Programming manual

TC L 2530, TC L 3020
TC L 3050, TC L 4050, TC L 6050
TC L 3030, TC L 4030, TC L 6030
TC HSL 2502 C, TC HSL 4002 C

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TRUMPF GmbH & Co.
D-71254 Ditzingen
Johann-Maus-Straße 2
Telephone (07156)303-0
Telefax (07156)303-540
Internet: http://www.trumpf.com
e-mail: docu.501@de.trumpf.com

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Before reading any further ...

Programming manual

This programming manual documents NC programming for laser processing machines TC L 3050, TC L 4050, TC L 6050, TC L 2530, TC L 3020, TC L 3030, TC L 4030, TC L 6030, TC HSL 2502 C and TC HSL 4002 C.
In standard practice, all data applies for all machines listed. Data that only applies to one of the above-listed machines are listed separately.
For the TC L 3050, TC L 4050 and the TC L 6050, all laser technology table parameters are described directly with SELECT on the user interface screen. They are therefore not additionally listed again in the programming manual.

Intended readers of this manual

The programmer's manual is not only intended for the user (owner) and the operator of the machine, but also for the programmer. It must be accessible to those people.

Programming manual

Chapter 1: Master file / NC programming
Chapter 2: Overview of NC functions
Chapter 3: G-functions / path conditions
Chapter 4: Path information
Chapter 5: M-functions
Chapter 6: Cycles for laser processing
Chapter 7: Sheet handling cycles
Chapter 8: Jump programming
Chapter 9: Subroutine technology
Chapter 10: Working with CatEye (optional)
Chapter 11: Pipe and tube processing (optional)
Key words

Additional documentation

In addition to this programming manual, the following are part of the machine documentation:

- Operating manual for the machine.
- Operation manual for the laser.
- List of replacement parts for the machine.
- List of replacement parts for the laser.
- Circuit diagram.
- Data collection.

Handbooks for programming systems and documents accompanying courses are also available.

There is important safety information throughout the machine documentation regarding prevention of injuries and potential hazards to life and health. This information is marked with a corresponding symbol next to it.

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1. Program structure (Master file)

An NC program as processed by the SIEMENS SINUMERIK 840D is laid out like a characteristic file. DIN V4001 is the guideline which describes the content and syntactic structure of characteristic files.

This NC program is transferred from the programming location to the control system in the form of a master file with the suffix .Act. There the master file is disassembled by the control system and the data is processed appropriately. This master file must be generated by the programming system according to set rules.

The master file can be divided into three sections:

1. Unit identification
2. Table leader
3. Processing code (NC code)

Unit identification

The unit identification states which dimension system serves as the basis of the subsequent NC code:

SET_METRIC: metric programming
SET_INCH: programming in inches.

☞ However, unit identification is not based on the units of the table parameters in the table lead. The table parameters describe themselves in a separate characteristic description block.

Table leader

The table leader acts as means of transmitting information. The following information is transmitted:

- Setup schedule information.
- Sheet handling tables.
- Master data from the laser technology tables (optional).
- Laser technology tables call-up instructions.

The control system extracts the information contained in the table leader and depicts this data in the form of tables and interfaces at the user interface.
When cycles within the NC program are being executed, the control system accesses the stored data in the tables and interfaces and can thus execute the ongoing cycle with these parameters.

NC code

The actual processing code is listed according to unit identification and table leader, see 3. "NC code".

2. Characteristic file

Data statements in a block are separated by a comma, texts are additionally bracketed with inverted commas. The blocks within a table block follow a set order:

1. Number of characteristic description blocks.
   This statement specifies the number of characteristics laid out in the form of characteristic description blocks.
   Example: ZA, MM, 3

2. Characteristic description blocks.
   Every characteristic description block describes a table parameter. The sequence of these blocks establishes the respective position of the characteristics in the characteristic data block.
   Example:
   AT, 1, 10, 1, 1, , 'table identifier', , , T
   AT, 1, 20, 1, 1, , 'sheet dimension X', , , Z
   AT, 1, 30, 1, 1, , 'sheet dimension Y', , , Z

3. In a characteristic description block, all parameters are listed in sequence, which are required for the description of a characteristic. A set order must be adhered to:

   - The line type-**identifier** describes the type of data in the relevant line. It is there solely to aid understanding and is not utilized by the system. The identifier MM, AT for attribute characteristics is always displayed in the table leader of the NC programs.

   - **Version** (number): This entry identifies the version in which the relevant characteristic description block was modified. This statement must agree with the corresponding version of the characteristic file (always 1 in the table leader of NC programs).

   - **Identification number** (number): This entry must be unequivocal for every characteristic description block within a table block. The identification numbers do not necessarily have to be consecutive or continuous. If various versions of the characteristic file are published in the course of time, the identification numbers of deleted characteristic description blocks must not be reused. However, modified characteristic description blocks must retain the same identification number which they have had in the past.

   - **Responsible location** (number): This statement indicates by whom the characteristic description block has been created or most recently edited.

- **Status** (number): This entry indicates whether the data for this characteristic is itemized in the characteristic file.
  0 Data is not in the file.
  1 Data is in the file.
  2 Data are given as constants prior to the data blocks or data are defined as algorithms dependent on other table values.
  3 Characteristic with value range.
  4 Reference to another standard.
  Status 1 always appears at this position in the table leader of NC programs. The data is always itemized in the characteristic data blocks (see Point 4).
- **Characteristic identification**: is not utilized.
- **Characteristic designation** (Text): this entry contains the plain text designation of the characteristic.
- **Dimension characteristics**: is not utilized.
- **Dimension unit**: the unit of measure indicates the unit in which the table parameter is shown in the following characteristic data block.
- **Data type** (Name): the data type indicates whether the described characteristic is a number (N) or a text (T). Both numbers and texts are permitted.

4. Number of characteristic data blocks.
   This specifies the number of characteristic data blocks, their various values or texts which are assigned to the individual characteristic description blocks.
   Example: ZA, DA, 1

5. Characteristic data block.
   A characteristic data block always refers to a block of characteristic description blocks. The parameters of a characteristic data block are assigned in sequence to the previously listed characteristic description blocks. Thus, the number of data in a characteristic data block always corresponds to the number of characteristic description blocks.
   Example: DA, 'SHL-1', 1697.500, 500

☞ First the form of the data is described (Point 2) (characteristic**description**blocks), and then the data are listed (Point 4) (characteristic**data**blocks).

Several table blocks can be listed one under the other. The end of a characteristic file must be marked with its own unequivocal end code:

Example: ENDE_SHEET_LOAD

Comments

If comments are to be added to the characteristic file, these should be prefixed with "C".

Syntax master file

TC L 2530, TC L 3030, TC L 4030, TC L 6030,

All characteristic description blocks which can be evaluated from the control system are listed as follows:

```
BD
SET_METRIC
C
BEGIN_EINRICHTEPLAN_INFO
C
ZA,MM,18
MM,AT,1,    10,  1,1,,'Machine'                        ,,",T
MM,AT,1,    20,  1,1,,'Type'                           ,,",Z
MM,AT,1,    30,  1,1,,'Control system'                 ,,",T
MM,AT,1,    40,  1,1,,'Variant'                        ,,",Z
MM,AT,1,    50,  1,1,,'Company'                        ,,",T
MM,AT,1,    60,  1,1,,'Program number'                 ,,",T
MM,AT,1,    70,  1,1,,'Programmer'                     ,,",T
MM,AT,1,    80,  1,1,,'Date'                           ,,",T
MM,AT,1,    90,  1,1,,'Job name'                       ,,",T
MM,AT,1,   100,  1,1,,'Number of program runs'         ,,",Z
MM,AT,1,   110,  1,1,,'Sheet name'                     ,,",T
MM,AT,1,   120,  1,1,,'Memory requirement'             ,,",Z
MM,AT,1,   130,  1,1,,'Material ID'                    ,,",T
MM,AT,1,   140,  1,1,,'Sheet weight'                   ,,kg,Z
MM,AT,1,   150,  1,1,,'Processing time'                ,,min,Z
MM,AT,1,   160,  1,1,,'Comment'                        ,,",T
MM,AT,1,   170,  1,1,,'Flag automated'                 ,,Bool,Z
MM,AT,1,   180,  1,1,,'Flag ToPsxxx program'           ,,Bool,Z
C
ZA,DA,1
DA,...
C
BEGIN_EINRICHTEPLAN_INFO
C
BEGIN_SHEET_TECH
C
ZA,MM,8
MM,AT,1,    10,  1,1,,'Table identifier'               ,,",T
MM,AT,1,    20,  1,1,,'Sheet dimension X'              ,,mm,Z
MM,AT,1,    30,  1,1,,'Sheet dimension Y'              ,,mm,Z
MM,AT,1,    40,  1,1,,'Sheet dimension Z'              ,,mm,Z
MM,AT,1,   200,  1,1,,'Trumpf ID'                      ,,",Z
MM,AT,1,   220,  1,1,,'Sheet dimension X real'         ,,'mm',Z
MM,AT,1,   230,  1,1,,'Sheet dimension Y real'         ,,'mm',Z
MM,AT,1,   240,  1,1,,'Material ID'                    ,,",T
C
ZA,DA,.1
DA,.'SHT-1',...
C
ENDE_SHEET_TECH
C
BEGIN_SHEET_LOAD
C
```

```
ZA,MM,16
MM,AT,1,    10,  1,1,,'Table identifier'                    ,,",T
MM,AT,1,    70,  1,1,,'Trumpf ID'                           ,,",Z
MM,AT,1,   500,  1,1,,'Loading device'                      ,,",Z
MM,AT,1,   520,  1,1,,'Lift suction cup group 1'            ,,",Z
MM,AT,1,   530,  1,1,,'Lift suction cup group 2'            ,,",Z
MM,AT,1,   540,  1,1,,'Lift suction cup group 3'            ,,",Z
MM,AT,1,   550,  1,1,,'Lift suction cup group 4'            ,,",Z
MM,AT,1,   580,  1,1,,'Lift double sheet det. active'       ,,'Bool',Z
MM,AT,1,   590,  1,1,,'Lift peel-off'                       ,,'Bool',Z
MM,AT,1,   620,  1,1,,'Sheet stopper'                       ,,",Z
MM,AT,1,   630,  1,1,,'Measure sheet position'              ,,",Z
MM,AT,1,   640,  1,1,,'Measuring range X'                   ,,mm,Z
MM,AT,1,   650,  1,1,,'Measuring range Y'                   ,,mm,Z
MM,AT,1,   660,  1,1,,'Calibration'                         ,,Bool,T
MM,AT,1,   690,  1,1,,'Pallet-change type'                  ,,",Z
MM,AT,1,   700,  1,1,,'Measuring corner'                    ,,",Z
C
ZA,DA,.1
DA,...
C
ENDE_SHEET_LOAD
C
BEGIN_LTT_STAMM
C
ZA,MM,119
MM,AT,1,    10,  1,1,,'Table identifier'                    ,,,T
MM,AT,1,    20,  1,1,,'Programmer'                          ,,,T
MM,AT,1,    30,  1,1,,'Date of creation'                    ,,,T
MM,AT,1,    40,  1,1,,'Last modification'                   ,,,T
MM,AT,1,    50,  1,1,,'Comment'                             ,,,T
MM,AT,1,    60,  1,1,,'Display status'                      ,,,Z
MM,AT,1,    70,  1,1,,'Creation unit'                       ,,,Z
MM,AT,1,    80,  1,1,,'Machine type'                        ,,T
MM,AT,1,    90,  1,1,,'Laser rated output'                  ,,W,Z
MM,AT,1,   100,  1,1,,'Material'                            ,,,,T
MM,AT,1,   110,  1,1,,'Material thickness'                  ,,mm,Z
MM,AT,1,   120,  1,1,,'Lens focal length'                   ,,inch,Z
MM,AT,1,   130,  1,1,,'Nozzle type nozzle diameter'         ,,,T
MM,AT,1,   140,  1,1,,'Cutter head number'                  ,,,Z
MM,AT,1,   150,  1,1,,'Gas purging Cutting / Piercing'      ,,s,Z
MM,AT,1,   160,  1,1,,'Gas purging Piercing / Cutting'      ,,s,Z
MM,AT,1,   170,  1,1,,'CUT Setting value'                   ,,mm,Z
MM,AT,1,   180,  1,1,,'Reduced cutting acceleration'        ,,m/s²,Z
MM,AT,1,   190,  1,1,,'CUT Acceleration'                    ,,m/s²,Z
MM,AT,1,   200,  1,1,,'CUT Corner cooling-time'             ,,s,Z
MM,AT,1,   210,  1,1,,'CUT V-red first cut thick sheet'     ,,%,Z
MM,AT,1,   220,  1,1,,'CUT Gas type cutting'                ,,,Z
MM,AT,1,   230,  1,1,,'CUT Gas type reduced',,",Z cutting'  ,,,Z
MM,AT,1,   240,  1,1,,'CUT-GR Cutting gap'                  ,,mm,Z
MM,AT,1,   250,  1,1,,'CUT-L-N Laser power'                 ,,W,Z
MM,AT,1,   260,  1,1,,'CUT-L-N Modulation frequency'        ,,Hz,Z
MM,AT,1,   270,  1,1,,'CUT-L-N Speed'                       ,,m/min,Z
MM,AT,1,   280,  1,1,,'CUT-L-N Nozzle standoff'             ,,mm,Z
MM,AT,1,   290,  1,1,,'CUT-L-N Gas pressure'                ,,bar,Z
```

```
MM,AT,1,   300,   1,1,,'CUT-L-R Laser power'                 ,,W,Z
MM,AT,1,   310,   1,1,,'CUT-L-R Modulation frequency'        ,,Hz,Z
MM,AT,1,   320,   1,1,,'CUT-L-R Speed'                       ,,m/min,Z
MM,AT,1,   330,   1,1,,'CUT-L-R Nozzle standoff'             ,,mm,Z
MM,AT,1,   340,   1,1,,'CUT-L-R Gas pressure'                ,,bar,Z
MM,AT,1,   350,   1,1,,'CUT-M Kerf'                          ,,mm,Z
MM,AT,1,   360,   1,1,,'CUT-M-N Laser power'                 ,,W,Z
MM,AT,1,   370,   1,1,,'CUT-M-N Modulation frequency'        ,,Hz,Z
MM,AT,1,   380,   1,1,,'CUT-M-N Speed'                       ,,m/min,Z
MM,AT,1,   390,   1,1,,'CUT-M-N Nozzle standoff'             ,,mm,Z
MM,AT,1,   400,   1,1,,'CUT-M-N Gas pressure'                ,,bar,Z
MM,AT,1,   410,   1,1,,'CUT-M-R Laser power'                 ,,W,Z
MM,AT,1,   420,   1,1,,'CUT-M-R Modulation frequency'        ,,Hz,Z
MM,AT,1,   430,   1,1,,'CUT-M-R Speed'                       ,,m/min,Z
MM,AT,1,   440,   1,1,,'CUT-M-R Nozzle standoff'             ,,mm,Z
MM,AT,1,   450,   1,1,,'CUT-M-R Gas pressure'                ,,bar,Z
MM,AT,1,   460,   1,1,,'CUT-SM Cutting gap'                  ,,mm,Z
MM,AT,1,   470,   1,1,,'CUT-SM-N Laser power'                ,,W,Z
MM,AT,1,   480,   1,1,,'CUT-SM-N Modulation frequency'       ,,Hz,Z
MM,AT,1,   490,   1,1,,'CUT-SM-N Speed'                      ,,m/min,Z
MM,AT,1,   500,   1,1,,'CUT-SM-N Nozzle standoff'            ,,mm,Z
MM,AT,1,   510,   1,1,,'CUT-SM-N Gas pressure'               ,,bar,Z
MM,AT,1,   520,   1,1,,'CUT-SM-R Laser power'                ,,W,Z
MM,AT,1,   530,   1,1,,'CUT-SM-R Modulation frequency'       ,,Hz,Z
MM,AT,1,   540,   1,1,,'CUT-SM-R Speed'                      ,,m/min,Z
MM,AT,1,   550,   1,1,,'CUT-SM-R Nozzle standoff'            ,,mm,Z
MM,AT,1,   560,   1,1,,'CUT-SM-R Gas pressure'               ,,bar,Z
MM,AT,1,   570,   1,1,,'PIERCING Setting value'              ,,mm,Z
MM,AT,1,   580,   1,1,,'PIERCING-N Time'                     ,,s,Z
MM,AT,1,   590,   1,1,,'PIERCING-N Ramp cycle number'        ,,,Z
MM,AT,1,   600,   1,1,,'PIERCING-N Nozzle standoff'          ,,mm,Z
MM,AT,1,   610,   1,1,,'PIERCING-N blowout time'             ,,s,Z
MM,AT,1,   620,   1,1,,'PIERCING-N Gas type'                 ,,,Z
MM,AT,1,   630,   1,1,,'PIERCING-N gas pressure'             ,,bar,Z
MM,AT,1,   640,   1,1,,'PIERCING-N Spray oil'                ,,,Z
MM,AT,1,   650,   1,1,,'PIERCING-R time'                     ,,s,Z
MM,AT,1,   660,   1,1,,'PIERCING-R Ramp cycle number'        ,,,Z
MM,AT,1,   670,   1,1,,'PIERCING-R nozzle standoff'          ,,mm,Z
MM,AT,1,   680,   1,1,,'PIERCING-R blowout time'             ,,s,Z
MM,AT,1,   690,   1,1,,'PIERCING-R Gas type'                 ,,,Z
MM,AT,1,   700,   1,1,,'PIERCING-R Gas pressure'             ,,bar,Z
MM,AT,1,   710,   1,1,,'PIERCING-R Spray oil'                ,,,Z
MM,AT,1,   720,   1,1,,'EVAP Setting value'                  ,,mm,Z
MM,AT,1,   730,   1,1,,'EVAP Time'                           ,,s,Z
MM,AT,1,   740,   1,1,,'EVAP Nozzle standoff'                ,,mm,Z
MM,AT,1,   750,   1,1,,'EVAP Laser power'                    ,,W,Z
MM,AT,1,   760,   1,1,,'EVAP Modulation frequency'           ,,Hz,Z
MM,AT,1,   770,   1,1,,'EVAP Speed'                          ,,m/min,Z
MM,AT,1,   780,   1,1,,'EVAP Gas type'                       ,,,Z
MM,AT,1,   790,   1,1,,'EVAP Gas pressure'                   ,,bar,Z
MM,AT,1,   800,   1,1,,'LABEL Setting value'                 ,,mm,Z
MM,AT,1,   810,   1,1,,'LABEL Nozzle standoff'               ,,mm,Z
MM,AT,1,   820,   1,1,,'LABEL Laser power'                   ,,W,Z
MM,AT,1,   830,   1,1,,'LABEL Modulation frequency'          ,,Hz,Z
MM,AT,1,   840,   1,1,,'LABEL Speed'                         ,,m/min,Z
```

```
MM,AT,1,   850,  1,1,,’LABEL Gas type’                        ,,,Z
MM,AT,1,   860,  1,1,,’LABEL Gas pressure’                    ,,bar,Z
MM,AT,1,   870,  1,1,,’POINTMARK-G Setting value’             ,,mm,Z
MM,AT,1,   880,  1,1,,’POINTMARK-G Nozzle standoff’           ,,mm,Z
MM,AT,1,   890,  1,1,,’POINTMARK-G Laser power’               ,,W,Z
MM,AT,1,   900,  1,1,,’POINTMARK-G Modulation freq’           ,,Hz,Z
MM,AT,1,   910,  1,1,,’POINTMARK-G speed’                     ,,m/min,Z
MM,AT,1,   920,  1,1,,’POINTMARK-G Gas type’                  ,,,Z
MM,AT,1,   930,  1,1,,’POINTMARK-G Gas pressure’              ,,bar,Z
MM,AT,1,   940,  1,1,,’POINTMARK-P Piercing time’             ,,s,Z
MM,AT,1,   950,  1,1,,’POINTMARK-P Ramp cycle number’         ,,,Z
MM,AT,1,   960,  1,1,,’POINTMARK-P Nozzle standoff’           ,,mm,Z
MM,AT,1,   970,  1,1,,’POINTMARK-P Gas type’                  ,,,Z
MM,AT,1,   980,  1,1,,’POINTMARK-P Gas pressure’              ,,bar,Z
MM,AT,1,   990,  1,1,,’DOT Setting value’                     ,,mm,Z
MM,AT,1, 1000,  1,1,,’DOT-S Time’                             ,,s,Z
MM,AT,1, 1010,  1,1,,’DOT-S Ramp cycle number’                ,,,Z
MM,AT,1, 1020,  1,1,,’DOT-S Nozzle standoff’                  ,,mm,Z
MM,AT,1, 1030,  1,1,,’DOT-S Gas type’                         ,,,Z
MM,AT,1, 1040,  1,1,,’DOT-S Gas pressure’                     ,,bar,Z
MM,AT,1, 1050,  1,1,,’DOT-F Time’                             ,,s,Z
MM,AT,1, 1060,  1,1,,’DOT-F Ramp cycle number’                ,,,Z
MM,AT,1, 1070,  1,1,,’DOT-F Nozzle standoff’                  ,,mm,Z
MM,AT,1, 1080,  1,1,,’DOT-F Gas type’                         ,,,Z
MM,AT,1, 1090,  1,1,,’DOT-F Gas pressure’                     ,,bar,Z
MM,AT,1, 1100,  1,1,,’TRUMPF ID’                              ,,,Z
MM,AT,1, 1110,  1,1,,’Feed approach from punch hole’          ,,%,Z
MM,AT,1, 1120,  1,1,,’CUT-GR Setting value’                   ,,,Z
MM,AT,1, 1130,  1,1,,’CUT-MI Setting value’                   ,,bar,Z
MM,AT,1, 1140,  1,1,,’CUT-KL Setting value’                   ,,,Z
MM,AT,1, 1150,  1,1,,’PIERCING-N Time SprintLas’              ,,%,Z
MM,AT,1, 1160,  1,1,,’CUT High acceleration’                  ,,’m/s2’,Z
MM,AT,1, 1730,  1,1,,’PMS Active’                             ,,“,Z
MM,AT,1, 1740,  1,1,,'PMS Threshold value 1'                  ,,“,Z
MM,AT,1, 1750,  1,1,,'PMS Threshold value 2'                  ,,“,Z
C
ZA,DA,.1
DA,...
C
ENDE_LTT_STAMM
C
BEGIN_LTT_CALLS
C
ZA,MM,1
MM,AT,1,    10,  1,1,,'Table identifier'                      ,,,T
C
ZA,DA,.1
DA,.'3529'
C
ENDE_LTT_CALLS
C
BEGIN_PARTS_IN_PROGRAM
C
```

```
ZA,MM,8
MM,AT,1,    10,  1,1,,'Main program name'                          ,,",T
MM,AT,1,    30,  1,1,,'Part ID number'                             ,,",Z
MM,AT,1,    50,  1,1,,'Geometry file name'                         ,,",T
MM,AT,1,    60,  1,1,,'Amount'                                     ,,",Z
MM,AT,1,    70,  1,1,,'Geometry file name (simple display)'        ,,",T
MM,AT,1,    80,  1,1,,'Processing time'                         ,,'min',Z
MM,AT,1,    90,  1,1,,'Surface'                                 ,,'mm2',Z
MM,AT,1,   500,  1,1,,'TRUMPF ID'                                  ,,",Z
C
ZA,DA,2.
DA,...
DA,...
C
ENDE_PARTS_IN_PROGRAM
C
BEGIN_PARTS_IN_PROGRAM_POS
C
ZA,MM,11
MM,AT,1,    10,  1,1,,'Serial number of machined part'             ,,",Z
MM,AT,1,    20,  1,1,,'Main program name'                          ,,",T
MM,AT,1,    30,  1,1,,'Part ID number'                             ,,",T
MM,AT,1,    60,  1,1,,'Position X-coordinate'                   ,,'mm',Z
MM,AT,1,    70,  1,1,,'Position Y-coordinate'                   ,,'mm',Z
MM,AT,1,    80,  1,1,,'Dimension in X'                          ,,'mm',Z
MM,AT,1,    90,  1,1,,'Dimension in Y'                          ,,'mm',Z
MM,AT,1,   100,  1,1,,'Relative pos'                               ,,",Z
MM,AT,1,   150,  1,1,,'X-coordinate center of gravity'          ,,'mm',Z
MM,AT,1,   160,  1,1,,'Y-coordinate center of gravity'          ,,'mm',Z
MM,AT,1,   500,  1,1,,'TRUMPF ID'                                  ,,",Z
C
ENDE_PARTS_IN_PROGRAM_POS
C
BEGIN_PROGRAMM
C
ZA,MM,4
MM,AT,1,    10,  1,1,,'Program number'                             ,,",T
MM,AT,1,    20,  1,1,,'Program type'                               ,,",T
MM,AT,1,    30,  1,1,,'Comment'                                    ,,",T
MM,AT,1,    40,  1,1,,'Processing time'                         ,,'min',Z
C
ZA, DA,
DA, ...
START_TEXT
...
STOP_TEXT
...
START_TEXT
...
STOP_TEXT
ENDE_PROGRAMM
ED
```

TC HSL 2502 C
TC HSL 4002 C
TC L 3050
TC L 4050

All characteristic description blocks which can be evaluated from the control system are listed as follows:

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BD
SET_METRIC
C
BEGIN_EINRICHTEPLAN_INFO
C
ZA,MM,22
MM,AT,1,    10,  1,1,,'Machine'                      ,,“,T
MM,AT,1,    20,  1,1,,'Type'                         ,,“,Z
MM,AT,1,    30,  1,1,,'Control system'               ,,“,T
MM,AT,1,    40,  1,1,,'Variant'                      ,,“,Z
MM,AT,1,    50,  1,1,,'Company'                      ,,“,T
MM,AT,1,    60,  1,1,,'Program number'               ,,“,T
MM,AT,1,    70,  1,1,,'Programmer'                   ,,“,T
MM,AT,1,    80,  1,1,,'Date'                         ,,“,T
MM,AT,1,    90,  1,1,,'Job name'                     ,,“,T
MM,AT,1,   100,  1,1,,'Number of program runs'       ,,“,Z
MM,AT,1,   110,  1,1,,'Panel name'                   ,,“,T
MM,AT,1,   120,  1,1,,'Memory requirement'           ,,“,Z
MM,AT,1,   130,  1,1,,'Material ID'                  ,,“,T
MM,AT,1,   140,  1,1,,'Panel weight'                 ,,'kg',Z
MM,AT,1,   150,  1,1,,'Machine time'                 ,,'min',Z
MM,AT,1,   160,  1,1,,'Comments'                     ,,“,T
MM,AT,1,   170,  1,1,,'Flag automated'               ,,'Bool',Z
MM,AT,1,   180,  1,1,,'Flag ToPsxxx program'         ,,'Bool',Z
MM,AT,1,   190,  1,1,,'Set-up plan file name'        ,,“,T
MM,AT,1,   200,  1,1,,'Storage item identification'  ,,“,T
MM,AT,1,   210,  1,1,,'Palleting flag'               ,,'Bool',Z
MM,AT,1,   220,  1,1,,'Palleting mode'               ,,“,Z
C
ZA,DA,1
DA,...
C
ENDE_EINRICHTEPLAN_INFO
C
BEGIN_SHEET_TECH
C
ZA,MM,9
MM,AT,1,    10,  1,1,,'Table identifier'             ,,“,T
MM,AT,1,    20,  1,1,,'Sheet dimension X'            ,,'mm',Z
MM,AT,1,    30,  1,1,,'Sheet dimension Y'            ,,'mm',Z
MM,AT,1,    40,  1,1,,'Sheet dimension Z'            ,,'mm',Z
MM,AT,1,   200,  1,1,,'TRUMPf ID'                    ,,“,Z
MM,AT,1,   220,  1,1,,'Sheet dimension X real'       ,,'mm',Z
MM,AT,1,   230,  1,1,,'Sheet dimension Y real'       ,,'mm',Z
MM,AT,1,   240,  1,1,,'Material ID'                  ,,“,T
MM,AT,1,   260,  1,1,,'Material density'             ,,'kg/dm3',Z
C
ZA,DA,1
DA,'SHT-1',...
C
ENDE_SHEET_TECH
C
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BEGIN_SHEET_LOAD
C
ZA,MM,16
MM,AT,1,    10,  1,1,,'Table identifier'                    ,,",T
MM,AT,1,    70,  1,1,,'TRUMPF ID'                           ,,",Z
MM,AT,1,   500,  1,1,,'Loading device'                      ,,",Z
MM,AT,1,   520,  1,1,,'LIFT_SUCTION CUP GROUP_1'            ,,",Z
MM,AT,1,   530,  1,1,,'LIFT_SUCTION CUP GROUP_2'            ,,",Z
MM,AT,1,   540,  1,1,,'LIFT_SUCTION CUP GROUP_3'            ,,",Z
MM,AT,1,   550,  1,1,,'LIFT_SUCTION CUP GROUP_4'            ,,",Z
MM,AT,1,   580,  1,1,,'Lift double sheet det. active'       ,,'Bool',Z
MM,AT,1,   590,  1,1,,'Lift peel-off'                       ,,'Bool',Z
MM,AT,1,   620,  1,1,,'Sheet stopper'                       ,,",Z
MM,AT,1,   630,  1,1,,'Measure sheet position'              ,,",Z
MM,AT,1,   640,  1,1,,'Measuring range X'                   ,,'mm',Z
MM,AT,1,   650,  1,1,,'Measuring range Y'                   ,,'mm',Z
MM,AT,1,   660,  1,1,,'Calibration'                         ,,'Bool',Z
MM,AT,1,   690,  1,1,,'Pallet-change type'                  ,,",Z
MM,AT,1,   700,  1,1,,'Measuring corner'                    ,,",Z
C
ZA,DA,1
DA,...
C
ENDE_SHEET_LOAD
C
BEGIN_LTT_STAMM
C
ZA,MM,172
MM,AT,1,  10,1,1,,'Table identifier'                        ,,",T
MM,AT,1,  20,1,1,,'Programmer'                              ,,",T
MM,AT,1,  30,1,1,,'Date of creation'                        ,,",T
MM,AT,1,  40,1,1,,'Last modification'                       ,,",T
MM,AT,1,  50,1,1,,'Comments'                                ,,",T
MM,AT,1,  60,1,1,,'Display status'                          ,,",Z
MM,AT,1,  70,1,1,,'Creation unit'                           ,,",Z
MM,AT,1,  80,1,1,,'Machine type'                            ,,",T
MM,AT,1,  90,1,1,,'Rated laser output'                      ,,'W',Z
MM,AT,1, 100,1,1,,'Material'                                ,,",T
MM,AT,1, 110,1,1,,'Material thickness'                      ,,'mm',Z
MM,AT,1, 120,1,1,,'Lens focal length'                       ,,'in',Z
MM,AT,1, 130,1,1,,'Nozzle type nozzle diameter'             ,,",T
MM,AT,1, 140,1,1,,'Cutting head no.'                        ,,",Z
MM,AT,1, 150,1,1,,'Gas purging Cutting / Piercing'          ,,'s',Z
MM,AT,1, 160,1,1,,'Gas purging Piercing / Cutting'          ,,'s',Z
MM,AT,1, 170,1,1,,'CUT Setting value'                       ,,'mm',Z
MM,AT,1, 180,1,1,,'Reduced cutting acceleration'            ,,'m/s2',Z
MM,AT,1, 190,1,1,,'CUT Acceleration'                        ,,'m/s2',Z
MM,AT,1, 200,1,1,,'CUT Corner cooling-time'                 ,,'s',Z
MM,AT,1, 210,1,1,,'CUT V-red first-cut thick sheet'         ,,'%',Z
MM,AT,1, 220,1,1,,'CUT Gas type cutting'                    ,,",Z
MM,AT,1, 230,1,1,,'CUT Gas type reduced cutting'            ,,",Z
MM,AT,1, 240,1,1,,'CUT-GR Cutting gap'                      ,,'mm',Z
MM,AT,1, 250,1,1,,'CUT-GR-N Laser power'                    ,,'W',Z
MM,AT,1, 260,1,1,,'CUT-GR-N Modulation frequency'           ,,'Hz',Z
MM,AT,1, 270,1,1,,'CUT-GR-N Speed'                          ,,'m/min',Z
MM,AT,1, 280,1,1,,'CUT-GR-N Nozzle standoff'                ,,'mm',Z
MM,AT,1, 290,1,1,,'CUT-GR-N Gas pressure'                   ,,'bar',Z
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MM,AT,1, 300,1,1,,’CUT-GR-R Laser power’                 ,,’W’,Z
MM,AT,1, 310,1,1,,’CUT-GR-R Modulation frequency’        ,,’Hz’,Z
MM,AT,1, 320,1,1,,’CUT-GR-R Speed’                       ,,’m/min’,Z
MM,AT,1, 330,1,1,,’CUT-GR-R Nozzle standoff’             ,,’mm’,Z
MM,AT,1, 340,1,1,,’CUT-GR-R Gas pressure’                ,,’bar’,Z
MM,AT,1, 350,1,1,,’CUT-MI Kerf’                          ,,’mm’,Z
MM,AT,1, 360,1,1,,’CUT-MI-N Laser power’                 ,,’W’,Z
MM,AT,1, 370,1,1,,’CUT-MI-N Modulation frequency’        ,,’Hz’,Z
MM,AT,1, 380,1,1,,’CUT-MI-N Speed’                       ,,’m/min’,Z
MM,AT,1, 390,1,1,,’CUT-MI-N Nozzle standoff’             ,,’mm’,Z
MM,AT,1, 400,1,1,,’CUT-MI-N Gas pressure’                ,,’bar’,Z
MM,AT,1, 410,1,1,,’CUT-MI-R Laser power’                 ,,’W’,Z
MM,AT,1, 420,1,1,,’CUT-MI-R Modulation frequency’        ,,’Hz’,Z
MM,AT,1, 430,1,1,,’CUT-MI-R Speed’                       ,,’m/min’,Z
MM,AT,1, 440,1,1,,’CUT-MI-R Nozzle standoff’             ,,’mm’,Z
MM,AT,1, 450,1,1,,’CUT-MI-R Gas pressure’                ,,’bar’,Z
MM,AT,1, 460,1,1,,’CUT-KL Kerf’                          ,,’mm’,Z
MM,AT,1, 470,1,1,,’CUT-KL-N Laser power’                 ,,’W’,Z
MM,AT,1, 480,1,1,,’CUT-KL-N Modulation frequency’        ,,’Hz’,Z
MM,AT,1, 490,1,1,,’CUT-KL-N Speed’                       ,,’m/min’,Z
MM,AT,1, 500,1,1,,’CUT-KL-N Nozzle standoff’             ,,’mm’,Z
MM,AT,1, 510,1,1,,’CUT-KL-N Gas pressure’                ,,’bar’,Z
MM,AT,1, 520,1,1,,’CUT-KL-R Laser power’                 ,,’W’,Z
MM,AT,1, 530,1,1,,’CUT-KL-R Modulation frequency’        ,,’Hz’,Z
MM,AT,1, 540,1,1,,’CUT-KL-R Speed’                       ,,’m/min’,Z
MM,AT,1, 550,1,1,,’CUT-KL-R Nozzle standoff’             ,,’mm’,Z
MM,AT,1, 560,1,1,,’CUT-KL-R Gas pressure’                ,,’bar’,Z
MM,AT,1, 570,1,1,,’PIERCING Setting value’               ,,’mm’,Z
MM,AT,1, 580,1,1,,’PIERCING-N Time’                      ,,’s’,Z
MM,AT,1, 590,1,1,,’PIERCING-N Ramp cycle number’         ,,“,Z
MM,AT,1, 600,1,1,,'PIERCING-N Nozzle standoff'           ,,'mm',Z
MM,AT,1, 610,1,1,,'PIERCING-N Blowout time'              ,,'s',Z
MM,AT,1, 620,1,1,,'PIERCING-N Gas type'                  ,,“,Z
MM,AT,1, 630,1,1,,'PIERCING-N gas pressure'              ,,'bar',Z
MM,AT,1, 640,1,1,,'PIERCING-N Spray oil'                 ,,“,Z
MM,AT,1, 650,1,1,,'PIERCING-R Time'                      ,,'s',Z
MM,AT,1, 660,1,1,,'PIERCING-R Ramp cycle number'         ,,“,Z
MM,AT,1, 670,1,1,,'PIERCING-R nozzle standoff'           ,,'mm',Z
MM,AT,1, 680,1,1,,'PIERCING-R Blowout time'              ,,'s',Z
MM,AT,1, 690,1,1,,'PIERCING-R Gas type'                  ,,“,Z
MM,AT,1, 700,1,1,,'PIERCING-R Gas pressure'              ,,'bar',Z
MM,AT,1, 710,1,1,,'PIERCING-R Spray oil'                 ,,“,Z
MM,AT,1, 720,1,1,,'EVAP Setting value'                   ,,'mm',Z
MM,AT,1, 730,1,1,,'EVAP Time'                            ,,'s',Z
MM,AT,1, 740,1,1,,'EVAP Nozzle standoff'                 ,,'mm',Z
MM,AT,1, 750,1,1,,'EVAP Laser power'                     ,,'W',Z
MM,AT,1, 760,1,1,,'EVAP Modulation frequency'            ,,'Hz',Z
MM,AT,1, 770,1,1,,'EVAP Speed'                           ,,'m/min',Z
MM,AT,1, 780,1,1,,'EVAP Gas type'                        ,,“,Z
MM,AT,1, 790,1,1,,'EVAP Gas pressure'                    ,,'bar',Z
MM,AT,1, 800,1,1,,'LABEL Setting value'                  ,,'mm',Z
MM,AT,1, 810,1,1,,'LABEL Nozzle standoff'                ,,'mm',Z
MM,AT,1, 820,1,1,,'LABEL Laser power'                    ,,'W',Z
MM,AT,1, 830,1,1,,'LABEL Modulation frequency'           ,,'Hz',Z
MM,AT,1, 840,1,1,,'LABEL Speed'                          ,,'m/min',Z
MM,AT,1, 850,1,1,,'LABEL Gas type'                       ,,“,Z
MM,AT,1, 860,1,1,,'LABEL Gas pressure'                   ,,'bar',Z
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MM,AT,1, 870,1,1,,’POINTMARK-G Setting value’            ,,’mm’,Z
MM,AT,1, 880,1,1,,’POINTMARK-G Nozzle standoff’          ,,’mm’,Z
MM,AT,1, 890,1,1,,’POINTMARK-G Laser power’              ,,’W’,Z
MM,AT,1, 900,1,1,,’POINTMARK-G Modulation frequency’     ,,’Hz’,Z
MM,AT,1, 910,1,1,,’POINTMARK-G speed’                    ,,’m/min’,Z
MM,AT,1, 920,1,1,,’POINTMARK-G Gas type’                 ,,“,Z
MM,AT,1, 930,1,1,,'POINTMARK-G Gas pressure'             ,,'bar',Z
MM,AT,1, 940,1,1,,'POINTMARK-P Piercing time'            ,,'s',Z
MM,AT,1, 950,1,1,,'POINTMARK-P Ramp cycle number'        ,,“,Z
MM,AT,1, 960,1,1,,'POINTMARK-P Nozzle standoff'          ,,'mm',Z
MM,AT,1, 970,1,1,,'POINTMARK-P Gas type'                 ,,“,Z
MM,AT,1, 980,1,1,,'POINTMARK-P Gas pressure'             ,,'bar',Z
MM,AT,1, 990,1,1,,'DOT Setting value'                    ,,'mm',Z
MM,AT,1,1000,1,1,,'DOT-S Time'                           ,,'s',Z
MM,AT,1,1010,1,1,,'DOT-S Ramp cycle number'              ,,“,Z
MM,AT,1,1020,1,1,,'DOT-S Nozzle standoff'                ,,'mm',Z
MM,AT,1,1030,1,1,,'DOT-S Gas type'                       ,,“,Z
MM,AT,1,1040,1,1,,'DOT-S Gas pressure'                   ,,'bar',Z
MM,AT,1,1050,1,1,,'DOT-F Time'                           ,,'s',Z
MM,AT,1,1060,1,1,,'DOT-F Ramp cycle number'              ,,“,Z
MM,AT,1,1070,1,1,,'DOT-F Nozzle standoff'                ,,'mm',Z
MM,AT,1,1080,1,1,,'DOT-F Gas type'                       ,,“,Z
MM,AT,1,1090,1,1,,'DOT-F Gas pressure'                   ,,'bar',Z
MM,AT,1,1100,1,1,,'TRUMPF ID'                            ,,“,Z
MM,AT,1,1110,1,1,,'Feed approach from punch hole'        ,,'%',Z
MM,AT,1,1120,1,1,,'CUT-GR Setting value'                 ,,'mm',Z
MM,AT,1,1130,1,1,,'CUT-MI Setting value'                 ,,'mm',Z
MM,AT,1,1140,1,1,,'CUT-KL Setting value'                 ,,'mm',Z
MM,AT,1,1150,1,1,,'PIERCING-N Time SprintLas'            ,,'s',Z
MM,AT,1,1160,1,1,,'CUT High acceleration'                ,,'m/s2',Z
MM,AT,1,1730,1,1,,'PMS Active'                           ,,“,Z
MM,AT,1,1740,1,1,,'PMS Threshold value 1'                ,,'%',Z
MM,AT,1,1750,1,1,,'PMS Threshold value 2'                ,,'%',Z
MM,AT,1,1760,1,1,,'LPC - LFS Mode'                       ,,“,Z
MM,AT,1,1770,1,1,,'LPC Upper limit in %'                 ,,'%',Z
MM,AT,1,1780,1,1,,'Power at upper limit in %'            ,,'%',Z
MM,AT,1,1790,1,1,,'LPC Lower limit in %'                 ,,'%',Z
MM,AT,1,1800,1,1,,'Power at lower limit in %'            ,,'%',Z
MM,AT,1,1810,1,1,,'LFS Upper limit in %                  ,,'%',Z
MM,AT,1,1820,1,1,,'Frequency at upper limit in %'        ,,'%',Z
MM,AT,1,1830,1,1,,'LFS Lower limit in %'                 ,,'%',Z
MM,AT,1,1840,1,1,,'Frequency at lower limit in %'        ,,'%',Z
MM,AT,1,1850,1,1,,'Sensor Normal piercing'               ,,“,Z
MM,AT,1,1860,1,1,,'Sensor Soft piercing'                 ,,“,Z
MM,AT,1,1870,1,1,,'CUT-GR Beam diameter'                 ,,'mm',Z
MM,AT,1,1880,1,1,,'CUT-MI Beam diameter'                 ,,'mm',Z
MM,AT,1,1890,1,1,,'CUT-KL Beam diameter'                 ,,'mm',Z
MM,AT,1,1900,1,1,,'PIERCING Beam diameter'               ,,'mm',Z
MM,AT,1,1910,1,1,,'EVAP Beam diameter'                   ,,'mm',Z
MM,AT,1,1920,1,1,,'LABEL Beam diameter                   ,,'mm',Z
MM,AT,1,1930,1,1,,'POINTMARK Beam diameter'              ,,'mm',Z
MM,AT,1,1940,1,1,,'DOT Beam diameter'                    ,,'mm',Z
MM,AT,1,1950,1,1,,'LPC Speed at upper limit'             ,,'m/min',Z
MM,AT,1,1960,1,1,,'Power at upper limit'                 ,,'W',Z
MM,AT,1,1970,1,1,,'LPC Speed at lower limit'             ,,'m/min',Z
MM,AT,1,1980,1,1,,'Power at lower limit'                 ,,'W',Z
MM,AT,1,1990,1,1,,'LFS Speed at upper limit'             ,,'m/min',Z
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MM,AT,1,2000,1,1,,’Frequency at upper limit’                ,,’Hz’,Z
MM,AT,1,2010,1,1,,’LFS Speed at lower limit’             ,,’m/min’,Z
MM,AT,1,2020,1,1,,’Frequency at lower limit’                ,,’Hz’,Z
MM,AT,1,2030,1,1,,’PIERCING Soft setting value’             ,,’mm’,Z
MM,AT,1,2040,1,1,,’PMS Active middle contour’                 ,,“,Z
MM,AT,1,2050,1,1,,’PMS Active small contour’                  ,,“,Z
MM,AT,1,2060,1,1,,'Acceleration Special processing'        ,,'m/s2',Z
MM,AT,1,2070,1,1,,'PCS-PIERCING Beam diameter'          ,,'mm',Z
MM,AT,1,2080,1,1,,'PCS-PIERCING-N Setting value'          ,,'mm',Z
MM,AT,1,2090,1,1,,'PCS-PIERCING-N Time'                      ,,'s',Z
MM,AT,1,2100,1,1,,'PCS-PIERCING-N Ramp cycle number'      ,,“,Z
MM,AT,1,2110,1,1,,'PCS-PIERCING-N Nozzle standoff'       ,,'mm',Z
MM,AT,1,2120,1,1,,'PCS-PIERCING-N Blowout time'             ,,'s',Z
MM,AT,1,2130,1,1,,'PCS-PIERCING-N Gas type'                   ,,“,Z
MM,AT,1,2140,1,1,,'PCS-PIERCING-N gas pressure'          ,,'bar',Z
MM,AT,1,2150,1,1,,'PCS-PIERCING-N Spray oil'                  ,,“,Z
MM,AT,1,2160,1,1,,'PCS-PIERCING-N Sensor type'                ,,“,Z
MM,AT,1,2170,1,1,,'PCS-PIERCING-N Horizontal blow'     ,,'Bool',Z
MM,AT,1,2180,1,1,,'PCS-PIERCING-R Setting value'          ,,'mm',Z
MM,AT,1,2190,1,1,,'PCS-PIERCING-R Time'                      ,,'s',Z
MM,AT,1,2200,1,1,,'PCS-PIERCING-R Ramp cycle number'      ,,“,Z
MM,AT,1,2210,1,1,,'PCS-PIERCING-R Nozzle standoff'       ,,'mm',Z
MM,AT,1,2220,1,1,,'PCS-PIERCING-R Blowout time'             ,,'s',Z
MM,AT,1,2230,1,1,,'PCS-PIERCING-R Gas type'                   ,,“,Z
MM,AT,1,2240,1,1,,'PCS-PIERCING-R Gas pressure'          ,,'bar',Z
MM,AT,1,2250,1,1,,'PCS-PIERCING-R Spray oil'                  ,,“,Z
MM,AT,1,2260,1,1,,'PCS-PIERCING-R Sensor type'                ,,“,Z
MM,AT,1,2270,1,1,,'PCS-PIERCING-R Horizontal blow'     ,,'Bool',Z
MM,AT,1,2280,1,1,,'CUT High acceleration kinematics 2'   ,,'m/s2',Z
C
ZA,DA,1
DA,...
C
ENDE_LTT_STAMM
C
BEGIN_LTT_CALLS
C
ZA,MM,1
MM,AT,1,10,1,1   ,,'Table identifier'                                   ,,“,T
C
ZA,DA,1
DA,'T2D-5394'
C
ENDE_LTT_CALLS
C
BEGIN_PARTS_IN_PROGRAM
C
ZA,MM,15
MM,AT,1,10,1,1,,'Main program name'                                 ,,“,T
MM,AT,1,20,1,1,,'Reserved'                                          ,,“,T
MM,AT,1,30,1,1,,'Part ID number'                                    ,,“,T
MM,AT,1,40,1,1,,'Reserved'                                          ,,“,Z
MM,AT,1,50,1,1,,'Geometry file name'                                ,,“,T
MM,AT,1,60,1,1,,'Amount'                                            ,,“,Z
MM,AT,1,70,1,1,,'Geometry file name (simple display)'               ,,“,T
MM,AT,1,80,1,1,,'Processing time'                                 ,,'min',Z
```

```
MM,AT,1,90,1,1,,'Surface'                                        ,,'mm²',Z
MM,AT,1,100,1,1,,'ToPs Drawing info'                             ,,'',T
MM,AT,1,110,1,1,,'ToPs Part numbering'                           ,,'',T
MM,AT,1,120,1,1,,'ToPs Drawing name'                             ,,'',T
MM,AT,1,130,1,1,,'Dimension X'                                   ,,'mm',Z
MM,AT,1,140,1,1,,'Dimension Y'                                   ,,'mm',Z
MM,AT,1,500,1,1,,'TRUMPF ID'                                     ,,'',Z
C
ZA,DA,1
DA,...
C
ENDE_PARTS_IN_PROGRAM
C
BEGIN_PARTS_IN_PROGRAM_POS
C
ZA,MM,15
MM,AT,1,10,1,1,,'Serial number of machined part'                 ,,'',Z
MM,AT,1,20,1,1,,'Main program name'                              ,,'',T
MM,AT,1,30,1,1,,'Part ID number'                                 ,,'',T
MM,AT,1,60,1,1,,'Position X-coordinate'                          ,,'mm',Z
MM,AT,1,70,1,1,,'Position Y-coordinate'                          ,,'mm',Z
MM,AT,1,80,1,1,,'Dimension in X'                                 ,,'mm',Z
MM,AT,1,90,1,1,,'Dimension in Y'                                 ,,'mm',Z
MM,AT,1,100,1,1,,'Relative pos'                                  ,,'deg',Z
MM,AT,1,150,1,1,,'X-coordinate center of gravity'                ,,'mm',Z
MM,AT,1,160,1,1,,'Y-coordinate center of gravity'                ,,'mm',Z
MM,AT,1,190,1,1,,'Removal number'                                ,,'',Z
MM,AT,1,200,1,1,,'Reference part'                                ,,'',Z
MM,AT,1,210,1,1,,'Name of the PartUnloadData table'              ,,'',T
MM,AT,1,220,1,1,,'Name of the PartPalettData table'              ,,'',T
MM,AT,1,500,1,1,,'TRUMPF ID'                                     ,,'',Z
C
ZA,DA,1
DA,...
C
ENDE_PARTS_IN_PROGRAM_POS
C
BEGIN_MICROJOINT
C
ZA,MM,12
MM,AT,1,  10,1,1,,'Table identifier'                             ,,'',T
MM,AT,1,100,1,1,,'Programmed microjoints active'                 ,,'Bool',Z
MM,AT,1,110,1,1,,'Automatic microjoints active'                  ,,'Bool',Z
MM,AT,1,120,1,1,,'Microjoint width small contour'                ,,'mm',Z
MM,AT,1,130,1,1,,'Microjoint width middle contour'               ,,'mm',Z
MM,AT,1,140,1,1,,'Microjoint width large contour'                ,,'mm',Z
MM,AT,1,150,1,1,,'Extension of contour min X autom. microjoint',,'mm',Z
MM,AT,1,160,1,1,,'Extension of contour max X autom. microjoint',,'mm',Z
MM,AT,1,170,1,1,,'Extension of contour min Y autom. microjoint',,'mm',Z
MM,AT,1,180,1,1,,'Extension of contour max Y autom. microjoint',,'mm',Z
MM,AT,1,190,1,1,,'Piercing type acc. to microjoint'              ,,'',Z
MM,AT,1,500,1,1,,'TRUMPF ID'                                     ,,'',Z
C
ZA,DA,1
DA,...
C
```

```
ENDE_MICROJOINT
C
BEGIN_PROGRAM
C
ZA,MM,4
MM,AT,1,10,1,1,,’Program number’                    ,,“,T
MM,AT,1,20,1,1,,'Program type'                      ,,“,T
MM,AT,1,30,1,1,,'Comments'                          ,,“,T
MM,AT,1,40,1,1,,'Processing time'                   ,,'min',Z
C
ZA,DA,2
DA,...
START_TEXT
...
STOP_TEXT
...
START_TEXT
...
STOP_TEXT
ENDE_PROGRAMM
ED
```

3. NC code

Inside the master file, whose construction is governed by a characteristic file, the NC code (the actual processing program) comprises of data blocks which are described in the "PROGRAM" table block in the form of characteristic description blocks. The NC code is composed of:

- Subroutines
- The main program.

Each of these programs corresponds to a data record and every data record is part of the NC code. A main program as well as a subroutine can be divided into different parts:

- Program beginning.
- Processing program.
- Program end.

Program start

Messages and comments which relay technical information to the machine operator are programmed at the program start.

Processing program

The NC text actually needed for the processing of the part is programmed in the processing program. The individual NC blocks are executed in sequence. The program sequence can be modified by means of:

- Subroutines called up from the main program.
- Jump destinations (labels).
- Selective block suppression.
- Repeat instructions.

Program end

The word for "Program end" must be in the last block for processing. The functions M2, M30 (Main program end) or M17 (Subroutine end) can be used for this.

3.1 Linguistic elements of the programming language

Programs consist - as does the language we speak - of sentences (i.e. blocks), which in turn consist of words.

A word of the "NC language" consists of an address character and a numeric character or of a numeric sequence, which represents an arithmetical value.

Program block

A block consists of a block number and one or more words which contain information for the movement of the machine (path conditions and path information) as well as help and additional functions. A block can contain a maximum of 242 characters and ends with the character "LF" (= line feed).

☞ The character "LF" does not need to be written; it is automatically produced by the line feed.

The programming table determines the sequence in which the individual words must be ordered. Spaces can be entered between the words in order to create an easy to read block structure.

N200	G01	X320.5	Y32	F12000	LF
Block number		Words			End of block

Program word

Individual commands are called words.

A word consists of an address letter and a sequence of digits. With the address letters (e.g. X, Y, G, M etc.) the meaning of the information or the memory location is labeled. The digit sequence indicates the memory content.
The digit sequence can contain decimal points and operational signs (the latter are always placed between the address letter and the digit sequence). Positive operational signs, leading zeros and non-significant zeros after the decimal point do not need to be programmed.

Example:

X157.5 instead of X+0157.50
X65 instead of X+65.00
X-.57 instead of X-0.57

Only information that changes needs to be programmed.

Important addresses

Address	Meaning
F	Feed
G	Path condition
I	Interpolation parameters
J	Interpolation parameters
L	Subroutine call-up
M	Additional function
P	Number of program runs
R	Calculation parameters
X	Axis
Y	Axis
Z	Axis
AC	Absolute data input for individual axes
IC	Relative data input for individual axes
CR	Circle radius
AR+	Opening angle

☞ The calculation parameters R1 - R100 are disabled for TRUMPF applications, since accidental use can lead to collisions. The user can freely use the calculation parameters R101 - R150.

Designator

The words (according to DIN 66025) are completed by designators (names). Within a given NC block, these compliments have the same meaning as the words.

Designators must be unequivocal: The same designator must never be used for different objects. Designators can stand for:

- Variable
- Subroutines
- Code words.
- DIN addresses with several letters.

Designators consist of a maximum of 32 characters. The following may be used as characters:

- Letters
- Underline characters.
- Digits

The first two characters must be letters or underline characters.

The designators used by TRUMPF to stand for cycles always begin with TC_.

Example: TC_LASER_ON

☞ We distinguish between **self-holding** (modally) effective words and words that are effective **block-by-block**. Modal addresses remain valid (in all subsequent blocks) until a new value is programmed under the same address. Block-by-block addresses only apply in the block in which they have been programmed.

3.2 Program code

The individual words are arranged in groups in the program code. The functions of a group delete each other simultaneously. There is always only one function from each group active. The respective switch-on condition should be referred to in the overview of all NC functions (chapter 2).

3.3 Block number (N address)

Definition

The block number is for numbering individual program blocks and is necessary for the normal program sequence. A consecutive block numbering is recommended. Double block numbers should not be allocated, because this can lead to problems during the block search run. Recommended is exponent steps of 10.
Blocks added subsequently must be whole numbers.

Example

Input format: 5.2 (means: 5 places before the point, 2 places after the point).

N1	Minimum
N10	
N20	
N21	Addition
N30	
.	
.	
N99999	Maximum

3.4 Selective block suppression

Definition

Blocks, which should not be executed with every program run, can be removed.

Mark the blocks which are to be skipped with the sign "/" (slash) in front of the block number. Several blocks can also be skipped in sequence. The instructions in the skipped blocks will not be executed, and the program will continue with the next (non-skipped) block.

Example

N110	G01	X0	Y0	
/N120		X20	Y35	Block skipped
/N130		X35	Y40	Block skipped
N140		X60	Y30	

Application

In one program, two different versions of a family of parts can be recorded. All the parts which are required in Version A, but not in Version B, can be skipped when creating Version B.

☞ In the case of incremental programming (G91), the starting point of the first block that has been skipped must be the same as the starting point of the next block that has not been skipped.

3.5 Programming messages

Messages can be programmed to notify the operator of the current processing situation during program execution. The relevant current message appears at the top in the message line with the black background.

Programming

- A message is produced in an NC program by writing the message text in round brackets "()" and inverted commas after the code word "MSG".
- Messages are automatically deleted after 5 seconds.
- A message can also be deleted by "MSG()".

Example

N100	MSG("Removing scrap")	Activate message
N110	M00	
N..		
N130	MSG()	Delete message from N100

3.6 Comments

To make an NC program understandable and easy to follow for other programmers, we recommend adding pertinent comments that explain individual blocks in more detail.

Programming

- Comments are placed at the end of a block and separated from the program part of the NC block by a semicolon (;).
- Comments are saved and appear in the current block display during the execution of the program.

Example

N100	G01 X50 Y60
N110	Y200; Bypasses punched hole
N120	X300
N130	Y60

Chapter 2

Overview of all NC functions

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1. G-functions / Path conditions

Definition

G-functions determine the interpolation type, the dimension input type, the reference point for dimension input, and data corrections. Together with the coordinate values, they form the geometrical part of the program.

Programming note

- G-functions must be written before the path information.
- A maximum of one G-function from one function group may be written per block.
- Related functions are combined into a function group. The functions within a group cancel themselves mutually. Hence only one function per group is ever active.
- The active function or the active turn-on condition is always the one that was programmed last of the group.
- When programming G functions, the initial zero can be omitted, e.g. G3 instead of G03.

1.1 Modal-effective motion commands

Code	Meaning	self holding	block-by-block	turn-on condition
G00	Rapid movement.	x		
G01	Linear interpolation.	x		x
G02	Clockwise circular interpolation.	x		
G03	Counterclockwise circular interpolation.	x		

1.2 Dwell time

Code	Meaning	self holding	block-by-block	turn-on condition
G04	Dwell time, predetermined timing.		x	

1.3 Programmed zero-point Offset and programmable rotation

Code	Meaning	self holding	block-by-block	turn-on condition
TRANS	Programmable translation.	x		
RED	Programmable rotation.	x		
ATRANS	Additive programmable offset.	x		
AROT	Additive programmable rotation.	x		

1.4 Measuring systems

Code	Meaning	self holding	block-by-block	turn-on condition
G70	Input system inch.	x		
G71	Input system metric.	x		x

1.5 Dimension input

Code	Meaning	self holding	block-by-block	turn-on condition
G90	Absolute dimension input.	x		x
G91	Incremental data input (chain data input).	x		

2. M-functions

Definition

M-functions trigger the routines stored in the control system, with which the machine components such as valves, cylinders or electrical switching units are addressed and activated.

For the SINUMERIK 840D, machining cycles have been developed which include the operations of "classic" M-functions. Only the standardized stop and program-end functions remain as M-functions.

Programming note

- M-functions need to be written after the path information.
- A maximum of 5 M-functions per NC block can be programmed.
- Related functions are combined into a function group. The functions within a group cancel themselves mutually. Hence only one function per group is ever active.
- Only one command from a function group may be programmed per NC block. If several M commands appear in a group in the NC block, the most recently programmed is activated.
- The active function or the active turn-on condition is always the most recently programmed of the group.

2.1 Holding functions

Code	Meaning	self holding	block-by-block	turn-on condition
M00	Programmed stop.		x	
M01	Optional hold.		x	

2.2 Program-end functions

Code	Meaning	self holding	block-by-block	turn-on condition
M02	Program end. Main program with reset to program start.		x	
M30	Program end, as with M02.		x	
M17	End of subroutine.		x	

3. Cycles for laser processing

3.1 Laser cutting

Code	Meaning	self holding	block-by-block	turn-on condition
TC_LASER_ON	Laser cutting ON	x		
TC_LASER_OFF	Laser cutting OFF.	x		x
TC_WAIT	Corner cooling.		x	
TC_LASER_HEAD	Select cutting head, define head distance (TC HSL 2502 C, TC HSL 4002 C)	x		

3.2 Measuring sheet thickness

Code	Meaning	self holding	block-by-block	turn-on condition
TC_SHEET_THICK	Measure sheet thickness.	x		

3.3 Kerf correction

Code	Meaning	self holding	block-by-block	turn-on condition
TC_LASERCORR_ON	Activate kerf correction.	x		
TC_LASERCORR_OFF	Deselect kerf correction.	x		x

3.4 Overshoot height

Code	Meaning	self holding	block-by-block	turn-on condition
TC_POS_LEVEL	Switch off overshoot height for laser beam.	x		

4. Sheet handling cycles

Code	Meaning
TC_SHEET_LOAD	Load sheet.
TC_SHEETPOS_RELOAD	Activate measuring values.
TC_SHEET_TECH	Call up sheet technology data.
TC_SHEET_MEASURE	Measure sheet position.

5. Time measurement for parts processing

Code	Meaning
TC_TIMER	Carry out parts time measurement.

6. Programming selectable microjoint

Code	Meaning
TC_MICROJOINT	Call up table using microjoint data.
G821	Program contour-related microjoints.
G822	Suppress automatic microjoints.

Chapter 3

G-functions/Path conditions

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1. Linear interpolation

1.1 G00

Definition

The programmed position is interpolated on a straight line.

With G00, the machine moves with maximum speed (rapid traverse) along the shortest path from the current starting point to the programmed target position. All programmed axes reach the final position simultaneously.

Rapid traverse speed is fixed separately for each axis:

TC L 2530, TC L3030, TC L4030, TC L 6030:
- 60 m/min in X direction.
- 60 m/min in Y direction.
- 85 m/min simultaneously.

TC L 3050:
- 200 m/min in X direction.
- 200 m/min in Y direction.
- approx. 300 m/min simultaneous.

TC HSL 2502 C, TC HSL 4002 C:
- 215 m/min in X-Richtung.
- 215 m/min in Y-Richtung.
- > 300 m/min simultan.

Programming

G00
- Self-holding effect.
- Can be programmed with or without path information.
- Suppresses a programmed speed (F-word).
- Is deleted by G01, G02 and G03.

Application

Rapid traverse movement is applied in order to:

- Approach start position.
- Position quickly.

☞ This function is not suitable for workpiece machining!

1.2 G01

Definition

The programmed position is interpolated on a straight line.

With G01, the machine moves with a maximum speed programmed in F-word and takes the shortest route from the current starting point to the programmed target position. All programmed axes reach the final position simultaneously.

Programming

G01

- Is the turn-on condition.
- Self-holding effect.
- Can be programmed with or without path information.
- At the very latest, the speed (F-word) must be programmed by the time the machine begins to move.
- Is deleted by G00, G02 and G03.

Example

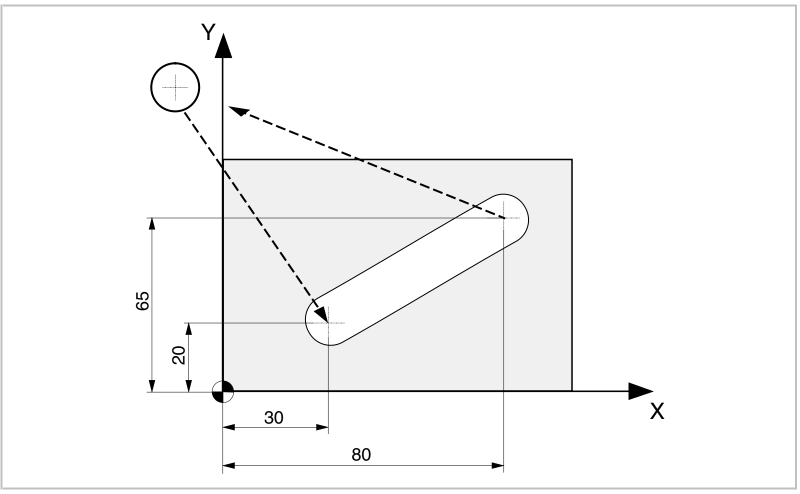

Fig. 11642

N100	G00 X30 Y20	Approaching the start position with max. speed
N110	G01 F...	Programming the speed
N120	TC_LASER_ON(1,"1734",10,100)	Laser ON
N130	X80 Y65	Cutting path
N140	TC_LASER_OFF(1)	Laser OFF
N150	G00 X... Y..	Approaching next start position

2. Circular interpolation

2.1 G02

Definition

The programmed position is interpolated onto a clockwise circle.

The machine travels to all subsequent positions in the program while describing a clockwise arc with the speed specified in the F-word.

Programming

G02

- Self-holding effect.
- Can be programmed with or without path information.
- The speed (F-word) has to be programmed before the machine makes its first movement.
- In addition to the circle end point, the interpolation parameters I and J or the radius CR are also necessary for programming the arc.

2.2 G03

Definition

The programmed position is interpolated onto a counterclockwise circle.

The machine travels to all subsequent positions in the program while describing an anti-clockwise arc with the speed specified in the F-word.

Programming

G03

- Self-holding effect.
- Can be programmed with or without path information.
- The speed (F-word) has to be programmed before the machine makes its first movement.
- In addition to the circle end point, the interpolation parameters I and J or the radius CR are also necessary for programming the arc.

2.3 I and J, Interpolation parameters

Definition

When programming the circle with G02 or G03, the position of the center of the circle must be programmed in addition to its end point using the interpolation parameters I and J. Since it is not permissible to program two X or Y dimensions in one block, the circle center distances are programmed to the starting point as I (X direction) and J (Y direction).

I Circle center distance in X direction
J Circle center distance in Y direction

☞ Radius programming presents a further possibility for circle programming with G02 or G03.

Programming

I and J

- Are entered incrementally as standard practice, based on the circle starting point.
- Must be programmed parallel to the axes and with the correct operational signs.
- Can be programmed with help from the AC function and be completely specific to the workpiece zero point.
- If I=0 or J=0, this value does not have to be written.
- With full circle programming, it is not necessary to specify the end point.

2.4 CR, Radius programming

Definition

When programming the circle with G02 or G03, the circle radius CR must also be programmed next to the circle end point in order to define the circle movement more closely.

☞ When programming the circle with G02 or G03, it can also present circle center programming on the basis of the interpolation parameters I and J.

Programming

CR

- The assignment of values is carried out using a "="-sign: CR=15, not CR15!
- By entering the operational sign "+/-", you can program whether the travel angle should be larger or smaller than 180°. A positive operational sign can be dispensed with, indicating:
  CR=+..angle less than or equal to 180°.
  CR=-.. angle greater than 180°.
- Complete circles cannot be programmed using the circle radius CR, but only by determination of the circle middle point using the interpolation parameters I and J.

Example G02

Programming example for circle programming with G02 and the interpolation parameters I and J (incremental):

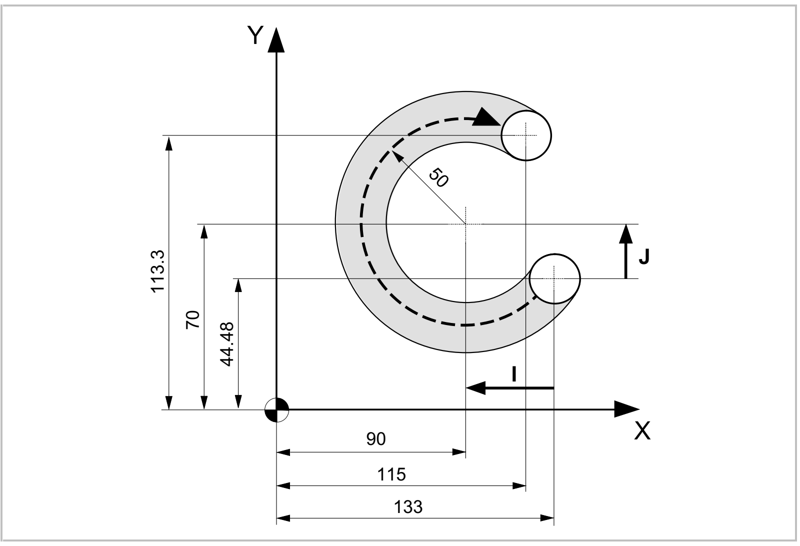

Fig. 11645

N100	G0 X133 Y44.48	Approaching start position
N110	TC_LASER_ON(1,"1734",10,100)	Laser ON
N120	G02 X115 Y113.3 I-43 J25.52	Laser path
N130	LASER_OFF(1)	Laser OFF

Programming example for circle programming with G02 and the interpolation parameters I and J (absolute):

N100	G0 X133 Y44.48	Approaching start position
N110	TC_LASER_ON(1,"1734",10,100)	Laser ON
N120	G02 X115 Y113.3 I=AC(90) J=AC(70)	Laser path
N130	TC_LASER_OFF(1)	Laser OFF

Programming example for radius circle programming with G02 and CR=:

N100	G0 X133 Y44.48	Approaching start position
N110	TC_LASER_ON(1,"1734",10,100)	Laser ON
N120	G02 X115 Y113.3 CR=-50	Laser path
N130	TC_LASER_OFF(1)	Laser OFF

G03 examples

Programming example for circle programming with G03 and the interpolation parameters I and J (incremental):

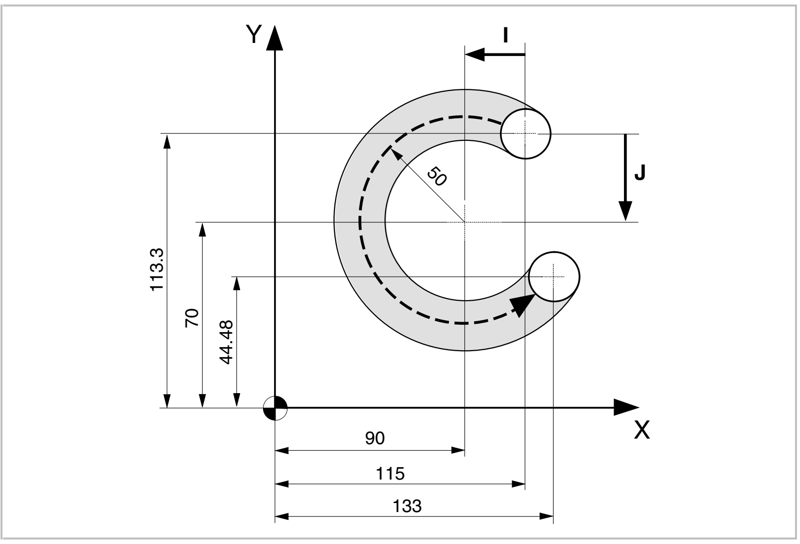

Fig. 11646

N100	G0 X115 Y113.3	Approaching start position
N110	TC_LASER_ON(1,"1734",10,100)	Laser ON
N130	G03 X133 Y44.48 I-25 J-43.3	Laser path
N140	TC_LASER_OFF(1)	Laser OFF

Programming example for circle programming with G03 and the interpolation parameters I and J (absolute):

N100	G0 X115 Y113.3	Approaching start position
N110	TC_LASER_ON(1,"1734",10,100)	Laser ON
N120	G03 X133 Y44.48 I=AC(90) J=AC(70)	Laser path
N130	TC_LASER_OFF(1)	Laser OFF

Programming example for radius circle programming with G03 and CR=:

N100	G0 X115 Y113.3	Approaching start position
N110	TC_LASER_ON(1,"1734",10,100)	Laser ON
N120	G03 X133 Y44.48 CR=-50	Laser path
N130	TC_LASER_OFF(1)	Laser OFF

3. Programmable dwell time, G04

Definition

A defined dwell time is programmed together with an F-word.

The machine interrupts all movements and continues automatically with the program when the programmed dwell time expires.

Using G04, workpiece processing can be interrupted between two NC blocks for the programmed time.

Programming

G04

- Acts block-by-block.
- Must be programmed into its own NC block without path information.
- Is programmed with an F-word in seconds (desired dwell time):
  min. F0.01 0.01 seconds
  max. F999.99 999.99 seconds.
- Laser must be switched off.

4. Adjustable zero point offset

Definition

With reference point offsets, the machine control system adds certain X- and Y-values algebraically to the programmed dimensions. These adjustment values are entered under "User-defined zero offset" in the control system in the activity field "PRODUCTION - Program options" and calculated automatically with all programmed dimensions.

5. Programmable zero point offset

5.1 TRANS

Definition

Programmable absolute zero point offset; refers to the current valid set workpiece zero point.

With TRANS, zero point offsets can be programmed for the X and Y axes in the direction of the indicated axis.

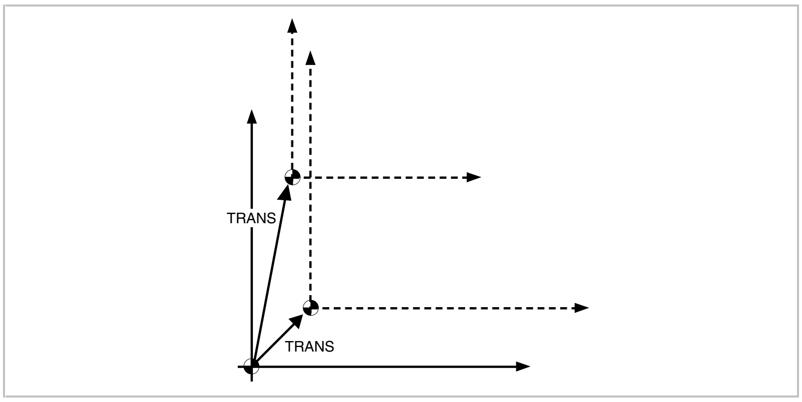

Fig. 12334

Programming

TRANS

- Self-holding effect.
- Must be programmed in its own NC block, together with the correction values of all axes, for which the zero point offset is to be effective, e.g. TRANS X10 Y10.
- Is an absolute value, relative to the currently set workpiece zero point, hence additive to the adjustable (user) zero point offset.
- Is overwritten by ROT and renewed programming of TRANS with axis data.
- When there are no axis statements with TRANS, the zero point offset for all axes is switched off.
- Is not deleted by ATRANS.
- Should not be programmed as long as a processing function (TC_LASER_ON) is active.

5.2 ATRANS

Definition

Programmable zero point offset is additive in reference to the current valid set or programmable zero point.

With ATRANS, zero point offsets can be programmed for the X and Y axes in the direction of the indicated axis.

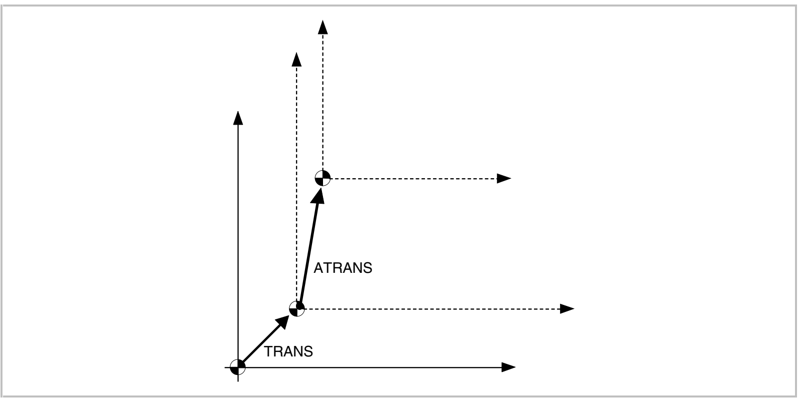

Fig. 12333

Programming

ATRANS

- Self-holding effect.
- Must be programmed in its own NC block, together with the correction values of all axes, for which the zero point offset is to be effective, e.g. ATRANS X10 Y10.
- Works as an additive, refers to the currently set or programmed zero point, thus additive to TRANS.
- When there are no axis statements with TRANS, the zero point offset for all axes is switched off.
- Should not be programmed as long as a processing function (TC_LASER_ON) is active.

Application For recurrent machining cycles at different workpiece positions.

Example With this workpiece, the shapes shown occur several times within the same program. The processing sequence for this shape is stored in the subroutine. Set the required workpiece zero points via the zero point offset and then call up the subroutine.

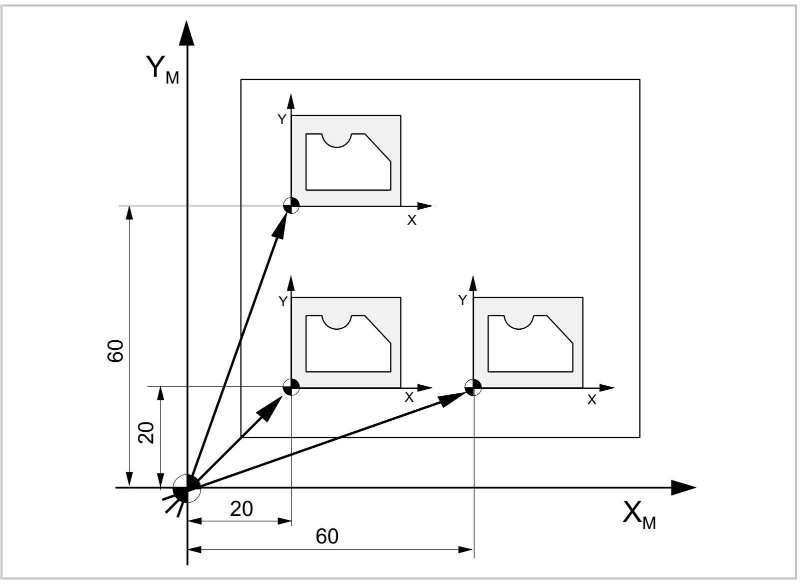

Fig. 14881

N110	TRANS X20 Y20	Absolute zero point offset
N120	L10	Calling up a subroutine
N130	TRANS X20 Y60	Absolute zero point offset
N140	L10	Calling up a subroutine
N150	TRANS X60 Y20	Absolute zero point offset
N160	L10	Calling up a subroutine

6. Programmable rotation

6.1 ROT

Definition

Rotation is absolute, relative to the currently set workpiece zero point.

With ROT, the coordinate system can be rotated around the turning angle programmed with RPL.

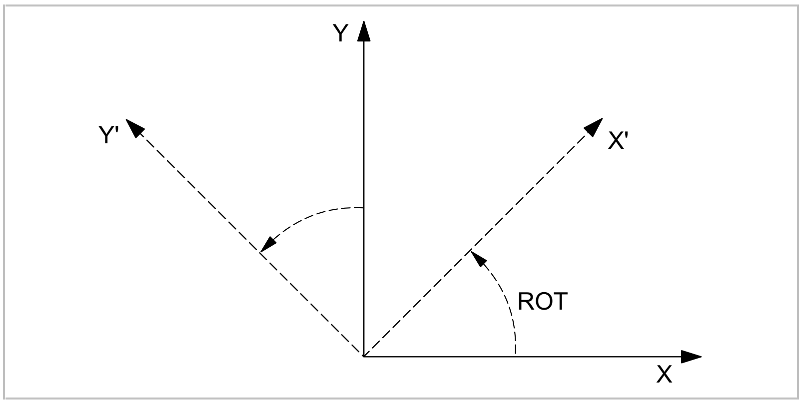

Fig. 14878

Programming

ROT

- Self-holding effect.
- Must be programmed in a separate NC block with the rotation angle RPL= in degrees.
- Is absolute, relative to the currently set workpiece zero point.
- Is overwritten by TRANS and renewed programming of ROT with RPL=.
- With ROT RPL=0 the rotation is switched off.
- Is not deleted by AROT.
- Should not be programmed as long as a processing function (TC_LASER_ON) is active.

6.2 AROT

Definition

Additive rotation, referring to the currently set or programmed zero point.

With AROT, the coordinate system can be rotated around the turning angle programmed with RPL.

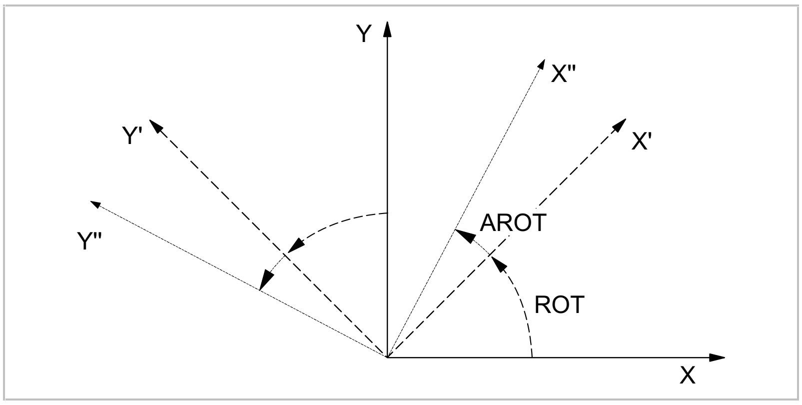

Fig. 14879

Programming

AROT

- Self-holding effect.
- Must be programmed in a separate NC block with the rotation angle RPL= in degrees.
- Works as an additive, refers to the currently set or programmed zero point, thus additive to ROT.
- With ROT RPL=0 the rotation is switched off.
- Should not be programmed as long as a processing function (TC_LASER_ON) is active.

Application

With repeated processing phases on different workpiece positions, if the forms are not parallel to the axis.

Example

With this workpiece, the shapes shown occur several times within the same program. In addition to the zero point offset, rotations must now be carried out as the forms are not parallel to the axis.

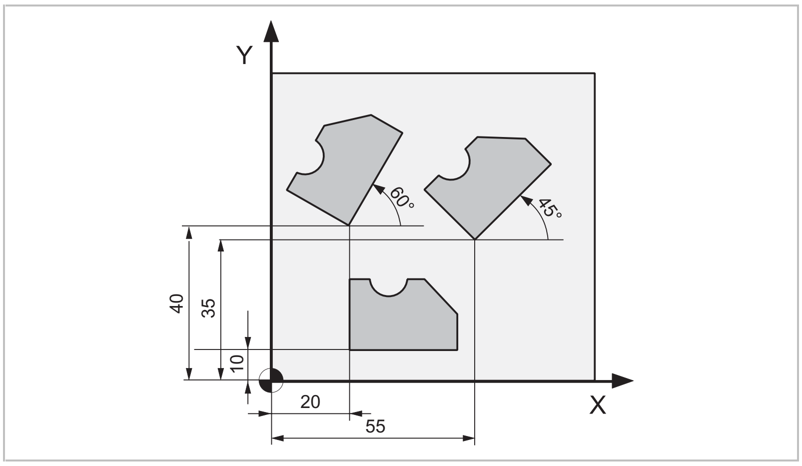

Fig. 14880

N110	TRANS X20 Y10	Absolute zero point offset
N120	L20	Calling up a subroutine
N130	TRANS X55 Y35	Absolute zero point offset
N140	AROT RPL=45	Rotation of the coordinate system by 45°
N150	L20	Calling up a subroutine
N160	ATRANS X-35 Y5	Additive zero point offset
N170	AROT RPL=15	Additive rotation by 15°
N180	L20	Calling up a subroutine

7. Measurement systems

Definition

A measurement system describes the unit used for the programmed dimensions. Depending on the measurement entries in the working plan, geometrical entries specific to workpieces can be alternately programmed in metric or inch measurements.

7.1 G70

Definition

Measurement systems: Inch programming.

With G70, the following geometry data must be entered in inches:

- Path information X, Y.
- Interpolation parameters I, J, CR.
- Zero point offsets.
- Feed rates.
- Overshoot heights.

Programming

G70
- Self-holding effect.
- Can be programmed with or without path information.
- When switching over from inch programming to metric programming, all processing functions must be deselected.
- Is deleted with G71.

Example

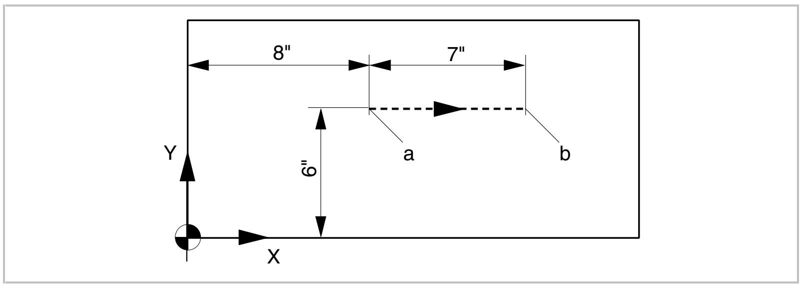

Fig. 3655

N100	TC_LASER_OFF(1)	Laser OFF
N110	G70	Selection of inch programming
N120	G1 X8 Y6 F1575	Entry of 1st position (a) in inches, F-word in inch/min
N130	X15	Entry of 2nd position (b) in inches

7.2 G71

Definition

Measurement system: metric programming.

With G71, the following geometry data must be entered in mm:

- Path information X, Y.
- Interpolation parameters I, J, CR.
- Zero point offsets.
- Feed rates.
- Overshoot heights.

Programming

G71

- Turn-on condition.
- Self-holding effect.
- Can be programmed with or without path information.
- When switching over from metric programming to inch programming, all processing functions must be deselected.
- Is deleted with G70.

Example

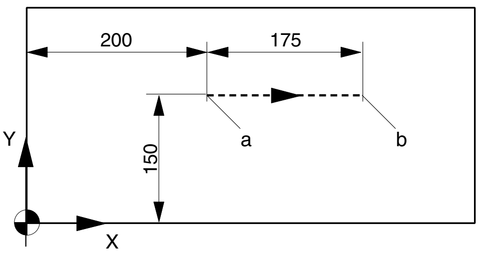

Fig. 3656

N100	TC_LASER_OFF(1)	Laser OFF
N110	G71	Selection of metric programming
N120	G1 X200 Y150 F40000	Entry of 1st position (a) in mm, F-word in mm/min
N130	X375	Entry of 2nd position (b) in mm

8. Measurement data absolute/relative

Definition

The type of dimensional input determines the reference point from which the programmed dimensions apply.

8.1 G90

Definition

Absolute data input.

The dimensions are determined in relation to the zero point of the currently valid coordinate system. What is being programmed is **where** the tool should move to.

Programming

G90

- Is the turn-on condition.
- Self-holding effect.
- Can be programmed with or without path information.
- Works with all axes.
- With IC, the chain dimension input can be set block-by-block for individual axes.
- Is deleted with G91.

8.2 G91

Definition

Incremental dimension input (chain dimension input).

The dimensions are taken from to the most recently approached point (current position of the tool). What is being programmed is **how much** the tool should move.

Programming

G91

- Self-holding effect.
- Can be programmed with or without path information.
- Works with all axes.
- With AC, the absolute dimension input can be set block-by-block for individual axes.
- Is deleted with G90.

Example

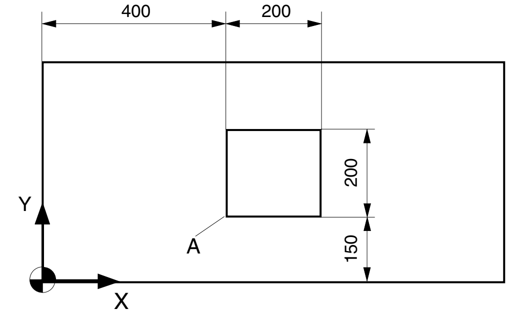

Fig. 3658

N100	G90 X400 Y150 F40000	Approach to A absolute
N110	G91 Y200	Incremental movement in +Y direction
N120	X200	Incremental movement in +X direction
N130	Y-200	Incremental movement in -Y direction
N140	X-200	Incremental movement in -X direction
N150	G90 X... Y... F...	

8.3 AC data

Definition

With AC, absolute dimension input can be set block-by-block for individual axes when G91 is preset.

Programming

AC

- Acts block-by-block.
- Is assigned to a path information (e. g. the X and Y words; I and J) with the "=" sign.
- Value allocation appears after AC in round brackets.

When G91 is preset, switching over to absolute dimension input is carried out block-by-block:

N100	G90 X400 Y150 F40000	Approach to A absolute
N110	G91 Y200	Changeover to chain dimension input
N120	X200	
N130	Y=AC(600)	Block-by-block changeover to absolute dimension input
N140	X=AC(400)	

8.4 IC data

Definition

With IC, chain dimension input can be set block-by-block for individual axes when G90 is preset.

Programming

IC

- Acts block-by-block.
- Is assigned to a path information (e. g. the X and Y words; I and J) with the "=" sign.
- Value allocation appears after IC in round brackets.

Example

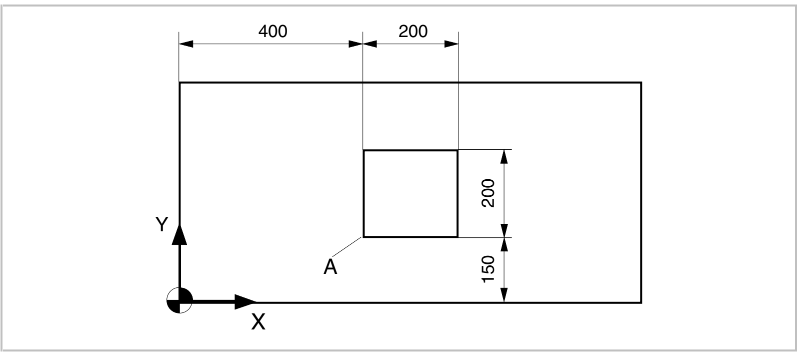

Fig. 3658

When G90 is preset, changeover to chain dimension input occurs block-by-block:

N100	G90 X400 Y150 F40000	Approach to A absolute
N110	Y=IC(200)	Block-by-block changeover to chain dimension input
N120	X=IC(200)	
N130	Y=IC(-200)	
N140	X=IC(-200)	

Chapter 4

Path information / Feed

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1.1 X-word ... 4-2

1.2 Y-word ... 4-3

2. Feed rate ... 4-4

2.1 F-word ... 4-4

1. Path information

Definition

Path information (X-, and Y-word) are relayed to the appropriate axis as movement commands. In conjunction with the interpolation type, they describe the geometry of the workpiece.

1.1 X-word

Definition

Movement command for the X-axis.

TC HSL 2502 C, TC HSL 4002 C: movement command for the X1- and X2-axis.
The X-word defines the position of both cutting heads in X-direction in connection with the laser cutting head table (TC_LASER_HEAD). It is important which one of the two cutting heads is active, or whether both cutting heads are active.
The laser cutting head table defines which cutting head is active or not active (0 or 1 for the respective cutting head), and with what distance both cutting heads traverse to one another.

Programming

X-word

- Has a self-holding effect, i.e. if no X-word is programmed in the block, then there is no movement in X-direction.
- And with metric programming, it can be exactly programmed between min. -99999.999 mm and max. +99999.999 mm to within 0.001 mm.
- With programming in inches, it can be exactly programmed between min. -999.9999 inches and max. +999.9999 inches.

Examples TC HSL 2502 C, TC HSL 4002 C:

Single-head mode: head 1 active, X=1000

The left cutting head (head 1) is active. Cutting head 2 travels with it deactivated.
Position of cutting head 1: X=1000
Position of cutting head 2: X=1000+minimum distance 450 mm.

Single-head mode: head 2 active, X=1000

The right cutting head (head 2) is active. Cutting head 1 travels with it deactivated.
Position of cutting head 2: X=1000
Position of cutting head 1: X=1000-minimum distance 450 mm.

Two-head mode: X=1000

Both cutting heads are active.
Position of cutting head 1: X=1000
Position of cutting head 2: X=1000+distance from laser cutting head table.

1.2 Y-word

Definition

Movement command for the Y-axis.

TC HSL 2502 C, TC HSL 4002 C: movement command for the Y1- and Y2-axis.
Both Y-axes are coupled via a gantry drive. They are always at the same position and move synchronously. The Y-word is specified once. It acts on both Y-axes.

Programming

Y-word

- Has a self-holding effect, i.e. if no Y-word is programmed in the block, then there is no movement in Y-direction.
- And with metric programming, it can be exactly programmed between min. -99999.999 mm and max. +99999.999 mm to within 0.001 mm.
- With programming in inches, it can be exactly programmed between min. -999.9999 inches and max. +999.9999 inches.

Example

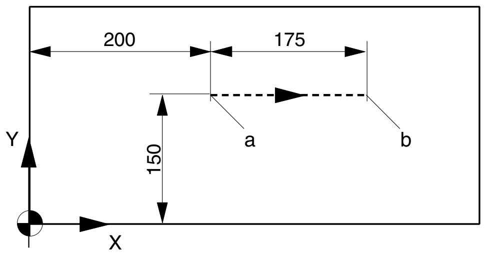

Fig. 3656

N100	G01 X200 Y150	a anfahren
N110	X375	b anfahren

2. Feed rate

2.1 F-word

Definition

The F-word determines the feedrate of the interpolation types G01, G02 and G03 The maximum speed at which the machine may travel is determined.

Programming

F-word

- Must be programmed in the block with the first travel movement at the latest (Exception: traveling with G00).
- Has a self-holding effect until overwritten by a new F-word.
- Minimum and maximum speeds:

Machines	Speeds	metric input [mm/min]	inch input [inch/min]
TC L 2530, TC L 3030, TC L 4030, TC L 6030	F_{min} F_{max}	1 85 000	0.04 3 346
TC L 3050, TC L 4050	F_{min} F_{max}	1 283 000	0.04 11 142
TC HSL 2502 C TC HSL 4002 C	F_{min} F_{max}	1 305 000	0.04 12 008

Beispiel

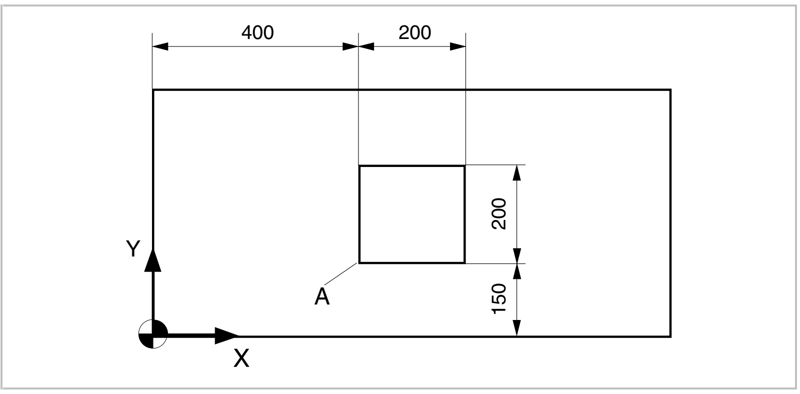

Fig. 3658

N100	G01 X400 Y150 F85000	Approaches A with 85 m/min
N110	X600 F40000	Contour with 40 m/min and
N120	Y350	Without processing
N130	X400	Traveling down
N140	Y150	

Chapter 5

M-functions

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1.1 M00 5-2
1.2 M01 5-2

2. Program end 5-3
2.1 M02 5-3
2.2 M30 5-3
2.3 M17 5-3

1. Programmed stop

1.1 M00

Definition

Programmed stop (absolute).

IN the NC block with M00, the control system interrupts the current program and processing is stopped.
If M17 **and** M00 appear in the last block of a program, the program will be put on hold after jumping back to the program that called it up.
When the START button is pressed, the program run resumes.

Programming

M00
- Acts block by block.
- All processing functions must be deselected.
- Is canceled by pressing the START button.

Application

M00 no longer appears in an NC program created by the programming system. The "Hold" function, as it was programmed earlier, is now integrated into the corresponding cycles as required.

M00 is only applied in order to insert a "hold" into the NC program, e.g. when:

- Running in programs.
- Measuring and testing.

1.2 M01

Definition

Programmed stop (optional).

If "Programmed hold" is activated before the program is started via the user interface of the control system in the activity field "1 PRODUCTION - 2 Program options", then a programmed M01 causes a precision hold.
By pressing the start button, the program is carried out when the following NC block is processed.

Programming

M01
- Acts block by block.
- Is executed only when "Program. Hold" is selected under "Program options" on the user interface of the control system.
- Is canceled by pressing the START button.

2. Program end

2.1 M02

Definition

Program end of main program.

A main program is ended with M02 and set back to program start.

Programming

M02
- Acts block by block.
- All processing functions must be deselected.

2.2 M30

Definition

Program end of main program.

A main program is ended with M30 and set back to program start.

Programming

M30
- Acts block by block.
- All processing functions must be deselected.

2.3 M17

Definition

Program end of a subroutine.

M17 ends the subroutine and causes the jump back into the main program.

Programming

M17
- Acts block by block.
- All processing functions must be deselected.

Chapter 6

Cycles for laser processing

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1.2 TC_LASER_OFF ... 6-26
1.3 TC_WAIT ... 6-29
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6.1 TC_MICROJOINT 6-40
6.2 G821.. 6-43
6.3 G822.. 6-45

Definition

Laser cycles contain sequences of machine commands, which cover both the functionality and the technology of laser processing.
A laser cycle consists of individual cycle elements. An element may include an NC command, a technology data call-up instruction or PLC/laser data transmission sequences. Laser-processing cycles are the result of the compilation of these elements. The sequence is thus established according to the individual machine commands executed and also the recall of technology data, which depend on material type and sheet thickness.

Laser technology tables

All technology data for the processing of a material type and sheet thickness are summarized in a table. A table is divided into various processing types, e.g. "Cutting", "Piercing", "Marking", etc.

The technology data required for a particular machining situation is called up selectively from the laser technology table by respective parameter entries during the cycle call-up in the NC program.

☞ Laser technology tables are **superordinate** tables.

☞ The table parameters for the TC L 3050 V and TC L 4050 are not described here separately. The description is displayed directly when selecting on the machine.

1. Laser cutting

1.1 TC_LASER_ON

Definition

with the TC_LASER_ON cycle call-up in the NC-program, the following machine commands are executed dependent upon the entered cycle parameters.

- Activate the height regulation.
- Select piercing gas.
- Move Z-axis to piercing position.
- Switch on beam for piercing.
- Select cutting gas.
- Move Z-axis to cutting position.
- Switch on beam for cutting.

Programming

The TC_LASER_ON cycle is called up in the NC program with the following cycle parameters:

TC_LASER_ON (Laser method, "Laser technology table", Piercing type, Cutting type)

- Laser methods 1-8 can be used to switch on the laser beam for conventional laser machining. Laser methods 9-12 are intended for processing with laser power control.
- If pure cutting or piercing cycles are called up, the value "0" must be entered for the cycle parameters "Piercing type" or "Cutting type".
- Is deleted by TC_LASER_OFF.

Laser method

Cycle parameters: a fixed programmed "list" of cycle elements is called up via the laser method. The sequence is established via this "list" by which the individual commands should be executed. The following laser-methods are available:

Laser-method	Function
1	Piercing and cutting with height regulation
2	Piercing and cutting without distance control system
3	Piercing without height regulation, cutting with height regulation
4	Piercing with height regulation, cutting without height regulation
5	Cutting with height regulation
6	Cutting without height regulation
7	Piercing with distance control system, beam OFF
8	Piercing without distance control system, beam OFF
9	Piercing without ramp cycle, and cutting with distance control system with analog laser power control (LPS) (SprintLas, common cuts)
10	Piercing without ramp cycle and cutting without distance control system with analog laser power control (SprintLas, common slitting cuts)
11	Cutting without height regulation with analog laser power control (SprintLas, common slitting cuts)
12	Cutting without height regulation with analog laser power control (SprintLas, common slitting cuts)
30	Microweld

Cutting with "floating data exchange"

Cutting with "floating data exchange" can be programmed with laser methods 5, 6, 11 and 12: if a further TC_LASER_ON call-up with one of the methods 5, 6, 11 or 12 is programmed when the beam is already activated, it is possible to:

- switch between the various cutting data within a laser technology table (e.g. contour change)
- or switch between various laser technology tables.

Advantages

- No pits due to reduction of the cutting speed during data exchange.
- Faster processing due to "floating data exchange".

Example

N100	TC_LASER_ON(1,"1778",10,100)	Pierce and cut a large contour with dist. con. ON
N110	G01 X20 Y40	
N120	TC_LASER_ON(5,"1778",0,300)	"Floating data exchange": cutting sm. contour with dist. con.
N130	G02 I0 J10	Contour processing
N140	TC_LASER_OFF(1)	Laser OFF, Z axis at overshoot height

Processing with laser power control

When working with laser power control the laser beam remains on during the entire processing process. Only the power changes. Switching off in this case means reducing the laser power to 1 percent. It is possible to change to a conventional processing type.

☞ It is not yet possible at this time to machine with laser power control without the distance control system. In this case, cutting ensues without laser power control.

Laser methods 11 or 12 are always used for special machining types.

Laser technology table

Cycle parameters: the appropriate laser technology table is selected by entering the table designation.
The table number must always be entered with inverted commas.

Table parameters – 1:General

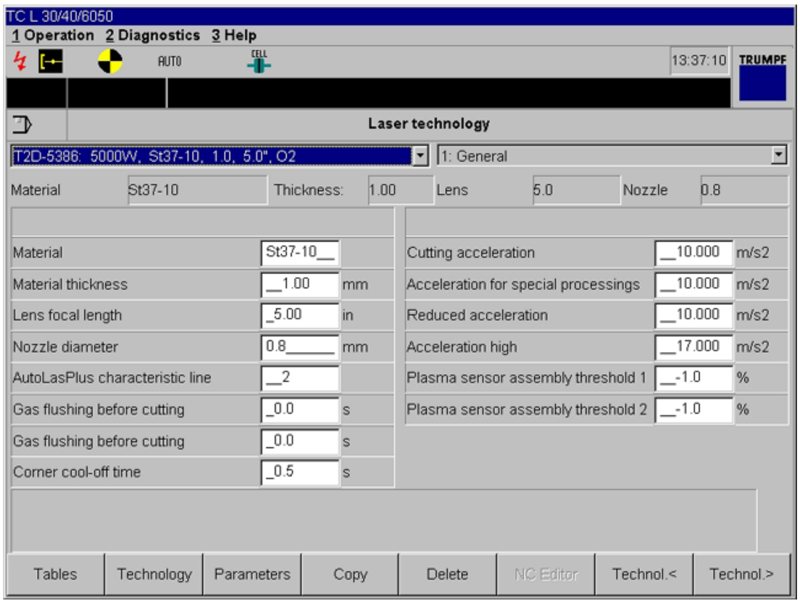


Fig. 34507en

- **Material:** an abbreviation for the material type is shown, followed by a hyphen and the material thickness in 1/10 mm steps.
- **Material thickness:** the material thickness is shown in mm.
- **Lens focal length:** the focal length of the lens in the cutter head is shown in inches. Lenses with focal lengths of 3.75", 5.0" and 7.5" can be used.
- **Nozzle diameter:** the nozzle diameter is shown in mm.
- **Characteristic curve of AutoLasPlus:** the characteristic curve number that controls the AutoLas Plus system is displayed. The characteristic curves are arranged as follows:

Characteristic curve 1:	high-pressure cutting using the 5" cutting head.
Characteristic curve 2:	standard pressure cutting using the 5" cutting head.
Characteristic curve 3:	high-pressure cutting using the 7.5" cutting head.
Characteristic curve 4:	standard pressure cutting using the 7.5" cutting head.
Characteristic curve 5:	high-pressure cutting using the 9" cutting head.
Characteristic curve 6:	standard pressure cutting using the 9" cutting head.
Characteristic curve 7:	high-speed cutting with nitrogen using the 3.75" cutting head.
Characteristic curve 8:	standard pressure cutting and high-pressure cutting using the 3.75" cutting head.

- **Gas purging before piercing:** if a value >0.0 is displayed, the gas conducting parts will be purged with piercing gas for the allotted time when switching from cutting to piercing gas. The piercing gas is used for purging. The gas pressure corresponds to the piercing gas pressure. If the piercing gas pressure is under 4 bar, a gas pressure of 4 bar is used for purging.
- **Gas purging before cutting:** if a value >0.0 is entered, the gas conducting parts will be purged with piercing gas for the allotted time when switching from piercing to cutting gas. The cutting gas is used for purging. The gas pressure corresponds to the cutting gas pressure. If the cutting gas pressure is under 4 bar, a gas pressure of 4 bar is used for purging.
- **Corner cool-off time:** time in which the beam is switched off on corners to prevent burn-in (programming with TC_WAIT).
- **Acceleration cutting:** a value displayed in m/s^2 which indicates the acceleration rate applied until the axes have attained the programmed cutting speed.
- **Accel. special processing:** this is the acceleration rate in m/s^2 during special processing (marking, dot marking, vaporizing ...) until the axes have reached the programmed cutting speed.
- **Reduced acceleration:** a value displayed in m/s^2 which indicates the acceleration rate applied until the axes have attained the programmed cutting speed.
- **High acceleration:** is selected using TC_LASER_ON (xx, "table", piercing type, cutting type).
- **Plasma sensor system threshold 1:** the value for the first threshold of the plasma sensor system is displayed in %. This value normally amounts to the following for the these materials:
  Mild steel: 115 % of threshold 1.
  Special steel: 100 % of threshold 1.
  Aluminum: 90 % of threshold 1.
- **Plasma sensor system threshold 2:** the value for the first threshold of the plasma sensor system is displayed in %. This value normally amounts to the following for the these materials:
  Mild steel: 50 % of threshold 2.
  Special steel: 100 % of threshold 2.
  Aluminum: 40 % of threshold 2.

Table parameters – 2:Cutting, general

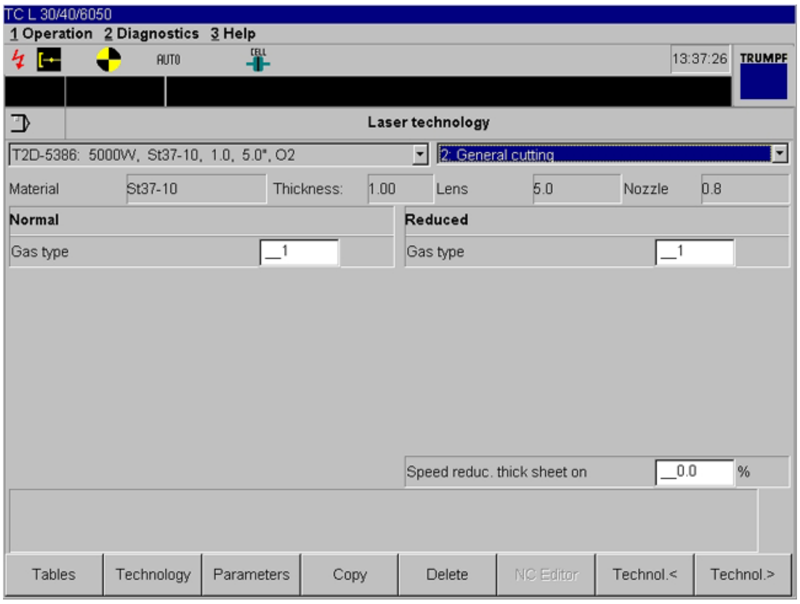


Fig. 34508en

- **Gas type:**
  0 no gas
  1 oxygen (O_2)
  2 nitrogen (N_2)
  3 customized gas (optional)
  4 air (optional)
- **Speed reduced (thick sheet) to:** a percentage is displayed to which the cutting speed is reduced when approaching the thick plate.

Table parameters – 3-5:Cutting a large contour, 6-7:Cutting a medium contour, 8-9:Cutting a small contour

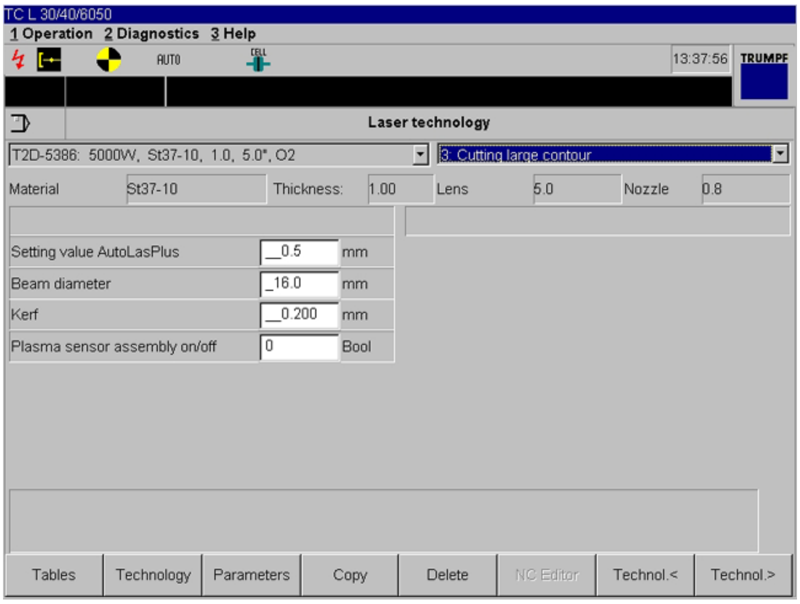


Fig. 34509en

- **AutoLasPlus setting value:** the setting value is displayed in mm and gives the position of the focus in relation to the nozzle tip. The setting value is automatically set by the AutoLasPlus system for machines with AutoLasPlus.
- **Beam diameter:** the set beam diameter is displayed (only TC L 3050 and TC L 4050).
- **Kerf:** a value for the width of the kerf is displayed in mm. This value is evaluated when working with the function TC_LASERCORR_ON (Kerf correction).
- **Plasma sensor system On/Off:** the plasma sensor system is activated or deactivated using this parameter.
  1 Activated
  2 Deactivated
  It is recommended to use the plasma sensor system for the following material thicknesses:
  Mild steel (high pressure cutting with nitrogen): s ≥4 mm
  Special steel: s ≥8 mm
  Aluminum: s ≥6 mm

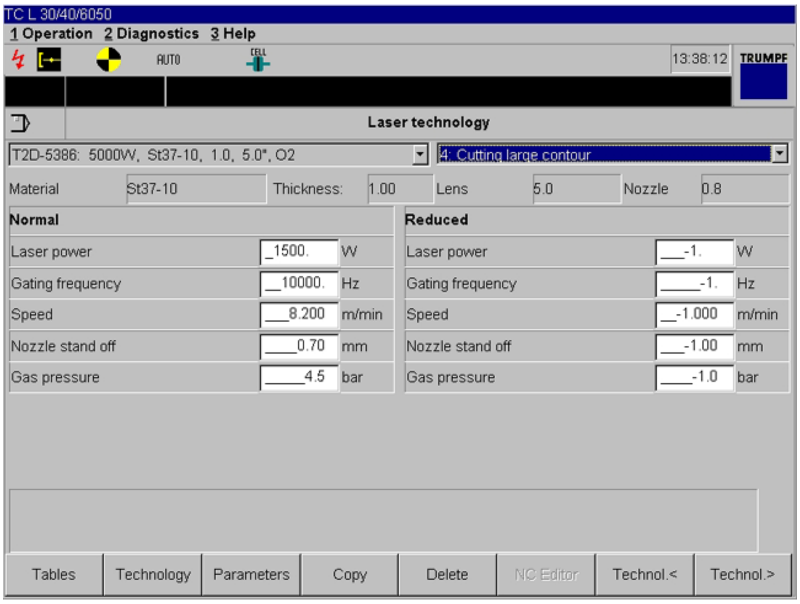


Fig. 34510en

- **Laser power:** the programmed contours will be processed with this laser power, displayed in watts.
- **Modulation frequency:** the frequency at which the laser operates is displayed in Hz (10 - 99 000 Hz).
- **Speed:** displays the speed in m/min with which the programmed contour is cut.
- **Nozzle stand-off:** stand-off between nozzle and material surface is shown in mm.
- **Gas pressure:** displays the programmed gas pressure in bar with which the cutting gas is released during contour processing.

For TC HSL 2502 C, TC HSL 4002 C and TC L 3050:

- **Analog value control:** linear control system of laser power and modulation frequency depending on the speed.
  - **0** No analog value control.
  - **1** Analog value control activated.

Parameters for analog value control:

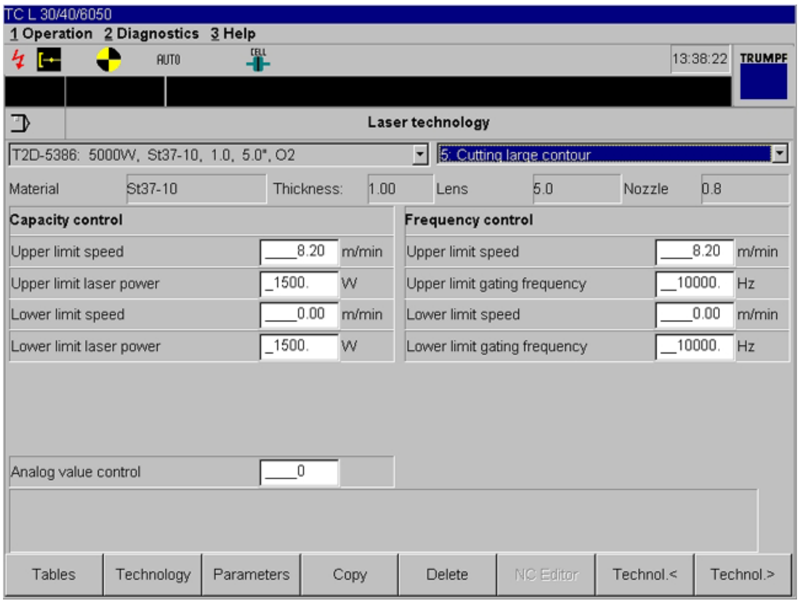


Fig. 34511en

- **Upper limit of speed:** between the upper- and lower limit of the cutting speed or modulation frequency there is a linear control system. The upper limit of the cutting speed or modulation frequency is displayed as an absolute value.
- **Lower limit of speed:** the lower limit of the cutting speed or modulation frequency is displayed as an absolute value.
- **Upper limit of laser power:** specification of maximum laser power as absolute value.
- **Lower limit of laser power:** specification of minimum laser power as absolute value.
- **Upper limit of modulation frequency:** specification of maximum modulation frequency as absolute value.
- **Lower limit of modulation frequency:** specification of minimum modulation frequency as absolute value.

Table parameters – 10:Piercing, general

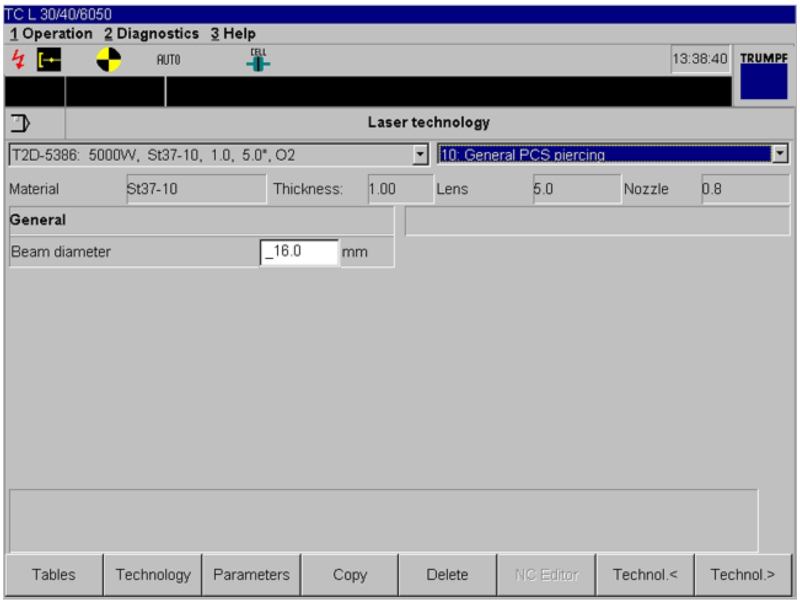


Fig. 34516en

- **Beam diameter:** the set beam diameter is displayed (only TC L 3050 and TC L 4050).

Table parameters – 11-12:Piercing

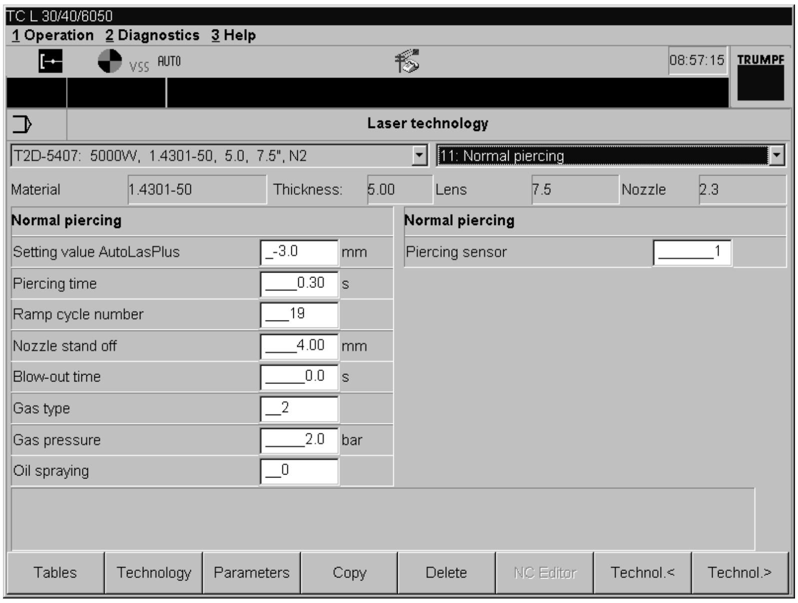


Fig. 34517en

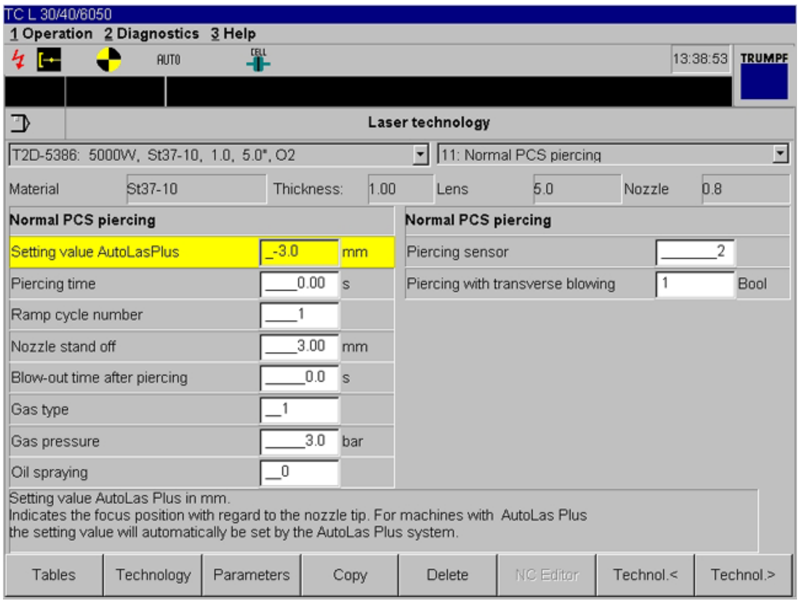


Fig. 34518en

Fig. 34519en

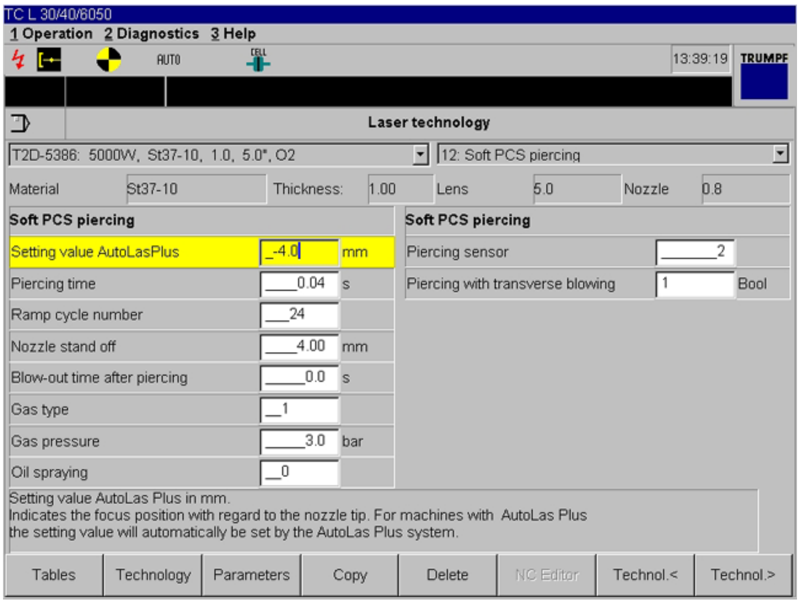


Fig. 34520en

- **AutoLas *Plus* setting value:** the setting value is displayed in mm and gives the position of the focus in relation to the nozzle tip. The dimension is set automatically via AutoLas *Plus*.
- **Piercing time:** displayed here is the time taken in seconds for the conventional piercing process to be completed (laser in operating mode LPC cycle).
- **Ramp cycle number:** displayed here is the number of the ramp cycle used for piercing in material.
- **Nozzle stand-off:** stand-off between nozzle and material surface is shown in mm.
- **Blow-out time after piercing:** displayed here is the time taken in seconds in which the slag on the piercing hole is blown out after piercing.
- **Gas type:**
  0 no gas
  1 oxygen (O_2)
  2 nitrogen (N_2)
  3 customized gas (optional)
  4 air (Option)
- **Gas pressure:** displays the programmed gas pressure in bar with which the cutting gas is released during contour processing.
- **Spray oil:** spray oil before piercing.
  0 no oil.
  1 oil is sprayed on the piercing point before piercing.
- **Piercing sensor system:**
  0 piercing without piercing sensor-system
  1 piercing with PMS, providing available (PMS is only active during piercing)
  2 piercing with PCS, providing available (otherwise an error will be issued)

☞ The piercing sensor system may only be applied for the material thicknesses specified at the bottom of the table.
Their activation has already been entered by TRUMPF in the technology tables for the respective material types and thicknesses. It must not be activated for other material types and thicknesses.

Type of material	Processing	Material thickness range	
		Normal piercing	Soft piercing
Mild steel	Oxygen	1 – 4 mm	1 – 4 mm
	High-pressure nitrogen	1 – 10 mm	-
	High speed	1 – 1.5 mm	-
Stainless steel	High-pressure nitrogen	1 – 12 mm	1 – 4 mm
	High speed	1 – 1.5	-
Aluminium	High-pressure nitrogen	1 – 8 mm	-
	High speed	1 – 2 mm	-

Application range of the piercing sensor system for normal and soft piercing.

Table parameters – 13:Vaporizing

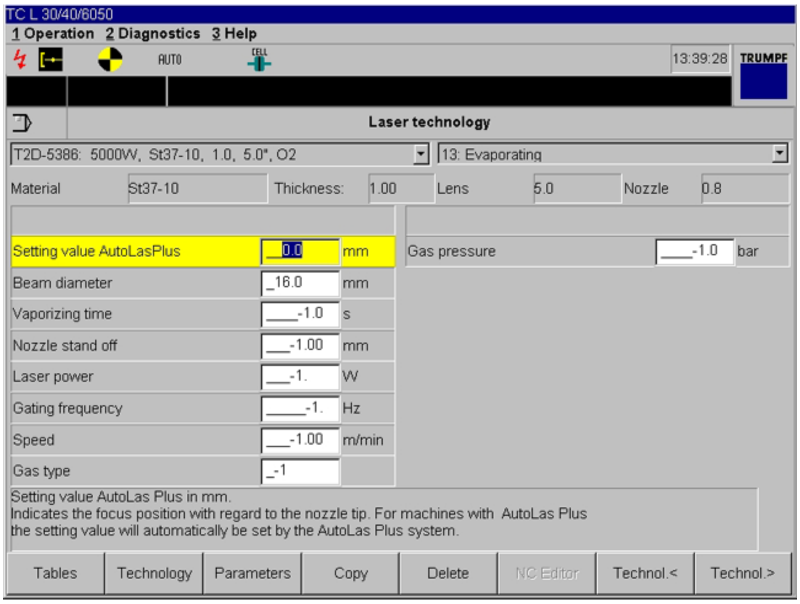


Fig. 34521en

- **AutoLasPlus setting value:** the setting value is displayed in mm and gives the position of the focus in relation to the nozzle tip. The setting value is automatically set by the AutoLasPlus system for machines with AutoLasPlus.
- **Beam diameter:** the set beam diameter is displayed (only TC L 3050 and TC L 4050).
- **Vaporization time:** displays the time in seconds for which the laser remains fired during vaporization.
- **Nozzle stand-off:** stand-off between nozzle and material surface is shown in mm.
- **Laser power:** the programmed contours will be processed with this laser power, displayed in watts.
- **Modulation frequency:** the frequency at which the laser operates is displayed in Hz (10 - 99 000 Hz).
- **Speed:** displays the speed in m/min with which the programmed contour is cut.
- **Gas type:**
  0 no gas
  1 oxygen (O_2)
  2 nitrogen (N_2)
  3 customized gas (optional)
  4 air (Option)
- **Gas pressure:** displays the programmed gas pressure in bar with which the cutting gas is released during contour processing.

Table parameters – 14:Marking

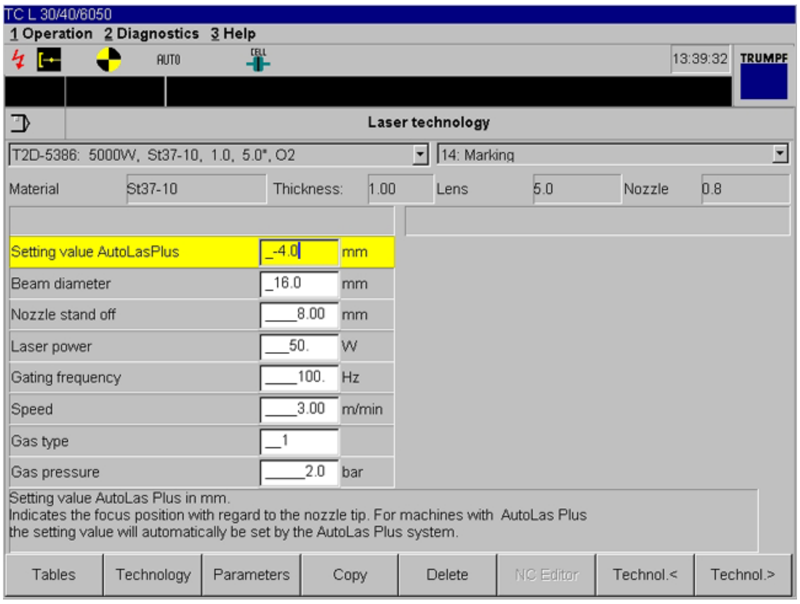


Fig. 34522en

- **AutoLasPlus setting value:** the setting value is displayed in mm and gives the position of the focus in relation to the nozzle tip. The setting value is automatically set by the AutoLasPlus system for machines with AutoLasPlus.
- **Beam diameter:** the set beam diameter is displayed (only TC L 3050 and TC L 4050).
- **Nozzle stand-off:** stand-off between nozzle and material surface is shown in mm.
- **Laser power:** the programmed contours will be processed with this laser power, displayed in watts.
- **Modulation frequency:** the frequency at which the laser operates is displayed in Hz (10 - 99 000 Hz).
- **Speed:** displays the speed in m/min with which the programmed contour is cut.
- **Gas type:**
  0 no gas
  1 oxygen (O_2)
  2 nitrogen (N_2)
  3 customized gas (optional)
  4 air (Option)
- **Gas pressure:** displays the programmed gas pressure in bar with which the cutting gas is released during contour processing.

Table parameters – 15:Dot marking

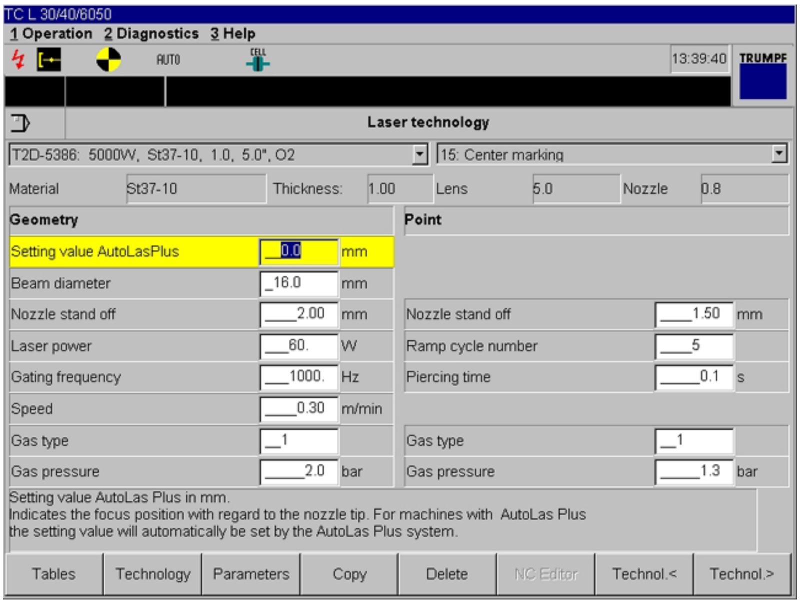


Fig. 34523en

- **AutoLasPlus setting value:** the setting value is displayed in mm and gives the position of the focus in relation to the nozzle tip. The setting value is automatically set by the AutoLasPlus system for machines with AutoLasPlus.
- **Beam diameter:** the set beam diameter is displayed (only TC L 3050 and TC L 4050).
- **Nozzle stand-off:** stand-off between nozzle and material surface is shown in mm.
- **Laser power:** the programmed contours will be processed with this laser power, displayed in watts.
- **Modulation frequency:** the frequency at which the laser operates is displayed in Hz (10 - 99 000 Hz).
- **Speed:** displays the speed in m/min with which the programmed contour is cut.
- **Piercing time:** displayed here is the time taken in seconds for the conventional piercing process to be completed (laser in operating mode LPC cycle). The methods with the number 1, 2, 3, 4, 7, 8, 9, and 10 take the piercing time into consideration.
- **Ramp cycle number:** displayed here is the number of the ramp cycle used for piercing in material.

- **Gas type:**
  0 no gas
  1 oxygen (O_2)
  2 nitrogen (N_2)
  3 customized gas (optional)
  4 air (Option)
- **Gas pressure:** displays the programmed gas pressure in bar with which the cutting gas is released during contour processing.

Table parameters – 11:Microweld

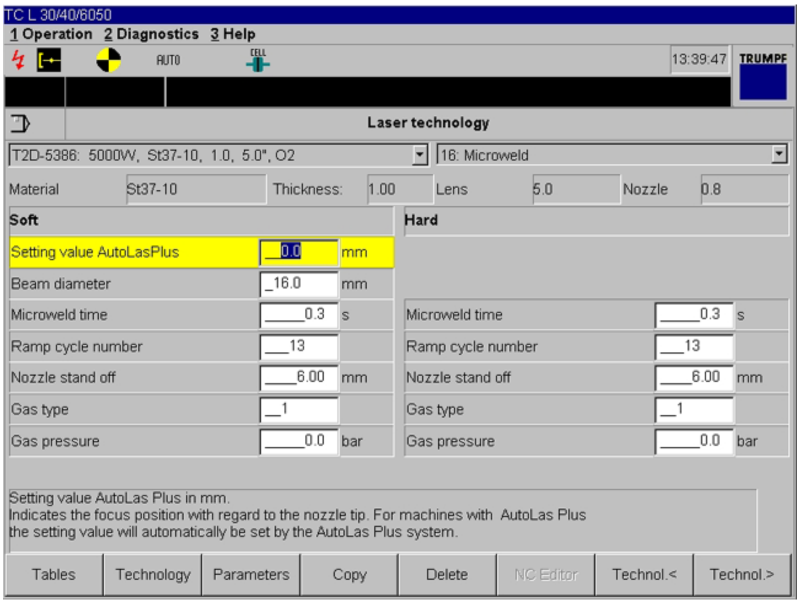


Fig. 34524en

- **AutoLasPlus setting value:** the setting value is displayed in mm and gives the position of the focus in relation to the nozzle tip. The setting value is automatically set by the AutoLasPlus system for machines with AutoLasPlus.
- **Beam diameter:** the set beam diameter is displayed (only TC L 3050 and TC L 4050).
- **Microweld time:** displays the time in seconds for which the laser beam remains fired during the setting of the welding spot (=welding duration).
- **Ramp cycle number:** displays the number of the ramp cycle for the microweld.
- **Nozzle stand-off:** stand-off between nozzle and material surface is shown in mm.
- **Gas type:**
  0 no gas
  1 oxygen (O_2)
  2 nitrogen (N_2)
  3 customized gas (optional)
  4 air (Option)
- **Gas pressure:** displays the programmed gas pressure in bar with which the cutting gas is released during contour processing.

Piercing type

Cycle parameters: data is selected from the active laser technology table according to piercing type. Various piercing types are stored in the table:

Number	Function
0	No piercing
10	Normal piercing
11	Soft piercing
20	Center marking (spot shaped)
30	Special processing hard microweld
31	Special processing soft microweld

Cutting type

Cycle parameters: depending on the cutting type, data is selected from the active laser technology table. Cutting data (e.g. laser power, cutting and approach parameters) for different processing requirements are stored there. A distinction is made between:

- Large, medium, and small contours.
- Normal and reduced cutting speed.
- Normal, reduced, and high acceleration values.

The cutting type is selected by way of a three digit number, each digit of which has a definite meaning.
Example: 100

1		**0**		**0**	
Contour:		**Cutting speed:**		**Acceleration:**	
1	Large contour	0	Normal	0	Normal
2	Medium contour	1	Reduced from punching hole	1	Reduced
3	Small contour	2	Reduced from pre-punching hole	2	High
		3	Reduced in thick plate		

The following cutting types can be selected:

Number	Function
0	No cutting
100	Cutting large contours with normal acceleration
101	Cutting large contours with reduced acceleration
102	Cutting large contours with high acceleration
110	Cutting large contours with reduced initial speed from the piercing hole and normal acceleration
111	Cutting large contours with reduced initial speed from the piercing hole and reduced acceleration
120	Cutting large contours with reduced initial speed from the pre-punching hole and normal acceleration
121	Cutting large contours with reduced initial speed from the pre-punching hole and reduced acceleration
130	Cutting large contours with reduced initial speed in thick plate and normal acceleration
131	Cutting large contours with reduced initial speed in thick plate and reduced acceleration
200	Cutting medium contours with normal acceleration
201	Cutting medium contours with reduced acceleration
202	Cutting medium contours with high acceleration
210	Cutting medium contours with reduced initial speed from the piercing hole and normal acceleration
211	Cutting medium contours with reduced initial speed from the piercing hole and reduced acceleration
230	Cutting medium contours with reduced initial speed in thick plate and normal acceleration
231	Cutting medium contours with reduced initial speed in thick plate and reduced acceleration

Number	Function
300	Cutting small contours with normal acceleration
301	Cutting small contours with reduced acceleration
302	Cutting small contours with high acceleration
310	Cutting small contours with reduced initial speed from the piercing hole and normal acceleration
311	Cutting small contours with reduced initial speed from the piercing hole and reduced acceleration
320	Cutting small contours with reduced initial speed from the pre-punching hole and normal acceleration
321	Cutting small contours with reduced initial speed from the pre-punching hole and reduced acceleration
330	Cutting small contours with reduced initial speed in thick plate and normal acceleration
331	Cutting small contours with reduced initial speed in thick plate and reduced acceleration
400	Special processing: vaporization
500	Special processing: marking
600	Special processing: geometric point marking

Example

TC_LASER_ON (1, "1778", 10, 100)
or
TC_LASER_ON (1, "T2D-5102", 10, 100)

Laser method 1:	piercing and cutting with height regulation.
Table 1778:	data from laser technology table 1778.
or	
Table T2D-5102:	data from laser technology table T2D-5102.
Piercing type 10:	normal piercing.
Cutting type 100:	cutting a large contour with normal acceleration.

1.2 TC_LASER_OFF

Definition

Depending on the parameters entered, the following machine commands are executed with the help of the TC_LASER_OFF cycle call-up:

- Switch the laser beam off.
- Switch the cutting gas off.
- Position Z-axis.

Programming

The TC_LASER_OFF cycle is called up with a cycle parameter in the NC program:

TC_LASER_OFF (Laser method)

- Laser methods 1-2 can be used to switch off the laser for conventional processing. Laser methods 3 and 4 are to be used for processing with laser power control. Laser methods 10 and 11 are available for microweld.

Laser-method

Cycle parameters: a fixed programmed "list" of cycle elements is called up via the laser method. The sequence is established via this "list" by which the individual commands should be executed. The following TC_LASER_OFF cycles are available:

Laser-method	Function
1	Laser OFF, Z-axis at overshoot height
2	Laser OFF, Z-axis at home position (115 mm, for Liftmaster pallets 90 mm)
3	Laser at 1 % power, Z-axis to overshoot height
4	Laser at 1 % power, Z-axis to cutting height with distance control system (DCS) ON (a hole must not be traveled over)
10	Beam OFF, preparation for hard microweld
11	Beam OFF, preparation for soft microweld

- If **laser method 1** (laser OFF, Z-axis at overshoot height) is programmed, the overshoot height, which should approach the Z-axis, must be previously programmed with TC_POS_LEVEL (TC HSL 2502 C, TC HSL 4002 C: the participating cutting heads in the cutting process). This method is used to switch off the laser beam after a processed part and to position the next part.
- **Laser method 2** is used to switch on the laser beam at the end of the part program. The beam is completely deleted.
- **Laser method 3** is used to switch off the laser beam when processing with SprintLas between two parts. The laser beam is not switched off completely so that it can be switched on quicker for the following cut.
- **Laser method 4** is used for processing "common slitting cuts" and for SprintLas+. During positioning, under no circumstances may a hole be traveled over or around.

Example of SprintLas processing

N100	TC_POS_LEVEL(10)	Overshoot height 10 mm
N110	X... Y... F...	Approaching the start position
N120	TC_LASER_ON(9,"4220",10,100)	Piercing and cutting large contours LPC and HR ON
:	X... Y...	Contour processing
N200	TC_LASER_ON(11,"4220",0,300)	"Floating data exchange": cutting small contours with LPC and HR ON
:	X... Y...	Contour processing
N300	TC_LASER_OFF(3)	Laser at 1 % power, Z-axis to overshoot height
N310	X... Y...	Positioning motion
N320	TC_LASER_ON(11,"4220",0,500)	Marking with LPC and distance control ON
:	X... Y...	Contour processing
N400	TC_LASER_OFF(3)	Laser at 1 % power, Z-axis to overshoot height
N410	X... Y...	Positioning motion
N420	TC_LASER_ON(9,"4220",10,100)	Piercing and cutting large contours LPC and HR ON
:	X... Y...	Contour processing
N500	TC_LASER_OFF(2)	Laser OFF, sheet end

Example of "common slitting cuts"

N100	TC_POS_LEVEL(10)	Overshoot height 10 mm
N110	X... Y... F...	Approaching the start position
N120	TC_LASER_ON (7,"4220",10,0)	Piercing with ramp cycle
N130	TC_LASER_ON (11,"4220",0,100)	Cutting small contours with LPC and HR ON
	X... Y...	Contour processing
N200	TC_LASER_OFF(4)	Laser at 1% power, Z-axis to cutting height, DCS stays ON
N210	X... Y...	Positioning in the clearance
N220	TC_LASER_ON(11,"4220",0,100)	Cutting small contours with LPC and HR ON
	X... Y...	Contour processing
N300	TC_LASER_OFF(3)	Laser at 1 % power, Z-axis to overshoot height
N310	X... Y...	Positioning motion
N320	TC_LASER_ON(7,"4220",10,0)	Cutting small contours with LPC and HR ON
N220	TC_LASER_ON(11,"4220"0,100)	Schneiden kleine Kontur mit LLS und AR EIN
	X... Y...	Contour processing

1.3 TC_WAIT

Definition

Laser cycle for corner cooling to prevent scorching. The laser beam will be switched off.

Programming

TC_WAIT (function, time)

Function

0 the delay time from the laser technology table is used
1 the delay time from the transfer parameter "Time" is used
2 waiting for start button (unconditional hold M0)
3 waiting for start button (optional hold M1).

1.4 TC_LASER_HEAD (TC HSL 2502 C, TC HSL 4002 C)

Definition

With the TC_LASER_HEAD cycle, the program-specific laser cutting head table is called up in the NC program. In the laser cutting head table one determines which cutting heads are active and with which distance (in X-direction) both cutting heads travel.

Programming

The TC_LASER_HEAD cycle is always linked with a program-specific laser cutting head table. Its content is transferred from the programming system to the control system using the NC program:

TC_LASER_HEAD ("Laser cutting head table")

- Results in modal operation.
- Must be programmed before the first travel motion and after TC_SHEET_LOAD.
- Must always be programmed if the head mode (single- or two-head mode) or the distance of the cutting heads to each other is changed.
- Must be programmed in all positions in the NC program where re-entry can ensue.
- The table is called up using LHT, for LASER HEAD TABLE, and a running number in the NC program; and must be specified in brackets with quotation marks, e.g. ("LHT-1").

Laser cutting head table

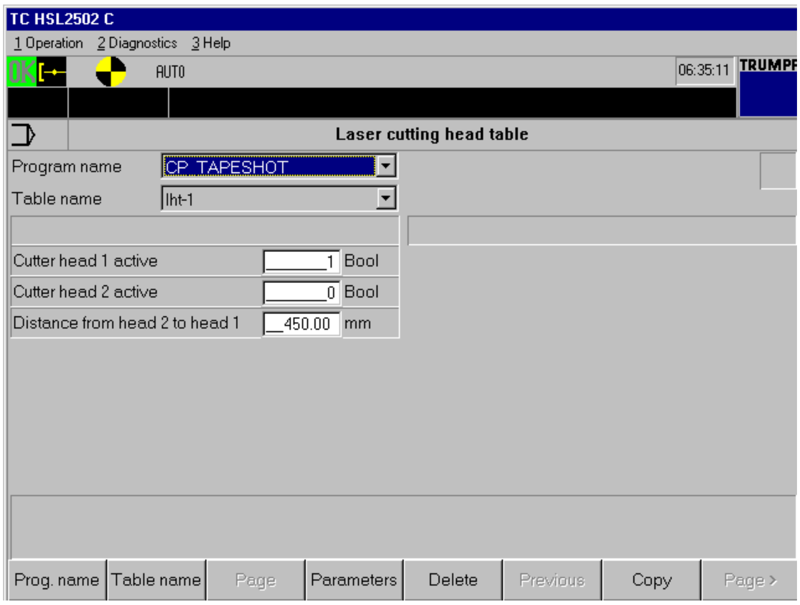


Fig. 27796en

- **Cutting head 1 active:** indicates whether cutting head 1 is active.
  0 not active.
  1 active.
- **Cutting head 2 active:** indicates whether cutting head 2 is active.
  0 not active.
  1 active.
- **Distance of head 2 to head 1:** indicates with which distance in X-direction both cutting heads travel in two-head mode during processing. The minimum distance is 450 mm. When single-head mode is used, the cutting heads always travel with the minimum distance (450 mm).

Example

N110	TC_SHEET_TECH ("SHT-1")	Determine sheet characteristics.
N120	TC_SHEET_LOAD ("SHL-1")	Call up pallet change.
N130	TC_LASER_HEAD ("LHT-1")	activate cutting heads (head).
N140	X500 Y300	Travel to position.
N150	TC_LASER_ON(1,"T2D-5102",10,100)	Laser ON
...		
N200	TC_LASER_OFF(1)	Laser OFF

2. Measuring sheet thickness

2.1 TC_SHEET_THICK

Definition

Measuring sheet thickness.

The sheet thickness of the loaded sheet is measured by calling up the TC_SHEET_THICK cycle'. With the following TC_LASER_ON call-ups, the cutting head does not travel to the position specified in the laser technology table, but rather to the position measured with the TC_SHEET_THICK cycle.

Programming

TC_SHEET_THICK ("Laser technology table")

- In the laser cutting head table, single-head mode must be selected (otherwise error message).
- Is always called up using a program-specific laser technology table.
- The table designation must be indicated in parentheses with quotation marks, e.g. ("LTT-1").
- Acts with the next TC_LASER_ON call-up which is programmed with one of the laser methods 2, 3, 4, 6, or 8 (acts on all laser methods that have absolute positions).
- Is deleted by M30 and RESET.

Application

- Processing initial blanks.
- Severing waste grids.

Example

N100	TC_LASER_ON (1,"1978",10,100)	Laser ON
N110	X... Y...	Contour processing
N120	TC_LASER_OFF (1)	Laser OFF
N130	TC_SHEET_THICK ("1978")	Measuring sheet thickness
N140	X... Y...	Positioning motion
N150	TC_LASER_ON (6,"1978",0,100)	Laser ON (cutting without distance control system)
N160	X... Y...	Contour processing with
N170	X... Y...	Measured sheet thickness
N180	TC_LASER_OFF (1)	Laser OFF
N190	M30	Main program end

3. Kerf correction

Definition

The kerf (cutting gap) correction enables the processing of a part-related program equidistantly to the programmed path. A path is described with a constant distance to the programmed contour.

3.1 TC_LASERCORR_ON

Definition

Activation of kerf correction without extension of correction.

Programming

The TC_LASERCORR_ON cycle call-up is called up by using a parameter in the NC program:

TC_LASERCORR_ON (correction direction)

- Is programmed after TC_LASER_ON is called up.
- In the next NC block, the extension of the correction must be programmed with a linear interpolation type (G00 or G01).
- In order to calculate the equidistant path, the parameter "Kerf" from the technology table previously selected in the TC_LASER_ON cycle is evaluated.
- Is deleted by TC_LASERCORR_OFF (switching off the kerf correction without retraction of the correction).
- Is deleted by TC_LASER_OFF (beam OFF, automatic switching off of the kerf correction and retraction of the correction).
- Can be called up several times in sequence if the correction direction should be changed with a correction that has already been extended. The correction is linearly extended in each case before the subsequent movement.

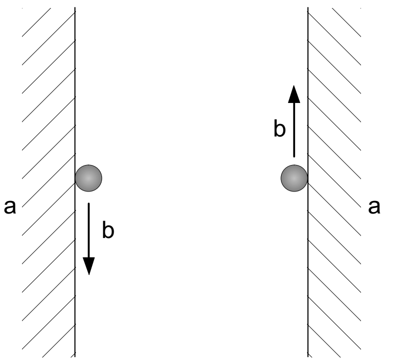
Contour change

If a contour change with modified cutting gap is to be executed with a ready-extended correction, the kerf (cutting gap) correction must not be switched off. All that has to be programmed is a TC_LASER_ON call-up with the suitable cutting type. The new correction is corrected linearly in the subsequent movement block for the whole block.

Correction direction

The kerf (cutting gap) correction is carried out independently of the set parameters to the left or right of the programmed contour.

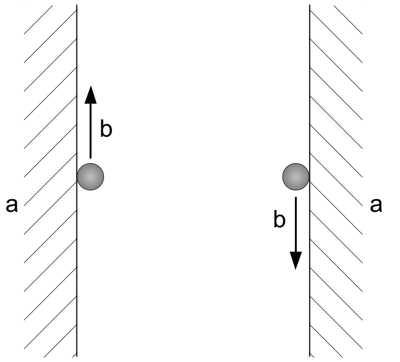
TC_LASERCORR_ON (T_LEFT):
Activation of the kerf correction **left** of the contour without correction extension.



a Kontur des Werkstücks b Laserstrahl

Fig. 13226

TC_LASERCORR_ON (T_RIGHT):
Activation of the kerf correction **right** of the contour without correction extension.



a Contour of workpiece b Laser beam

Fig. 13227

Example of kerf correction during contour change

N110	G01 X500 Y100	Positioning motion
N120	TC_LASER_ON(1,"1978",10,100)	Laser ON
N130	TC_LASERCORR_ON (T_LEFT)	Activation of the kerf correction to left of the contour
N140	X400 Y100	Correction extension
N150	G03 X500 Y200 I100	Contour processing
N160	TC_LASER_ON (5,"1978",0,300)	Contour change
N170	G02 X450 Y150 I-50	Adaptation of correction to first displacement block
N180	G03 X400 Y100 J-50	
N190	TC_LASER_OFF (1)	Laser OFF, switch off kerf correction and retraction of the correction
N200	G03 ...	Active G-function

Example during change of the correction direction

N110	X20 Y50	Positioning motion
N120	TC_LASER_ON(1,"1978",10,100)	Laser ON
N130	TC_LASERCORR_ON (T_RIGHT)	Activation of the kerf correction to the right of the contour
N140	X20 Y40	Correction extension
N150	Y30	Inner contour
:		
N200	TC_LASERCORR_ON (T_LEFT)	Change in the correction direction
N210	X50	Outer contour
N220	Y0	
:		
N270	TC_LASER_OFF (1)	Laser OFF, switch off kerf correction and retraction of the correction

3.2 TC_LASERCORR_OFF

Definition

Deselection of kerf (cutting gap) correction without retraction of correction.

Programming

TC_LASERCORR_OFF

- Is programmed in order to deselect cutting gap correction when laser beam is switched on.
- In the next NC block, the removal of the correction must be programmed with a linear interpolation type (G00 or G01).

☞ Since the beam remains activated after deselecting the cutting gap correction with TC_LASERCORR_OFF, it must be ensured that the contour is not transgressed during retraction of the correction in the next NC block.

4. Overshoot height

4.1 TC_POS_LEVEL

Definition

Switch off overshoot height for laser beam.

With the TC_POS_LEVEL call-up in the NC program, a certain overshoot height is added to the specified material thickness in the sheet technology table. After that, the cutting head travels to the calculated overshoot height when switching off the laser beam with TC_LASER_OFF (1).

Programming

TC_POS_LEVEL is programmed with a parameter in the NC program:

TC_POS_LEVEL (overshoot height)

- Results in modal operation.
- Becomes effective with TC_LASER_OFF (1).
- Can be overwritten with a new value for "Overshoot height".
- Is deleted by M02, M30, or home position.
- If TC_POS_LEVEL is not programmed, the Z-axis approaches the uppermost position in TC_LASER_OFF (1) (for machines without LiftMaster: 115 mm; for machines LiftMaster: 90 mm, due to higher support slats).

Overshoot height

- Minimum and maximum overshoot heights:

	metric input [mm]	**inch input [inch]**
min.	0.1	0.004
max.	115	4.53

- Between the minimum and maximum, any overshoot height can be programmed in steps of 0.1 mm or 0.004 inches.

Example

N100	TC_POS_LEVEL (20)	Selects overshoot height (distance of workpiece to Z-axis = 20 mm)
N110	X20 Y40	Approaching the start position
N120	TC_LASER_ON (1, "1755", 10, 100)	Processing
N130	X100	
N140	TC_LASER_OFF (1)	Switches off laser beam, Z-axis travels to overshoot height
N150	X100 Y40	Approach of next start position

5. Time measurement for parts processing

5.1 TC_TIMER

Definition

Time measurement for carrying out parts processing and printing a file.

With the TC_TIMER cycle in the NC program, processing time-measurements of single parts are measured and displayed, or written in a file as a protocol. The protocol can be printed.

Programming

TC_TIMER is programmed with three parameters in the NC program:

TC_TIMER (P1, P2, "Name")

Parameter P1

1 Start time measurement.
2 Stop time measurement and store time for later display. The NC program continues to run. Several times can be measured and displayed when necessary.
3 Stop all programmed time measurements and display measured times. The NC program is suspended until the dialog is closed.
4 Stop all time measurements and store all measured times in the ’tc_timer.txt’ protocol. The protocol is written in the ’c:\dh\topsmanu.dir\log\tc_timer’ directory. The NC program continues to run.

Parameter P2

1-5 Five different times can be measured.

"Name"

Comments (max. 20 characters) for time measurement as text display.

Conditions

- The TC_TIMER cycle can be added in the main program or in a subroutine.
- Starting and stopping time measurement and the display for measured time may not be carried out while the laser beam is ignited.
- The maximum measurable time is 9 hours.
- Time measurements can be started one after the other or parallel.
  Started one after the other means:
  Start time measurement 1
  Stop time measurement 1
  Start time measurement 2
  Stop time measurement 2

  Started parallel means:
  Start time measurement 1
  Start time measurement 2
  Stop time measurement 2
  Stop time measurement 1
- If measurements are started parallel, then please observe that e.g. the start of every time measurement needs approx. 2 seconds. This time is then measured with the initially started time measurement.
  Example: 3 time measurements are started parallel. Approximately 4 seconds for both the subsequent time measurements are included in the measurements for the initially started time measurement.
- The sequence in which the time measurements are started is random.
- The display for the measured times with TC_TIMER(3) stops all time measurements. TC_TIMER(3) must initially be programmed as last call-up for time measurements started parallel.
- TC_TIMER(2) can be replaced by TC_TIMER(3) if the time is to be immediately stopped and displayed.

Protocol for time measurement

With TC_TIMER(4), the cycle writes the result of the measurements into the ’tc_timer.txt’ protocol. The protocol is written into the ’c:\dh\topsmanu.dir\log\tc_timer’ directory, and is formatted via a table calculation for evaluation.

- The maximum file size is 100 KB.
  If this is reached, 20 % is deleted from the beginning of the file, i.e. the oldest entries.
- The file may be completely deleted by the operator. It will then automatically be recreated in the next measurement.

Example of a protocol:

PROGRAM	DATE	TIMERNR	VALUE	COMMENT
HP_1	2001-01-05 15:38:54	1	00:01:14	Up1
HP_1	2001-01-05 15:38:54	2	00:00:53	Up2
HP_1	2001-01-05 15:38:54	3	01:33:07	Up3
HP_1	2001-01-05 15:38:54	4	00:27:00	Up4
HP_1	2001-01-05 15:38:54	5	00:03:25	Up5

Meaning of entries in the protocol:

PROGRAM	Name of the main program.
DATE	Date/Time when the protocol entry was written.
TIMERNR	Number of the timer (parameter 2 from TC_TIMER).
VALUE	Measured time in HH:MM:SS.
COMMENT	Comments (parameter "name" of TC_TIMER).

Example

N10	TC_MSG("SUBROUTINE NUMBER,P100031704"	
N20	G91	
N30;	(PART NUMBER: 1)	Processing part 1.
N40	TC_POS_LEVEL(40.0)	Selects overshoot height (distance of workpiece to Z-axis = 40 mm).
N45	TC_TIMER(1, 1, "First part")	Start first time measurement.
N50	TC_LASER_ON(9,"3529",10,100); SPRINTLAS	
N60	X2.410Y-2.763	
N70	TC_LASER_OFF(3);SPRINTLAS_ END	
N73	TC_TIMER(2,1)	Stop first time measurement.
N75	TC_TIMER(1, 2, "Second part")	Start second time measurement.
...		
N600	G01X-304.186	
N610	G03X-0.925Y-0.925J-0.925	
N620	G01Y-43.000	
N630	TC_LASER_OFF(3);SPRINTLAS_ END	Stop second time measurement.
N635	TC_TIMER(2,1)	
N640	G01	
N650	G90	
N660	M17	
N665	TC_TIMER(3)	Display times of time measurements.
N670	M02	

6. Programming selectable microjoints

Machines

This function is standard in the TC L 3050, TC L 4050, and optional in TC L 3030, TC L 4030, TC L 6030, and TC L 2530.

Microjoints

Microjoints are micro bridges which, until now, could only be programmed via ToPs programming software. The so defined microjoints are firmly anchored in the NC program. They can no longer be modified or deselected for processing parts on the machine.

Programmed or automatic microjoints, program-specific table

Microjoints are now programmable directly at the machine, and can be selected or deselected as required. One differentiates between:

- Programmed microjoints, which are defined via G-functions inside the contour or at the end of the contour. It is here that the contour is directly marked in the NC text for the part program.
- Automatic microjoints, which are always set at the end of the contour, and are defined without G-functions. The definition is made here via the expansion of the contour in X- and Y-direction. The contour is not marked in the NC text.

The following points still apply:

- The data is stored in a program-specific table for both microjoint types. The data can be displayed and modified via the user interface on the control system. With this table, the microjoint types can be activated or deactivated separately. The table is called up using NC cycle TC_MICROJOINT ("Table name").
- Both microjoint types are available in normal mode and in SprintLas mode.
- The activation status of the microjoints in the table is stored with the program. It is thus guaranteed that even with fully-automatic systems an available program is executed under the same conditions after every program change.

6.1 TC_MICROJOINT

Definition

Calls up table with microjoint data directly at the control system and activates or deactivates programmed or automatic microjoints in the NC text.

With the TC_MICROJOINT cycle in the NC program, a table is called up in which all parameters and the activation status of the functions are stored. Data can be modified in the table. The modified table is automatically updated in the NC kernel.

Programming

TC_MICROJOINT is called up in the NC program as follows:

TC_MICROJOINT ("Table name")

- Call up as early as possible before the required contour processing.
- Results in modal operation.
- Is deselected with program end or on selecting a new table.

Table parameters - 1:Microjoints, general

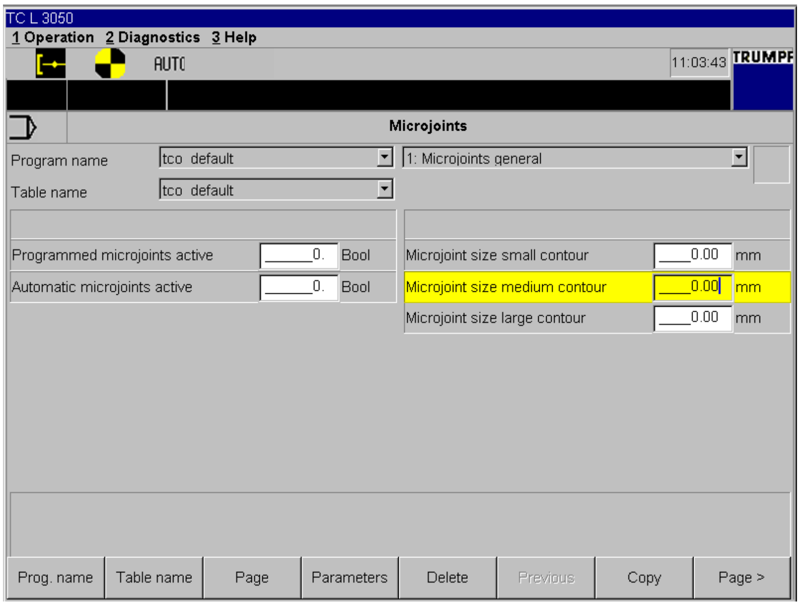


Fig. 30270en

Activating microjoints in the table

- **Programmed microjoints active**: activate or deactivate programmed microjoints.
  Standard 0 = not active, 1 = active.
- **Automatic microjoints active**: activate or deactivate automatic microjoints.
  Standard 0 = not active, 1 = active.

Define microjoint sizes for contours in the table

- **Microjoint-size for small contour**: enter the length of the microjoint for small contour. Standard 0 = no value.
- **Microjoint-size for medium contour**: enter the length of the microjoint for medium contour. Standard 0 = no value.
- **Microjoint-size for large contour**: enter the length of the microjoint for large contour. Standard 0 = no value.

Table parameters - 2:Microjoint data

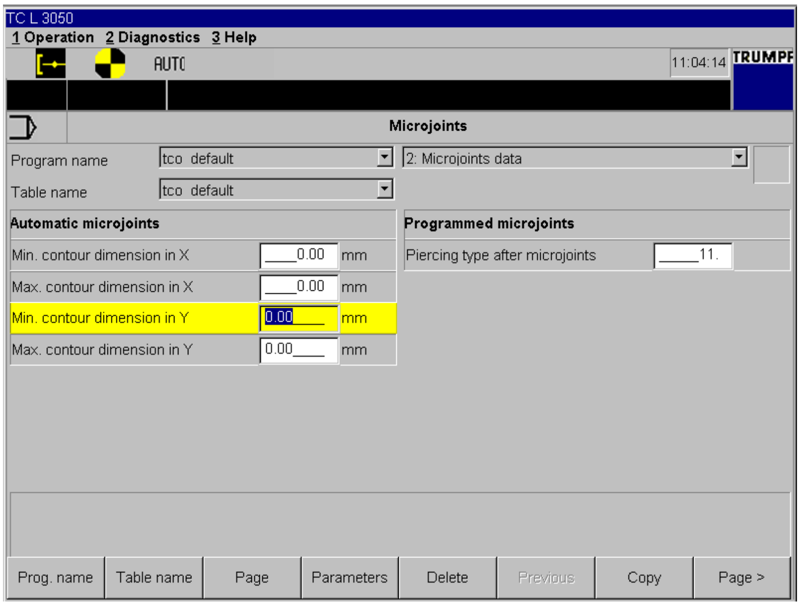
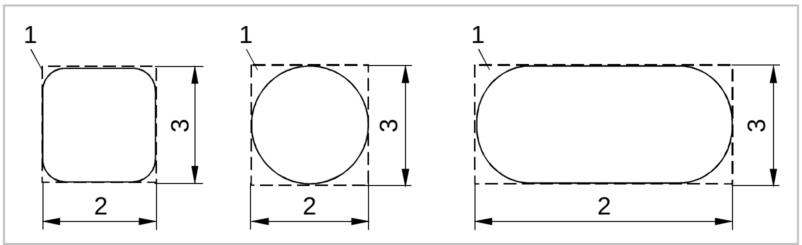


Fig. 30271en

Define data for automatic microjoints in the table

- **Min. extension of contour in X:** enter minimum extension of contour in X-direction. Standard –1.
- **Max. extension of contour in X:** enter maximum extension of contour in X-direction. Standard –1.
- **Min. extension of contour in Y:** enter minimum extension of contour in Y-direction. Standard –1.
- **Max. extension of contour in Y:** enter maximum extension of contour in Y-direction. Standard –1.

Extension of contour means the X- and Y-length of the circumscribed rectangle of the contour.



1 Circumscribing rectangle
2 Extension of contour in X-direction
3 Extension of contour in Y-direction

Fig. 30333

Define data for programmed microjoints in the table

- **Piercing type after microjoint**: piercing type after microjoint on the contour. Standard: 11 ("Soft piercing"). If a microjoint is set inside the contour, then piercing must be started again when processing the second contour part. "Soft piercing" is entered in the table as a standard feature.

6.2 G821

Definition

Defining programmable, contour-relevant microjoints.

With this G-function, the NC block is marked inside the contour where the microjoint should be set. The microjoint can be set inside the contour or at the end of the contour.
If the microjoint is set inside the contour, then piercing is renewed automatically.

Limitations with microjoints inside the contour

- Special types of the piercing process, such as "pilger step-by-step", are not supported, because the approach process in the contour is subsequently not possible.
- Approaching with reduced cutting parameters and then switching to normal parameters is not possible.

Programming

G821
- Is taken into consideration if programmed microjoints are activated or deactivated via microjoint table. The microjoint table is called up via TC_MICROJOINT ("Table name").
- Is not normally activated in the microjoint table. Standard: 0 = not activated; 1 = activated.
- Is written into the NC block of the contour at whose end the microjoint is supposed to be set.
- Is immediately effective after activation if the laser cutting head is located within the positioning motion between two contours. If the laser cutting head is located directly at the processing of a contour, then the function will only become effective for the next contour processing.
- If the function is deactivated when a contour is being processed, then a microjoint will be set in that contour. The following contour will be processed without a microjoint. If the machining head is located inside a positioning motion between two contours, then the following contour will be processed without a microjoint.

Example Programmed microjoints at the end of the contour:

N70	TC_MICROJOINT ("MJT1")	Call up microjoint table
N80	TC_SHEET_TECH ("SHT-1)	Call up sheet technology table
...		
N100	G90 X20 Y 69 F100000	
N200	TC_LASER_ON (1,"4711",10,100)	Laser ON
N210	G02 X20 Y 60 J-10 G821	Full circle with microjoint at the end of the contour
N220	TC_LASER_OFF (1)	Laser OFF
N...	...	
N300	G01 X40 Y 30	Positioning motion
N...	...	
N400	TC_LASER_ON (1,"4711",10,100)	Laser ON
N410	G02 X40 Y10 J-10	Oblong hole
N420	G01 X20 Y10	
N430	G02 X20 Y30 J10 G821	Oblong hole with microjoint at the end of the contour
N440	TC_LASER_OFF (1)	Laser OFF
N...	...	
N500	G01 X0 Y0	

Programmed microjoints in the contour:

N100	G90 X20 Y 69 F100000	
N200	TC_LASER_ON (1,"4711",10,100)	Laser ON
N210	G02 X20 Y 40 J-10 G821	1. semi-circle from full circle with microjoint inside the contour
N220	G02 X20 Y60 J10	2. semi-circle from full circle without microjoint
N230	TC_LASER_OFF (1)	Laser OFF
N...	...	
N300	G01 X20 Y 30	Positioning motion
N...	...	
N400	TC_LASER_ON (1,"4711",10,100)	Laser ON
N410	G01 X40 Y30	oblong hole
N420	G02 X40 Y10 J-10 G821	1. part of oblong hole with microjoint inside the contour
N430	G01 X20 Y10 J10	
N440	G02 X20 Y30 J10	
N459	TC_LASER_OFF (1)	Laser OFF
N...	...	
N500	G01 X0 Y0	

6.3 G822

Definition

Suppressing automatic microjoint in relation to contour.

The criteria for an automatically set microjoint at the end of a contour is the expansion of the contour in X- and Y-direction. If the maximum expansion of the contour in X- **or** Y-direction lies within a defined range (also defined in the microjoint table), then a microjoint will automatically be set at the end of every contour.
Because the control system can not differentiate between closed and open contours, every open contour must already be marked as one in the programming system. Otherwise microjoints will also be set at open contours, i.e. these open contours will be shortened.
With the G822 G-function, not required, automatic microjoints can now be suppressed at the control system.

Programming

G822

- Is taken into consideration if automatic microjoints are activated or deactivated via microjoint table. The table is called up via TC_MICROJOINT ("Table name").
- Is not normally activated in the microjoint table. Standard: 0 = not activated; 1 = activated..
- Can be written for the relevant contour in a separate block or at the end of an NC block, albeit after TC_LASER_ON and before TC_LASER_OFF.
- Is immediately effective after activation if the laser cutting head is located within the positioning motion between two contours. If the laser cutting head is located directly at the processing of a contour, then the function will only become effective for the next contour processing.
- If the function is deactivated when a contour is being processed, then a microjoint will be set in that contour. The following contour will be processed without a microjoint. If the machining head is located inside a positioning motion between two contours, then the following contour will be processed without a microjoint.
- Is deleted with the next TC_LASER_OFF.

Example Suppressing automatic microjoints:

N100	G90 X20 Y 69 F100000	
N200	TC_LASER_ON (1,"4711",10,100)	Laser ON
N205	G822	Suppress automatic microjoint (separately in an NC block)
N210	G02 X20 Y 60 J-10 G821	Full circle with microjoint at the end of the contour
N220	TC_LASER_OFF (1)	Laser OFF
N...	...	
N300	G01 X40 Y 30	Positioning motion
N...	...	
N400	TC_LASER_ON (1,"4711",10,100)	Laser ON
N410	G02 X40 Y10 J-10 G822	Oblong hole, with suppression of an automatic microjoint (at the end of an NC block)
N420	G01 X20 Y10	
N430	G02 X20 Y30 J10	Oblong hole with microjoint at the end of the contour
N440	TC_LASER_OFF (1)	Laser OFF
N...	...	
N500	G01 X0 Y0	

Chapter 7

Sheet handling cycles

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Definition

The following actions are completely covered using sheet handling cycles:

- Sheet technology (TC_SHEET_TECH).
- Load sheet (TC_SHEET_LOAD, TC_SHEETPOS_RELOAD, TC_SHEET_MEASURE).
- Unload parts (TC_PARTS_UNLOAD, TC_PARTS_PALLET).

Sheet handling cycles are generated by the control system scanning the program-specific tables for data. Each sheet handling cycle is based on a separate table with the respective parameters.

Each of these tables is filled out (according to the processing requirements) for each NC program and subsequently transferred together with the NC text from the programming software to the control system. There the table contents are scanned and the resulting machine motions are initiated.

☞ Sheet handling tables are **program-specific** tables!

1. Sheet technology

1.1 TC_SHEET_TECH

Definition

Defined here, with the TC_SHEET_TECH cycle call-up in the NC program, are the properties found in the sheet.

Programming

The TC_SHEET_TECH cycle call-up instruction in the NC program is always linked with a program-specific sheet technology table, the contents of which are transmitted with the NC text from the programming system to the control system:

TC_SHEET_TECH ("Sheet technology table")

- Must be programmed before the first travel motion and before TC_SHEET_LOAD.
- Must be programmed if the sheet properties change.
- The table designation must always be entered with quotation marks.
- The table is called up using SHT for SHEET TECH and a running number in the NC text, and must be specified in brackets with quotation marks ("SHT-1").

Sheet technology table

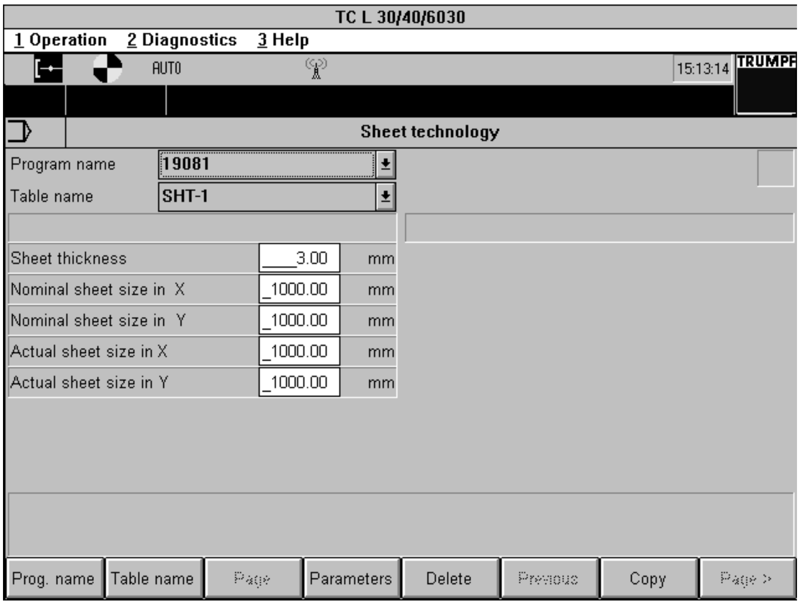


Fig. 27793en

- **Sheet thickness:** the sheet thickness of the sheet to be processed is shown in mm. (Default value: 8 mm).
- **Req. sheet dim. in X:** the dimension of the sheet in X-direction is shown in mm. (Default value: 2000 mm).
- **Req. sheet dim. in Y:** the dimension of the sheet in Y-direction is shown in mm. (Default value: 1000 mm).
- **Act.sheet dim. in X:** the actual dimension of the sheet in X-direction is shown in mm.
- **Act.sheet dim. in Y:** the actual dimension of the sheet in Y-direction is shown in mm.

2. Load sheet

2.1 TC_SHEET_LOAD

Definition

The TC_SHEET_LOAD cycle call-up in the NC program is used for loading the machine with sheets.

- Loading by pallet changer.
- Loading by LiftMaster / LiftMasterSort and pallet changer.
- Calibrating distance control system.
- Measuring sheet position.

Programming

The TC_SHEET_LOAD cycle call-up is always linked with a program-specific sheet-loading table, the contents of which are transferred with the NC text from the programming system to the control system:

TC_SHEET_LOAD ("Load sheet table")

- The table is called up using SHL for SHEET LOAD and a running number in the NC text, and must be specified in brackets with quotation marks ("SHL-1").
- The first travel motion after TC_SHEET_LOAD call-up must be programmed with X- **and** Y-word.

Load sheet table

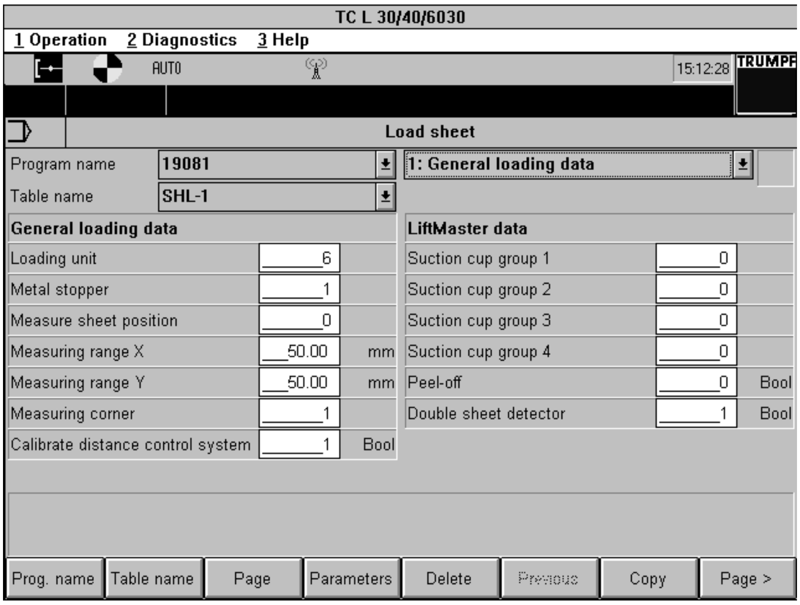


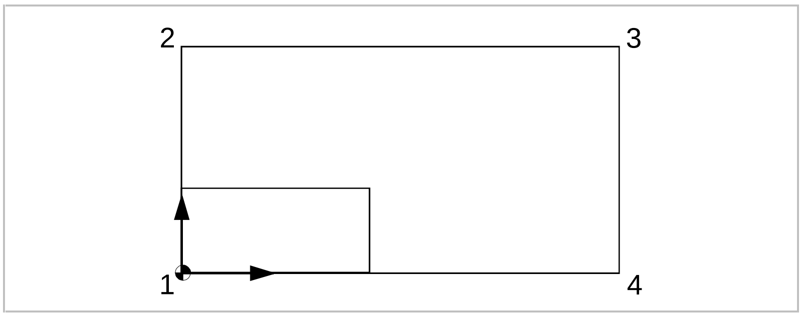
Fig. 27792en

Parameters for general loading data

- **Loading unit**:
  switch for manual/automatic loading.
  - **1** No automatic pallet change (standard).
  - **5** Pallet changer (see parameter description at the end of the section).
  - **6** Loading with LiftMaster (see parameter description at the end of the section).
  - **7** Single pallet mode: Loading pallet A with LiftMaster (see parameter description at the end of the section).
  - **10** Loading with LiftMaster sort (see parameter description at the end of the section).
  - **11** Loading with LiftMaster sort with "pulling device" (optional). The raw sheet can be aligned during the loading operation (see parameter description at the end of the section).

- **Metal stopper:** indicates in which corner (1-4) the sheet is hit.
  1 Machine zero point (standard).
  2, 3, 4 Starting from the machine zero point, the corners are numbered clockwise.

  If measuring is not selected, the zero point is calculated from the sheet mass in the SHEET_TECH table and placed on the bottom, left corner of the sheet.
  Metal stopper for TC HSL 2502 C and TC HSL 4002 is **always** the machine zero point or corner 2.



Four corners for the metal stopper Fig. 27192

- **Measuring sheet position:** measuring device for measuring sheet position.
  0 No measuring (standard).
  1 Measuring with distance control system.

- **Measuring range X:** maximum distance of sheet edge from back stop in X-direction (standard: 50 mm).
  Measuring range Y: maximum distance of sheet edge from back stop in Y-direction (standard: 50 mm).

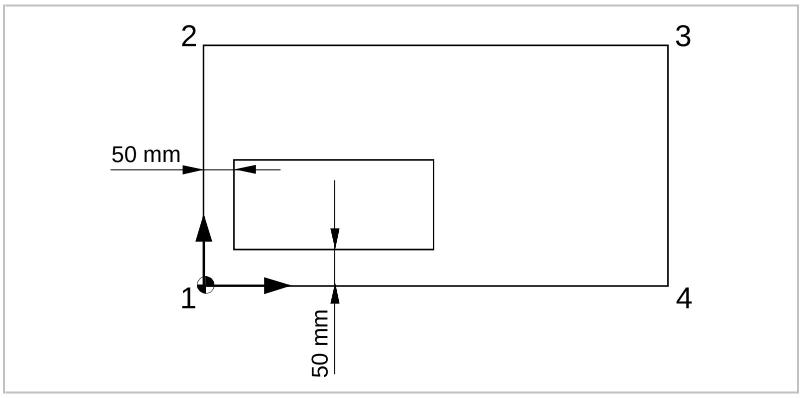
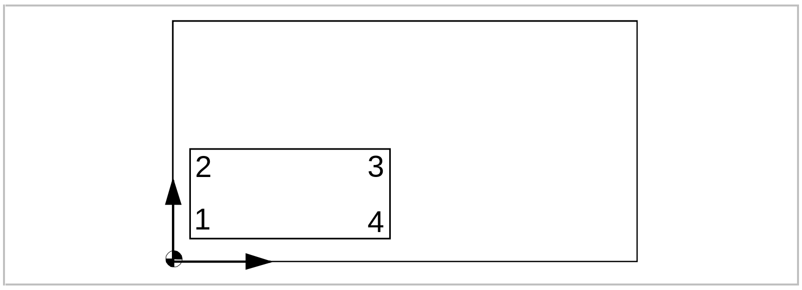


Fig. 27193

- **Measuring corner:** enter the sheet corner (1-4) which is to be used when measuring.
  1 Machine zero point (standard).
  2, 3, 4 Starting from the machine zero point, the corners are numbered clockwise.



Four measuring corners for measuring Fig. 27197

Sheet mass: the exact actual sheet mass from TC_SHEET_TECH must be entered.
TC_SHEET_TECH must be programmed before TC_SHEET_LOAD.

Metal stopper and measuring corner: measuring is carried out in the sheet corner determined in measuring corner. Normally measuring is carried out in the corner where the sheet is placed.
The zero point of the sheet is ascertained. Rotation of the sheet is included in the calculation.

Example 1: zero point (a) and measuring point (b) are identical.

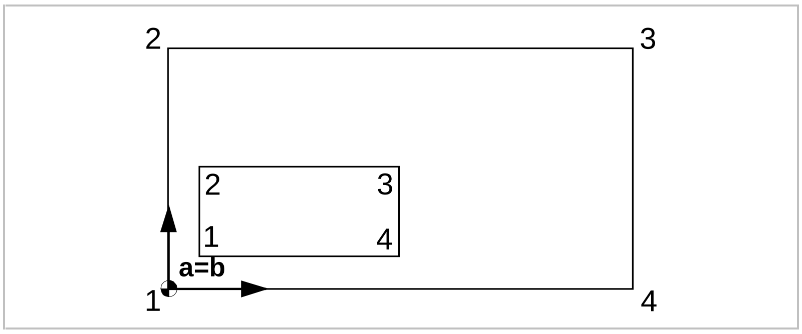


Fig. 27199

Example 2: zero point (a) and measuring point (b) are not identical.

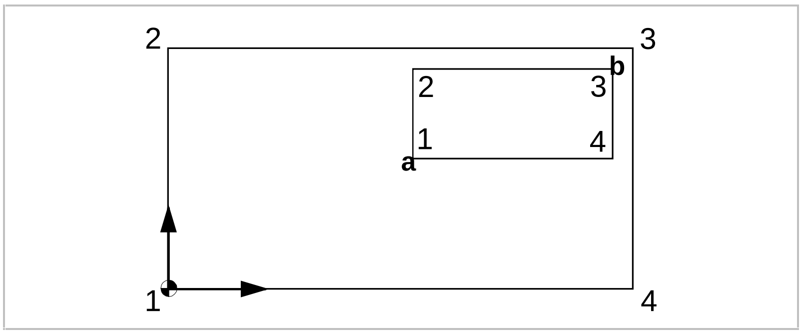


Fig. 27198

- **Calibrating distance control system**:
  1 The calibration of the distance control system is carried out at the start of the first laser processing (standard).

Parameters when selecting pallet changer

- **Pallet-change type:**
  1 Change of pallets (standard).
  4 Container processing (not with TC HSL 2502 C and TC HSL 4002 C).

Parameters for loading with LiftMaster and single pallet mode

- **Suction cup group 1:** is selected for small-, medium-, large- and maxi format.
  0 No selection.
  1 Selection.
- **Suction cup group 2:** is selected for medium-, large- and maxi format.
  0 No selection.
  1 Selection.
- **Suction cup group 3:** is selected for large- and maxi format.
  0 No selection.
  1 Selection of large format.
  3 Selection of maxi format.
- **Suction cup group 4:** suction cups of peeling device are selected.
  0 No selection.
  1 Selection.
- **Peel off:** the peel-off function is selected or deselected. Peel-off of sheets is supported by expanding magnets.
  0 No peel-off function.
  1 Peel-off function activated.
- **Double sheet detector:** the double sheet detector can be selected or deselected.
  0 Without double sheet recognition.
  1 With double sheet recognition.
- **Rotating cylinder:** selection and deselection of rotating cylinder for sheet centering.
  0 No selection.
  1 Selection.

Load sheet Table 2

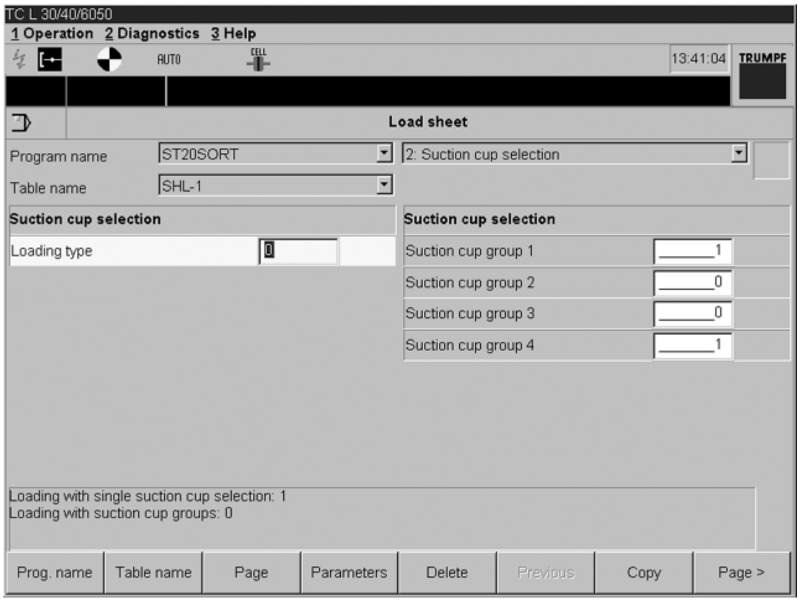


Fig. 34833en

Parameters for suction cup selection

- **Loading mode**:
  Switch for single suction-cup selection.
  0 Single suction-cup selection not active. Suction cups are, as with LiftMaster, programmed with suction cup groups.
  1 Single suction-cup selection active. Suction cups can be selected and activated individually.

- **Suction cup group 1:** is selected for small-, medium-, large- and maxi format.
  0 No selection.
  1 Selection.
  For other format, value of 0-3.
  For single suction-cup selection, value of 0-65535 (FFFF).
- **Suction cup group 2:** is selected for medium-, large- and maxi format.
  0 No selection.
  1 Selection.
  For other format, value of 0-3.
  For single suction-cup selection, value of 0-65535 (FFFF).
- **Suction cup group 3:** is selected for large- and maxi format.
  0 No selection.
  1 Selection of large format.
  3 Selection of maxi format.
  For other format, value of 0-7.
  For single suction-cup selection, value of 0-65535 (FFFF).
- **Suction cup group 4:** suction cups of peeling device are selected.
  0 No selection.
  1 Selection.
  For single suction-cup selection, value of 0-32767 (7FFF).

Parameters for activated single suction-cup selection

- **Suction cup_1:** information about active/not active suction cup 1-32 for loading operation.
  The single selectable suction cups can be activated via hexadecimal programming. In doing so, every character represents 4 suction cups (= 4 bit). This corresponds hexadecimally to the input range "0" to "F". All 4 suction cups active, i.e. all 4 bit equal "1"; therefore, 1 + 2 + 4 + 8 = 15 corresponds with "F". 32 suction cups are coded per parameter (8 characters x 4 = 32).

- **Suction cup_2:** information about active/not active suction cup 1–63 for loading operation (for programming, see parameters for suction cup_1).

2.2 TC_SHEETPOS_RELOAD

Definition

With **TC_SHEETPOS_RELOAD**, the last measured values calculated can be activated without having to carry out another measuring process.

Programming

The cycle **TC_SHEETPOS_RELOAD** must be programmed **before** the SHEET_LOAD table.

Application

Re-entry into the NC program after program interruption.

2.3 TC_SHEET_MEASURE

Definition

The sheet position is measured and defined using the TC_SHEET_MEASURE cycle call-up in the NC program. The actual position of the sheet is measured, and a coordinates transformation carried out.
Also see chapter 10 "Working with CatEye".

☞ When using the CatEye, the sheet must always be loaded at the machine zero point.

Programming

The TC_SHEET_MEASURE cycle call-up is always linked with a program-specific sheet-measuring table, the contents of which are transferred with the NC text from the programming system to the control system:

TC_SHEET_MEASURE ("Sheet measurement table")

- The first travel motion after TC_SHEET_MEASURE call-up must be programmed with an X- and Y-word.
- A user-defined zero offset is not taken into consideration during the measuring process.

3. Unloading parts

3.1 PARTS_UNLOAD_DATA

Definition

With the PARTS_UNLOAD_DATA cycle call-up in the NC program, the unloading of a finished part from the machine is carried out.

- Removing small parts (SortMaster).
- Removing maxi parts (LiftMaster sort).

Programming

The PARTS_UNLOAD_DATA cycle call-up is always linked with a program-specific "Parts removal table", whose contents are transferred from the programming system to the control system together with the NC text:

PARTS_UNLOAD_DATA ("Parts removal table")

Parts removal -Table 1

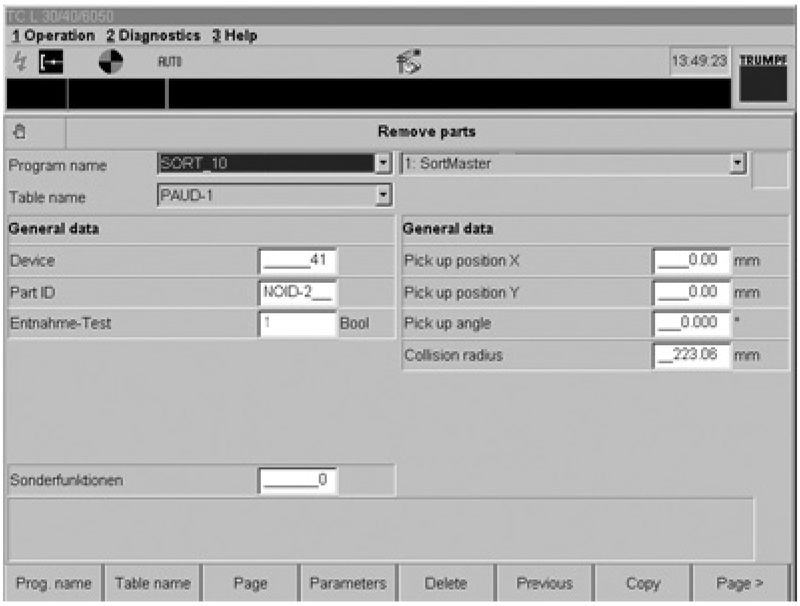


Table for parts removal 1 Fig. 34957en

- **Device:** device with which the selected part is to be removed.
  10 LiftMaster sort up to max. 32 suction cups.
  30 SortMaster without rotary axis, without strips.
  40 SortMaster with rotary axis, without strips.
  41 SortMaster with rotary axis, two strips.
- **Parts ID:** ID number of the part to be removed.
- **Removal test:** specifies whether a test for successful parts splitting should be carried out during removal.
  0 Test is not carried out.
  1 Test is carried out.
- **Special functions:** presently no functions stored.
- **Pick-up position X:** X-coordinate of the removal position, relative to the center of gravity of the reference part.
- **Deposit position Y:** Y-coordinate of the removal position, relative to the center of gravity of the reference part.
- **Pick-up angle:** angle of rotation of the gripper for parts removal, relative to part position. (Only with Sortmaster with rotary axis)
- **Collision radius:** outer circle radius of part during rotational movements. (Only with Sortmaster with rotary axis)

Parts removal -Table 2

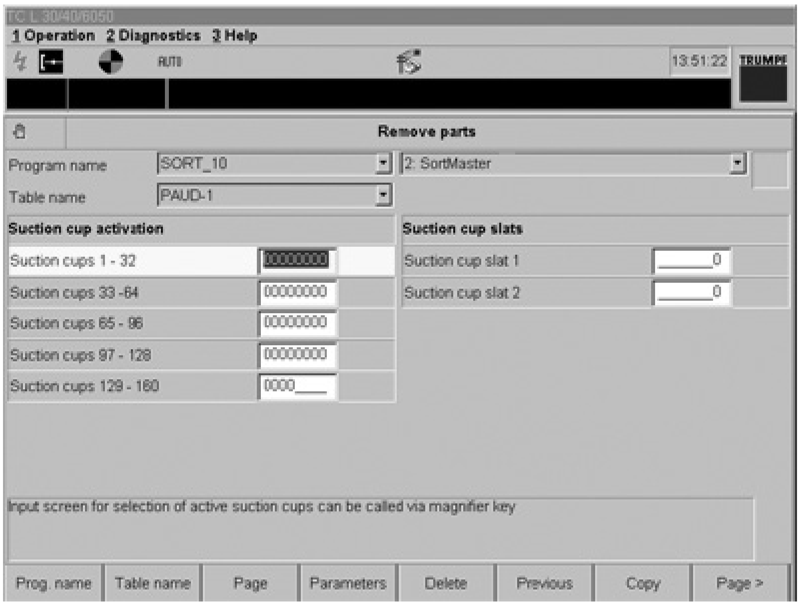


Table for parts removal 2 Fig. 34958en

- **Suction cup activation, suction cups X - X:** information about active/not active suction cups for removal process.
  The single selectable suction cups can be activated via hexadecimal programming. In doing so, every character represents 4 suction cups (= 4 bit). This corresponds hexadecimally to the input range "0" to "F". All 4 suction cups active, i.e. all 4 bit equal "1"; therefore, 1 + 2 + 4 + 8 = 15 corresponds with "F". 32 suction cups are coded per parameter (8 characters x 4 = 32).

- **Suction cup strip 1, 2:** specifies whether the (optional) suction cup strip for SortMaster should be expanded for the removal of the selected part.
  0 Strip is not expanded.
  1 Strip is expanded.

3.2 PARTS_PALLET_DATA

Definition

With the PARTS_PALLET_DATA cycle call-up in the NC program, the depositing of a finished part from the machine is carried out.

- Deposit small parts sorted (SortMaster).
- Deposit maxi parts (LiftMaster sort).

Programming

The PARTS_PALLET_DATA cycle call-up is always linked with a program-specific "Deposit parts table", whose contents are transferred from the programming system to the control system together with the NC text:

PARTS_PALLET_DATA ("Deposit parts table")

Deposit parts table

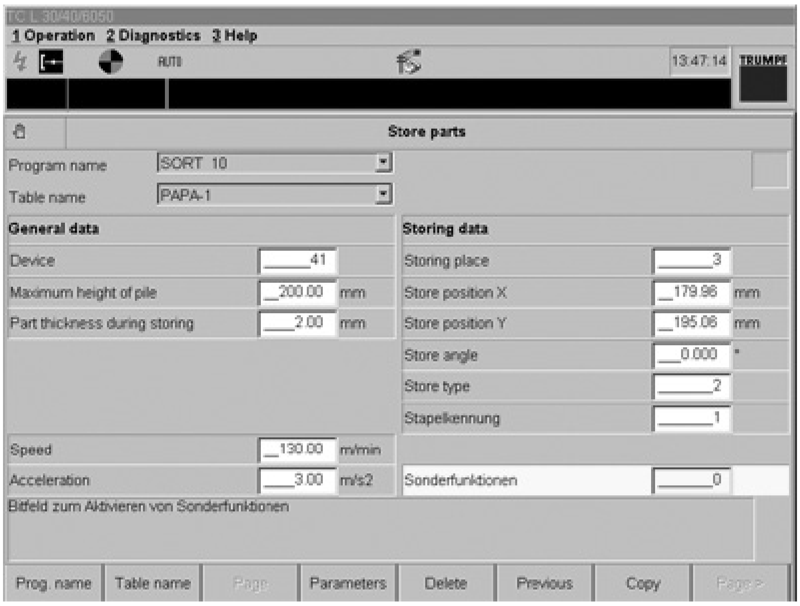


Table for parts deposit Fig. 34956en

- **Device:** device with which the selected part is to be removed.
  10 LiftMaster sort.
  30 SortMaster without rotary axis, without strips.
  40 SortMaster with rotary axis, without strips.
  41 SortMaster with rotary axis, two strips.
- **Maximum stack height:** Permissible height of the finished-part stack. The upper limit is preset by ToPs. If it is exceeded, SortMaster generates an error message and will not remove the parts which are due to be deposited on this stack.
- **Parts thickness when depositing:** sheet thickness plus burr, foil etc. This value is applied by SortMaster for calculating the stack height.
- **Speed:** speed while traveling with sucked-in sheet parts. The speed is dependent upon the part weight and part geometry. Standard: 130 m/min.
- **Acceleration:** acceleration while approaching with sucked-in sheet parts. The acceleration is dependent upon the part weight and part geometry. Standard: 3 m/s².

- **Depositing place:** unit on which the parts are due to be deposited. The coordinates for the units are adjustable in machine data (MACODA); however, they must be adjusted with ToPs accordingly.
  - **1** Pallet changer for machine.
  - **2** Boxes on the unloading platform on the side of the pallet changer.
  - **3 – 6** Depositing places on pallets.
- **Deposit position X:** X-coordinate of the deposit position, relative to the zero point of the unit.
- **Deposit position Y:** Y-coordinate of the deposit position, relative to the zero point of the unit.
- **Depositing angle:** angle of rotation of the C-axis at which the part is deposited on the unit. (Only with Sortmaster with rotary axis)
- **Depositing type:** determines how the part is to be deposited:
  - **1** Being set down.
  - **2** Thrown down from the maximum stack height set in the machine data.
  - **3** Thrown down from above.
- **NO_PPD_StackGroupNo:** number of the stack to which the selected part belongs.
- **Special functions:** presently no functions stored.

4. Additional functions in NC text

Definition

The PARTS_IN_PROGRAM_POS cycle call-up in the NC program includes relevant entries to the control system for the removal process of a finished part by LiftMaster sort and SortMaster.

Excerpt from NC text PARTS_IN_PROGRAM_POS

(...)

```
BEGIN_PARTS_IN_PROGRAM_POS
C
ZA,MM,16
MM,AT,1,  10,1,1,,'Serial number of machined part' ,,'',Z
MM,AT,1,  20,1,1,,'Main program name'              ,,'',T
MM,AT,1,  30,1,1,,'Part ID number'                 ,,'',T
MM,AT,1,  60,1,1,,'Position X-coordinate'          ,,'mm',Z
MM,AT,1,  70,1,1,,'Position Y-coordinate'          ,,'mm',Z
MM,AT,1,  80,1,1,,'Dimension in X'                 ,,'mm',Z
MM,AT,1,  90,1,1,,'Dimension in Y'                 ,,'mm',Z
MM,AT,1, 100,1,1,,'Relative pos'                   ,,'deg',Z
MM,AT,1, 150,1,1,,'X-coordinate center of gravity'  ,,'mm',Z
MM,AT,1, 160,1,1,,'Y-coordinate center of gravity'  ,,'mm',Z
MM,AT,1, 190,1,1,,'Removal number'                 ,,'',Z
MM,AT,1, 200,1,1,,'Reference part'                 ,,'',Z
MM,AT,1, 210,1,1,,'Name of the PartUnloadData table'  ,,'',T
MM,AT,1, 220,1,1,,'Name of the PartPalettData table'  ,,'',T
MM,AT,1, 240,1,1,,'Classification'                 ,,'',Z
MM,AT,1, 500,1,1,,'Trumpf ID'                      ,,'',Z
C
ZA,DA,2
DA,1,'MAXITEIL','NOID-
    1',20.00,95.00,700.00,800.00,0.00,370.00,495.00,1,1,
*  'PAUD-1','PAPA-1',1,1
DA,2,'MAXITEIL','@GRID-
    1',0.00,0.00,2000.00,1000.00,0.00,1000.00,500.00,
*  999,1,'','',5,1
C
END_PARTS_IN_PROGRAM_POS
```

(...)

- **Removal number:** number of the removal process for the currently produced part.
  0 Part remains in waste grid.
  X Part is unloaded by removal process X (X>0).

  Note:
  A "multi removal" describes a simultaneous removal of several of the same components.
  If "multi removal" is active during a removal process, then all parts which are due to be removed together receive the same removal number.

- **Reference part:** the value indicates whether the current part is the reference part in the removal process.
  0 Current part in not a reference part.
  1 Current part is a reference part.

  Note:
  If a "single removal" is in process, the part to be removed is automatically a reference part.
  If "multi removal" is active, exactly one part receives the status of reference part.
  The positional specifications from the appropriate PARTS_UNLOAD_DATA relate to the center of gravity of the reference part.

- **Name of the PartUnloadData table:** reference specification to the appropriate PARTS_UNLOAD_DATA table.
  If a part is unloaded from the waste grid via a removal process, then this part will have its own PARTS_UNLOAD_DATA data block. The suction cups relevant for removal are coded in this.

  The entry is only relevant in connection with a removal number for the part.

- **Name of the PartPalletData table:** reference specification to the appropriate PARTS_PALLET_DATA table.
  If parts are removed using SortMaster, then the depositing situation must be defined along with the removal situation. In this connection, SortMaster supports stacking as well as sorting in containers for the produced parts.

  Note:
  There is an appropriate depositing process for each removal process. If several parts are picked up by a "multi removal", these are then stacked by a corresponding depositing process, deposited or thrown downwards.

  The entry is only relevant in connection with a removal number for the part.

- **Classification:** type of currently produced part.
  0 Undefined
  1 Normal
  2 Section
  3 Microjoint part in section
  4 Scrap
  5 Waste grid

Chapter 8

Jump Programming

1. LABEL (Jump destination) 8-3

2. GOTOF (Jump instruction) 8-3

3. GOTOB (Jump instruction) 8-3

Definition

It is standard that main programs, subroutines and cycles process the blocks in the sequence in which they were programmed. This sequence can be changed with program jumps.

In one program, jump destinations (LABELS) can be fixed with user defined names. Branching off to a jump destination from other positions within the same program is possible with the jump instructions (GOTOF or GOTOB). The program then continues the processing with statement that follows directly on from the jump destination.

The assignment of jump destinations is also necessary for the application of the function "Program re-entry" on the user interface of the control system.

1. LABEL (Jump destination)

Definition

Target (label within a program)

Branches within a program can be programmed by defining jump destinations (labels).

Programming

- Label names are allocated at least 2 and at most 32 characters (letters, digits, underline characters).
- The first two characters must be letters or underline characters.
- A colon always follows the label name.
- Labels always appear at the start of an NC block immediately after the block number.
- With the help of jump instructions (GOTOF or GOTOB), the jump destinations can be triggered.

2. GOTOF (Jump instruction)

Definition

Jump instruction with forward jump destination (in the direction of the program end).

Programming

GOTOF

- Must be programmed in a separate block.
- Is programmed in conjunction with a jump destination (Label).

3. GOTOB (Jump instruction)

Definition

Jump instruction with backwards jump destination (in the direction of the program start).

Programming

GOTOB

- Must be programmed in a separate block.
- Is programmed in conjunction with a jump destination (Label).

Chapter 9

Subroutine technology

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2.2 Calling up subroutines.. 9-3
2.3 Repeating subroutines 9-4
2.4 Nesting subroutines.. 9-4

1. Subroutine technology in general

Working steps which are necessary for making a workpiece and which occur repeatedly are arranged in subroutines. A subroutine can be called up in any main program, and executed.

Advantages

Faster programming.
Clearer NC text.

2. Working with subroutines

2.1 The structure of subroutines

The subroutine is set up in the same way as the main program. Please observe the characteristic description blocks for the program syntax in chapter 1 of the programming manual.

Programming

- The subroutine name can be a number sequence, a text or a combination of numbers and letters.
- Subroutines must be terminated with M17. M17 causes the return to the currently running program.

☞ In subroutines the travel motions are, in general, entered incrementally (with G91). This makes it possible for the subroutine to be executed at different points in the main program.

☞ The end of a subroutine must correspond to its entry conditions.

2.2 Calling up subroutines

In the main program the subroutine is called up either with the L-address and subroutine number or by giving the program name.

Example

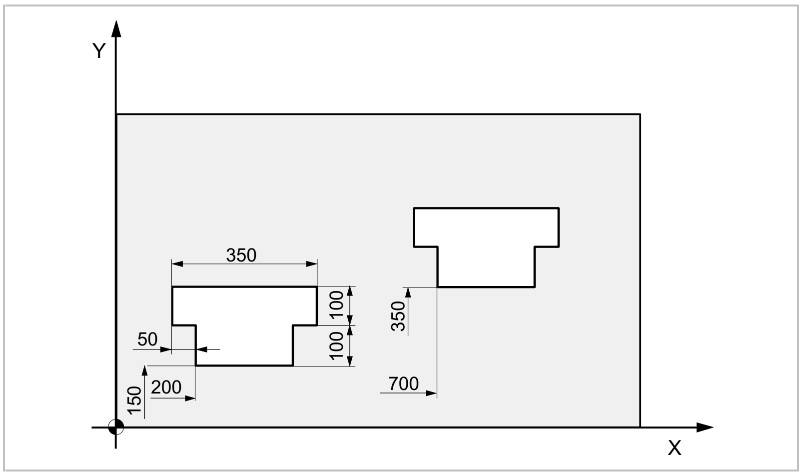

Fig. 12853

Subroutine:

DA,'L10001000','UP',,		
START_TEXT		
N100	MSG("LASER")	
N110	G91	Incremental dimension input
N120	G64	Contour control mode ON
N130	TC_LASER_ON(1,"1983",10,110)	Laser ON
N140	Y100	Contour processing
N150	X-50	
N160	Y100	
N170	X350	
N180	Y-100	
N190	X-50	
N200	Y-100	
N210	X-250	
N220	TC_LASER_OFF(2)	Laser OFF
N230	G90 M17	Absolute measurement input subroutine end
STOP_TEXT		

Main program:

```
DA,'1000','MP',,
START_TEXT
N10
:
N120    G01
N130    X200 Y150
N140    L10001000                 Subroutine call-up
N150    G01
N160    X700 Y350
N170    L10001000                 Subroutine call-up
N180    M30                       Main program end
STOP_TEXT
```

2.3 Repeating subroutines

If a subroutine should be executed several times in sequence, the required number of program repetitions can be programmed in the block under the P-address.

Maximum number of program repetitions: 9999

Example The program GEARWHEEL_3 should be executed 5 times in sequence:

N40 GEARWHEEL_3 P5

2.4 Nesting subroutines

A further subroutine can be called up in a subroutine. On the other hand, a subroutine call-up can stay in this subroutine, etc. The maximum number of program levels or nesting depths is 12, which includes 4 levels already occupied by the manufacturer. This means 7 nested subroutine call-ups can be issued from a main program.

Chapter 10

Working with CatEye (optional)

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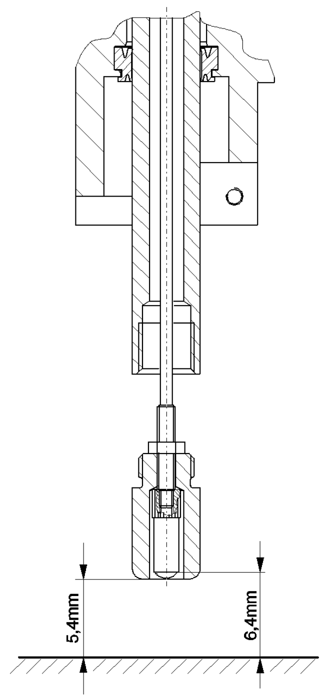
1. Description

Definition

The "CatEye" is a photoelectric sensor for measuring the workpiece position or for sheet-edge recording.

A red beam of light, guided via fiber glass optics, is focussed on the workpiece surface using a glass lens (see Fig. 3602).
The contour is calculated by means of the intensity of the reflected light when traveling over a workpiece edge.
The geometry data are registered by the CNC control, and the coordinate system is corrected.



CatEye Fig. 3602

Focussing distance of lens - sheet surface	6.4 mm
Distance of protection sleeve - sheet surface	5.4 mm

In the working range of the machine, a dead area appears from the offset between the laser beam center and CatEye beam. The CatEye can not measure in this area.

Example value of dead area

+X - direction 73 mm
+Y - direction 34 mm

☞ When programming in inches, the values are entered or displayed in inches.

Application

Recording the sheet position for processing prepunched sheets

2. Conditions for the use of CatEye

The following general conditions are to be observed when using CatEye so that a repeating accuracy of ± 0.1 mm can be attained.

- Material: stainless steel, mild steel, aluminum.
- The scanned edges of a bore hole must be even.
- The measured distance from the protection sleeve of the CatEye to the sheet surface must be 5.4 ± 0.1 mm.
- The sheet must have an evenness of approx. 0.2 mm in the range of the measured section (approx. 15 mm) (without edge catchment).
- The minimum bore hole diameter is 20 mm with an insertion accuracy of ± 5 mm.
- The focussing distance of 6.4 ± 0.1 mm is measured with the distance control system. It may not be influenced by sheet edges, i.e. the whole material must be available around the measuring point in a diameter of at least 20 mm.
- The measured section of the sensor may not be interrupted.
- The offset is to be recalculated for the cutting head change and for the recentering of the nozzle - lens.
- Workpiece sheets punched strongly have often already experienced a geometrical change (swelling effect), which is why measuring can be inaccurate.
  Because during the coordinates transformation, a rotation as well as an offset of the parallel is affected, it must be observed that when the measuring holes are in an unfavorable position, the inaccuracies between punched and laser-cut contour can become worse in relation to the path lengths (beam block).
- Carry out a visual inspection to check whether the CatEye is clean and sits tight.

3. Calibrating CatEye

"CATEYE" calibration program

Before a measurement can be carried out using CatEye, the sensor must be calibrated. For this purpose, the calibration program "CATEYE" is stored in the control system. During the execution of the dialog-driven program, the sensor height is initially calibrated and the sensitivity of the sensors adjusted. After that, a round hole is cut to calculate the offset of the cutting head in X- and Y-direction, and is then measured. The calculated values are stored in the control system.

The CatEye must be calibrated in the following cases:

- Changing the type of Material (e.g. mild steel - stainless steel).
- Replacing the cutting head or nozzle.

Auxiliary tools

- Small screwdriver.
- 5.4 mm slip gauge.

Conditions

- Load sheet (approx. 200 x 200 mm); material type and material thickness corresponds to the material to be processed.
- Move the cutting head jog mode to a position above the load sheet before starting the program. The position of the cutting head must be selected in such a way that a round hole can be cut and measured with ∅ 25 mm.

Program sequence

Select and start the "CATEYE" program.

⇓

Start of the dialog-driven program sequence.

⇓

Selecting the required laser technology table.

⇓

Positioning of the laser cutting head to required measuring position.

⇓

Measuring of sheet height and positioning of the sensor to working height.

⇓

Control of working height by the operator; if necessary, adjustment of focus offset.

⇓

When changing the focus offset, the sheet height is remeasured and the sensor positioned to working height. The program continues if the focus offset has not changed.

⇓

Setting the sensitivity of the sensor by the operator.

⇓

The round hole is cut.

⇓

Removing the cut-out part below the cutting head by the operator.

⇓

The sheet height is measured at four places on the hole using the distance control system.
Position of the hole is measured.
The calculated offset values are stored.

⇓

End of the calibration.

3.1 Setting work

Setting sensitivity

- Turn the sensitivity potentiometer counterclockwise using the small screwdriver until the red and green display lamp no longer illuminate.
- Turn clockwise until initially the red and then the green diode illuminate.
- Then turn a further 1-2 revolutions clockwise.

Controlling the working height of the CatEye sensor

- Carefully push the slip gauge between the sheet surface and the CatEye sensor.
- If the dimension is not correctly set, then the corrective value must be corrected in the "Focus offset" field:

  Example: There is 0.2 mm play between the slip gauge and the protection sleeve for the sensor.
  Select menu via PRODUCTION – PROGRAM PROCESSING OPTIONS activity.
  Press the CATEYE softkey.
  The sensor must be positioned downwards by 0.2 mm.
  Subtract 0.2 mm from the entered focus value. Enter the new value in the "Focus offset" field.

4. TC_SHEET_MEASURE

Definition

The sheet position is measured and defined using the TC_SHEET_MEASURE cycle call-up in the NC program. The actual position of the sheet is measured, and a coordinates transformation carried out.

☞ When using the CatEye, the sheet must always be loaded at the machine zero point!

Programming

The TC_SHEET_MEASURE cycle call-up is always linked with a program-specific sheet-measuring table, the contents of which are transferred with the NC text from the programming system to the control system:

TC_SHEET_MEASURE ("Sheet measurement table")

- The first travel motion after TC_SHEET_MEASURE call-up must be programmed with an X- and Y-word.
- A user-defined zero offset may not be active.

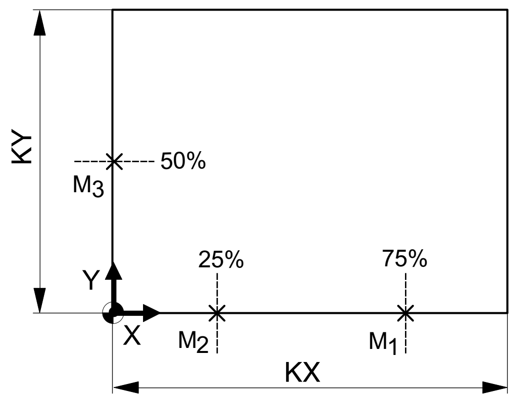
4.1 Parameters in the sheet measurement table

The parameters "Measuring type", "Parameter input in dialog" and "Measuring-point distance", from where the sheet height is remeasured must be entered as standard practice. Other parameters depend on the selected "measuring type".

Measuring type

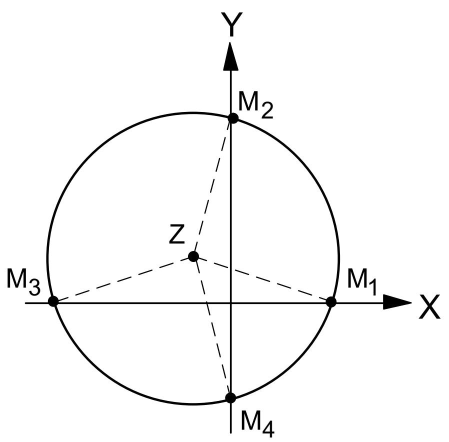
The amount and type of contour to be measured and the sensor to be used are selected with the measuring-type parameter:

1 Measuring an outside corner using CatEye.
2 Measuring an inside corner using CatEye.
3 Measuring two inside corners using CatEye.
4 Measuring a round hole using CatEye.
5 Measuring two round holes using CatEye.
6 Measuring a round hole and an inside corner using CatEye.
10 Measuring an outside corner using distance control system.



M1	Measurement 1	KX	Edge length in X-direction
M2	Measurement 2	KY	Edge length in Y-direction
M3	Measurement 3		

Measurement at a corner Fig. 16504



M1	Measurement 1	M3	Measurement 3
M2	Measurement 2	M4	Measurement 4
Z	Center of round hole		

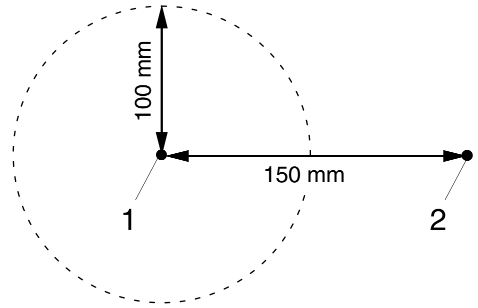
Measurement at a round hole Fig. 16503

Parameter input via dialog

Dialog programming is presently not supported; a 0 must thus be entered at this point as a standard practice.

Measuring-point distance from where the sheet height is remeasured

- If two measuring points are further apart than the entered value at this point, then the sheet height is remeasured using the distance control system (see Fig. 16501).
- Default value 100 mm; should only be lowered for extremely undulating sheets.



1 Measuring point 1 2 Measuring point 2

Position of both measuring points Fig. 16501

Parameters for corner measurements

The same parameters apply for measuring type 3 for measuring a second corner.

Programmed position X

This parameter defines the programmed position of the respective corner in X-direction.

Programmed position Y

This parameter defines the programmed position of the respective corner in Y-direction.

Approximate position X

This parameter defines the approximate position of the respective corner in X-direction.

- Inner contours must be specified with an accuracy of ±5 mm.
- Outer contours must be specified with an accuracy of ±10 mm.

Approximate position Y

This parameter defines the approximate position of the respective corner in Y-direction.

- Inner contours must be specified with an accuracy of ±5 mm.
- Outer contours must be specified with an accuracy of ±10 mm.

Edge length X

This parameter defines the programmed edge length in X-direction.

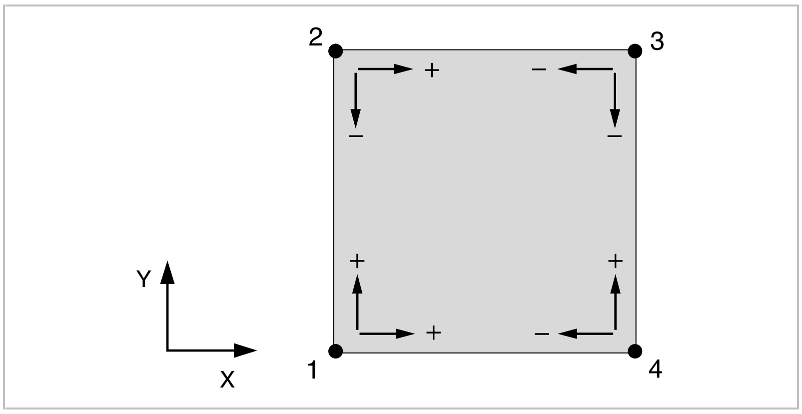
- A negative value must be entered if the edge runs in a negative direction from the corner.
- A positive value must be entered if the edge runs in a positive direction from the corner.
- The edge length must be specified with an accuracy of ±1 mm.

Edge length Y

This parameter defines the programmed edge length in Y-direction.

- A negative value must be entered if the edge runs in a negative direction from the corner.
- A positive value must be entered if the edge runs in a positive direction from the corner.
- The edge length must be specified with an accuracy of ±1 mm.

Definition of operational sign of edge length:



Operational sign for edge length Fig. 16502

- Specification of edge length from corner 1: X+ / Y+
- Specification of edge length from corner 2: X+ / Y-
- Specification of edge length from corner 3: X- / Y-
- Specification of edge length from corner 4: X- / Y+

Parameters for measurements at round holes

The same parameters apply for measuring type 5 for measuring a second round hole.

Center of programmed position X

This parameter defines the programmed position of the round hole center in X-direction.

Center of programmed position Y

This parameter defines the programmed position of the round hole center in Y-direction.

Center of approximate position X

This parameter defines the approximate position of the round hole center in X-direction.

- The position of the round hole center must be specified with an accuracy of ±5 mm.

Center of approximate position Y

This parameter defines the approximate position of the round hole center in Y-direction.

- The position of the round hole center must be specified with an accuracy of ±5 mm.

Diameter

This parameter defines the diameter of the round hole.

- The diameter must be specified with an accuracy of ±1 mm.
- The diameter must be ≥20 mm.

4.2 Combination measuring of inaccurately loaded sheets

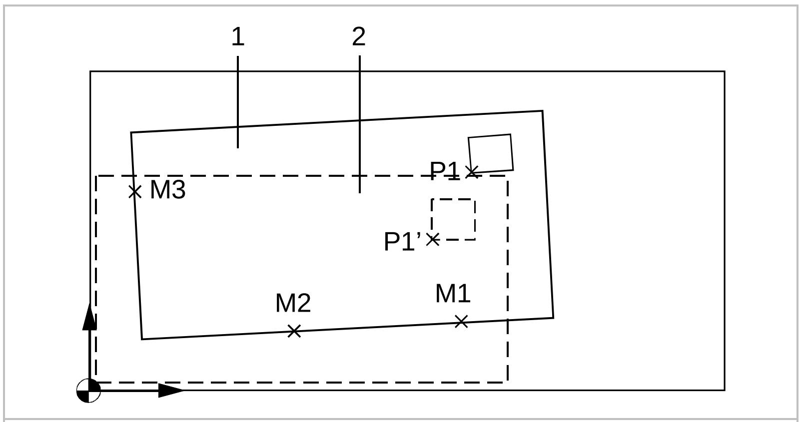
Combination measuring comprises of two measuring procedures:

1. Rough measurement of sheet using distance control system (measuring type 10).
2. Subsequent exact measurement of an inner- or outer contour using CatEye (measuring type 1-6).

When measuring inner- or outer contours using CatEye, the offset of a previous measurement using the distance control system had not been considered until now. The machine zero point continued to be used here as zero point.
If an edge scan is carried out with the distance control system before measuring with the CatEye, then the resulting zero point offset can now be considered for the calculation of the measuring positions for CatEye.

Applied case: loading with LiftMaster.

Example:



1	Inaccurately loaded sheet before combination measuring	2	Sheet position after rough measurement with the distance control system
M1 to M3	Measuring points with rough measurement	P1	Measuring point in machine coordinates
		P1'	Measuring point corresponds to approx. programmed geometry point

Fig. 30332

Chapter 11

Pipe and tube processing (optional)

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1. Laser cycles for pipe and tube processing

Laser cycles

Laser cycles contain sequences of machine commands that call up technology data (which depend on the material and the material thickness) from the laser technology tables. They also control the switching on and off of process parameters (e.g. the laser beam), the machining gas, or the distance control system.

Laser technology tablen

All technology data for the processing of a material type and sheet thickness are summarized in a table. A table is divided into various processing types, e.g. "Cutting", "Piercing", "Marking", etc.

The technology data required for a particular machining situation is called up selectively from the laser technology table by respective parameter entries during the cycle call-up in the NC program.

☞ Laser technology tables are **program-wide** or **global** tables.

1.1 TC_LASER_ON

Definition

With the TC_LASER_ON cycle call-up in the NC-program, the following machine commands are executed dependent upon the entered cycle parameters.

- Activate the height regulation.
- Select piercing gas.
- Move Z-axis to piercing position.
- Switch on beam for piercing.
- Select cutting gas
- Move Z-axis to cutting position.
- Switch on beam for cutting.

Programming

The TC_LASER_ON cycle is called up in the NC program with the following cycle parameters:

TC_LASER_ON (Laser method, "Laser technology table", Piercing type, Cutting type)

TRUMPF

- Is deleted by TC_LASER_OFF.
- Laser methods 1-8 can be used to switch on the laser beam for conventional laser machining.
- Laser methods 9-12 are intended for machining with SprintLas.
- Method 30 is intended for the making welding points with the "Microweld" function.

☞ The "Microweld" function has not yet been realized in the machines software update 4.0 and in ToPs 400 Version 3.4 (only TC L 3030).

Laser method

The following laser methods are available:

Laser method	Function
1	Piercing and cutting with height regulation
2	Piercing and cutting without distance control system
3	Piercing without height regulation, cutting with height regulation
4	Piercing with height regulation, cutting without height regulation
5	Cutting with height regulation
6	Cutting without height regulation
7	Piercing with height regulation
8	Piercing without distance control system
9	Piercing without ramp cycle, and cutting with distance control system with analog laser power control (LPS) (SprintLas, common cuts)
10	Piercing without ramp cycle and cutting without distance control system with analogue laser power control (SprintLas, common slitting cuts)
11	Cutting without height regulation with analog laser power control (SprintLas, common slitting cuts)
12	Cutting without height regulation with analog laser power control (SprintLas, common slitting cuts)
30	Microweld

Cutting with "floating data exchange"

Cutting with "floating data exchange" can be programmed in conventional machining with laser methods 5 and 6 and in SprintLas machining with laser methods 11 and 12. If a further TC_LASER_ON call-up with one of the methods 5, 6, 11 or 12 is programmed when the beam is already activated, it is possible to

- switch between the various cutting data within a laser technology table (e.g. contour change)
- or switch between various laser technology tables

without it being necessary to reduce the cutting speed in the meantime.

Advantages

- No pits due to reduction of the cutting speed during data exchange.
- Faster processing due to "floating data exchange".

Example

N100	TC_LASER_ON(1,"TRO-4120",10,100)	Pierce and cut a large contour with dist. con. ON
N110	G01 X20 Y40	Contour processing
N120	TC_LASER_ON(5,"TRO-4120",0,300)	"Floating data exchange": cutting sm. contour with dist. con.
N130	G02 I0 J10	Contour processing
N140	TC_LASER_OFF(1)	Laser OFF, Z axis at overshoot height

SprintLas machining with laser power control

When working with SprintLas with laser power control, the laser beam remains on during the entire processing process. Only the power changes. Switching off the laser beam in this case means reducing the laser power to 1 percent. Essentially, it is possible to change over to conventional processing types after switching off the laser beam via TC_LASER_OFF (3), (6) or (2).

☞ It is not yet possible at this time to machine with laser power control without the distance control system. In this case, cutting ensues without laser power control.

Laser methods 11 or 12 are always used for special machining types, such as marking, circular point marking, etc.

Laser technology table

Cycle parameters The appropriate laser-technology table is selected by entering the table designation.

- Table designations for the tube technology tables always consist of the prefix "TRO" (for **T**RUMPF **Ro**toLas), a hyphen, and a four-digit number.
- The table number must always be entered with inverted commas.

Machining types

These are the available machining types:

1: General

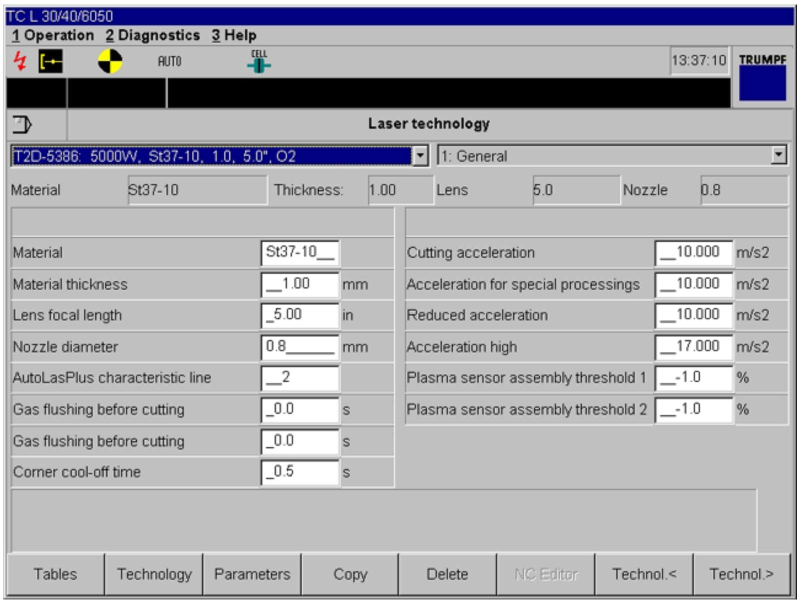


Fig. 34507en

- **Material:** an abbreviation for the material type is shown, followed by a hyphen and the material thickness in 1/10 mm steps.
- **Material thickness:** the material thickness is shown in mm.
- **Lens focal length:** the focal length of the lens in the cutter head is shown in inches. Lenses with focal lengths of 5.0" and 7.5" can be used.
- **Nozzle diameter:** the nozzle diameter is shown in mm.
- **AutoLas *Plus* characteristic curve:** the characteristic curve number that controls the AutoLas *Plus*system is indicated. The characteristic curves are arranged as follows:

Characteristic curve 1:	high-pressure cutting using the 5" cutting head.
Characteristic curve 2:	standard pressure cutting using the 5" cutting head.
Characteristic curve 3:	high-pressure cutting using the 7.5" cutting head.
Characteristic curve 4:	standard pressure cutting using the 7.5" cutting head.
Characteristic curve 5:	high-pressure cutting using the 9" cutting head.
Characteristic curve 6:	standard pressure cutting using the 9" cutting head.
Characteristic curve 7:	high-speed cutting with nitrogen using the 3.75" cutting head.
Characteristic curve 8:	standard pressure cutting and high-pressure cutting using the 3.75" cutting head.

- **Gas purging before piercing:** if a value >0.0 is displayed, the gas conducting parts will be purged with piercing gas for the allotted time when switching from cutting to piercing gas. The piercing gas is used for purging. The gas pressure corresponds to the piercing gas pressure. If the piercing gas pressure is under 4 bar, a gas pressure of 4 bar is used for purging.

- **Gas purging before cutting:** if a value >0.0 is entered, the gas conducting parts will be purged with piercing gas for the allotted time when switching from piercing to cutting gas. The cutting gas is used for purging. The gas pressure corresponds to the cutting gas pressure. If the cutting gas pressure is under 4 bar, a gas pressure of 4 bar is used for purging.

- **Corner cool-off time:** time in which the beam is switched off on corners to prevent burn-in (programming with TC_WAIT).
- **Acceleration cutting:** a value displayed in m/s² which indicates the acceleration rate applied until the axes have attained the programmed cutting speed.
- **Accel. special processing:** this is the acceleration rate in m/s² during special processing (marking, dot marking, vaporizing...) until the axes have reached the programmed cutting speed.
- **Reduced acceleration:** a value displayed in m/s² which indicates the acceleration rate applied until the axes have attained the programmed cutting speed.
- **High acceleration:** is selected using TC_LASER_ON (xx, "table", piercing type, cutting type).

- **Plasma sensor system threshold 1:** the value for the first threshold of the plasma sensor system is indicated in %. This value normally amounts to the following for the these materials:
  Mild steel: 115 % of threshold 1.
  Special steel: 100 % of threshold 1.
  Aluminum: 90 % of threshold 1.
- **Plasma sensor system threshold 2:** the value for the first threshold of the plasma sensor system is indicated in %. This value normally amounts to the following for the these materials:
  Mild steel: 50 % of threshold 2.
  Special steel: 100 % of threshold 2.
  Aluminum: 40 % of threshold 2.

2: Cutting, general

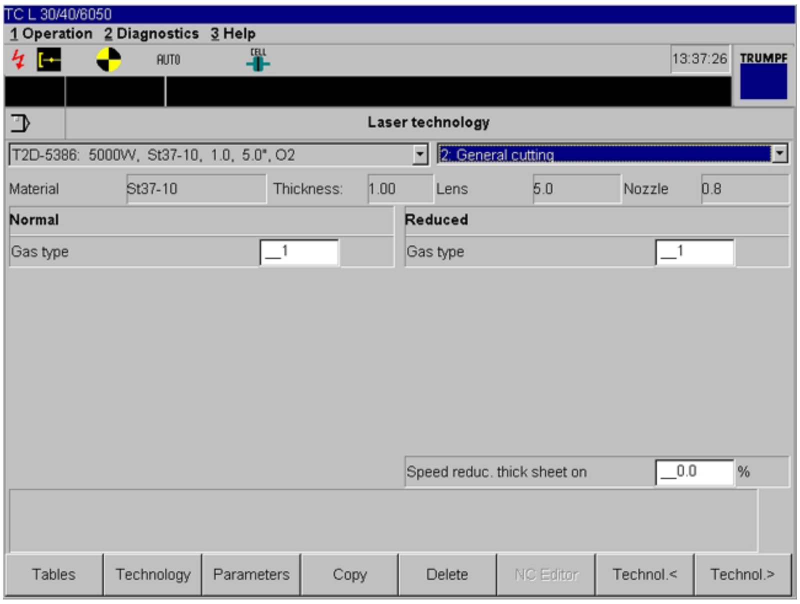


Fig. 34508en

- **Gas type:**
  0 no gas
  1 oxygen (O_2)
  2 nitrogen (N_2)
  3 customized gas (optional)
  4 air (optional)
- **Speed reduced thick plate:** the value in % at which the cutting speed will be reduced when the cutting type "Cutting speed : 1 reduced from piercing hole" is selected.

3-4: Cutting a large contour

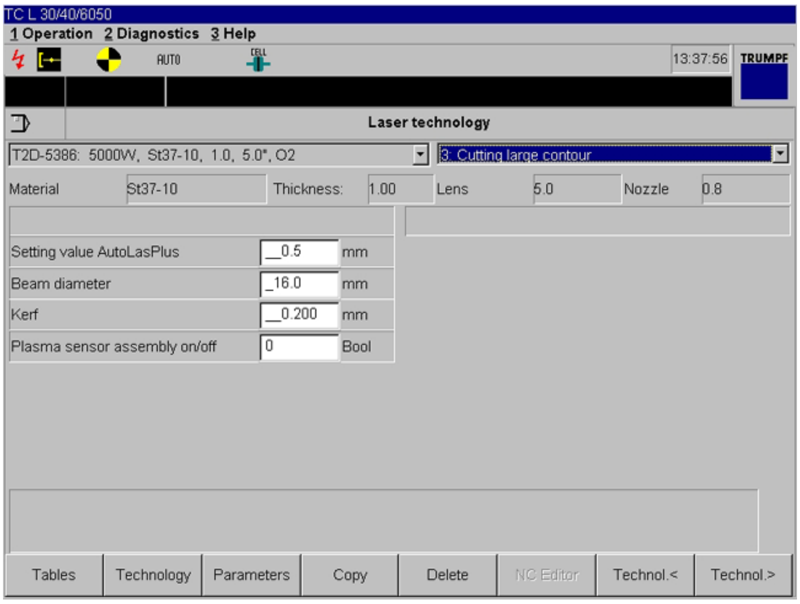


Fig. 34509en

- **AutoLasPlus setting value:** the setting value is displayed in mm and gives the position of the focus in relation to the nozzle tip. The setting value is automatically set by the AutoLasPlus system for machines with AutoLasPlus.
- **Beam diameter:** the set beam diameter is displayed (only TC L 3050 and TC L 4050).
- **Kerf:** a value for the width of the kerf is displayed in mm. This value is evaluated when working with the function TC_LASERCORR_ON (Kerf correction).
- **Plasma sensor system On/Off:** the plasma sensor system is activated or deactivated using this parameter.

  1 Activated

  2 Deactivated

  It is recommended to use the plasma sensor system for the following material thicknesses:

  Mild steel (high pressure cutting with nitrogen): s ≥4 mm

  Special steel: s ≥8 mm

  Aluminum: s ≥6 mm

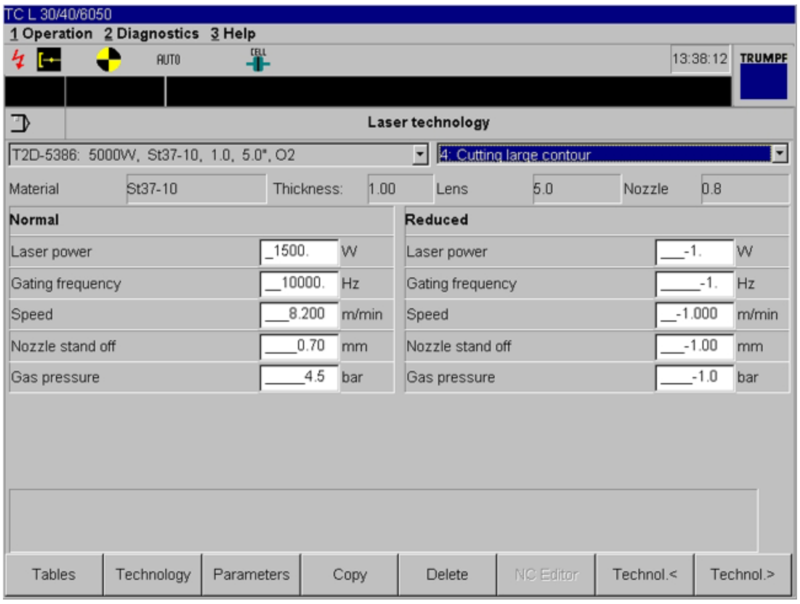


Fig. 34510en

- **Laser power:** the programmed contours will be processed with this laser power, indicated in watts.
- **Modulation frequency:** the frequency at which the laser operates is displayed in Hz (10 - 99 000 Hz).
- **Speed:** displays the speed in m/min with which the programmed contour is cut.
- **Nozzle stand-off:** stand-off between nozzle and material surface is shown in mm.
- **Gas pressure:** displays the programmed gas pressure in bar with which the cutting gas is released during contour processing.

6-7: Cutting a medium contour

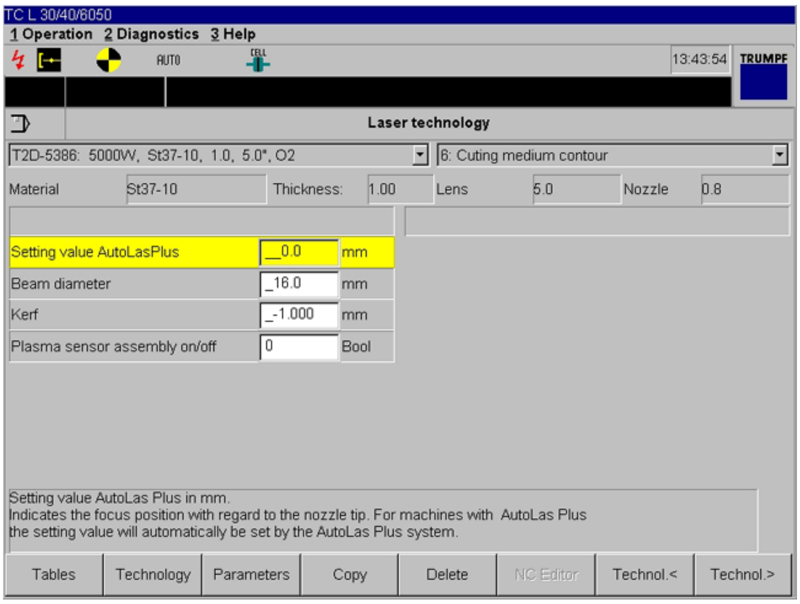


Fig. 34512en

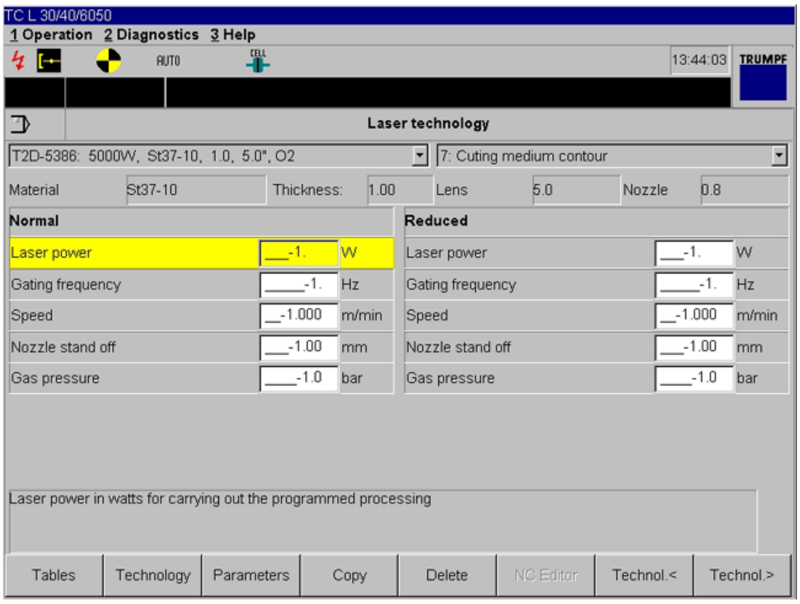


Fig. 34513en

See "Cutting a large contour" for a description of the parameters.

8-9: Cutting a small contour

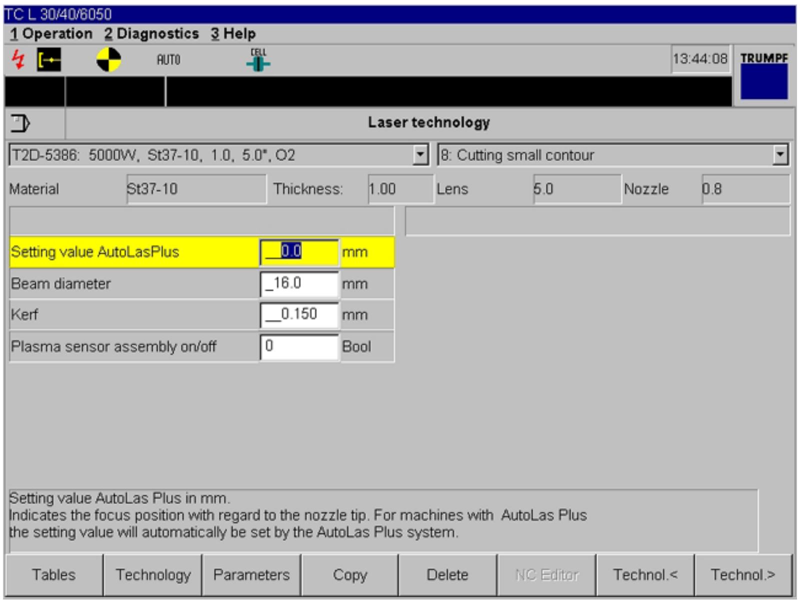


Fig. 34514en

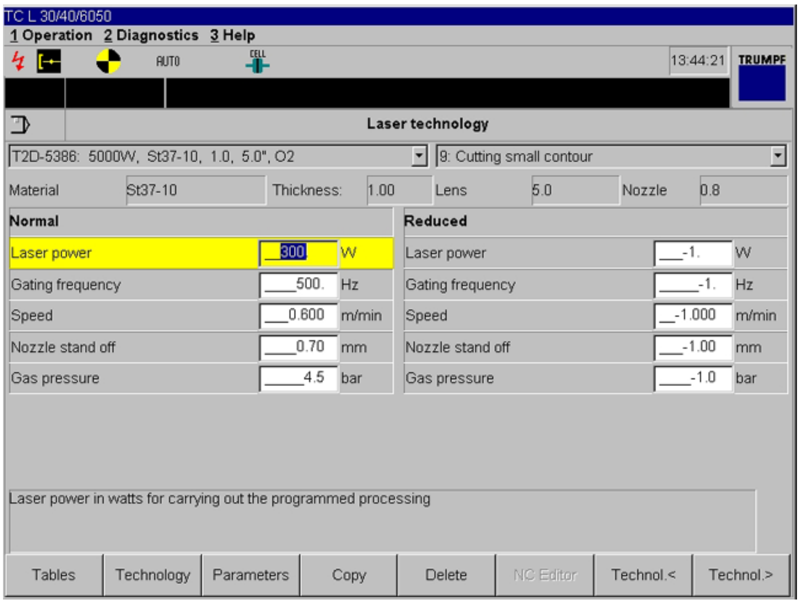


Fig. 34515en

See "Cutting a large contour" for a description of the parameters.

10: Piercing, general

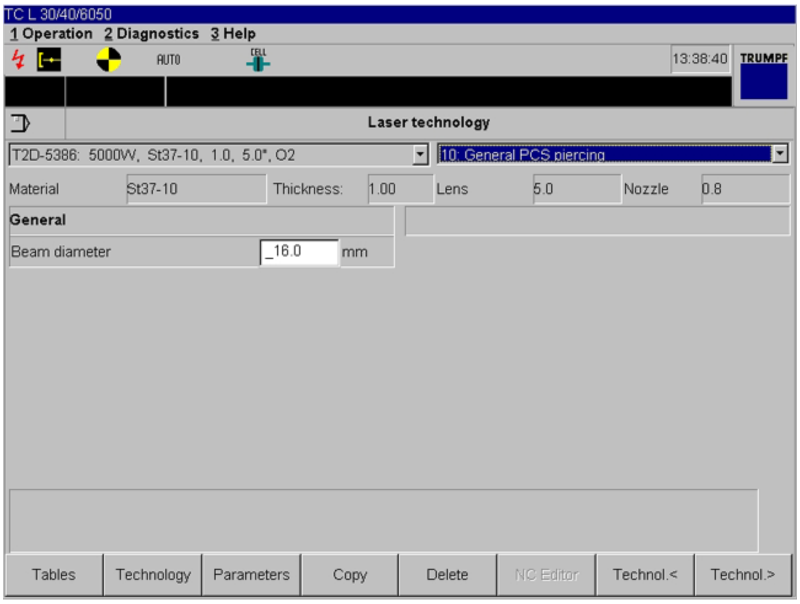


Fig. 34516en

- **Beam diameter:** the set beam diameter is displayed (only TC L 3050 and TC L 4050).

11-12: Piercing

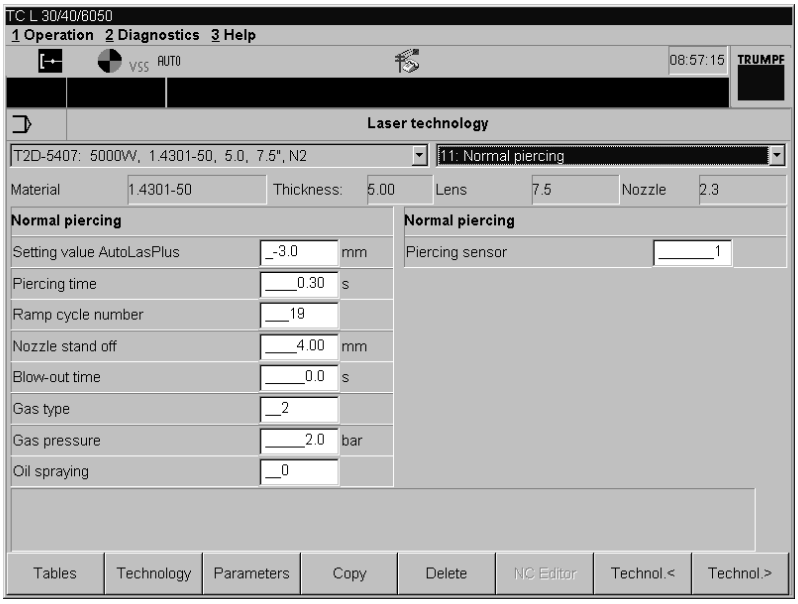


Fig. 34517en

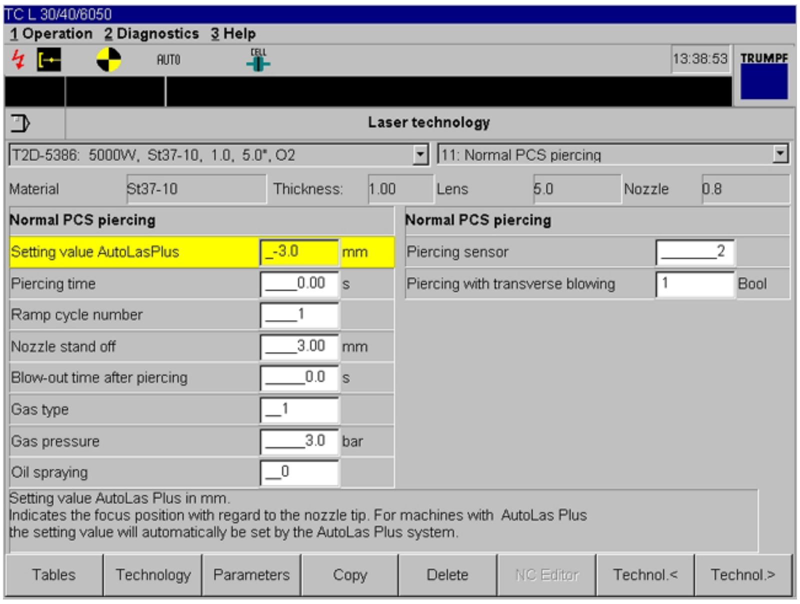


Fig. 34518en

Fig. 34519en

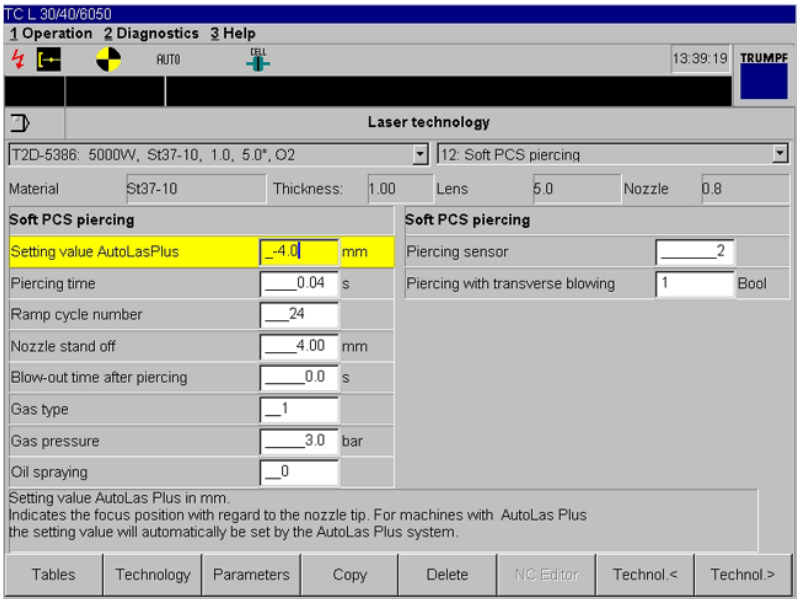


Fig. 34520en

- **AutoLas *Plus* setting value:** the setting value is displayed in mm and gives the position of the focus in relation to the nozzle tip. The dimension is set automatically via AutoLas *Plus*.
- **Piercing time:** displayed here is the time taken in seconds for the conventional piercing process to be completed (laser in operating mode LPC cycle).
- **Ramp cycle number:** displayed here is the number of the ramp cycle used for piercing in material.
- **Nozzle stand-off:** stand-off between nozzle and material surface is shown in mm.
- **Blow-out time after piercing:** displayed here is the time taken in seconds in which the slag on the piercing hole is blown out after piercing.
- **Gas type:**
  0 no gas
  1 oxygen (O_2)
  2 nitrogen (N_2)
  3 customized gas (optional)
  4 air (optional)
- **Gas pressure:** displays the programmed gas pressure in bar with which the cutting gas is released during contour processing.
- **Spray oil:** spray oil before piercing.
  0 no oil.
  1 oil is sprayed on the piercing point before piercing.
- **Piercing sensor system:**
  0 piercing without piercing sensor-system
  1 piercing with PMS, providing available (PMS is only active during piercing)
  2 piercing with PCS, providing available (otherwise an error will be issued)

13: Vaporizing

☞ The machining type "Vaporization" is not available for pipe and tube processing.

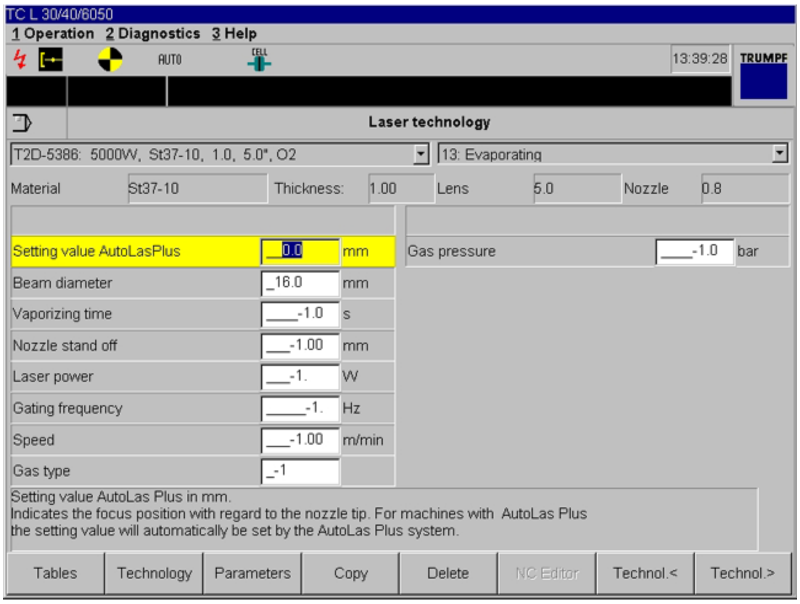


Fig. 34521en

- **Vaporization time:** indicates the time in seconds for which the laser remains fired during vaporization.
- **Speed:** displays the speed in m/min with which the programmed contour is cut.

14: Marking

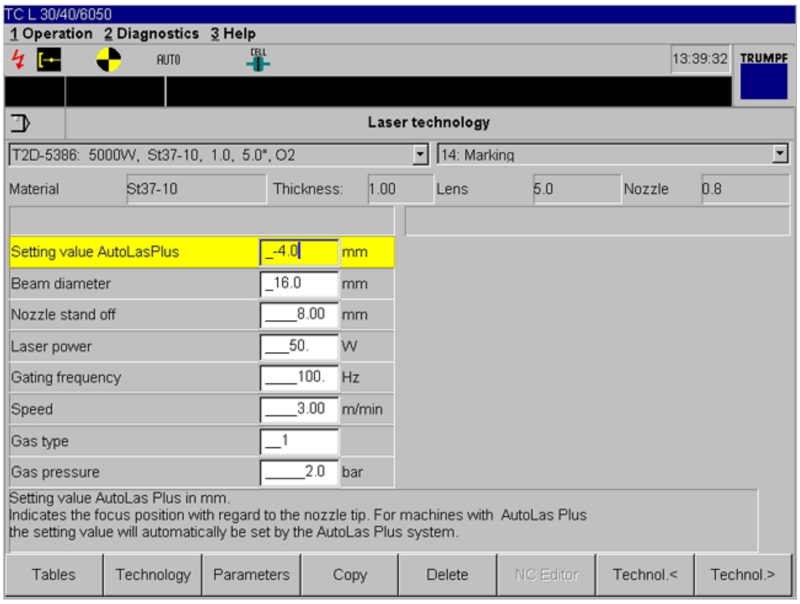


Fig. 34522en

See "Dot marking" for description of parameters.

15: Dot marking

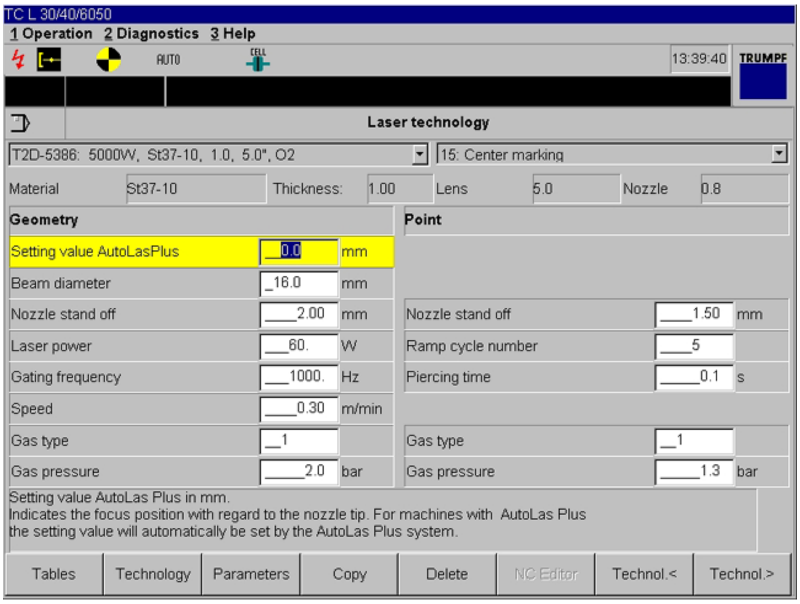


Fig. 34523en

- **Speed:** displays the speed in m/min with which the programmed contour is cut.
- **Piercing time:** displayed here is the time taken in seconds for the conventional piercing process to be completed (laser in operating mode LPC cycle). The methods with the number 1, 2, 3, 4, 7, 8, 9, and 10 take the piercing time into consideration.

16: Microweld

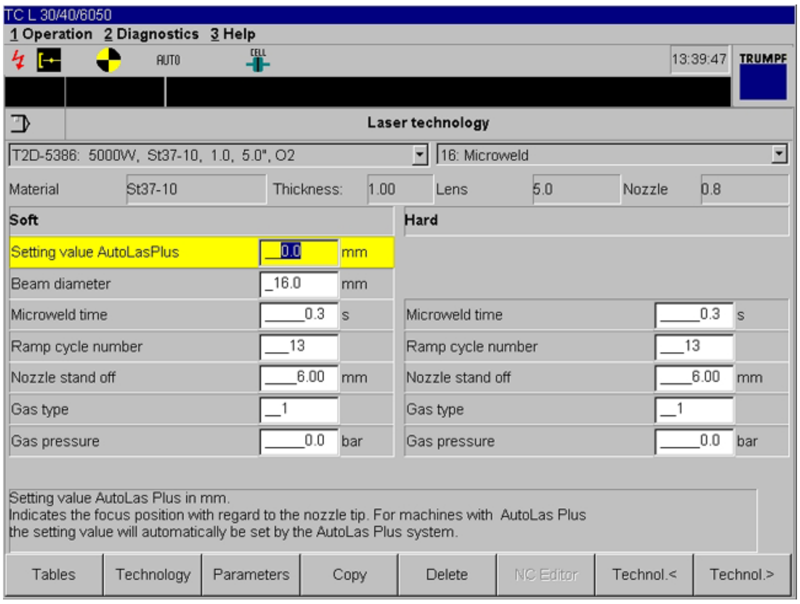


Fig. 34524en

- **Microweld time:** the time displayed for which the laser beam remains activated when micro welding.
- **Ramp cycle number:** displayed here is the number of the ramp cycle used for making welding points.

Piercing type

Cycle parameters: data is selected from the active laser technology table according to piercing type. Various piercing types are stored in the table:

Number	Function
0	No piercing
10	Normal piercing
11	Soft piercing
20	Center marking (spot shaped)
30	Special processing hard microweld
31	Special processing soft microweld

Cutting type

Cycle parameters: depending on the cutting type, data is selected from the active laser technology table. Cutting data (e.g. laser power, cutting and approach parameters) for different processing requirements are stored there. A distinction is made between:

- Large, medium, and small contours.
- Normal and reduced cutting speed.
- Normal, reduced, and high acceleration values.

The cutting type is selected by way of a three digit number, each digit of which has a definite meaning.
Example: 100

1		**0**		**0**	
Contour:		**Cutting speed:**		**Acceleration:**	
1	Large contour	0	Normal	0	Normal
2	Medium contour	1	Reduced from punching hole	1	Reduced
3	Small contour	3	Reduced in thick plate	2	High

The following cutting types can be selected:

Number	Function
0	No cutting
100	Cutting large contours with normal acceleration
101	Cutting large contours with reduced acceleration
102	Cutting large contours with high acceleration
110	Cutting large contours with reduced initial speed from the piercing hole and normal acceleration
111	Cutting large contours with reduced initial speed from the piercing hole and reduced acceleration
130	Cutting large contours with reduced initial speed in thick plate and normal acceleration
131	Cutting large contours with reduced initial speed in thick plate and reduced acceleration
200	Cutting medium contours with normal acceleration
201	Cutting medium contours with reduced acceleration
202	Cutting medium contours with high acceleration
210	Cutting medium contours with reduced initial speed from the piercing hole and normal acceleration
211	Cutting medium contours with reduced initial speed from the piercing hole and reduced acceleration
230	Cutting medium contours with reduced initial speed in thick plate and normal acceleration
231	Cutting medium contours with reduced initial speed in thick plate and reduced acceleration

Number	Function
300	Cutting small contours with normal acceleration
301	Cutting small contours with reduced acceleration
302	Cutting small contours with high acceleration
310	Cutting small contours with reduced initial speed from the piercing hole and normal acceleration
311	Cutting small contours with reduced initial speed from the piercing hole and reduced acceleration
330	Cutting small contours with reduced initial speed in thick plate and normal acceleration
331	Cutting small contours with reduced initial speed in thick plate and reduced acceleration
400	Special processing: vaporization
500	Special processing: marking
600	Special processing: geometric point marking

Example **TC_LASER_ON** (1, "TRO-5100", 10, 100)

Laser method 1:	piercing and cutting with height regulation.
Table TRO-5100:	data from laser technology table number TRO-5100 for tube processing.
Piercing type 10:	normal piercing.
Cutting type 100:	cutting a large contour with normal acceleration.

1.2 TC_LASER_OFF

Definition

Depending on the parameters entered, the following machine commands are executed with the help of the TC_LASER_OFF cycle call-up:

- Switch the laser beam off.
- Switch the cutting gas off.
- Position Z-axis.

Programming

The TC_LASER_OFF cycle is called up with a cycle parameter in the NC program:

TC_LASER_OFF (Laser method)

- Laser methods 1, 2, and 5 can be used to switch off the laser beam for conventional laser machining.
- Laser methods 2, 3, and 6 are to be used for SprintLas processing.
- Methods 10 and 11 are provided for the "Microweld" function.

Laser method

The following TC_LASER_OFF cycles are available:

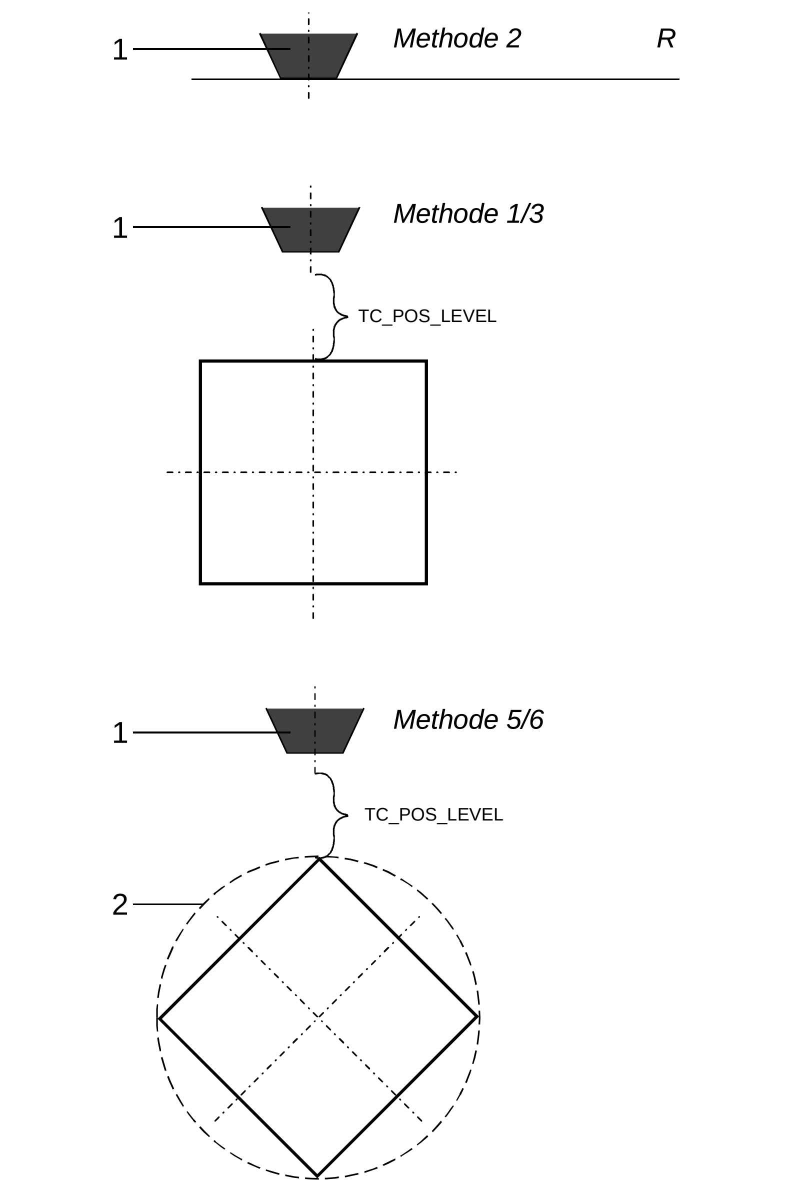
Laser method	Function
1	**Conventional processing:** Used with round, rectangular, and profile tubes, if the A position remains unchanged when approaching the next piercing position. • Laser beam is switched off. • Based on the value of the tube surface which was transferred before the piercing with TC_TUBE_LEVEL (..), the Z axis moves to overshoot height.
2	**Conventional processing and SprintLas processing:** Generally possible for all workpiece geometries; it is normally only used at program end. • Laser beam is switched off. • Z-axis moves to reference point dimension.

3	**SprintLas processing:** Used with round, rectangular, and profile tubes, if the A position remains unchanged when approaching the next piercing position. • Laser power is reduced to 1% • Based on the value of the tube surface which was transferred before the piercing with TC_TUBE_LEVEL (..), the Z axis moves to overshoot height.
5	**Conventional processing:** Used with rectangular or profile tubes, even if another A position is approached when approaching the next piercing position. • Laser beam is switched off. • Z-axis moves to overshoot height based on the outer circle radius (outer circle diameter is written from the programming system into the tube part technology table).
6	**SprintLas processing:** Used with rectangular or profile tubes, even if another A position is approached when approaching the next piercing position. • Laser power is reduced to 1%. • Z-axis moves to overshoot height based on the outer circle radius (outer circle diameter is written from the programming system into the tube part technology table).
10	**Conventional processing and SprintLas processing:** Used for all workpiece geometries. • Laser beam is switched off. • Z-axis moves to nozzle stand-off for hard microweld.
11	**Conventional processing and SprintLas processing:** Used for all workpiece geometries. • Laser beam is switched off. • Z-axis moves to nozzle stand-off for soft microweld.

If one of the laser methods 1, 3, 5 or 6 is programmed, then the overshoot height which the Z-axis is meant to approach must be programmed beforehand using TC_POS_LEVEL.

Overshoot height

This is a graphic representation of the overshoot heights which, depending on the selected laser method, will be approached for a rectangular tube.



R	Reference point	1	Nozzle

Fig. 34666

Example of SprintLas processing

N100	TC_POS_LEVEL(10)	Overshoot height 10 mm
N110	X... Y... F...	Approaching the start position
N120	TC_LASER_ON(9,"TRO-4711",10,100)	Piercing and cutting a large contour with laser power control and distance control system ON
:	X... Y...	Contour processing
N200	TC_LASER_ON(11,"TRO-4711",0,300)	"Floating data exchange": cutting a small contour with laser power control and distance control system ON
:	X... Y...	Contour processing
N300	TC_LASER_OFF(3)	Laser power reduced to 1 %, Z-axis to overshoot height
N310	X... Y...	Positioning motion
N320	TC_LASER_ON(11,"TRO-4711",0,500)	Marking with laser power control and distance control system ON
:	X... Y...	Contour processing
N400	TC_LASER_OFF(6)	Laser power reduced to 1 %, Z-axis to overshoot height + outer circle radius
N410	X... Y... A...	Positioning motion
N420	TC_LASER_ON(9,"TRO-4711",10,100)	Piercing and cutting a large contour with laser power control and distance control system ON
:	X... Y...	Contour processing
N500	TC_LASER_OFF(2)	Laser OFF, sheet end

1.3 TC_TUBE_POSFAST (speed limit)

Definition

During tube processing, there is an increased danger for the cutting head either from tilted parts or from very close positioning of the cutting head to the surface of tubes with larger tube diameters.
To prevent damage in case of a collision with the cutting head, a speed limit of 15 m /min is active.

Programming

If a program has been tested and it has been assured that there is no danger of collision, the speed limit of 15 m/min can be deactivated.

- The function TC_TUBE_POSFAST in the program has to be activated **after** the function TC_TUBE_PART_LOAD.
  (ToPs writes the function as a comment in the program; after the semicolon in front of TC_TUBE_POSFAST is deleted, TC_TUBE_POSFAST is activated)

1.4 TC_POS_LEVEL (overshoot height)

Definition

Determining the overshoot height when switching off the laser beam

A value for the Z-axis overshoot height after the laser beam has been switched off via the function TC_LASER_OFF method is determined with the TC_POS_LEVEL call-up in the NC program.

Programming

TC_POS_LEVEL is programmed with a parameter in the NC program:

TC_POS_LEVEL (overshoot height).

- Results in modal operation.
- Is active with the TC_LASER_OFF methods 1, 3, 5, and 6.
- Can be overwritten with a new value for "Overshoot height".
- Is deleted by M02, M30, or home position.
- If TC_POS_LEVEL is not programmed, the Z-axis approaches the uppermost position (for Liftmaster pallets, 90 mm, otherwise 115 mm).

Overshoot height

Minimum and maximum overshoot heights:

	metric input [mm]	inch input [inch]
min.	0.1	0.004
max.	115	4.53

Between the minimum and maximum, any overshoot height can be programmed in steps of 0.1 mm or 0.004 inches.

Example

N100	TC_POS_LEVEL (20)	Select overshoot height (distance between workpiece-cutting tip = 20 mm)
N110	X20 Y40	approaching the start position
N120	TC_LASER_ON(1,"TRO-5102",10, 100)	Processing
N130	X100	
N140	TC_LASER_OFF (1)	Switches off laser beam, Z-axis travels to overshoot height
N150	X100 Y40	Approach of next start position

1.5 TC_TUBE_LEVEL (required position of the tube surface)

Definition

The required Z-position of the tube surface will be transferred to the piercing position with the TC_TUBE_LEVEL call-up in the NC program.

Programming

TC_TUBE_LEVEL is programmed with a parameter in the NC program:

TC_TUBE_LEVEL (required position)

- Must be programmed before each TC_LASER_ON call-up in the NC program.

Required Z-position

- The value always corresponds to the tube radius for round tubes
- For rectangular tubes, there is a value for the short and the long tube side, whereby the value always corresponds to half the length of the tube side which is at a right angle when piercing. If piercing is to be done on the corner radius, the value will depend on the dimensions of the short and long side of the tube, the corner radius, and the A-axis position during piercing.
- For tubes with free geometry, the value depends on the profile geometry and the A-axis position during piercing.

1.6 TC_CORNER_LEVEL (step, stage)

Definition

Machining parameters can be changed with the TC_CORNER_LEVEL function.

Processing of corner radii for rectangular and profile tubes:

- Changing the programmed cutting distance.
- limiting the cutting feed to a maximum possible feed (depending on the corner radius).
- Changing spatter compensation of the distance control system from 2D to 3D operation.

"Level machining" for round tubes:

- Changing spatter compensation of the distance control system from 2D to 3D operation.

Programming

The TC_CORNER_LEVEL function is programmed with two parameters in the NC program.

TC_CORNER_LEVEL (step, stage)

- Results in modal operation.
- A tube-part technology table TC_TUBE_PART_TECH must be programmed before TC_CORNER_LEVEL.

Tube-part technology table

Up to 5 steps can be used depending on the tube profile.

The following two parameters are entered for each stage:

- **programmed nozzle stand-off stage...**
  When machining with the distance control system activated, the actual nozzle stand-off is changed in the following situations:
  - Cutting on the corner radius on profile and rectangular tubes.
  - Cutting on the plain side close to the corner radius on profile and rectangular tubes.
  - Mainly when cutting tubes sheets edges

  In order to counteract this distance change, a modified required nozzle stand-off has to be transferred to the distance control system.

- **Reduced cutting speed stage...**
  The X-, Y-, Z-, and A-axes interpolate together when machining corner radiuses, in the course of which the Y and Z axes have to execute "compensation motions" very quickly. In order to achieve a cutting tip path feed which is as consistent as possible relative to the tube surface when doing this, the cutting feed has to be reduced depending on the corner radius and the outer circle of the tube.

Rectangular tubes

There are four corner radii of the same kind for rectangular tubes. Two stages are shown in the tube part technology table, which are used for all four corner radii

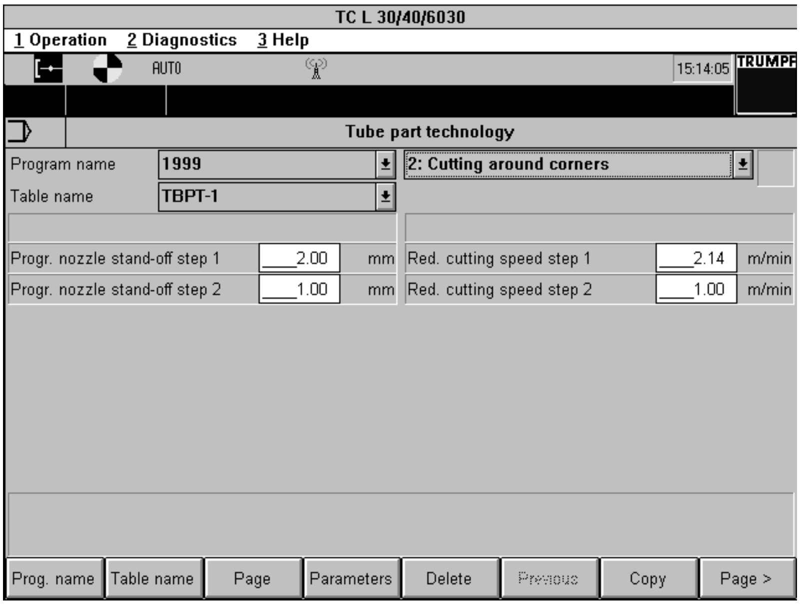
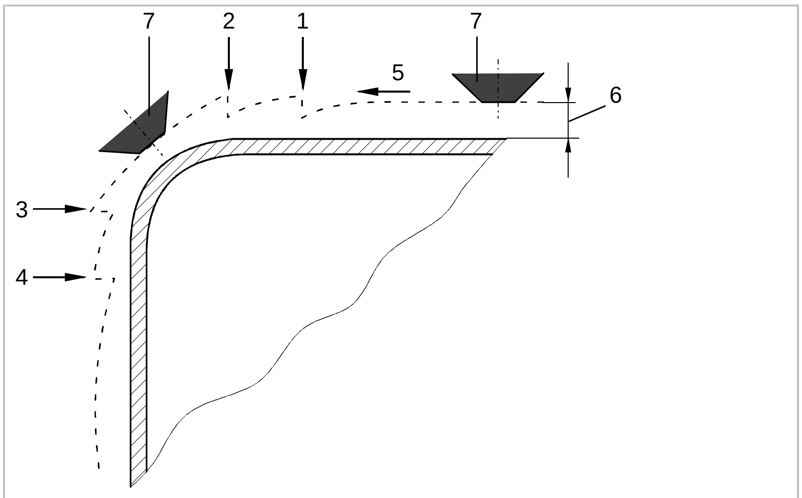


Fig. 27794en

The stages are switched over in four steps for each corner radius. These four steps are shown in the sketch below, as well as the qualitative course of the actual nozzle stand-off for corner machining:



1	Step 1/ Stage 1	5	Movement direction
2	Step 2/ Stage 2	7	Nozzle
3	Step 3/ Stage 1	6	Actual nozzle stand-off
4	Step 4: nozzle stand-off and cutting speed from the laser technology table		

Fig. 22125

Example of programming for a rectangular tube

N100	G90 X105.175 Y-0.250 A0.00	Approaching the piercing position
N110	TC_LASER_ON (1,"TRO-4711", 11, 200)	Piercing and cutting with height regulation, medium contour
N120	X109.675	Contour machining on the surface of the rectangular tube
N130	G03 X109.925 Y0.000 J0.250	
N140	G01 Y15.080	
N150	TC_LASER_ON(5,"TRO-4711",0,300)	Position for step 1: floating switch over to a small contour
N160	AF=$P_F	Reading the current cutting feed
N170	TC_CORNER_LEVEL (1,1)	Step 1 with Stage 1
N180	Y17.500	Contour processing on the surface
N190	TC_CORNER_LEVEL (2,2)	Step 2 with stage 2 at the changeover from the surface to the corner radius
N200	Y17.156 Z10.76 A2.50 F=AF*7.62	Corner radius contour processing
N210	Y16.780 Z11.50 A5.00 F=AF*7.62	
...		
N220	Y-6.730 Z20.31 A87.50 F=AF*7.62	
N230	Y-7.500 Z20.00 A90.00 F=AF*7.62	
N240	TC_CORNER_LEVEL(3,1)	Step 3 with stage 1 at the changeover from the corner radius to the surface
N250	Y-5.080 F=AF*1.00	Contour processing on the surface
N260	TC_CORNER_LEVEL(4,0)	Step 4: nozzle stand-off and cutting speed from the laser technology table active again
N270	TC_LASER_ON(5,"TRO-4711",0,200	Position for cut 4: floating switch over to a medium contour
N280	Y5.080	Contour processing on the surface
N290	TC_LASER_OFF(5)	Laser beam is OFF.

Profile tubes

Profile tubes can have different corner radii. Five stages are shown in the tube part technology table.
Stages 1 and 2, as well as stages 3 and 4 can be used for two different corner radii. In the same vein, the 5 stages can also be used for 5 different radii.
The automatic setting of stages for profile tubes has not been realized in ToPs 400.

Round tubes

There are two cases to differentiate between with round tubes:

- Usually, the cutting tip is positioned over the middle of the tube. The contours are made by movements of the X- and A-axes. A change in height or feed limitation using TC_CORNER_LEVEL is not necessary.
- To create parallel cutting edges, a "level machining" is possible. During this, the A-axis will not move. The contours are made by movements of the X- and A-axes. In this case, the spatter compensation of the distance control system has to be changed from 2D to 3D via TC_CORNER_LEVEL. This only happens with the parameters which are transferred with the function TC_CORNER_LEVEL (step, stage). For this there is no entry in the tube technology table.

Example of programming for a round tube

N100	G90 X136.700	Approaching the piercing position
N105	TC_TUBE_LEVEL (20,00)	Transfer of the tube surface required position
N110	TC_LASER_ON (1,"TRO-4711", 11, 300)	Piercing and cutting with height regulation, small contour
N120	X135.075	Creating a contour with X- and A-axes
N130	A-14.11	
N140	X144.925	
N150	A14.11	
N160	X135.075	
N170	A0.00	
N180	TC_LASER_OFF(1)	Laser beam is OFF.
N190	X106.700	Approaching the piercing position
N200	TC_CORNER_LEVEL (1,-1)	Changing Spatter compensation of the distance control system to 3D operation
N210	TC_TUBE_LEVEL (20.00)	
N220	TC_LASER_ON(1,"TRO-4711",11,300)	Piercing and cutting with height regulation, small contour

N230	X105.075	Creating a contour with X- and Y-axes
N240	Y-4.925	
N250	X114.925	
N260	Y4.925	
N270	X105.075	
N280	Y0.000	
N290	TC_LASER_OFF(1); SPR_OFF	
N300	X76.700	
N310	TC_CORNER_LEVEL (4,-1)	Changing spatter compensation of the distance control system back to 2D operation
N320	TC_TUBE_LEVEL (20.00)	
N330	TC_LASER_ON (1,"TRO-4711",11,300)	Piercing and cutting with height regulation, small contour
N340	X75.075	Creating a contour with X- and A-axes

1.7 TC_TUBE_CENTER ( )

Definition

With the TC_TUBE_CENTER function, differences between the center of the tube and the rotary shaft center in the Y-direction (caused, for example, by tube shape deviations or imprecise clamping) can be compensated.
By measuring the tube with the distance control system, the deviation of the center of the tube from the rotary shaft center is determined.
The coordinate system is moved by a Y zero point offset so that the programmed Y0 coordinate corresponds with the center of the tube.

Programming

Parameters:

0 The Y zero-point offset is set back to the rotary shaft center.
1 The tube is measured at the current X position and the Y zero point offset is adjusted by the measured deviation. (ToPs issues an approach block for the measured position before TC_TUBE_CENTER).

Notes

- The Y zero-point offset only applies for the A-position and in the range of the X-position at which it was measured. In another +X-position or A-position, the center of the tube must be remeasured using TC_TUBE_CENTER(1). The zero point offset can be reset using TC_TUBE_CENTER(0).
- TC_TUBE_CENTER ( ) can be used for round and rectangular tubes, which are to machined **without supports**.

1.8 TC_TUBE_SUPPMOVE (support direction)

Definition

Supports are moved with TC_TUBE_SUPPMOVE. The direction is shown via a predefined short form.

T_PLUS: move support in X+ direction
T_MINUS: move support in X-direction

Programming

The following test cycles can be switched on and off using the tube loading table:

- **Check movement area**
  A dialog asks the user to check whether there could have been a collision with parts knocked over during movement with the support disk (with rectangular tubes) or with the adjustable rollers (with round tubes). If need be, remove these parts manually. Only after the dialog is acknowledged will movement resume.

- **Check support position**
  It will be determined whether the position of the supports after movement should be remeasured via a distance regulation cycle.

1.9 TC_TB_REL (X-, Y-, A-position)

Definition

Before moving the supports, the X/Y axes have to moved if

- The "Check movement area" is switched on.
- The support disk could collide with the cutting head during movement (for rectangular tubes).

These path movements are not programmed in the NC program. Rather, they are calculated and executed by the TC_TUBE_SUPPMOVE cycle for the program running time. If incremental programming is done, the next X, Y, A position after movement will be incorrectly approached.
TC_TB_REL receives the coordinates of the next X, Y, A position as a parameter from the programming system after the movement.
When TC_TB_REL goes to this position, it will take a possible path movement which was executed before the movement into consideration.

Programming

The coordinates are transferred in accordance with the current dimension system.

- If G90 (absolute measurement programming) is active, absolute coordinates have to be transferred.
- If G91 (incremental measurement programming) is active, incremental coordinates have to be transferred.
- TC_TB_REL has to be programmed within a short time after each TC_TUBE_SUPPMOVE.

1.10 TC_TUBE_HORIZ ( )

Definition

TC_TUBE_HORIZ is used to horizontally align a rectangular tube.

- A 1 is always set by ToPs 400 at "Horizontally align tube" in the tube loading table. This causes the smallest possible X position horizontal alignment to be automatically executed in the TC_TUBE_PART_LOAD cycle when the program begins.
- TC_TUBE_HORIZ only has to be programmed if an additional horizontal alignment should be executed at some point in the program.

Programming Parameters:

1 Align horizontally to the current X position.
The X position which is to used in the alignment has to be programmed beforehand in the NC program.
(ToPs issues an approach block for the measured position before TC_TUBE_HORIZ).

2. Tube handling cycles

2.1 TC_TUBE_PART_TECH

Definition The TC_TUBE_PART_TECH function is used to read tube-specific data from the tube technology table.

Programming

- TC_TUBE_PART_TECH has to be programmed before the first TC_LASER_ON.

2.2 TC_TUBE_PART_LOAD

Definition The TC_TUBE_PART_LOAD function is used to read tube-specific data from the tube loading table.

Programming

- TC_TUBE_PART_LOAD has to be programmed before the first TC_LASER_ON.

  TC_TUBE_PART_LOAD carries out all functions for loading the tube:

- Set the working position of the swivel unit.
- Activate zero point offset for X/Y/Z/A.
- Approach position for inserting the tube in X and A.
- Activate setting and measuring of the supports, activate dead areas.
- Position NC back stop.
- Dialog for insertion of the tube.
- Dialog for the insertion and closing of the support disks.
- Align a rectangular tube horizontally. The horizontal alignment can also be inactivated in the TC_TUBE_PART_LOAD table via the "Horizontal alignment: 0/1" entry.
- Automatic characteristic curve recording DIAS3.

2.3 TC_TUBE_PART_UNLOAD

Definition

The TC_TUBE_PART_UNLOAD function offers different possibilities to remove the tube after it has been processed in the machine.
TC_TUBE_PART_UNLOAD opens a dialog window for removing the part.

At the end of the program, the A-axis is always turned back to the home position, so that the collet chuck can be manually or, as the case may be, hydraulically opened.
If there are cut-off parts of the tube which could cause jamming when the A-axis is turned back, then these have to be removed beforehand.
The A-axis will then return to home position when the "Home position" soft key is actuated.
When the "Open" softkey is actuated, the collet chucks of those machines equipped with optional hydraulic collet chucks will be automatically opened.

Programming

The TC_TUBE_PART_UNLOAD function is written by ToPs 400 after the last processing in the NC program.

Glossary

Adjustable zero point offset

Zero point offsets ensure that the machine control calculates certain X- and Y-values with the programmed dimensions. These adjustment values are entered into the zero point memory in the control system, and automatically calculated with all programmed dimensions by the control system after calling up the memory in the NC program.

Block-by-block

Functions resulting in block-by-block operation (non-modal functions) are automatically.

Center marking (spot shaped)

With this processing method, a spot-shaped indentation is made in the material surface by piercing without travel motion.

Cycle parameters

Cycle parameters are variables with which the called-up cycle is adjusted to the respective machining requirements (e.g. call-up of the correct laser technology table through the cycle parameter "table").

F-word

With the F-word, the feed rate is determined for the interpolation types G01, G02 and G03. The maximum speed at which the machine may travel is determined.

Function group

G- and M-functions are compiled in functional groups. Functions within a group are mutually canceling, only one function per group is ever active.

G-function

G-functions determine the path conditions, the dimension input type, the reference point for the dimension input and dimension corrections. Together with the coordinate values, they form the geometrical part of the program.

Incremental

An incremental dimension is determined from the current position of the tool to the end position.

Interpolation parameters

Interpolation parameters are variables which the contour control system needs to calculate the path which is to be traveled during processing. With linear path movements, only the start and end points are needed; with circular movements, further parameters are required; i.e., the interpolation parameters.

Laser cycle

Laser cycles contain sequences of machine commands, which cover both the functionality and the technology of laser processing. A laser cycle consists of individual cycle elements. An element may include an NC command, a technology data call-up instruction or PLC/laser data transmission sequences. Laser processing cycles are compilations of these elements. The sequence is thus established according to the individual machine commands executed and also the recall of technology data, which depend on material type and sheet thickness.

M-function

M-functions trigger the routines stored in the control unit, with which machine elements, such as valves, cylinders or electrical circuits, are addressed and activated.

Marking

When marking, a minute amount of material at the surface is removed and colored.

Measurement system

A dimension system describes the units of the programmed dimensions. Depending on the measurements entered in the working drawing, geometrical data for the workpiece can be programmed in inches or in metrical units.

Normal piercing

Piercing for one laser cycle with 100 % laser output.

Path information

Path information (X-, Y- and C-word) are relayed to the appropriate axis as movement commands. In conjunction with the interpolation type, they describe the geometry of the workpiece.

Path subdivision

The distance from stroke to stroke or the number of intervals must be programmed when processing contours or subdividing the path (row or circle of holes). In this way, the control system can undertake a division of the path into equal intervals and perform the programmed processing function after every interval.

Point-marking geometry

With this processing method, a circular indentation is produced in the material surface by piercing and circular traversing.

Programmable zero point offset

With the programmable TRANS and ATRANS zero point offsets, a zero point offset is carried out analogously to the adjustable reference point offsets. The zero point values are not stored in the correction memory of the control system, and must be written directly into the NC text with TRANS or ATRANS.

Self-holding

A self-holding (modal) function continues to be active until it is deleted by another function from the same functional group.

Sheet handling cycle

Sheet handling cycles are generated by the control system scanning the program-specific tables for data. Each sheet handling cycle is based on a separate table with the respective parameters. Each of these tables is filled out (according to the processing requirements) for each NC program and subsequently transferred together with the NC text from the programming software to the control system. There the table contents are scanned and the resulting machine motions are initiated.

Soft piercing

Piercing for one ramp cycle with reduced laser output.

Deselected at the end of an NC block, i.e. are only applicable in the current NC block.

Spotting

To prevent the individual parts which have been cut loose from being tipped over, a spot weld can be placed on the outer contour.

Vaporizing

When using foil that adheres poorly, there is a risk during high pressure cutting that the gas flow might get between the foil and the material, leading to bubbles in the foil. With vaporization, the protective film is welded around the starting hole to the left or right of the contour to be cut.

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		TRUMPF Werkzeugmaschinen GmbH + Co. KG
Deutschland	✉	Johann-Maus-Straße 2
Germany		D-71254 Ditzingen
Allemagne	☎	0 71 56/3 03-0
	☎	int. +49 (0) 71 56-3 03-0

		TRUMPF Maquinas Ltda.
Brasilien	✉	Avenida Juruá, 150-Alphaville
Brazil		BR-06455-010 Barueri-Sao Paulo
Brésil	☎	0 11/4 21-53 31
	☎	int. +55 (0) 11/4 21-53 31

		TRUMPF S.A.R.L.
Frankreich	✉	Boîte Postale 50239
France		86, Allée des Erables
France		Paris Nord II F-95956 Roissy-Charles de Gaulle Cedex
	☎	01 48/17 80-40
	☎	int. +33 (0) 1 48/17 80-40

		TRUMPF Ltd.
Großbritannien	✉	President Way
Great Britain		Airport Executive Park
Grande-Bretagne		GB-Luton, Beds. LU2 9NL
	☎	0 15 82/7 25-3 35
	☎	int. +44 (0) 15 82/7 25-3 35

		TRUMPF Homberger S.R.L.
Italien	✉	Via Malta 2/1
Italy		I-16121 Genova
Italie	☎	0 10/5 76 53 50
	☎	int. +39 0 10/5 76 53 50

		TRUMPF Corporation
Japan	✉	1-18-2 Hakusan
Japan		Midori-ku
Japon		J-Yokohama 226 0006
	☎	0 45/9 31-57 10
	☎	int. +81 (0) 45/9 31-57 10

		TRUMPF Pte Ltd.
Malaysia	✉	No. 74, 1st floor
Malaysia		Jalan SS 15/4D
Malaisie		Subang Jaya
		MAL-47500 Petaling Jaya
	☎	0 37/34 38 89
	☎	int. +60 (0) 37/34 38 89

		TRUMPF Maschinen Austria GesmbH & Co. KG
Österreich	✉	Industriepark 24
Austria		A-4061 Pasching
Autriche	☎	0 72 21/6 03-0
	☎	int. +43 (0) 72 21/6 03-0

		TRUMPF Maskin AB
Schweden	✉	Aleforsvägen 5
Sweden		Box 606
Suède		S-441 17 Alingsås
	☎	03 22/66 97 00
	☎	int. +46 (0) 3 22/66 97 00

		TRUMPF Maschinen AG
Schweiz	✉	Ruessenstraße 8
Switzerland		CH-6341 Baar
Suisse	☎	0 41/76 96-6 66
	☎	int. +41 (0) 41/76 96-6 66

		TRUMPF Pte Ltd
Singapur	✉	25 International Business Park
Singapore		02-28/29 German Centre
Singapour		SGP-Singapur 609916
	☎	5 62 77 80
	☎	int. +65 5 62 77 80

		TRUMPF Maquinaria, S.A.
Spanien	✉	Avenida de Valdelaparra, 13
Spain		E-28100 Alcobendas (Madrid)
Espagne	☎	91/6 57 36 62
	☎	int. +34 91/6 57 36 62

		TRUMPF Praha spol.s.r.o.
Tschech. Republik	✉	Stetkova 18
Czech Republic		CZ-140 00 Prag 4
Tchéquie	☎	02/42 33 29
	☎	int. +42 02/42 33 29

		TRUMPF Inc.
USA	✉	Farmington Industrial Park
United States		USA-Farmington, CT 06032
Etats-Unis	☎	8 60/2 55-60 00
	☎	int. +1 8 60/2 55-60 00

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