorer is both prohibited and useless.

File types that may not be copied using Windows Explorer:

- Conversational dialog programs (extension .H)
- smarT.NC unit programs (extension .HU)
- smarT.NC contour programs (extension .HC)
- ISO programs (extension .I)
- Tool tables (extension .T)
- Pocket tables (extension .TCH)
- Pallet tables (extension .P)
- Datum tables (extension .D)
- Point tables (extension .PNT)
- Cutting data tables (extension .CDT)
- Freely definable tables (extension .TAB)

Procedure for data transfer: See "Data transfer to or from an external data medium," page 97.

### ASCII files

There are no limitations regarding the direct copying of ASCII files (files with the extension .A) with Windows Explorer.



Please note that all the files you want to use on the TNC must be stored on drive D.



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7	Datum shift	■		page 427
8	Mirror image	■		page 433
9	Dwell time	■		page 446
10	Rotation	■		page 435
11	Scaling factor	■		page 436
12	Program call	■		page 447
13	Oriented spindle stop	■		page 448
14	Contour definition	■		page 371
19	Tilting the working plane	■		page 438
20	Contour data SL II	■		page 375
21	Pilot drilling SL II		■	page 376
22	Rough out SL II		■	page 377
23	Floor finishing SL II		■	page 378
24	Side finishing SL II		■	page 379
25	Contour train		■	page 380
26	Axis-specific scaling	■		page 437
27	Cylinder surface		■	page 382
28	Cylindrical surface slot		■	page 384
29	Cylinder surface ridge		■	page 384
30	3-D data		■	page 412
32	Tolerance	■		page 449
39	Cylinder surface external contour		■	page 384
240	Centering		■	page 275
200	Drilling		■	page 277
201	Reaming		■	page 279
202	Boring		■	page 281
203	Universal drilling		■	page 283



Cycle number	Cycle designation	DEF-active	CALL-active	Page
204	Back boring		■	page 285
205	Universal pecking		■	page 288
206	Tapping with a floating tap holder, new		■	page 293
207	Rigid tapping, new		■	page 295
208	Bore milling		■	page 291
209	Tapping with chip breaking		■	page 297
210	Slot with reciprocating plunge		■	page 352
211	Circular slot		■	page 355
212	Rectangular pocket finishing		■	page 344
213	Rectangular stud finishing		■	page 346
214	Circular pocket finishing		■	page 348
215	Circular stud finishing		■	page 350
220	Circular point pattern	■		page 362
221	Linear point pattern	■		page 364
230	Multipass milling		■	page 413
231	Ruled surface		■	page 415
232	Face milling		■	page 418
247	Datum setting	■		page 432
251	Rectangular pocket (complete machining)		■	page 325
252	Circular pocket (complete machining)		■	page 330
253	Slot milling		■	page 334
254	Circular slot		■	page 339
262	Thread milling		■	page 301
263	Thread milling/countersinking		■	page 303
264	Thread drilling/milling		■	page 307
265	Helical thread drilling/milling		■	page 311
267	Outside thread milling		■	page 315

# Table of Miscellaneous Functions

M	Effect	Effective at block	Start	End	Page
<b>M00</b>	Stop program/Spindle STOP/Coolant OFF			■	page 231
<b>M01</b>	Optional program STOP			■	page 570
<b>M02</b>	Stop program/Spindle STOP/Coolant OFF/Clear status display (depending on machine parameter)/Go to block 1			■	page 231
<b>M03</b>	Spindle ON clockwise		■		page 231
<b>M04</b>	Spindle ON counterclockwise		■		
<b>M05</b>	Spindle STOP			■	
<b>M06</b>	Tool change/Stop program run (depending on machine parameter)/Spindle STOP			■	page 231
<b>M08</b>	Coolant ON		■		page 231
<b>M09</b>	Coolant OFF			■	
<b>M13</b>	Spindle ON clockwise/Coolant ON		■		page 231
<b>M14</b>	Spindle ON counterclockwise/Coolant ON		■		
<b>M30</b>	Same function as M02			■	page 231
<b>M89</b>	Vacant miscellaneous function <b>or</b> Cycle call, modally effective (depending on machine parameter)		■	■	page 265
<b>M90</b>	Only in lag mode: Constant contouring speed at corners			■	page 235
<b>M91</b>	Within the positioning block: Coordinates are referenced to machine datum		■		page 232
<b>M92</b>	Within the positioning block: Coordinates are referenced to position defined by machine tool builder, such as tool change position		■		page 232
<b>M94</b>	Reduce display of rotary axis to value under 360°		■		page 252
<b>M97</b>	Machine small contour steps			■	page 237
<b>M98</b>	Machine open contours completely			■	page 239
<b>M99</b>	Blockwise cycle call			■	page 265
<b>M101</b>	Automatic tool change with replacement tool if maximum tool life has expired		■		page 158
<b>M102</b>	Reset M101			■	
<b>M103</b>	Reduce feed rate during plunging to factor F (percentage)		■		page 240
<b>M104</b>	Reactivate the datum as last defined		■		page 234
<b>M105</b>	Machining with second $k_v$ factor		■		page 618
<b>M106</b>	Machining with first $k_v$ factor		■		
<b>M107</b>	Suppress error message for replacement tools		■		page 157
<b>M108</b>	Reset M107			■	



M	Effect	Effective at block	Start	End	Page
<b>M109</b>	Constant contouring speed at tool cutting edge (increase and decrease feed rate)		■		page 242
M110	Constant contouring speed at tool cutting edge (feed rate decrease only)		■		
M111	Reset M109/M110			■	
<b>M114</b>	Automatic compensation of machine geometry when working with tilted axes		■		page 253
M115	Reset M114			■	
<b>M116</b>	Feed rate for angular axes in mm/minn		■		page 250
M117	Reset M116			■	
<b>M118</b>	Superimpose handwheel positioning during program runn		■		page 244
<b>M120</b>	Pre-calculate radius-compensated contour (LOOK AHEAD)		■		page 242
<b>M124</b>	Do not include points when executing non-compensated line blocks		■		page 236
<b>M126</b>	Shortest-path traverse of rotary axes		■		page 251
M127	Reset M126			■	
<b>M128</b>	Maintain the position of the tool tip when positioning with tilted axes (TCPM)		■		page 254
M129	Reset M128			■	
<b>M130</b>	Moving to position in an untilted coordinate system with a tilted working plane		■		page 234
<b>M134</b>	Exact stop at nontangential contour transitions when positioning with rotary axes		■		page 256
M135	Reset M134			■	
<b>M136</b>	Feed rate F in millimeters per spindle revolution		■		page 241
M137	Reset M136			■	
<b>M138</b>	Select tilting axes		■		page 256
<b>M140</b>	Retraction from the contour in the tool-axis direction		■		page 245
<b>M141</b>	Suppress touch probe monitoring		■		page 246
<b>M142</b>	Delete modal program information		■		page 247
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<b>M144</b>	Compensating the machine's kinematic configuration for ACTUAL/NOMINAL positions at end of block		■		page 257
M145	Reset M144			■	
<b>M148</b>	Automatically retract tool from the contour at an NC stop		■		page 248
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<b>M150</b>	Suppress limit switch message (function effective blockwise)		■		page 249
<b>M200</b>	Laser cutting: Output programmed voltage directly		■		page 258
M201	Laser cutting: Output voltage as a function of distance		■		
M202	Laser cutting: Output voltage as a function of speed		■		
M203	Laser cutting: Output voltage as a function of time (ramp)		■		
M204	Laser cutting: Output voltage as a function of time (pulse)		■		



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## 3-D Touch Probe Systems from HEIDENHAIN help you to reduce non-cutting time:

For example in

- workpiece alignment
- datum setting
- workpiece measurement
- digitizing 3-D surfaces

with the workpiece touch probes

**TS 220** with cable

**TS 640** with infrared transmission



- tool measurement
- wear monitoring
- tool breakage monitoring

with the tool touch probe

**TT 130**

