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## Product identification

These operating instructions apply to the laser cutting system

### - BYTUBE

These operating instructions are intended for owners and operators of the machine and for maintenance and repair personnel. They must be freely accessible to these persons. The laser cutting machine is CE compliant.

## Other documentation

The Bytube operating manual is part of the complete set of documentation for the laser cutting machine, They comprise the following documents:

- Bytube operating manual
- Laser operating manual
- Spare parts catalogue
- Diagrams
- Supplier documents
- Machine documentation
- Machine logbook

## Online Help facility

The Online Help facility is part of the controller and programming software of the laser cutting machine. It provides more detailed information not included in the operating instructions.

## Document identification

**Order No.:** BYTUBE\_BA\_V02\_DE

Please always quote the order number and version number of this operating manual when reordering.

Please notify us of any errors or any suggestions for changes, at:

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## Contents of operating manual

Chapter 1	Product specification
Chapter 2	Safety regulations
Chapter 3	Design and operation
Chapter 4	Operating and display elements, operating modes
Chapter 5	Commissioning *
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Chapter 9	Decommissioning the system *
Chapter 10	Packaging and transport *
Chapter 11	Disposal
Chapter 12	Cutting technology

\* = not included in this operating manual

**This operating manual must  
be kept readily accessible for  
everyone at the machine.**

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The graphic features a large, stylized black letter 'C' on the left and a large black number '1' on the right. Behind the '1' is a square image of a world map with orange continents and blue oceans. A laser cutting machine head is positioned over the map, with a yellow laser beam pointing towards the center of the globe. Below the 'C' and '1' is the word 'CHAPTER' in a black, serif, all-caps font.

# C1 CHAPTER

## **Product specification**

The «Product specification» chapter contains general information on the laser cutting machine, its purpose of use, safety precautions, danger areas, work stations, etc. It also contains specification data and information on the equipment fitted.

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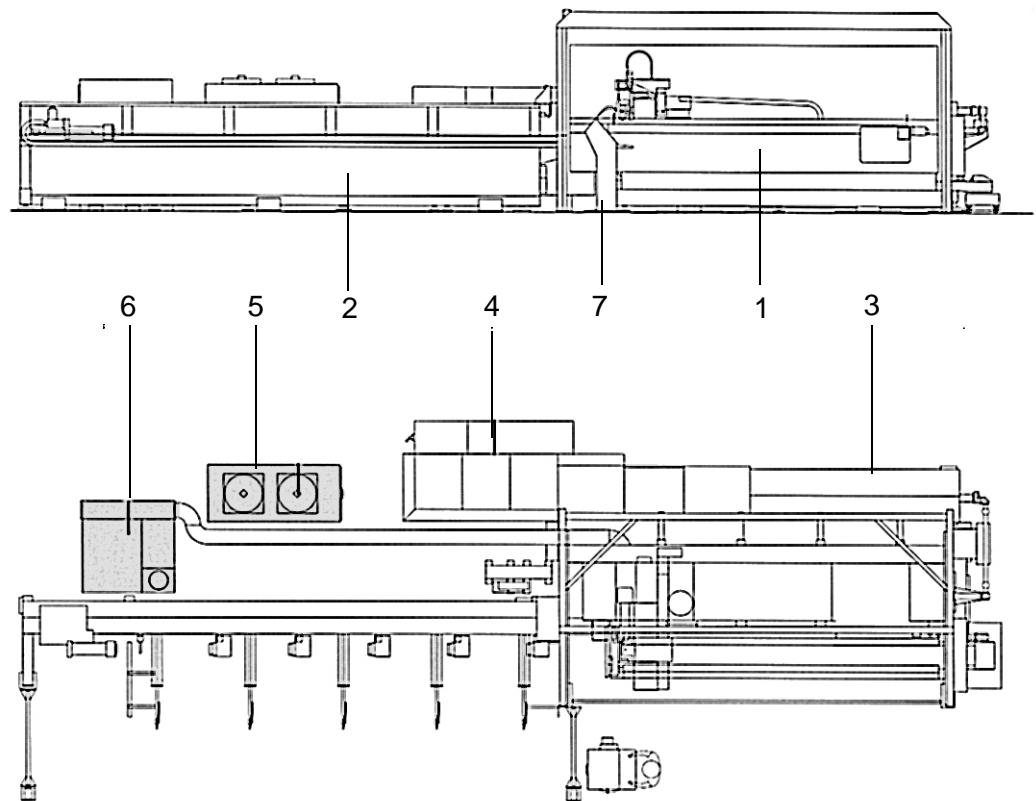
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## 1.1 Introduction

### 1.1.1 Overall view

Fig. 1.1 -1 Overall view of Bytube machine



The machine consists of the following components:

1. Laser cutting machine
2. Tube loader
3. Laser module
4. Control cabinets
5. Cooling unit
6. Exhaust air filter
7. Operating terminal



Fig. 1.1 -2 BYTUBE laser cutting machine



## 1.1.2 Machine components

### 1.1.2.1 Base frame

The base frame of the laser cutting machine bears the machining unit and the beam guidance system

### 1.1.2.2 Machining unit

The machining unit consists of the cutting bridge and cutting carriage.

### 1.1.2.3 Cutting bridge

The cutting bridge moves along the X-axis, longitudinal to the work piece.

The cutting bridge bears the carriage.

A mirror in the cutting bridge deflects the laser beam into the cutting carriage.

### 1.1.2.4 Cutting carriage

The cutting carriage moves along the Y axis.

A mirror in the cutting carriage deflects the laser beam in a vertical direction down towards the cutting head.

### 1.1.2.5 Cutting head

In order to cut, the cutting head is lowered along the Z-axis until there is a small gap between nozzle and work piece.

During breaks in cutting, this gap is increased by the cutting head moving back a suitable distance.

When cutting sections, the gap is held constant using a sensing device.

The cutting head is the final element of the beam guidance system. The built-in lens focuses the laser beam to the required power density. The basic kit includes 2 cutting heads with focal lengths of 5" and 7½".

Assist gas is supplied in the cutting head:

- During cutting the gas drives molten material out of the cut gap and prevents the focusing lens from being damaged by splashes of slag.
- The flow of assist gas is shaped by the nozzle so that the greatest possible percentage of the gas flows through the cut gap.

### 1.1.2.6 Detection

The nozzle must be at a constant distance from the work piece in order to achieve optimum machining quality. There are two options for measuring the distance between the nozzle and the work piece:

- Capacitive detection is normally used, where the electrical capacitance between nozzle and work piece is measured. Capacitive detection can only be used for electrically conductive materials.
- Tactile detection, which works by making contact with the work piece, can be used to sense all types of material. Tactile sensing is used primarily for non-conductive materials.

The distance between nozzle and work piece is adjusted to a predefined value by measuring the nozzle clearance and moving the Z-axis accordingly.

### 1.1.2.7 Travel unit

The guide, which is mounted on the base frame, carries a travel unit, which can take a lance, tray or support. The travel unit is referred to as the A-axis.

For manual loading ("conventional" operating mode) the guide can carry a tailstock.

### 1.1.2.8 Rotary axis

The rotational axis (U2) is supported by a plate on the base frame. A steady rest for circular-tubes and one for hollow rectangular tubes are provided for machining various cross-sections. A four-jaw chuck cannot be fitted in the "conventional" operating mode. The driven steady rest runs synchronously with the U-axis of the tube loader.

#### 1.1.2.9 Tube loader

Automatic loading is performed by a tube loader. Tubes and hollow sections are held in a tube magazine. A feed unit (X2-axis) pushes the tubes into the machining area. The rotational axis U provides the tube rotation.

#### 1.1.2.10 Control cabinet

The control box contains:

- Power switch
- Supply
- Power distribution system
- Safety circuits
- Programmable logic controller (PLC)
- CNC controller
- Drive modules for the main axes

The programmable controller controls the safety functions and the safety gate. It can also control optional components such as the lance, support or tailstock.

The CNC controller converts cutting plans (nested parts geometries) and process parameters into axis movements. It controls the path of the laser beam by a combination of movements of the cutting bridge, carriage, work piece and rotational axis. It automatically adjusts the cutting speed, assist gas, pressure and laser power to suit the contours of the parts geometry.

The machine works through the programs independently of when program input is made.

The CNC controller communicates with the operator by means of the MMC software. The MMC software is installed on the PC in the operating terminal. The hot keys <Shift> and <F1> can be used to open a software Help facility from the MMC Software.

#### 1.1.2.11 Operating terminal

The operator terminal is the interface between operator and machine. The PC in the operator terminal is available for creating and editing geometries while the machine is in the process of executing a program.

The CNC hand-held controller is mounted on the side of the terminal. An Emergency Stop button is provided for rapid shutdown of the machine in emergencies. Buttons for operating the safety gate are also provided here.

#### 1.1.2.12 Laser control cabinet

The laser control cabinet contains:

- Gas controller
- Laser controller
- High-voltage supply for laser excitation

In the gas controller, the laser gases are reduced to the correct pressure, mixed and fed to the laser. The laser controller starts the laser automatically on in manual steps. It controls and monitors the laser functions and, via the text display, provides information on the system pressure, power, discharge-path current, any faults and the operating status of the laser.

### 1.1.2.13 Laser module

The resonator, which generates the laser beam, is the heart of the laser module. The laser gas consists of a mixture of carbon dioxide, nitrogen and helium. The turboblower generates a rapid flow of gas in the axial direction of the resonator. The gas is cooled in pre- and post-coolers to ensure optimum power transfer from the applied high voltage to the laser gas. The laser is described in a separate operating manual.

### 1.1.2.14 Cooling unit

A large proportion of the electrical power consumed is converted into heat by the laser. This heat is removed via the cooling unit.

### 1.1.2.15 Operator protection

Operator protection includes the safety gate, light barriers and fixed barriers.

The safety gate is locked during cutting. It protects against:

- direct laser radiation
- reflected laser radiation
- splashes of material
- crushing risk

A safety light barrier provides protection against crushing in the tube magazine.

### 1.1.2.16 BYPOS adaptive optics

In machines with flying optics, the focal position changes. The greater the distance between the output coupler and the lens, the lower the focal point. The reason for this is the natural divergence of the laser beam. This results in a varying cutting quality over large work areas.

The adaptive optics system (BYPOS) is used to keep the focal parameters constant, irrespective of external influences such as a variable distance between the focusing lens and the laser source in machines using "flying optics", or even to adjust these focal parameters according to the process and work piece being used.

### 1.1.2.17 Crossjet

Crossjet prevents too much heat from building up during start-of-cut piercing. A thin oil film is applied to the work piece from a jet.

If working without oil, compressed air can be used to blow away splashes of metal.

Crossjet can also be operated with water in order to cool the work piece.

**1.1.2.18 Bysoft programming software**

The Bysoft software module can be used to create parts geometries and to generate cutting plans. The software can be used either on an operator terminal or on an external workstation. The Bysoft programming software is described in a separate operating manual or in an Online Help in the application.

**1.1.3 Power supply and resources**

The wiring, gas, pneumatic and cooling-water diagrams are held in the "Diagrams" folder.

**1.1.3.1 Pneumatic system**

- The supply unit provides a treated supply of compressed air.
- Filtered air is blown into the beam path, setting up an excess pressure that prevents moisture and dirt penetrating.
- The exhaust air filter and tube loader have a separate compressed-air supply.

**1.1.3.2 Cooling water**

Cooling is used to achieve a constant operating temperature in the laser. A preset temperature is necessary for optimum power transfer. The laser control cabinet, CNC control cabinet, machine mirror and cutting head are also cooled.

**1.1.3.3 Electrical supply**

The machine has a central supply point. The exhaust filter has a separate mains supply.

**1.1.3.4 Gases**

The gases are stored in gas bottles, sets of gas cylinders or sometimes in tanks.

Assist gases affect the machining quality. The laser gases are a critical factor in the laser operating performance. You must therefore comply with the specified gas qualities.

### 1.1.3.5 Tools

Tailstock	Centering cone for circular tubes 20-120 mm
	Centering cone for circular tubes 115-320 mm
	Nose piece for rectangular tubes, diagonal length 20-320 mm
Lance	Lance unit, internal diameter up to 100 mm max. parts length up to 500 mm
Support	Rest for circular tubes 20-170mm
	Rest for rectangular tubes according to customer specification (max. external diameter 170 mm)
Mounting plate	Plate for mounting on the guides of the travel unit
Table	A cutting table is available for cutting flat parts

### 1.1.4 Purpose of use and cutting range

The Bytube laser cutting machine has been designed to machine

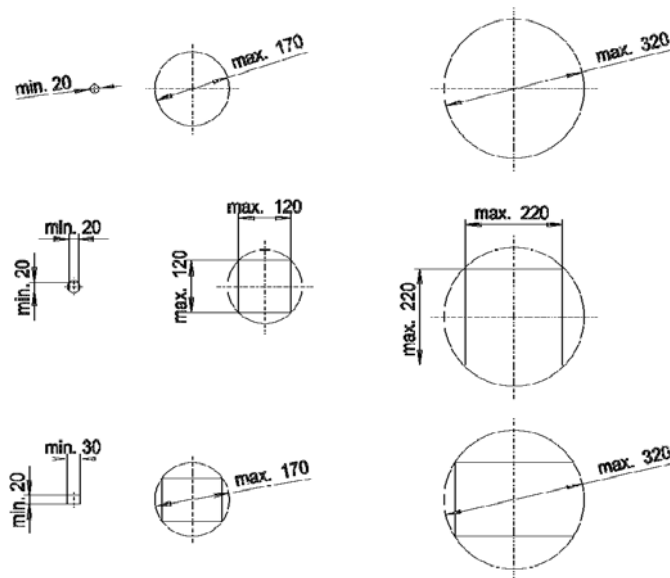
- circular tubes
- square hollow sections
- rectangular hollow sections
- flat parts up to a sheet width of 400 mm can be cut.

The primary machining technology is cutting by means of a laser.

Auxiliary functions are engraving and setting of weld points.

#### 1.1.4.1 Cross-section

Fig. 1.1 -3 Cross-section from the tube loader / in manual operation



#### 1.1.4.2 Tube length on delivery

	Flex mode	Hybrid mode
BYTUBE 3204	3000 mm	6500 mm
BYTUBE 6504	6000 mm	6500 mm

Special length using right-hand end stop: 2000 mm

#### 1.1.4.3 Materials

The laser cutting machine and its exhaust-air filter system are designed for the cutting of

- steel,
- aluminum



- titanium,
- brass,
- tubes and sheets covered by protective foil

### NOTE



*Materials that produce toxic vaporization gases require additional filters in the extraction unit or special extraction units. Please obtain the relevant information from the manufacturer of the material concerned.*

The machine has a state-of-the-art design. The safety standards specified in the EC Machinery Directive have been implemented.

Nevertheless, the machine still represents a risk to life and limb if it is not used properly and in accordance with regulations.

- The operating, maintenance and servicing instructions described in the operating manual must be followed.
- The machine must only be operated, maintained and repaired by persons trained in this work and instructed as to risks.
- The relevant accident prevention regulations and other generally recognized industrial health and safety rules must be observed.

### NOTE



*Any change in the agreed purpose and/or the agreed basic conditions without written approval by the manufacturer is at your own risk!*

### 1.1.5 Safety precautions

Only those materials permitted for this machine must be machined. For further information please see the order confirmation.


Danger to life and limb and damage to the machine can occur if it is used or operated improperly!

For this reason the following are forbidden:


- Transportation of persons,
- Unauthorized modifications or additions,
- Machining of materials not permitted for the machine,
- Remaining inside the danger zone.

**No liability will be accepted for any damage resulting from improperly executed repair or maintenance work.**

### 1.1.6 Danger zones

	<div><b>⚠ DANGER</b></div> <p>No-one is permitted to remain inside the machining area or within the light barrier whilst the machine is in operation. There is acute danger to life!</p>
---	---

The workstation must be arranged so that the operator is not at risk from, or hindered by, the transportation of work pieces to and from the machine. Open access to the Emergency stop buttons on the PPC must be guaranteed.


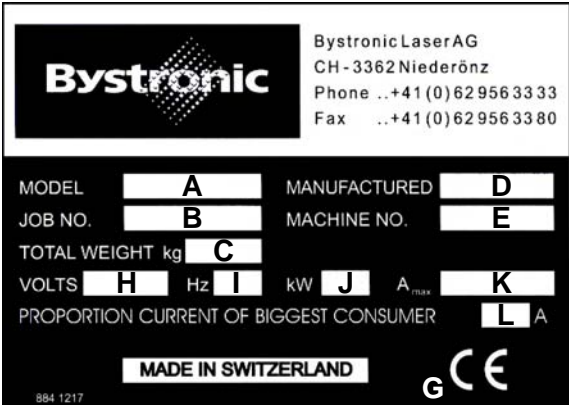
	<div><b>⚠ CAUTION</b></div> <p>Risk of crushing when loading the tube loader. Wear protective gloves! When loading the tube loader, ensure that there is no one in the danger zone.</p>
---	--

### 1.1.7 Conformance

The machine meets the relevant basic health and safety requirements of the EC Machinery Directive.

### 1.1.8 Product labeling

The machine type plates are located on the machine frame, on the cutting bridge and on the side wall of the CNC cabinet.

Type plate	Position
	<p>On the machine frame</p> <p>On the cutting bridge</p>
	<p>On the CNC cabinet</p>

A.	Machine name	G.	CE conformance mark
B.	Job number	H.	Mains voltage
C.	Total weight of machine in kg	I.	Mains frequency
D.	Date of manufacture	J.	Power
E.	Machine serial no.	K.	Peak current
F.	Max. weight of the material in kg/m <sup>2</sup>	L.	Rated current

## 1.2 Product data

### 1.2.0.1 BYTUBE 3204/6504 machine data

Max. tube length at delivery	mm	6500 (7700)
Tube storage: number of tubes on support	Qty	6
Work area		
X-axis	mm	3250 / 6500
Y-axis	mm	400
Z axis	mm	170
Tube outer diameter		
From tube feed	mm	20 - 170
Special section tubes min.	mm	20x20
Special section tubes, max. diagonal length	mm	170
Placed manually in the cutting area		
Circular tubes max.	mm	320
Rectangular tubes, max. diagonal length	mm	320
Tolerances in the length	mm / m	± 0.1

### 1.2.0.2 Assist gas

The level of consumption depends on the material and wall thickness of the hollow section.

Supply values

N <sub>2</sub> dynamic	25 bar (1600 l/min.)
N <sub>2</sub> static	max. 30 bar
O <sub>2</sub> dynamic	18 bar (500 l/min.)
O <sub>2</sub> static	30 bar
O <sub>2</sub> dynamic	10 bar (300 l/min.)
O <sub>2</sub> static	30 bar
Machine connection (diameter):	12 mm
Assist-gas pressure in nozzle:	0.1 bar to 20 bar

### 1.2.0.3 Laser gas

Supply values

Helium (min. purity: 99.996%)	5 bar (27 l/h.)
Nitrogen (min. purity: 99.999%)	5 bar (12 l/h.)
Carbon dioxide (min. purity: 99.995%)	5 bar (2 l/h.)

### 1.2.0.4 Compressed air values

#### NOTE



*Air taken in by the compressor must not contain any solvent vapors or aerosols. An oil-free screw compressor with a downstream compressed air treatment system (air drier) is required in order to ensure that there is no risk of contamination from the compressor. The air distribution network must be free from contamination and must not contain any oils.*

*If the above requirements cannot be met, a supply of compressed air or nitrogen must be connected from a bottle or a tank for ventilating the output-coupler and beam path. Likewise, a separate screw compressor with a compressed-air treatment system (air drier) can be used for ventilation.*

### 1.2.0.5 Machine

Minimum inlet pressure	6 bar
Connection	G ½
Maximum consumption	50 Nm <sup>3</sup> / h
Minimum compressed air quality at machine input	ISO 8573-1
Maximum particle diameter (Class 4 or better)	5 µm
Maximum particle density (Class 4 or better)	5 mg/m <sup>3</sup>
Maximum residual oil content (Class 3 or better)	0.1 mg/m <sup>3</sup>
Compressed-air dew point	3° C
Max. temperature of compressed air on entering maintenance unit.	40° C

### 1.2.0.6 Dust removal unit

#### NOTE



*The compressed air admitted must be clean and dry and must contain minimal oil. Where necessary, oil and/or water filters should be fitted as close as possible to the filter unit.*

Minimum inlet pressure	5.5 bar
Connection	G 1/2
Maximum consumption	27 Nm <sup>3</sup> / h
Residual oil content of the compressed air	< 5 mg/ m <sup>3</sup>

Supply connection:	3 phase & PE
Mains frequency:	50Hz /60Hz
Supply voltage:	3x400V / 3x480V
Maximum voltage tolerance:	+6% / -10%
Fuse:	25 AT
Connected load:	6.7 kW
cos (φ)	0.91

**1.2.0.7 Electrical connections****NOTE**

*The power supply must not be subject to frequent voltage fluctuations, or voltage spikes or dips outside the full mains tolerance range, such as can be eberated by spot-welding machines etc.*

*Equipment and machinery operated on the same mains must comply with the relevant EMC standards.*

Supply connection:	3 phase & PE	
Mains frequency:	50Hz	60Hz
Supply voltage:	3x400V	3x480V
Maximum voltage tolerance:	+6% / -10%	+5% / -10%
Fuse:	100AT	
Connected load:	54kVA	
cos (φ)	0.87	

**1.2.1 Environmental conditions**

The temperature in the factory hall must lie between 15 °C and 35 °C. No parts of the system should be exposed to direct sunlight.

If operated in tropical climates or workshop temperatures exceeding 35 °C, an air-conditioned room is required.

The dew point of the surrounding air must be below 10 °C in order to prevent condensation on the cooled parts of the system.

The machine must be placed on a low-vibration base in order to achieve a constantly good cutting result.

Fumes, e.g. from paint sprayers or solvents, can absorb the laser light and thus impair the machine performance. Moreover, such fumes constitute a severe risk of explosion in combination with the laser beam.

**1.3 Equipment****1.3.1 Model versions**

The machine described in the operating manual has a cutting area of length 3250 mm for machine type 3204, and of length 6500 mm for the 6504 version. Optional attachments are available. Please refer to your confirmation of order for more details.

The graphic features a large, stylized black letter 'C' on the left and a large black number '2' on the right. Behind the '2' is a small image of a globe with orange continents and blue oceans. Above the globe is a small, detailed image of a machine component, possibly a sensor or actuator, with a yellow warning triangle on its front. Below the '2' and the globe image, the word 'CHAPTER' is written in a black, serif, all-caps font.

## CHAPTER

### **Safety regulations**

Please read the “Safety regulations” chapter before you start working on the machine. This chapter describes important safety precautions for the protection of personnel and machine.





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## 2.1 Warning signs and symbols

	<b>⚠ DANGER</b>
	Immediate risk of severe injuries or death.

	<b>⚠ WARNING</b>
	Potentially dangerous situation leading to severe injuries or death

	<b>⚠ CAUTION</b>
	Potentially dangerous situation leading to minor injuries or damage to property

### HINWEIS



*Indicates technical features of the machine or control unit that the operating and maintenance staff must be aware of.*

### TIP



*Indicates useful tips on specific topics.*



1. Explains handling or the steps involved in an activity.
- 2.
- 3.



- This symbol describes actions or settings that must be made.
-

## 2.2 Product safety

The machine has a state-of-the-art design. It conforms to recognized safety regulations and the EU Machinery Directive.

Nevertheless, the machine still represents a risk to life and limb if it is not used properly and in accordance with regulations.

Safe working is guaranteed provided:

- you follow the Operating Instructions
- you are trained in the use of the machine
- you keep unauthorized persons away from the work area
- you refrain from any mode of work that impairs safety
- faults which impair safety are immediately rectified
- maintenance intervals are complied with.

The machine is used for the industrial cutting and engraving of sheets.

The extraction system is designed for steel, aluminum, titanium and brass.

Materials that produce toxic vaporization gases require special extraction units or additional filters.

Please consult Bystronic before machining such materials.

Any change in the agreed purpose and/or the agreed basic conditions without written approval by the manufacturer is at your own risk.

**Operate the system only in a proper state.**

## **2.3 Danger zones**

### **2.3.1 Workplaces, danger zones**

For detailed information concerning this machine please see Chapter 1, "Product description".

### **2.3.2 Safety and monitoring devices**

These devices are for your safety and must not be dismantled, bridged or bypassed.

The machine components are driven automatically by electrical and pneumatic drives. It can be dangerous to life and limb to remain inside the safety devices whilst the machine is in operation. For this reason:

**Never remove or  
switch off safety devices!**

Further information can be found in Chapter 3, "Design and operation".








### **2.3.3 Warning signals**

Information on the functioning of the «EMERGENCY STOP» devices can be found in Chapter 3, "Design and operation".

Chapter 4, "Operating and display elements", modes contains information on the location and meaning of the warning signals.

### 2.3.4 Warning and advice labels

Signs must be permanently affixed and legible. Do not change the position of labels when replacing them.

Symbol	Description	Position
	High voltage warning	Guard plate in MCS cabinet Protective cover on resonator
	Laser radiation warning	On the machine cutting head On the resonator
	Focal length of cutting head in inches	On the machine cutting head
	Electrical voltage warning	On the control cabinets of the machine
	Wear a light breathing mask	Dust removal unit
	Warning notice	Dust removal unit
	Hand injury warning	

## **2.4 Organization, personnel**

### **2.4.1 User classification**

We refer to all people who work with or on the machine as users.

Requirements placed on users vary depending on the actions they must perform. We therefore classify users according to the following roles:

#### **2.4.1.1 Owner**

The term "owner" is used to describe the signatory to the agreement with the manufacturer, or their representative. The owner is authorized as legally-binding signatory to agreements. He/she procures the machine and provides the conditions for its proper use.

#### **2.4.1.2 Operator**

The term "operator" refers to a person trained to operate the machine. The operator operates and looks after the machine in normal operation.

#### **2.4.1.3 Mechanic**

The term "mechanic" refers to a skilled person with training in mechanical or electrical engineering. The mechanic maintains the system, services it and carries out repairs as necessary.

### **2.4.2 Qualifications**

Only persons trained and instructed to do so by the owner may work on the machine. Personnel are responsible for third persons in the work area.

Training of the operator includes participation in a training course at the manufacturer's premises or at the site of use of the machine.

Personnel still requiring training, instruction or teaching are only allowed to operate the machine under constant supervision by an experienced person.

### **2.4.3 Responsibility**

Responsibility for the various activities on the machine must be laid down and followed. Undefined responsibilities are a safety risk.

The owner must provide the operator and mechanic with access to the operating manual, and ensure that it has been read and understood.

### **2.4.4 Protective clothing**

Where necessary, provide personal protection equipment (safety boots, protective gloves, etc.) and instruct personnel in its use.

### **2.4.5 Obligation to report faults**

Any faults in the machine must be reported to the immediate supervisor.

### **2.4.6 Modifications and alterations**

Structural modifications to the machine are prohibited for safety reasons.

### **2.4.7 Safety-conscious working**

Work on mechanical or electrical equipment must be carried out solely by qualified staff or under their supervision.

Staff responsibility for operation, set-up, maintenance and repair must be clearly defined. Ensure that only authorized personnel operate the machine.

Work on electrical equipment must be performed solely by trained electricians according to electrical engineering regulations.

Work on technical gas fittings must be performed solely by trained personnel.



## 2.5 Product-specific hazards

### 2.5.1 Laser radiation hazards

#### 2.5.1.1 Normal mode

In normal operating mode the machine corresponds to **Laser Class 1** (fully screened laser radiation). All covers must be fitted. Do not bypass any interlocks


The safety gate protects you from reflected and stray radiation. It is not necessary to wear safety goggles to protect yourself from reflected and stray radiation. However, wear goggles with an antidazzle filter if you observe the cutting beam for a prolonged period!

#### 2.5.1.2 Service mode

In service mode the machine corresponds to **Laser Class 4**. The direct laser beam, as well as reflected or stray radiation, is dangerous for eyes and skin. Fence off the laser zone. Cover or remove any reflective objects. Remove any combustible objects and prevent generation of explosive solvent fumes.

Please refer to Chapter 4, "Operating and display elements", operating modes for a precise description of the operating modes.

#### 2.5.1.3 Direct laser beam

	<b>⚠ WARNING</b>
	<p style="text-align: center; margin: 0;"><b>Laser Class 4</b></p> <p style="margin: 0;">The direct laser beam can cause life-threatening injuries to the whole body</p>

Therefore, observe the following points when working with laser radiation:

- Never intentionally expose yourself to direct laser radiation.
- Never change the way optical elements are mounted.
- Follow the instructions in the operating manual in order to protect yourself from direct laser radiation.

#### 2.5.1.4 *Reflected and stray radiation*

Avoid radiation in eyes and on skin due to reflected and leakage radiation.

Special laser safety glasses must be worn without fail for alignment and setup work in the optical area when the laser module is switched on. These glasses must be labeled as complying with regulations EN207:1998 stage 5 (also referred to as D5).

The safety glasses provide adequate protection from reflected and stray radiation from the CO<sub>2</sub> laser; they can also withstand the effect of the direct beam for up to ten seconds.

These safety glasses can be obtained from specialist stores or from the manufacturer.

#### 2.5.2 Electrical power hazards

**Work on electrical systems or equipment must be performed solely by trained electricians or under their guidance.**

	<div> <b>WARNING</b></div> <p>Work on electrical installations and equipment can cause life-threatening physical injuries.</p>
--	--

Observe the following points when working on electrical installations or equipment:

- Only use original fuses with the prescribed amperage. Switch the machine off immediately in the event of a fault in the electrical supply.
- Parts on which you are performing maintenance work must be powered down unless otherwise specified. First, check that exposed parts are de-energized, then ground and short-circuit them, and insulate any adjacent live parts.
- Inspect electrical equipment regularly. Faults such as loose connections or charred cables must be remedied immediately.
- When working on live parts, another person must be involved who can operate the Emergency Stop or power switch in an emergency. Block off the work area with a red and white safety chain and a warning sign. Always use insulated tools.
- When working with high voltage components, connect the supply cable to ground after switching off the power supply, and short circuit components, for example capacitors, with a grounding rod (MCS cabinet).

### **2.5.3 Pneumatic power hazards**

Inspect loads, valves, hoses regularly for leaks.

Depressurize sections of systems to be opened before starting maintenance and repair work.

Do not perform any assembly or disassembly work, or unscrew or tighten any screw connections, while the system is under pressure. There is a risk of injury from flying parts and escaping air.

### **2.5.4 Hazards due to gas, dust, smoke**

If there are leaks in the gas supply, escaping oxygen can combine with a naked flame to cause deflagrations. Check the lines on the gas supply are connected correctly.

Please see the «Laser Operating Manual» for further information on the gas supply and its attendant hazards.

The gases given off when cutting are filtered by an extraction system. Check that the extraction system is working properly if any smells are noticed during cutting.

Observe the maintenance intervals specified in the maintenance schedule to avoid the risk of inadequate gas extraction.

Ensure that there is sufficient ventilation when working in confined spaces. Observe national regulations where necessary.

### **2.5.5 Hazards associated with handling the optical system**

#### **2.5.5.1 General information**

The output coupler for the laser beam, and the lens in the cutting head are made of zinc selenide (ZnSe). When intact, the lenses pose no danger. However, toxic fumes are generated if thermal decomposition of a lens occurs. In addition, damage to the coating allows the escape of thorium fluoride, which is slightly radioactive.

#### **2.5.5.2 Warnings in case of fire or accident**

ZnSe is not combustible. Thermal decomposition sets in at temperatures above 400°C, releasing toxic fumes and dust particles. In the event of an accident, it is imperative to ventilate the working environment thoroughly. Wait until dust has settled before starting cleaning work. Avoid stirring up dust at all costs. Breathing mask and gloves must be worn during cleaning without fail. Defective lenses must be returned to the manufacturer in a sealed container.

ZnSe is not a water contaminant. Avoid spreading dust.

**2.5.5.3 Notes on health protection**

Nature of effect and toxicity: ZnSe has low acute toxicity. ZnSe vapors can cause breathlessness. ZnSe dust can cause irritation to the eyes and respiratory passages. Skin irritation is possible after prolonged and repeated contact.

First aid: if inhaled, remove the victim from the hazard area. Provide sufficient fresh air. Call doctor in event of breathlessness.

For further information, please refer to the safety data sheets on zinc selenide and thorium contained in the "Supplier Documents" folder.

**2.6 Additional hazards**

Unauthorized structural modifications to the machine are prohibited for safety reasons. When replacing defective parts, only use original spare parts or standard parts approved by the manufacturer.

Do not modify programmable control systems (software).

Laser machines must not be integrated into existing systems without the knowledge and consent of the manufacturer.

Always observe the manufacturer's safety instructions when handling working materials, particularly oil and grease. Relevant information can be found in the «Supplier Documentation» manual.

**2.7 Information for emergencies**

For personal injury:

- take first-aid measures
- notify a doctor
- inform immediate supervisor
- observe national and company regulations



## CHAPTER

### **Design and operation**

This chapter provides information on the design of each of the equipment modules in the laser cutting machine.

Operation of the equipment is dealt with under the module concerned.

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### **3.1 Introduction**

A Bytube laser cutting machine contains the following equipment modules:

- Tube loader containing
  - Tube magazine
  - Pillar rests
  - Gripper
- Machining area containing
  - Cutting bridge
  - Cutting carriage
  - Cutting head
  - Steady rests /Chuck
  - Travel unit
- Laser module
- Laser cabinet
- Control cabinets
- Supply unit
- Safety gate
- Operating terminal
- Hand-held controller

The laser module and laser cabinet are described in a separate operating manual, while the operating terminal and hand-held controller are dealt with in the next chapter.

Operation of the equipment is dealt with under the module concerned.



## 3.2 Safety and monitoring devices

Protective measures have been put in place at danger spots according to the safety regulations that apply to the machine.

It is the owner's responsibility to install the appropriate barriers and to check them regularly for proper functioning.

Protective and safety devices may only be removed, modified or put out of operation if this is absolutely essential for transportation and repair work, and if, for this work, appropriate measures have been taken to prevent risk to life and health of persons, and to prevent damage and breakage of structural parts.

Before putting the system into operation, it must be ensured that all protective devices are in place and that all danger zones are protected according to local safety regulations.

The following are included in the safety devices of the laser machine:

- «Emergency stop» button (described in chapter 4)
- Safety covers on tube loader
- Safety light barrier (tube loader)
- Laser machine safety gate

### 3.2.1 Safety light barrier

The light barrier protects against access to the danger area of the tube loader. As soon as the light beam is interrupted, the drives of the transport systems in question are switched off. The controller stores the last program step.

The following states are indicated by the illuminated reset button on the operating terminal:

**Button flashing:**

The light barrier circuit has been interrupted. Controller unit prompts to press the Reset button.

**Button permanently on:**

The light barrier circuit is in working order and active.

### 3.2.2 Safety gate

The safety gate can be opened and closed by pressing the buttons on the edge of the operator panel.

The safety gate can be opened to an intermediate position by pressing the button briefly. Pressing the button for longer than one second moves the gate to its limit of travel.

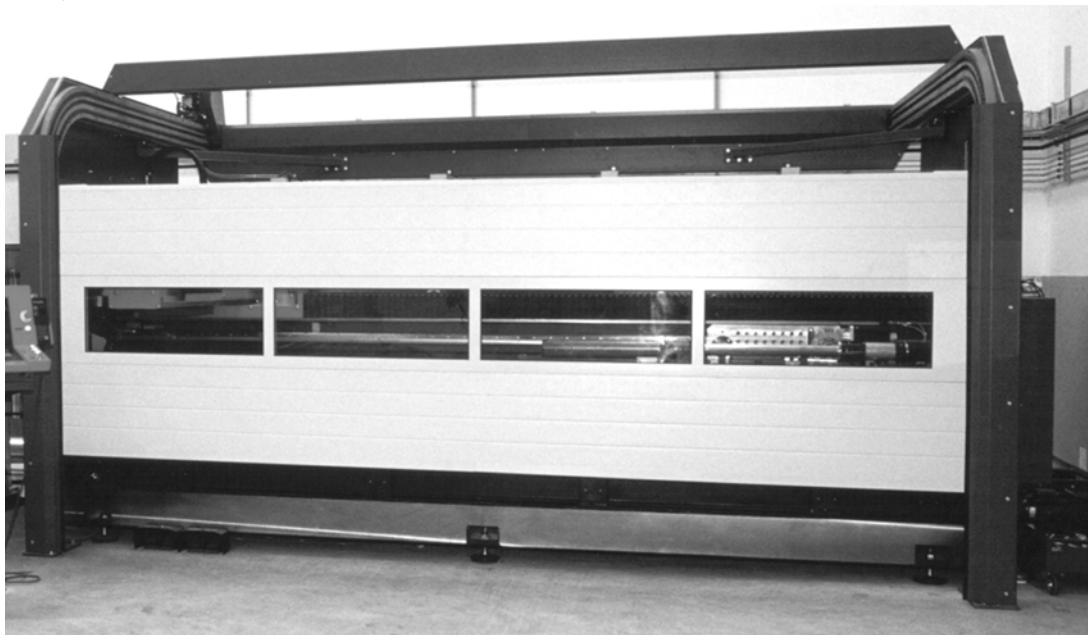
The button must be held down continuously to close the safety gate.

The gate moves at two speeds: normal and slow. The gate slows down shortly before reaching the limit of travel.

The safety gate is driven by a motor located at the back on a bracket on the safety cover. For the safety gate to be closed, both the limit switch at the lower of the guide and the switching tab in the top horizontal area of the guide must be actuated.

If the safety gate is open, the drives are de-energized and the U-axis / U2-axis is locked by a holding brake. This prevents any risk to the operator from uncontrolled movements of the axis.

*Fig. 3.2 -1 Safety door closed*



### 3.2.3 Safety covers on tube loader

The drive axes are de-energized when the safety covers are open (e.g. for adjustment tasks) so that they do not endanger the operator. Thus the safety covers on the automatic tube loader are monitored by non-contacting safety sensors. If the safety covers are opened during operation, then an "Emergency Stop CNC" occurs (equivalent to the "Emergency stop" mushroom-head button). The covers can only be opened once the safety gate on the cutting machine has been opened. After closing the covers and the safety gate, work can continue according to the cutting plan by pressing "CONT".

Fig. 3.2 -2 Tube loader safety cover with safety sensor



### 3.3 Control cabinets

#### 3.3.1 CNC cabinet

The CNC controller (CNC = Computer-Numeric-Control) is housed in the CNC cabinet.

The CNC controller converts plans and process parameters into axis movements. It controls the path of the laser beam by a combination of movements of the cutting bridge, the cutting carriage and the Z-axis. It automatically adjusts the travel speed and the laser power to the contours of the parts geometry.

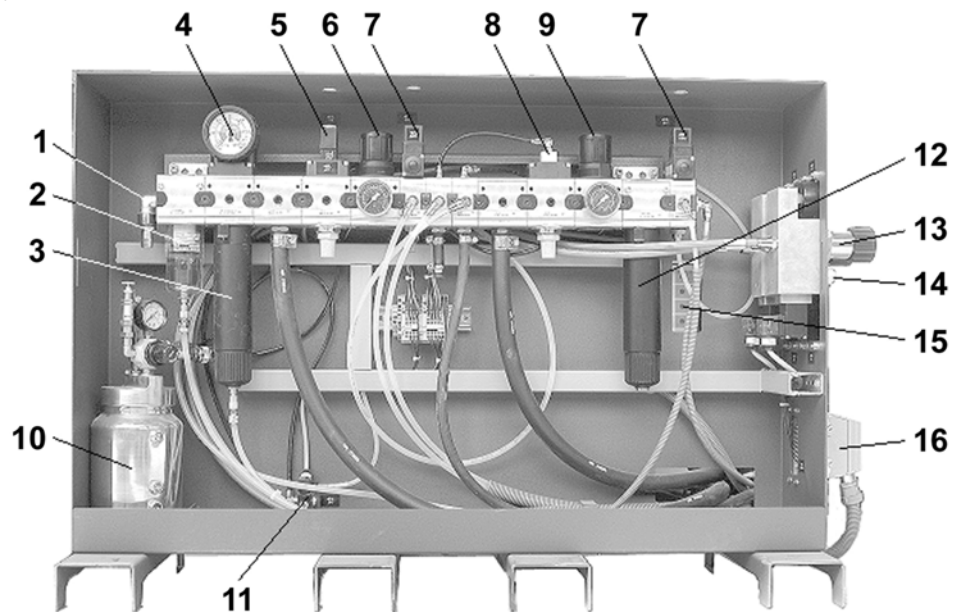
The machine works through the programs independently of program input. The operating terminal is available for creating and editing geometries while the machine is in the process of executing a program.

#### 3.3.2 STL cabinet

The controller and the safety functions are located in the SRL cabinet (SRL = Laser controller, tubes).

#### 3.3.3 Supply unit

Fig. 3.3 -1 Supply unit



1. Compressed-air connection
2. Water filter
3. Fine filter
4. Manometer

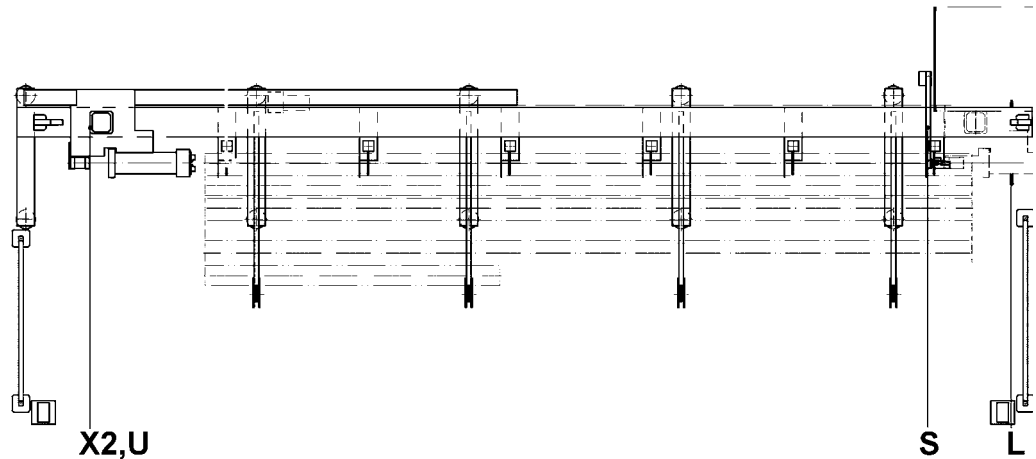
5. Compressed-air valve
6. Pressure regulator 6 bar
7. Compressed-air valve
8. Pressure switch 0.5 - 10 bar
9. Pressure regulator 2 bar (beam-path ventilation)
10. Pressure vessel, Crossjet oil
11. Stop valve (Crossjet)
12. Activated charcoal filter
13. Pressure regulator cutting gas N<sub>2</sub>/O<sub>2</sub>
14. Cutting gas connection 12mm
15. Opening for error display Ultrapac-filter
16. Connector electrical control

The containers for the drying-agent cartridges and the pre- and post-filters are located at the rear of the supply unit.

### 3.4 Tube loader

#### 3.4.1 Axis labeling

Fig. 3.4 -1 Axis labeling on tube loader



#### **X2, U**

- Feed unit X2 axis
- with rotary axis U
- with gripper

#### **S**

- Weld detection

#### **L**

- Light barrier for length measurement

### 3.4.2 Tube magazine

Fig. 3.4 -2 The tube magazine can hold 6 or 12 tubes.



The tubes must be placed in the gaps between pusher tabs. Tubes can lie at an angle within the pusher pieces on the chain. Rectangular tubes must lie on their broad side. They must also touch the left stop.

Tubes of length up to 2 m must lie against the right stop. "Short tubes" operating mode must be set to use this loading option. Longer tubes are detected by a switch and cannot be handled in the "short tubes" operating mode.

The tube magazine continues to cycle through the positioning steps until the switching tab in the limit switch "Tube in position" is actuated. The number of steps until the feed process is stopped can be defined in RS-View. The first tube to be machined must never be placed after the limit switch, otherwise the chain pushers will press against the rests. The stalled chain drive trips the motor safety switch.



3.4.2.1 Pillar rests

Tubes lying on pillar rests are raised until their longitudinal axis is aligned with that of the gripper.

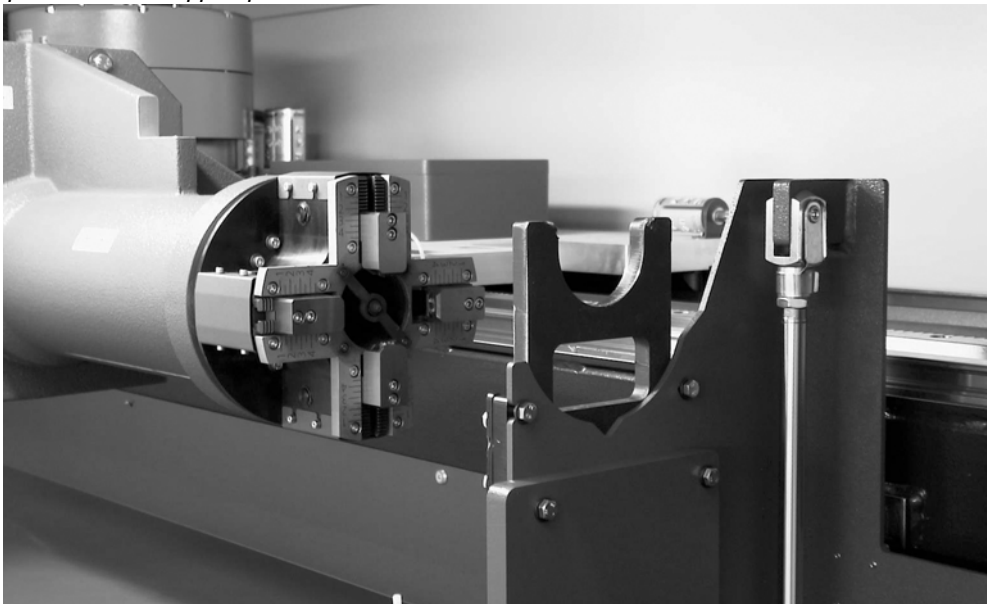
Fig. 3.4 -3 Tube loader with raised pillar rests



3.4.2.2 Support plates

Each pillar rest is fitted with a support plate or support roller whose form depends on the cross-section of the tube.

Fig. 3.4 -4 First pillar rest with support plate.



The first pillar rest takes only support plates (no support rollers, or vees fitted with ball bearings).

Support plate for square and rectangular sections	Support plates for circular tubes
The tubular sections must be able to rotate in the U-shaped recess.	The V-shaped recess ensures that the tubes are centered.



*Fig. 3.4 -5 Support roller for rectangular tubes*



Support rollers make it easier to feed the square and rectangular hollow sections forward. They prevent scratching of the work piece surface.

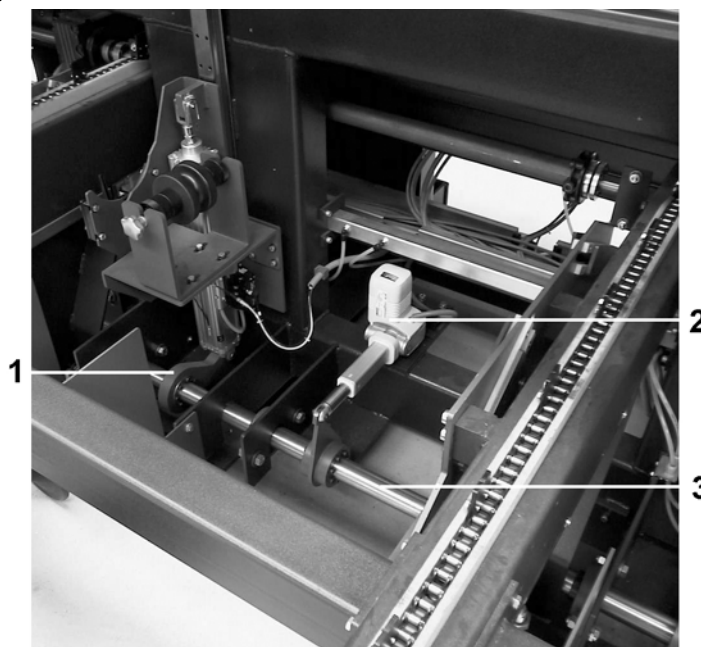
*Fig. 3.4 -6 Vee fitted with ball bearings for circular tubes*



### 3.4.2.3 Lifting-height adjustment device

The level to which the pillar rests need to lift a hollow section depends on its cross-section. The appropriate lifting height is achieved using a lever mechanism actuated by an electric motor.

Fig. 3.4 -7 View of lifting unit

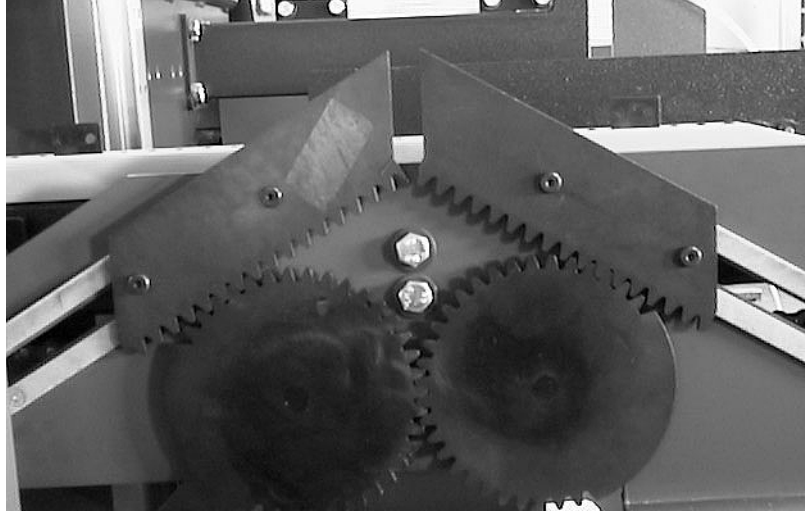


- 1 Pillar-rests lever
- 2 Actuating motor with lever
- 3 Synchronizing shaft

### 3.4.2.4 Centering mechanism for rectangular hollow sections

Square and rectangular tubes lying within the pusher tabs are placed precisely over the pillar rests by means of the centering mechanism, before being raised by the pillars with the appropriate inserts.

Fig. 3.4 -8 View of tube centering mechanism



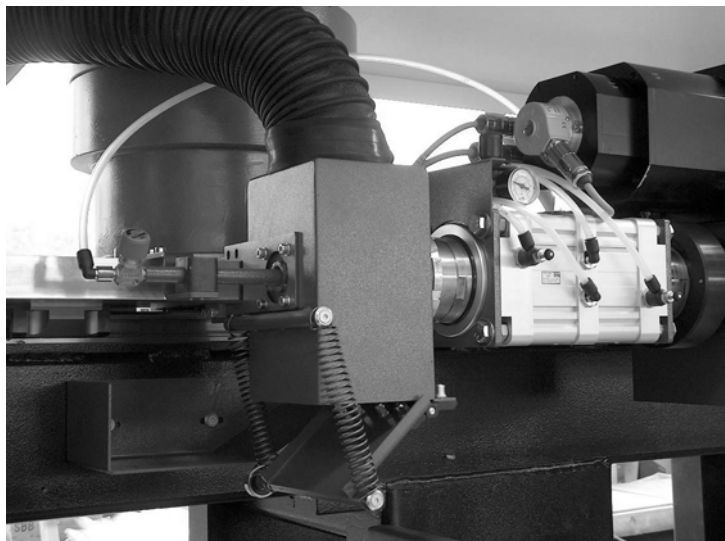
Circular tubes are centered by the wedge-shaped inserts when the pillar rests are raised (see Fig.«3.4 -6 »).

### 3.4.3 Feed unit drive (X2-axis / CNC)

The feed unit (X2-axis) pushes the tube into the machining area.

*Watch maximum possible tube dimensions.*

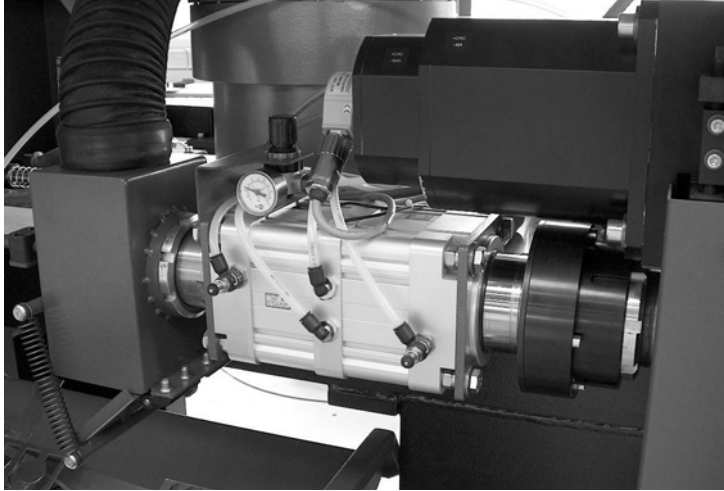
Fig. 3.4 -9 Feed unit with small parts hopper



### 3.4.4 Rotary drive (U-axis)

The rotary drive of the gripper is driven by a servo motor.

*Fig.3.4-10 Gripper rotary drive*

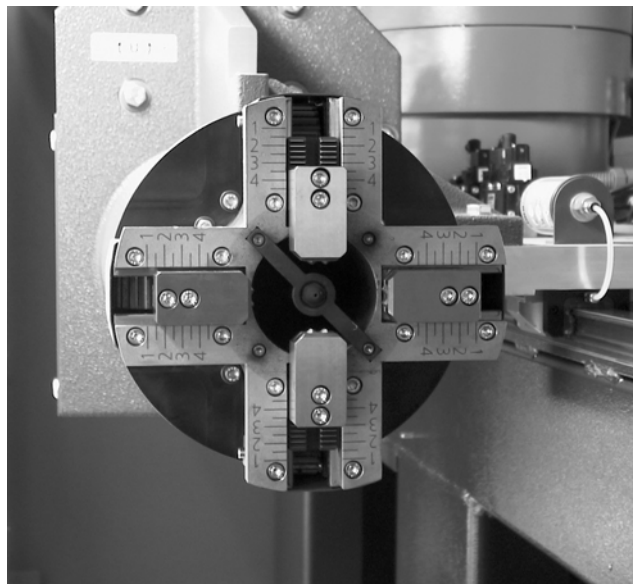


When the safety gate is open or the safety covers on the tube loader are open then all drives are de-energized. In order to prevent the axis rotating unintentionally when clamping a work piece, the axis is fitted with a holding brake that operates in the de-energized state, i.e. the axis cannot rotate with the safety gate open. To turn the axis, the safety gate must be closed and the axis moved with the hand controller.

#### 3.4.4.1 Gripper

The gripper jaws are operated pneumatically. The clamping force of the jaws can be varied.

*Fig.3.4-11 Gripper*



In the Setup menu, you can define whether the gripper is meant to clamp tubes from the inside or outside.

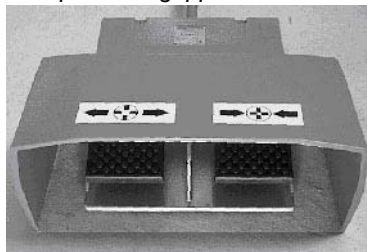
<b>Rectangular tubes:</b>	The adjustable parts of the jaws must all be set symmetrically with respect to the cross-sectional geometry (width and height of rectangular tube).
<b>Square sections / circular tubes:</b>	The adjustable parts of the jaws must all be set symmetrically.

The tube is pushed gently in front of the gripper to ensure it hits the end.

### 3.4.4.2 Foot pedal for gripper

The gripper can be operated using the foot pedal or from the operating terminal.

Fig.3.4-12 Foot pedal for gripper



### 3.4.4.3 Clamping the gripper

Jaws move towards the center.

- release work pieces held from inside
- clamp work pieces held from outside

	<b>⚠ Danger</b>
	<p><b>There is a risk of being crushed between the individual jaws and between the jaws and the work piece. Do not hold the work piece from the front. During setup work, do not lean against the jaws.</b></p>

### 3.4.4.4 Releasing the gripper

Jaws move outwards.

- clamp work pieces held from inside
- release work pieces held from outside

The clamping force of the gripper can be varied by means of a pressure-reducing valve (min. 2 bar). The necessary clamping force depends on the diameter of the tube and the wall thickness of the work piece.

**NOTE**

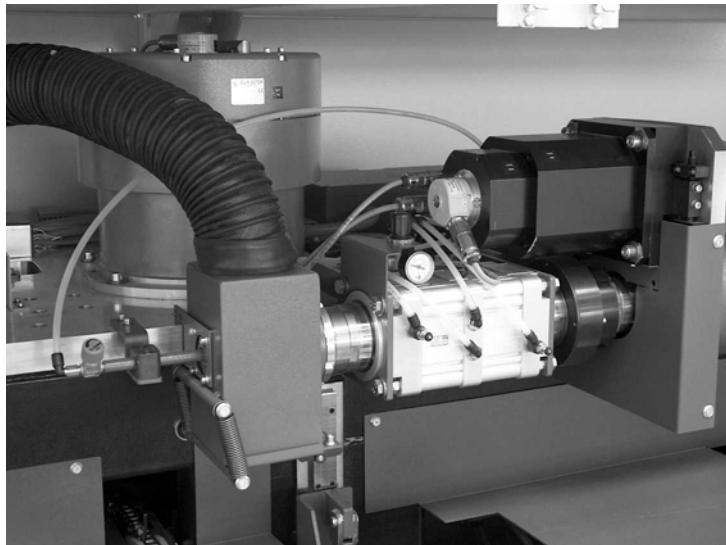
The dust produced during the machining process is also deposited inside the gripper, increasing friction and wear considerably. Thus if there is a loss of grip on the work piece, do not simply increase the pneumatic power but clean the gripper.

**3.4.5 Ventilation of the cutting tubes (extraction back-up)**

In order to cool small-diameter tubes and clear them of smoke, the tube can be ventilated from behind. To save air, ventilation is only active during the cutting process.

Instead of blowing in air, one can also extract air through the gripper towards the rear. In this case the air-supply valve must be completely closed.

*Fig.3.4-13 Tube ventilation valve*



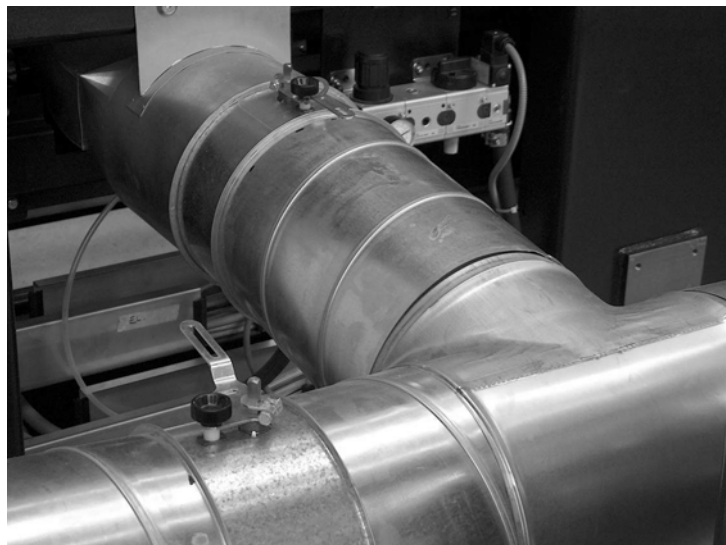


*Fig.3.4-14 Emptying the small parts hopper*



A small parts hopper is positioned at the end of the gripper to prevent the pipe being blocked by small waste parts that have been sucked backwards. The small parts hopper is always emptied whenever the X2 axis is referenced.

*Fig.3.4-15 Slide valves*



Slide valves in the suction piping (in the extraction unit) allow selective distribution and adjustment of the suction power (e.g. to extract air from behind the cutting head and through the gripper, the "tube ventilation" control valve must be closed).

### 3.4.6 Weld detection

Weld detection can be enabled / disabled in the Setup menu. Fluorescent adhesive tape must be applied to identify the weld seam.

Approx. 60 mm of adhesive tape must be applied about 120 mm from the end of the tube. The feed unit pushes the tube towards the machining area until it reaches the light barrier for measuring the length.

During the detection process, circular tubes are rotated through 360°. If the position of the weld seam is not detected, the detection process can be repeated with the "Cont" button. Square or rectangular hollow sections are rotated in steps of 90 ° between searches for the mark, the sensor being moved out of the way during each rotation.

The position of the weld seam is defined by saving the relevant angle of rotation.

The detection process can be interrupted using the "Abort" button. The cutting plan display disappears from the screen at this instant. Pressing the "CONT" button resumes cutting from the cutting plan (although the screen remains blank).

Fig.3.4-16 Weld detection



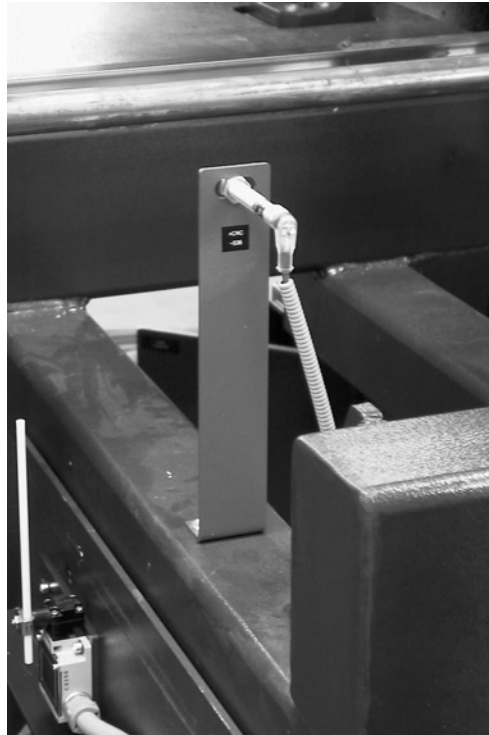


### 3.4.7 Light barrier for length measurement

When the hollow section is pushed towards the machining unit, the tubular section passes a light barrier. This is used to measure the length of the hollow section.

The cutting plan can be optimized using this information. For instance the cutting sequence can be altered or another suitable work piece inserted in the cutting plan in order to minimize the length of tube left over.

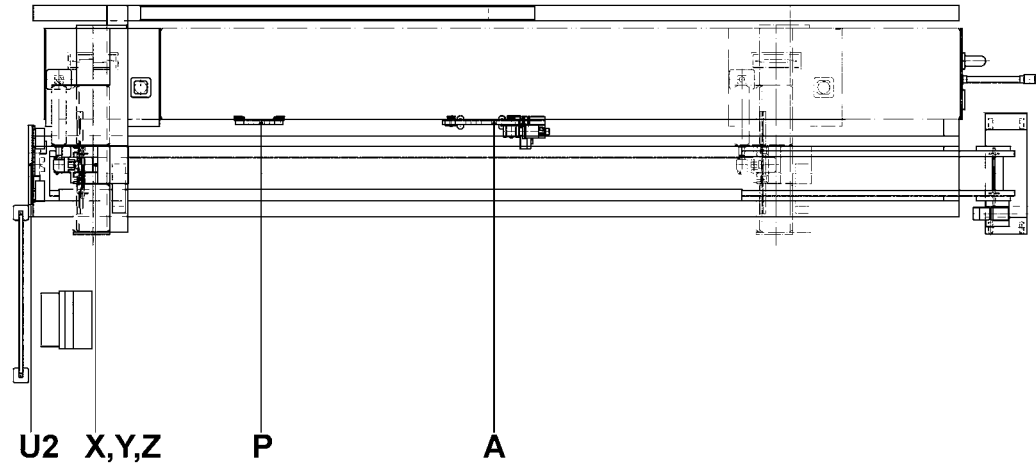
*Fig.3.4-17 Measuring the tube length*



## 3.5 Machining area

### 3.5.1 Axis labeling

Fig. 3.5 -1 Axis labeling on the laser cutting machine



#### U2

- Support plate with U2 rotary axis
  - with steady rest for rectangular tubes or chuck for Byflex operating mode
  - or with steady rest for circular tubes

#### X, Y, Z

- Machining unit X-axis
  - with cutting bridge Y-axis
  - with cutting head Z-axis

#### P

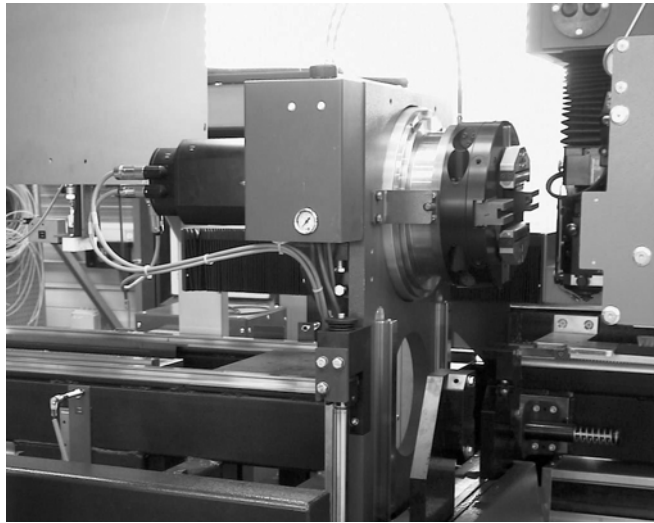
- Mounting plate
  - with guide for unstable tubes
  - or with tailstock

#### A

- Travel unit A-axis
  - with lance
  - or with support

### 3.5.2 Rotary axis U2

Fig. 3.5 -2 Rotary Axis

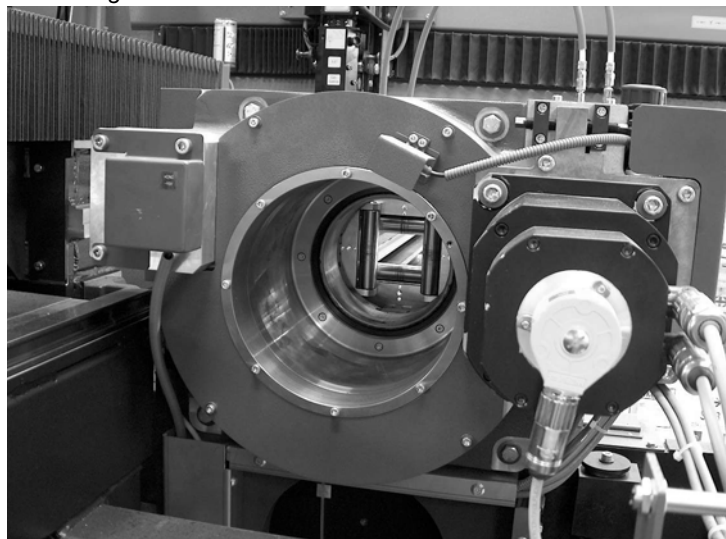


Depending on the operating mode, the rotary axis U2 can be operated with a

- Rotary chuck or
- driven steady rest .

When the safety gate is open or the safety covers on the tube loader are open then all drives are de-energized. In order to prevent the axis rotating unintentionally when clamping a work piece, the axis is fitted with a holding brake that operates in the de-energized state. i.e. the axis cannot rotate with the safety gate open. To turn the axis, the safety gate must be closed and the axis moved with the hand controller.

Fig. 3.5 -3 Rotary axis U2 with holding brake



### 3.5.3 Four-jaw chuck for conventional operation (flex mode)

For conventional use, i.e. manual loading, machining is performed with a four-jaw chuck and a tailstock.

*Fig. 3.5 -4 Manual loading with four-jaw chuck and tailstock*



Mounting the four-jaw chuck:

- remove the automatic steady rest (using the 3 screws on the mount)
  - Fit chuck
- Make sure its positioned correctly

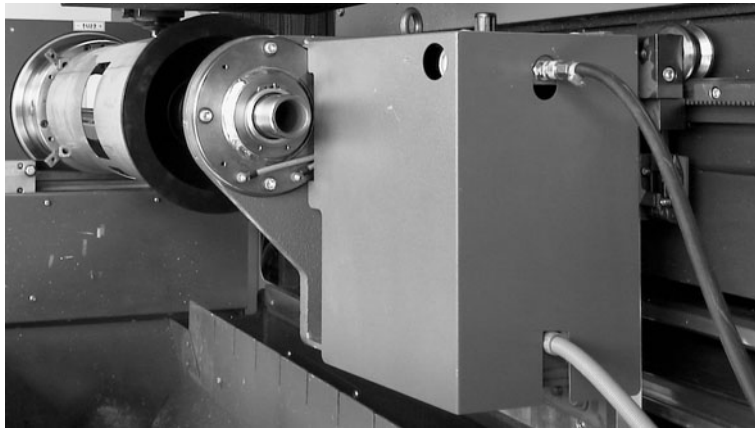
### 3.5.4 Tailstock

The tailstock is fitted on a mounting plate. The mounting plate is suspended on two bearing rollers on the guide rail. Two catches ensure that the mounting plate can be positioned securely at any point along the guide rail.

*Fig. 3.5 -5 Tailstock*

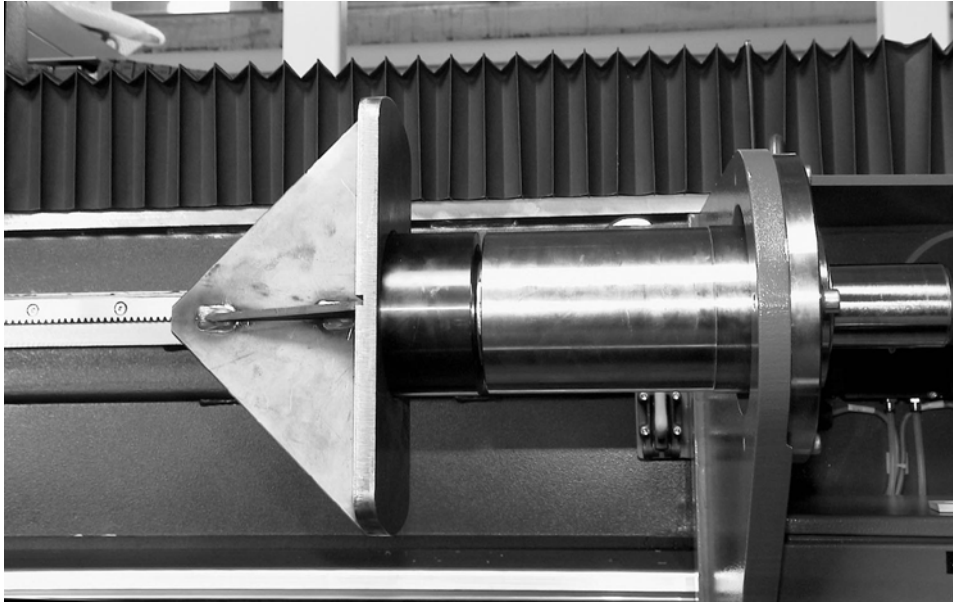


Fig. 3.5-6 Travel unit with tailstock



To set up the tailstock, the travel unit must be moved as close as necessary to connect the air supply and controller cable.

Fig. 3.5-7 Tailstock



The continuous piston rod of the pneumatic clamping cylinder consists of a tube. The tube takes various nose pieces and allows smoke extraction.

Conical nose pieces with smoke-extraction hole are used for clamping circular tubes and square hollow sections.

Rectangular sections require individual nose pieces, which do not include a smoke-extraction hole.

2 conical nose pieces with a hole of 8 mm and 30 mm respectively are included in the delivered parts.

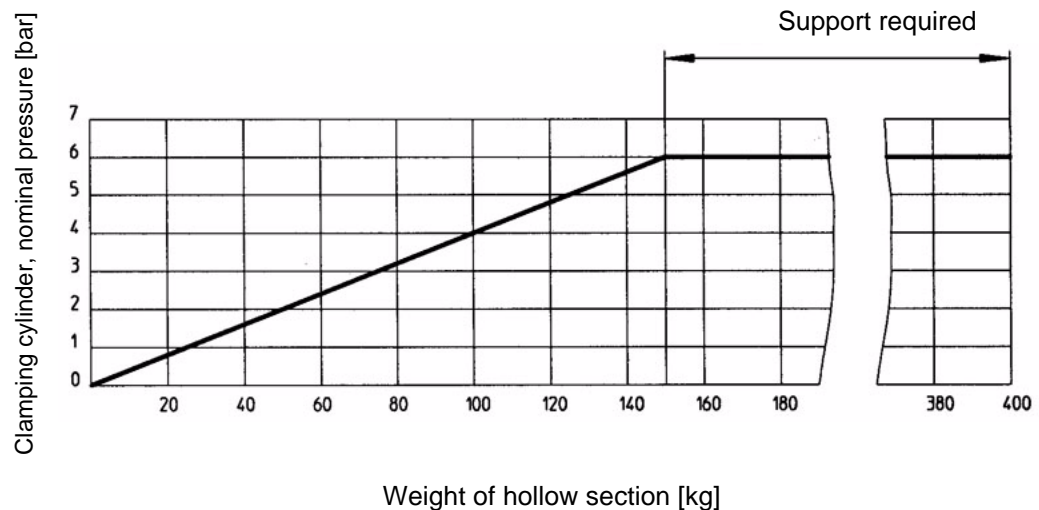
Clamping a hollow section:

- Clamp the hollow section in the four-jaw chuck.
- Push mounting plate and attached tailstock into the required position, and lock in place.
- Connect power cable plus compressed-air and smoke extraction pipes.

- Adjust clamping force using pressure reducing valve.  
The clamping force of the pneumatically operated tailstock can be varied using the pressure reducing valve to avoid buckling narrow hollow sections. The following graph shows the relationship between weight of the hollow section and the necessary pressure.

**Work pieces weighing more than 150 kg must be supported with an additional support (rolling friction).**

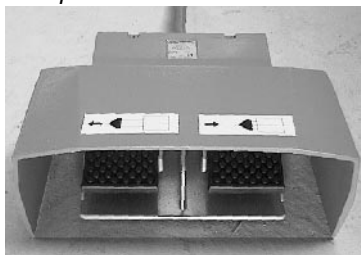
**The max. tube weight in Flex mode is limited to 400 kg.**



- Clamp hollow section by operating the foot pedal.
- Use suitable lifting gear when handling heavy tubes.

### 3.5.4.1 Foot pedal for operating the tailstock

Fig. 3.5 -8 Foot pedal



Risk of crushing from accidental clamping or releasing of tailstock

If possible, set up the machining head before clamping the work piece or after releasing it.

If possible, clamp or release the work piece with the safety gate closed.



### 3.5.5 Steady rests

#### 3.5.5.1 Adjustable clamping force

The force that the steady rest exerts on the work piece can be varied. It depends on the wall thickness, cross-section and weight of the tube.

Fig. 3.5-9



#### 3.5.5.2 Driven steady rest for rectangular tubes

The steady rest is used for centering, clamping and rotating square and rectangular hollow sections. The pneumatically applied clamping force can be adjusted using a pressure reducing valve.

Standard pressure: 6 bar

Pressure for tubes susceptible to deformation: according to judgement

A servomotor drives the rotary drive synchronously with the rotary drive of the tube-loader chuck (gripper).

Four jaws fitted with rollers transfer the torque to the tube.

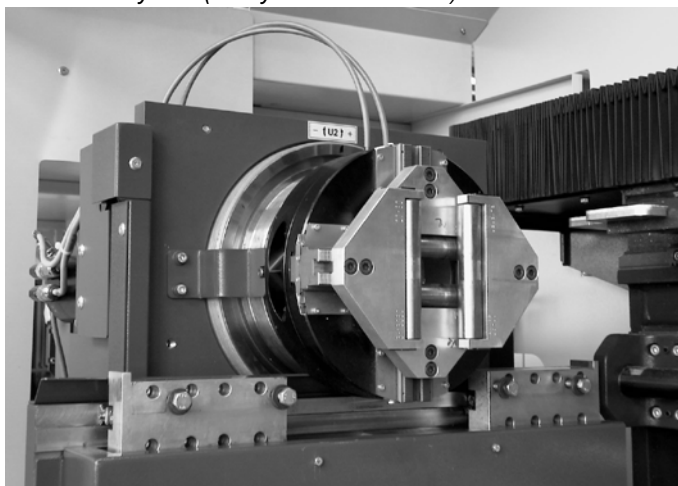
The jaws are removable. There are 4 different jaws available for use depending on the tube dimension.

The relevant combination is shown in Drawing number 0-11781.

The steady rest is also suitable for machining circular tubes.

Tubes are handled with more protection than in the steady rest for circular tubes, resulting in fewer slipping marks. More of the tube is wasted however.

Fig.3.5-10 Driven steady rest (rotary axis U2 lowered)

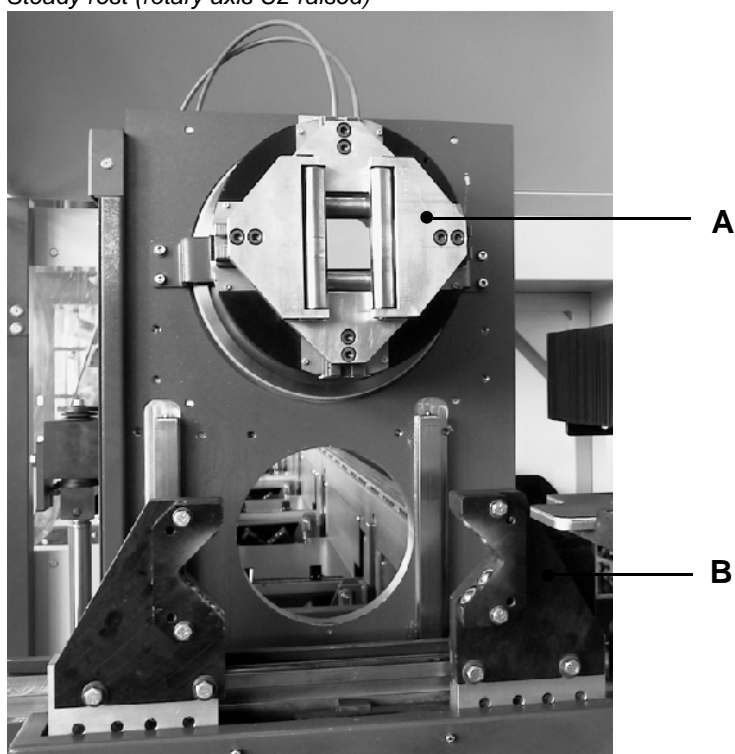


Once the rotary axis U2 (A) has been raised, circular tubes can be supported using the steady rest (B)

### 3.5.5.3 Steady rest for circular tubes

The rotary chuck must be raised using the operating terminal in order to work with the steady rest for circular tubes.

Fig.3.5-11 Steady rest (rotary axis U2 raised)



A) Driven steady rest

B) Steady rest for circular tubes.

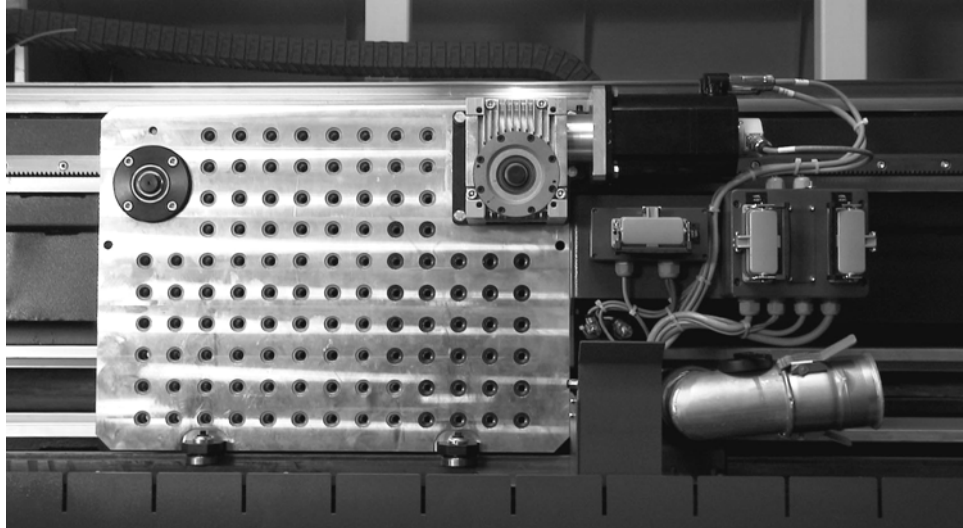
Different adapters need to be used according to the tube diameter. There are 3 different sets available.



### 3.5.6 Travel unit (A-axis)

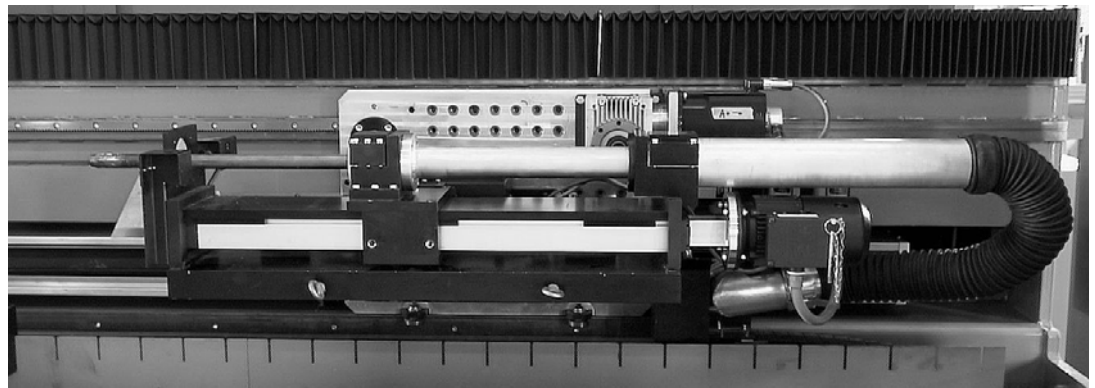
The travel unit carries either the lance unit, the support or a tray.

*Fig.3.5-12 Travel unit*



#### 3.5.6.1 Lance unit

*Fig.3.5-13 Lance unit*



The lance unit is a device that can be used to guide a lance into a tube in order to support the inner face of the tube during cutting. Cut parts can drop off by withdrawing the lance.

The lance unit is fixed onto the travel unit. It is positioned using two centering pins and attached with four screws, the two lower screws being inserted in the bottom row of holes in the travel unit plate. The three connectors X2A1, +SRL and X2E2 must be inserted in the correspondingly labeled and coded sockets, and the air ducts connected together. The lance can be pushed back and forth along the guide by hand by releasing the motor coupling using the attached pin and then moving the lance manually. If the support for the lance tube is positioned in the center of the rail, then a hole on the front face of the support provides access to two grease nipples.

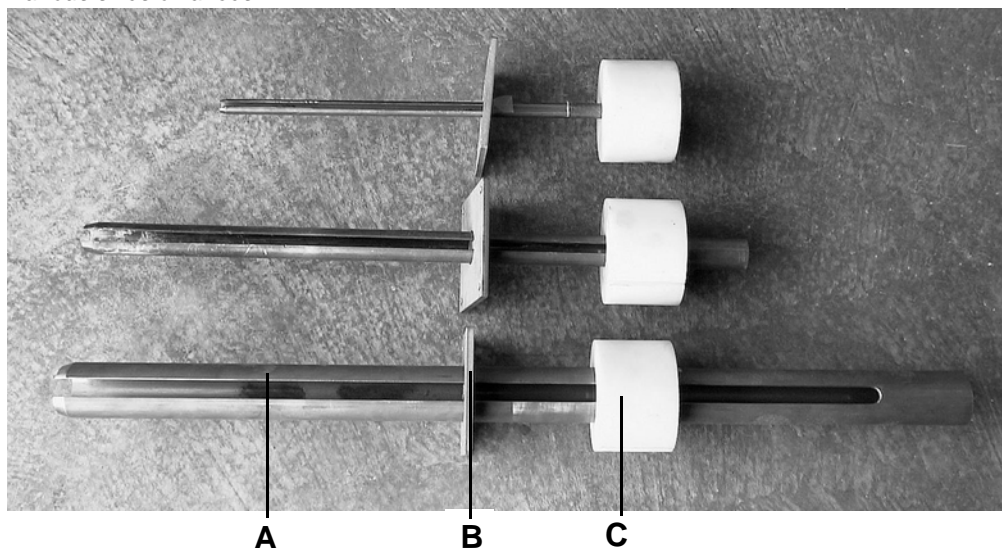
The smoke is extracted via a flexible pipe connected to the travel unit.

### 3.5.6.2 Lances

The outer diameter of a lance should be about 5 mm smaller than the internal diameter of the tube.

Lances with a diameter of less than 35 mm are subject to heavy wear.

Fig.3.5-14 Various sizes of lances

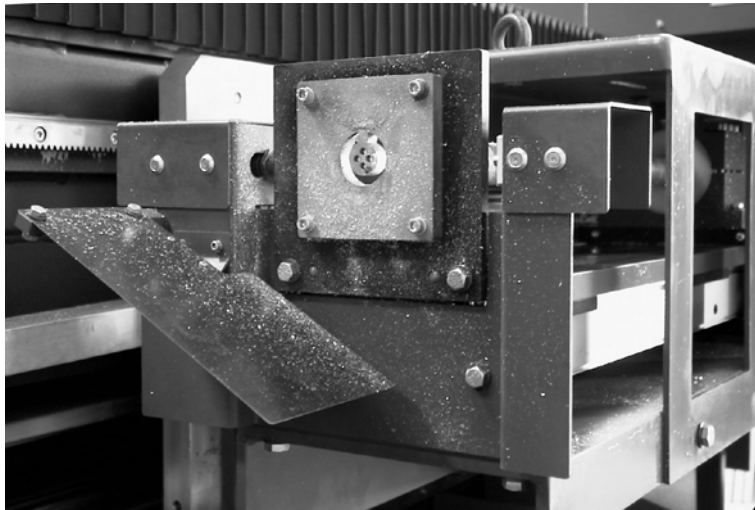


- A** Lance tube
- B** Wiper
- C** Intermediate ring

To change a lance:

- Remove connector X2A1
- Remove wiper (4 screws)
- Undo holder (6 screws)
- Replace lance tube together with intermediate ring
- Tighten holder (4 screws)
- Fit wiper (4 screws)
- Check alignment of wiper. Move lance manually with the brake released
- Plug in connector X2A1

Fig.3.5-15 Front view of lance unit



A baffle plate records when a cut part is dropped off.

The lance length, lance position and lance offset must be entered in the Setup menu of the MMC.

### 3.5.6.3 Selecting lance dimensions

Recommended values [mm]	
Max. lance length =	825
Max. length of parts =	550 (collision limits)
Lance length =	Length of parts + 175
Length of parts =	Lance length - 175
Max. lance travel =	660

Diameter [mm]	...20	...40	...60	...80	...100
Length [mm]	...200	...350	...500	...500	...500

Design rules for selecting the lance dimensions	
Tube inner diameter < 70 mm	Tube inner diameter – Lance outer diameter >= 5 mm
Tube inner diameter > 70 mm	Tube inner diameter – Lance outer diameter >= 10 mm
Reliable operation only for tube inner diameters > 40 mm	
Max. length of parts for reliable operation is 500 mm (dependent on diameter and wall thickness (=weight))	
Select as large a wall thickness as possible for the lance (heating, weight of parts)	

Design rules for selecting the lance dimensions	
Minimize Tube inner diameter – Lance outer diameter	better protection of inside of tube
High-quality tube interior required:	Tube inner diameter – Lance outer diameter, small
High-quality tube interior not required:	Tube inner diameter – Lance outer diameter, large

#### 3.5.6.4 Support

This device is used when machining long hollow sections. The support can be fitted with a solid vee for supporting circular tubes, or with rollers for supporting hollow sections.

The support platforms must be set to the correct height for the section to be machined by turning the hand wheel.

Before the support can perform its task, it must first be lowered by 50mm while the hollow section is being fed into the machining area, in order to avoid collision with the support platforms.

Fig.3.5-16 Travel unit with tube support for tubular profiles

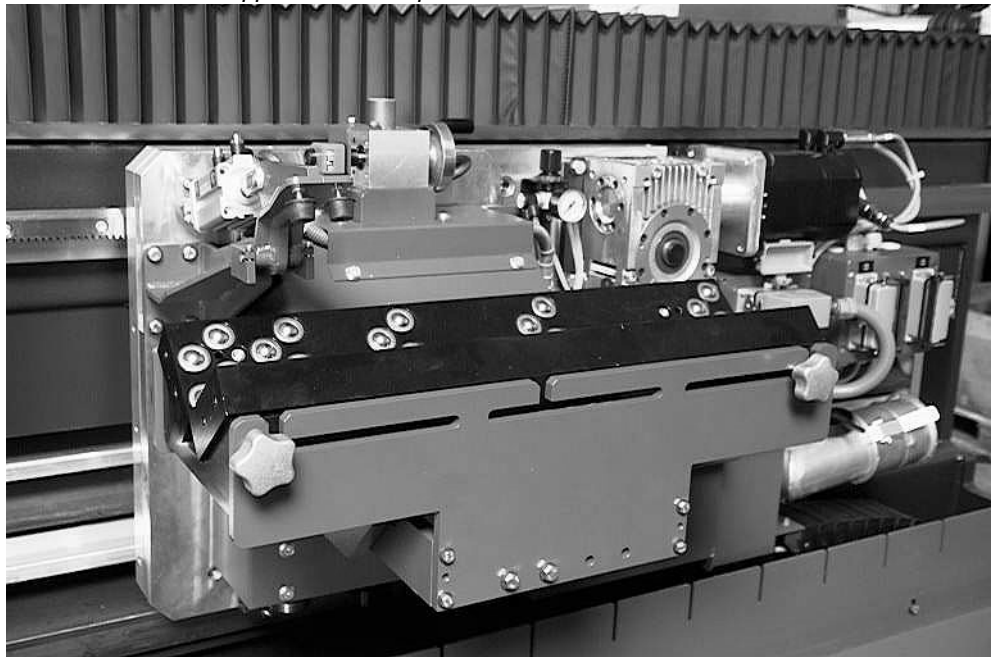


After cutting, the travel unit with mounted support retreats out of the cutting area, with the part held in position by a clamp.

During unloading, the clamp releases and the support platforms are tipped pneumatically together with the part through an angle of 90°. The part falls onto the conveyor belt and the support platforms rotate back into their working position.

The appropriate rollers must be used to suit the various rectangular dimensions.

*Fig.3.5-17 Travel unit with tube support for tubular profiles*

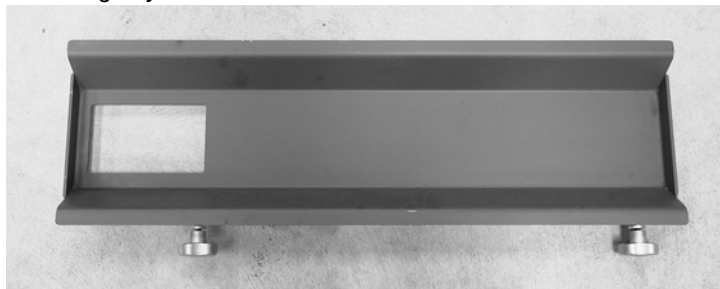


### 3.5.6.5 Collecting tray

When cutting small parts, instead of the support platforms the support unit can take a collecting tray for holding cut parts.

Cutting is carried out near the rectangular hole, which is closed by a replaceable wear plate.

*Fig.3.5-18 Collecting tray*





### 3.5.7 Table

A table can be fitted for flat cutting of small sheets. The table has dimensions 990 x 740 x 515 mm.

*Fig.3.5-19 Table for flat-part cutting*



### 3.5.8 Tray

A tray can be placed at the end of the hinged-plate conveyor for collecting the parts.

*Fig.3.5-20 Tray*



## 3.6 Laser

*Fig. 3.6-1 Laser*



The laser beam is generated in the upper section of the laser (resonator). The compressor, vacuum pump, gas preparation system, water distributor for the cooling system and part of the control system are located in the lower section. Please refer to the «Laser» operating manual for further details on the laser.

### 3.6.1 Laser cabinet

*Fig. 3.6-2 Laser cabinet*




The laser cabinet contains the electrical power supply, the laser gas mix unit and the microprocessor controller (MCS). Please refer to the «Laser» operating manual for further details on the laser cabinet.

### 3.7 Beam guidance


The laser beam is directed from the resonator output coupler via polarizing mirrors, deflecting mirrors and focusing lens to the work piece.

The route taken by the laser beam from the output of the laser source to the cutting head is called the beam path.

The bridge and carriage move during cutting, together with the deflecting mirrors mounted on them. This alters the length of the beam path. This principle of laser beam guidance is called “**Flying optics**”.

	<b>⚠ WARNING</b>
	<p><b>Risk of fire and explosion</b></p> <p>The laser beam can cause flammable and explosive fluids and vapors to ignite. Foreign bodies, liquids and gases can have an adverse effect on the beam quality. Cleaning agents and solvents and their vapors should therefore be kept away from the beam path!</p>

#### Radiation protection

	<b>⚠ DANGER</b>
	<p><b>Invisible laser radiation.</b></p> <p>The beam path protective covers must never be removed or modified! So not mechanically stress the beam protection tube between the laser and the machine! This can result in danger to life and limb, because any bending of the tube may mean that the laser beam exits without protection or damages the tube.</p>

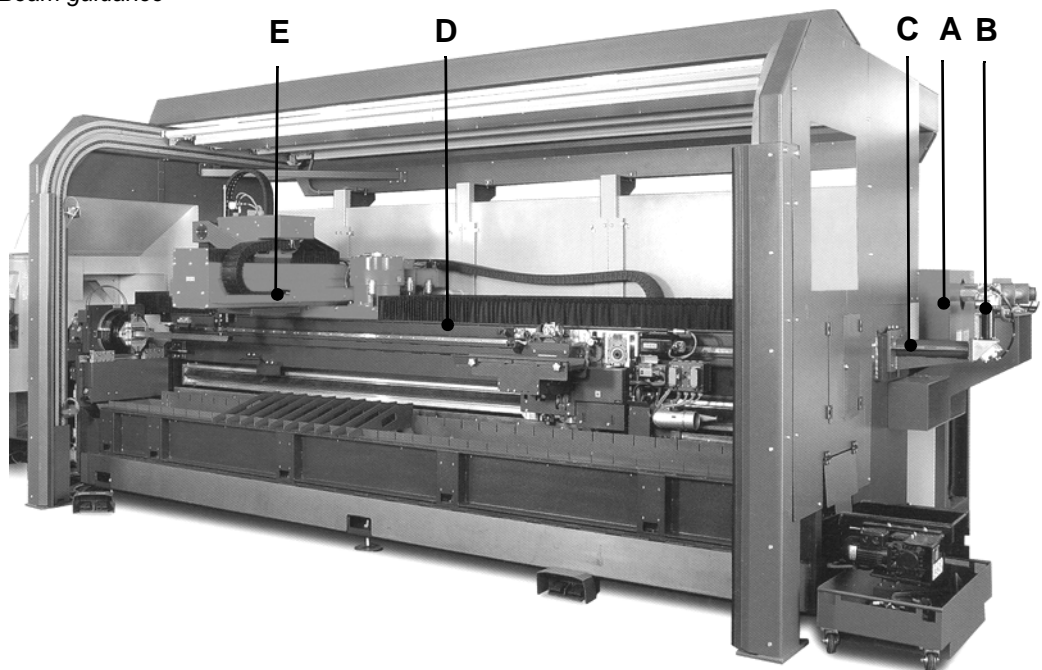
The beam path is totally sealed by structural parts, bellows and protective covers. Bellows and protective covers protect persons near the machine from stray radiation and from contact with the laser beam. At the same time they protect the optical system from outside influences.

Components that define the beam path are described in more detail below.



## 3.7.1 Labeling

Fig. 3.7 -1 Beam guidance

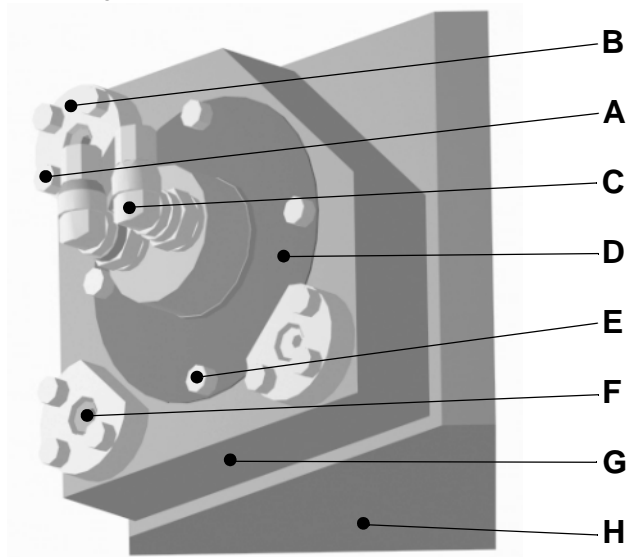


- |    |                      |    |                              |
|----|----------------------|----|------------------------------|
| A. | Laser                | E. | Cutting bridge               |
| B. | Deflecting mirror    | F. | Beam deflection BYPOS mirror |
| C. | Beam protection tube | G. | Cutting carriage             |
| D. | Bellows              | H. | Z axis / cutting head        |



### 3.7.2 Deflecting mirror

Fig. 3.7 -2 Deflecting mirror module



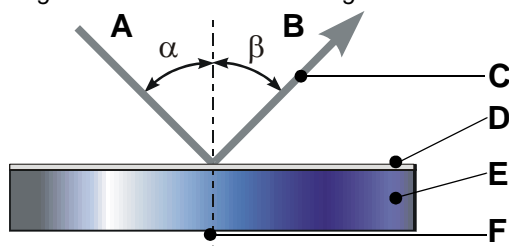
- |                                |                          |
|--------------------------------|--------------------------|
| A. Cover fixing screw          | E. Mirror fixing screw   |
| B. Cover for coarse adjustment | F. Fine adjustment screw |
| C. Cooling water connections   | G. Mirror mount          |
| D. Mirror support              | H. Deflection vee        |

Deflecting mirrors are used to deflect the laser beam along the line of the machine axes. The mirrors are flat. The beam quality (the parallelism, for example) is maintained with flat mirrors.

The angle of incidence and angle of reflection are measured with respect to the normal line. The angles of incidence and reflection are equal.

If the deflecting mirror is rotated by a certain angle then the direction of the reflected beam alters by twice that angle.

Fig. 3.7 -3 Angle of reflection of a deflecting mirror



Legend:

- |    |                             |
|----|-----------------------------|
| A. | $\alpha$ Angle of incidence |
| B. | $\beta$ Angle of reflection |
| C. | Laser beam                  |
| D. | Coating                     |
| E. | Base material               |
| F. | Normal line                 |

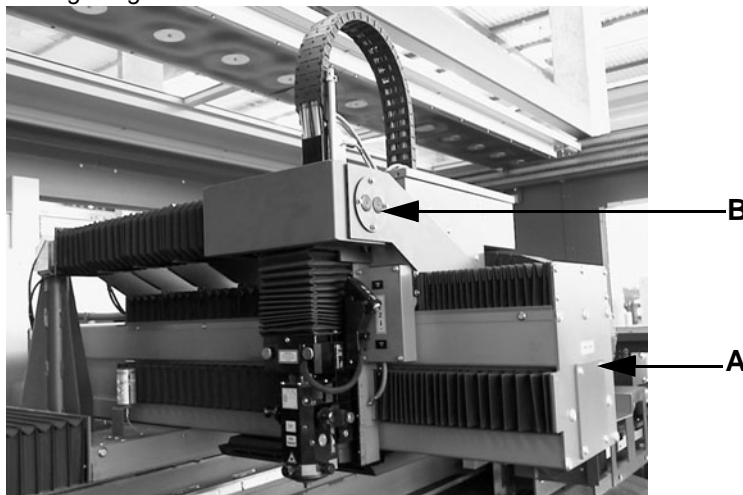
**NOTE**

*When replacing deflecting mirrors, take care to use replacement mirrors of the correct description. In particular note the difference between folding, deflection, telescopic and polarization mirrors! (See Spare Parts catalog)*

Deflection mirrors are held in a mirror holder with a locking ring. The mirror holder can be adjusted by rotating it horizontally and vertically using set screws. The adjustment screws for setting the beam path are set at commissioning and do not require any further adjustment.

### 3.8 Cutting bridge

Fig. 3.8 -1 Cutting bridge



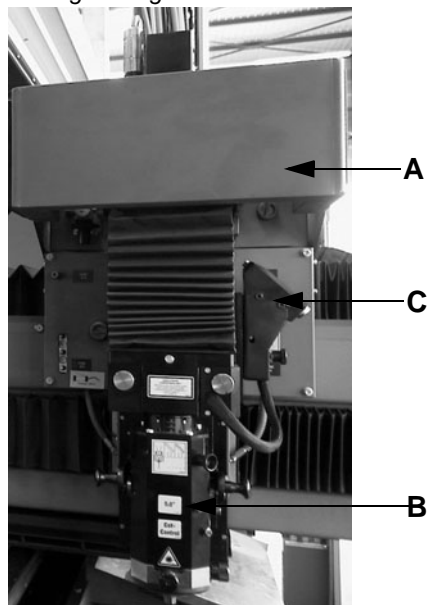
- A. Cutting bridge / X-axis
- B. Cutting bridge / Y-axis

The cutting bridge moves along the X-axis. It carries the cutting carriage, which moves along the Y-axis.

The mirror mounted on the cutting bridge deflects the laser beam from the X-axis onto the Y-axis.

## 3.8.1 Cutting carriage

Fig. 3.8-2 Cutting carriage

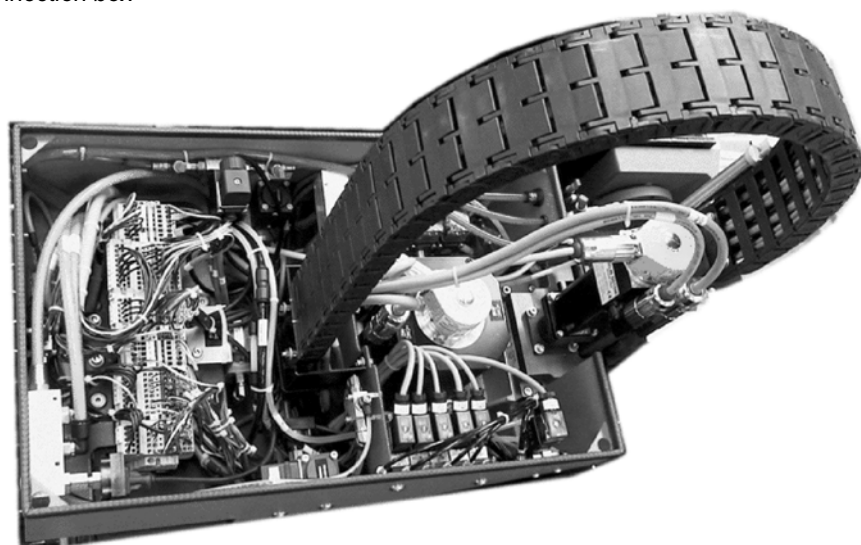


- A. Cutting carriage
- B. Z axis
- C. Crossjet

The cutting carriage carries the Z-axis with cutting head, the connection boxes with the assist-gas valves and the Crossjet (option).

### 3.8.1.1 Connection box

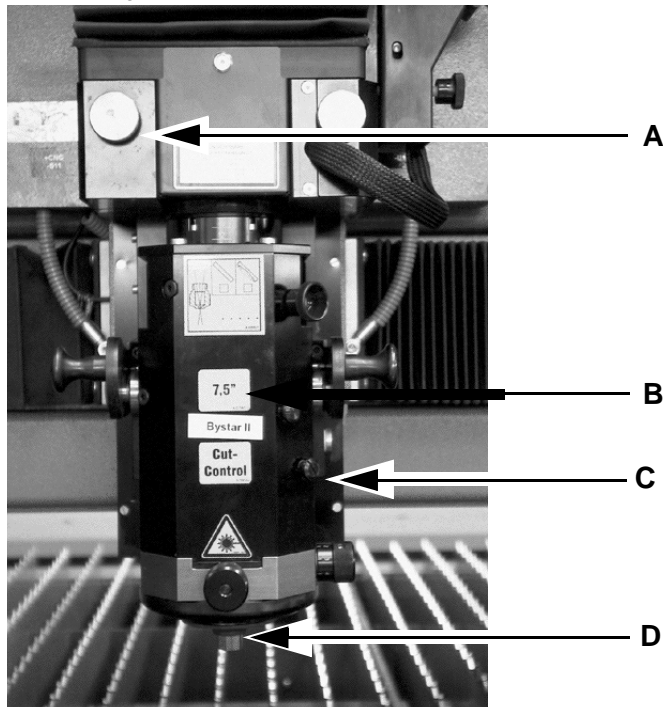
Fig. 3.8-3 Open connection box



All the lines and connections for the cutting carriage and the Z-axis are housed in the connection box, which is attached to the cutting carriage.

### 3.8.2 Z axis

Fig. 3.8 -4 Z-axis design



- A. Cover for tactile detection connection (optional)
- B. Focal length in inches
- C. Cutting head
- D. Jet

The Z-axis is the final section of the beam guidance system. The laser beam is focused in the cutting head to achieve the power density required for cutting.

The Z-axis moves the cutting head in a vertical direction. It raises the cutting head above the work piece to allow positioning between different figures, and ensures that the nozzle clearance remains constant even when there is unevenness in the work piece.

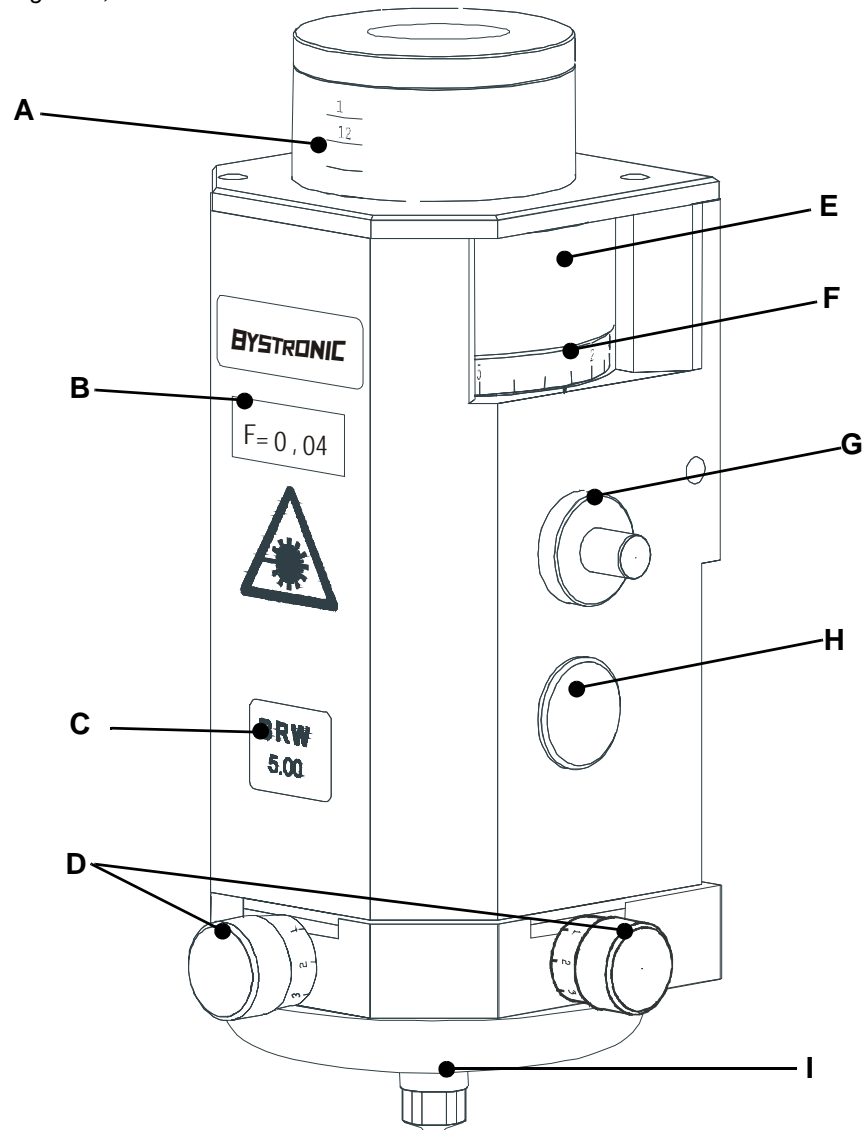
The Bypos mirror deflects the laser beam from the Y-axis onto the Z-axis.

The assist gas is supplied in the cutting head. During the cutting process this drives molten material out of the cut gap and prevents the focusing lens from being damaged by splashes of slag. The stream of gas is shaped by the nozzle so that the greatest possible percentage of the gas flows through the cut gap.

The nozzle is centered using a knurled screw.

### 3.8.2.1 Cutting head

Fig. 3.8 -5 5" cutting head, dismantled



- |   |  |
|---|--|
| <p><b>A. Millimeter scale</b> for reading the focal point position</p> <p><b>B. Effective focal position</b></p> <p><b>C. Focal length</b></p> <p><b>D. Centering screws</b> for horizontal movement of the nozzle</p> <p><b>E. Setting ring</b> for setting the focal point position</p> | <p><b>F. Scale of tenths</b> on the setting ring</p> <p><b>G. Pin</b> for the device for pressing on the Z axis</p> <p><b>H. Anti-rotation element</b></p> <p><b>I. Nozzle</b>, shapes the stream of assist gas, laser beam exit</p> |
|---|--|

The various cutting heads differ in the focal length of the lens.

### 3.8.2.2 Cutting head applications

Cutting heads with different focal lengths are available in order to provide optimum cutting results. The following focal lengths are available:

A. 5,0"

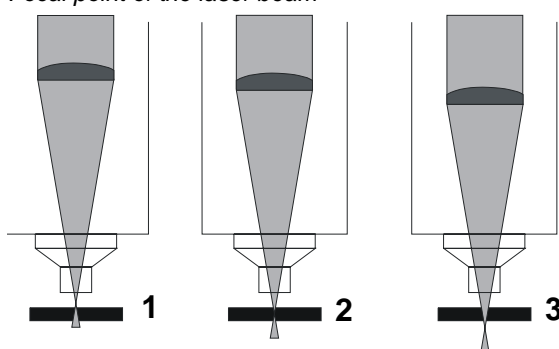
B. 7,5"

The focal length affects the use of the cutting head.

All lenses have the diameter 1,5" = 38 mm.

Depending on the material the focal point during cutting is either on (1), in (2) or below (3) the work piece.

Fig. 3.8 -6 Focal point of the laser beam



Focal length of lens	Focus diameter	Focus length	Application			
(Inches)	( $\mu\text{m}$ )	(mm)	Material	Thick-ness (mm)	Gas	Gas pressure (bar)
5.0"	130	0.6	Structural steel (St 37)	$\leq 3$ *	O <sub>2</sub>	$\leq 5$
			Galvanized structural steel	$\leq 4$	N <sub>2</sub>	$\leq 12$
			Stainless steel (1.4301)	$\leq 3$ *	N <sub>2</sub>	8 - 16
			Aluminum alloy	$\leq 4$	N <sub>2</sub>	8 - 16
7.5"	190	1.4	Structural steel (St 37)	$\leq 20$	O <sub>2</sub>	$\leq 0.5$
			Stainless steel (1.4301)	$\leq 15$	N <sub>2</sub>	8 - 20
			Aluminum alloy	$\leq 8$	N <sub>2</sub>	8 - 20

\* If one were to cut with a focal length of 7.5", the opposite wall would be damaged.



### 3.8.2.3 Effect of the focal length

Short focal length (5"):	Large focal length (7.5"):
– small focus diameter	– larger focus diameter
– higher intensity at focal point	– lower intensity at focal point
– higher cutting speed with thin sheets	– slower cutting speed with thin sheets
– Thick sheets cannot be cut	– higher cutting speed with thick sheets
– small depth of focus	– large depth of focus
– Focal position sensitive	– Focal position not sensitive
– narrow cut gap	– wider cut gap
– lens closer to work piece (soiling)	– lens further away from work piece

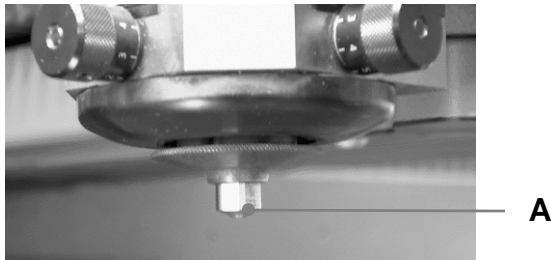
#### NOTE



*The replacement of a cutting head is described in Chapter 6 "Fitting / removing the cutting head".*

### 3.8.3 Nozzles

*Fig. 3.8 -7 Attachment of nozzle to the Z-axis*

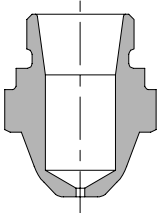
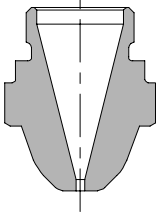
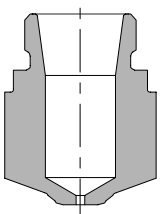
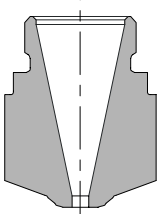


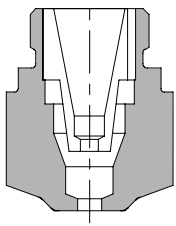
The shape and diameter of the nozzle (A) depend on the:

- Focal length
- Focal position
- Gas pressure
- Volume flow rate
- Gas-jet shape
- Type of detection
- Scope of application

The Bystronic nozzles are the result of optimizing these factors.

### 3.8.3.1 Nozzle shape and area of application

Nozzle shape	Area of application	Identification	Part no.
Normal pressure Tactile detection 	All applications for gas cutting (O <sub>2</sub> )  Structural sheet steel up to 20 mm thick	08	3-04271
		10	3-01894
		12	3-01895
		15	3-01896
		17	3-01897
		20	3-01898
		25	3-04272
High pressure Tactile detection 	All applications for fusion cutting (N <sub>2</sub> )  Aluminum and Chromium steel sheets up to 10 mm thick	H08	3-04275
		H10	3-01899
		H12	3-01900
		H15	3-01901
		H17	3-01902
		H20	3-01903
		H25	3-04276
Normal pressure Capacitive detection 	All applications for gas cutting (O <sub>2</sub> )  Structural sheet steel from 0.5 mm to 25 mm thick	K08	3-04273
		K10	3-01905
		K12	3-01906
		K15	3-01907
		K17	3-01908
		K20	3-01909
		K25	3-04274
High pressure Capacitive detection 	Universal nozzles for all applications  Steel up to 25 mm (O <sub>2</sub> and N <sub>2</sub> ) Stainless steel up to 12 mm (N <sub>2</sub> ) Aluminum up to 8 mm (N <sub>2</sub> ) various materials (O <sub>2</sub> and N <sub>2</sub> )	HK08	3-04277
		HK10	3-01910
		HK12	3-01911
		HK15	3-01912
		HK17	3-01913
		HK20	3-01914
		HK25	3-03584
		HK30	3-06112

Nozzle shape	Area of application	Identification	Part no.
Double nozzle Capacitive detection  <b>not suitable for Cut Control</b>	Structural sheet steel 4 - 5 mm (O <sub>2</sub> )	NK10-15	3-16058
	Structural sheet steel 6 - 8 mm (O <sub>2</sub> )	NK12-15	3-16059
	Structural sheet steel 10 - 12 mm (O <sub>2</sub> )	NK15-15	3-16060
	Structural sheet steel 15 mm (O <sub>2</sub> )	NK17-15	3-14317
	Structural sheet steel 16 - 18 mm (O <sub>2</sub> )	NK20-15	3-14318
	Structural sheet steel 20 mm (O <sub>2</sub> )	NK25-15	3-14319
	Aluminum 5 - 8 mm (N <sub>2</sub> )	NK25-20	3-16256
	Structural sheet steel 25 mm (O <sub>2</sub> )	NK30-17	3-16061
	Aluminum 10 - 12 mm (N <sub>2</sub> )	NK30-20	3-16257

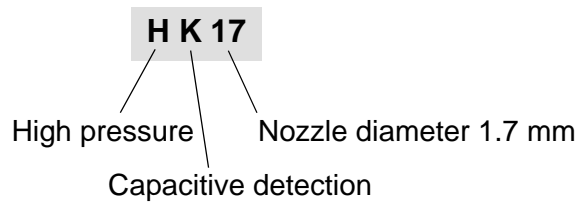
**NOTE**

*The nozzle actually to be used can be found from the relevant parameter set ( see “Process parameters” chapter).*

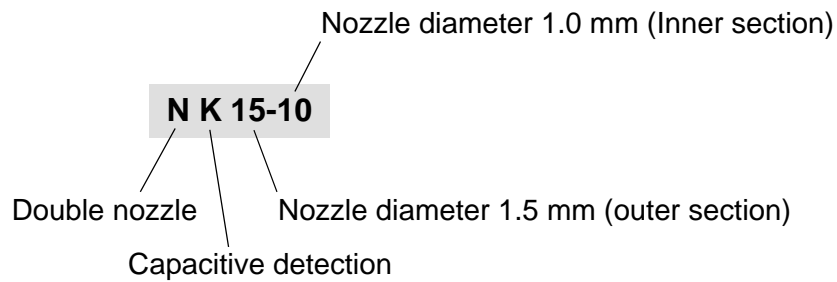
### 3.8.3.2 Labeling of nozzles

no letters	=	<b>Normal pressure (1 – 10 bar)</b>
H	=	<b>High pressure (8 – 20 bar)</b>
N	=	<b>Double nozzles</b>
K	=	<b>Capacitive detection</b>
08	=	<b>Nozzle diameter 0.8 mm</b>
10	=	<b>Nozzle diameter 1.0 mm</b>
12	=	<b>Nozzle diameter 1.2 mm</b>
15	=	<b>Nozzle diameter 1.5 mm</b>
17	=	<b>Nozzle diameter 1.7 mm</b>
20	=	<b>Nozzle diameter 2.0 mm</b>
25	=	<b>Nozzle diameter 2.5 mm</b>
30	=	<b>Nozzle diameter 3.0 mm</b>

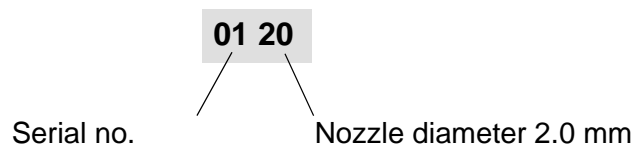
*Example 1 (standard nozzles):*



*Example 2 (double nozzles):*



*Example 3 (special nozzles):*



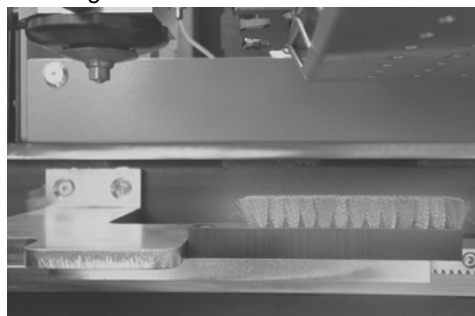
### NOTE



*How to change and center a nozzle is explained in chapter 6 "Changing the nozzle and centering the laser beam".*

### 3.8.3.3 Nozzle cleaning

*Fig. 3.8 -8 Cleaning brush*



Nozzles are cleaned using a brass brush attached to the base frame. This brush is an important tool for ensuring that work is trouble-free.

#### 3.8.3.4 Application

In the course of use the nozzle head becomes coated with splashes.

Moving the nozzle head over the brush cleans it.

Nozzle cleaning is suitable for the following materials:

- Structural steel (all thicknesses)
- Stainless steel (all thicknesses) especially for stainless steel with protective foil
- Aluminum up to 3 mm

When cutting aluminum, the splashes stick too firmly to the nozzle. They can only be removed with a brush by hand.

Nozzle cleaning is performed automatically after each work process, or manually via the MC Hand menu. Further details can be found in the «Nozzle Cleaning Set-Up Values» chapter of the «MMC Introductory Training» manual.

#### 3.8.3.5 Replacement

The brush no longer cleans effectively once it is full of splashes of metal. Please contact the Bystronic Replacement Parts Service to order a new brush.

#### 3.8.4 Detection

Optimal cutting quality is obtained if the separation of nozzle from work piece is constant. The nozzle clearance is set using the cutting parameters.

There are two options available for measuring the distance between the nozzle and the work piece:

- capacitive detection (default)
- tactile detection (optional)

Capacitive detection can be used to regulate the nozzle clearance for electrically conductive work pieces. For all other materials, the nozzle clearance can be regulated by means of tactile detection.

The distance between nozzle and work piece is adjusted to a defined value by moving the cutting head in the Z direction.

#### NOTE



*It is not possible to use both sensors simultaneously. The tactile sensor should be removed after use*

### 3.8.5 Capacitive detection

In capacitive detection, the electrical capacity between nozzle and work piece is measured. Capacitive detection can, therefore, only be used for electrically conductive materials. It is permanently integrated into the Z-axis.

The nozzle and work piece form the two plates of a variable capacitor. This capacitor is connected to the controller via a cable. The controller compares the capacitive charge with the target value, which corresponds to the nozzle distance selected.

#### 3.8.5.1 Assembly

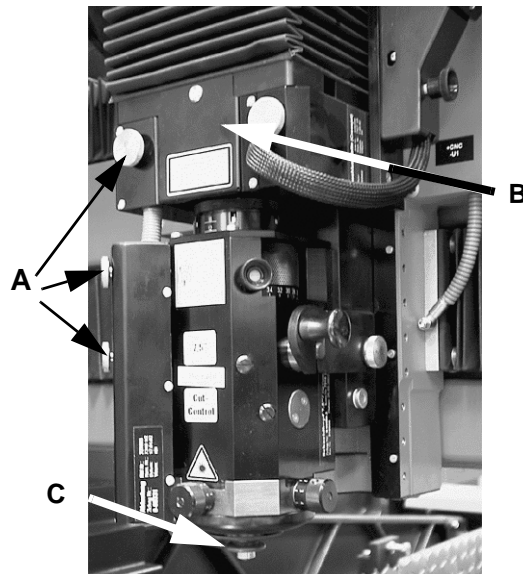
The capacitive detection device is mounted on the rear side of the cutting head. This must not be fiddled with!

#### 3.8.5.2 Referencing

When the cutting process is started, the distance is adjusted automatically at the reference point. Further details of referencing can be found in the "Laser machine" operating manual.

### 3.8.6 Tactile detection (optional)

Fig. 3.8 -9 Tactile detection



- A. Fixing screws
- B. Housing
- C. Ring sensor

The sensor makes contact with the surface of the work piece, thereby closing a circuit. The nozzle clearance is set relative to the sensor. The referencing process is performed on the same basis at the reference position.

Tactile (mechanical) detection can be used to detect the clearance for all types of material. Tactile detection is used primarily for non-conductive materials.

The tactile detection sensor is lowered down onto the work piece. The distance from the work piece to the cutting head is measured by the linear potentiometer. The nozzle distance is then set relative to the sensor.

The sensor is fitted on the side of the cutting head. Insert the cutting head and fix it using the clamping lever. Connect the plug to the mount on the carriage. You can also loosen only the two knurled screws and remove the sensor.

### 3.8.6.1 Referencing

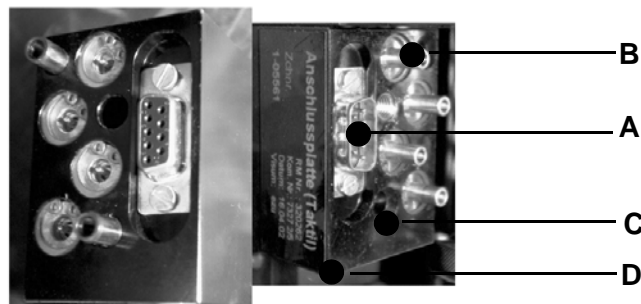
The distance between sensor and tip of the nozzle must be adjusted after the sensing system has been fitted.



1. Move to reference position.
2. Load job or press <Restart>.
3. Click on <Service> button (keyboard)
4. Press<Cont>
5. The referencing process is then performed automatically. The nozzle is lowered to the reference plate and triggers contact. The sensor follows the movement and also lowers itself to the base plate. The nozzle moves back to the set distance. This position is saved.

Referencing must always be done only once.

Fig.3.8-10 Attachment of tactile detection system to the Z-axis



- A. RS 232 interface for data transfer
- B. pneumatic connections
- C. Center holes
- D. Plate to hold tactile detection system

#### NOTE



*If no tactile sensor is fitted, the blind plug (shown below) must be fitted. No dirt must get into the mounting. The two guard plates must always be fitted.*



### 3.8.6.2 Blind plug

Keep the blind plug with the accessories.

Fig.3.8-11 Blind plug



#### NOTE



*The assembly and calibration of a tactile detection device is described in Chapter 6 «Fitting /removing the tactile detection system» .*

### 3.9 Cut Control (option)

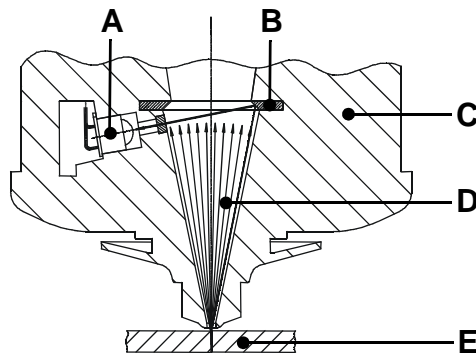
Cut Control monitors the cutting process during fusion cutting of stainless steel. The process monitoring system uses light reflected from the work piece and regulates the feed or interrupts the cutting process.

#### NOTE



*CutControl **cannot** be used with an NK nozzle*

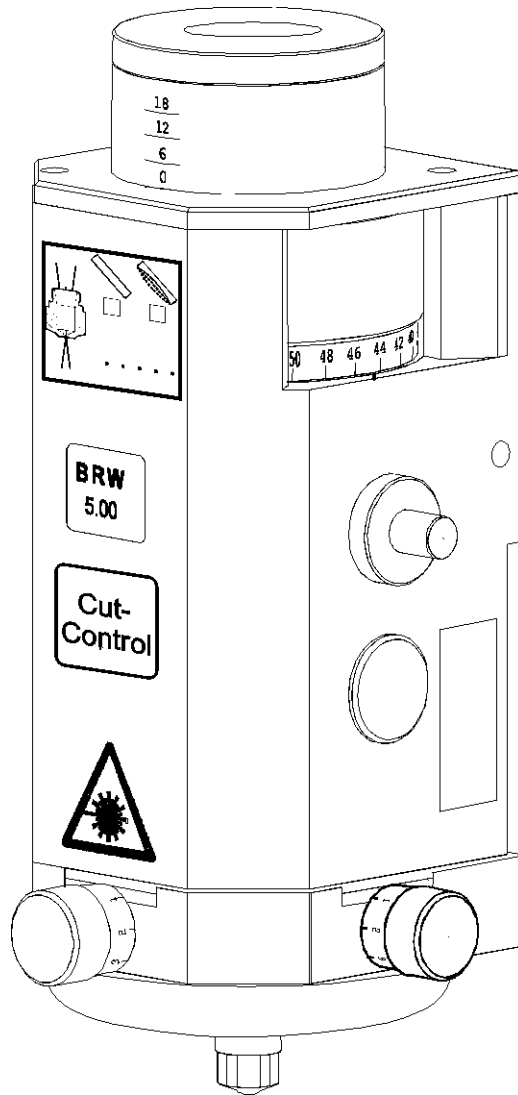
Fig. 3.9 -1 Section diagram of machining head with Cut Control



- A. Photodiode
- B. Deflecting mirror
- C. Cutting head
- D. Light reflected from work piece
- E. Work piece

The cutting head with the Cut Control option only differs externally from a conventional cutting head only by its Cut Control sticker. The Cut Control cutting head (5" and 7.5") can be fitted and operated instead of the conventional cutting head. It is still handled and adjusted in the same way (e.g. nozzle changing, centering, focal point position etc). The "Cut Control" function can only be activated with machines that are equipped with the necessary hardware and software. The CNC software version for this corresponds to P6110 or higher. Older machines can be retrofitted with Cut Control. Please talk to Bystronic Customer Services.

Fig. 3.9-2



The measurement signals from the photodiodes are converted on the «SENSOS circuit board» (integrated in the Z-axis) and passed on to the «PROMON Card» in the CNC rack. The CNC controller processes this signal and monitors the cutting process. Piercing, pulsing and engraving are now monitored. Cut control is not activated until after the starting cut acceleration. If the quality of the cutting process starts to deteriorate, this is recognized by the change in the signal and is then regulated by the following control functions.

### 3.9.1 Feed-rate reduction function

If the signal reaches the alarm or plasma threshold then the feed rate is reduced in steps to a predefined percentage level. This reduction continues until the signal falls below the alarm or plasma threshold or until the maximum reduction has been made. The reduced feed rate then remains constant during the «Reduced feed rate period». When the alarm has stopped or the plasma extinguished, acceleration back to the set feed rate (value in cutting parameters) takes place.

### 3.9.2 Stop feed-rate function

If the signal no longer drops below the alarm or plasma threshold or if the stop threshold is exceeded, the feed is stopped and piercing completed. After stopping and completion of the piercing a resetting by a defined amount (up to the last piercing as a maximum) takes place to repeat the cut. The resetting is limited to a maximum number of repetitions per contour section and after that a normal STOP function is triggered. This prevents endless repetition under faulty cutting conditions.

## 3.10 Crossjet (optional)

The Crossjet prevents too much heat from building up during the piercing process by spraying with a mixture of air and oil. It is located to the side of the cutting head. Weld protection oil is used. This can be procured from Bystronic.

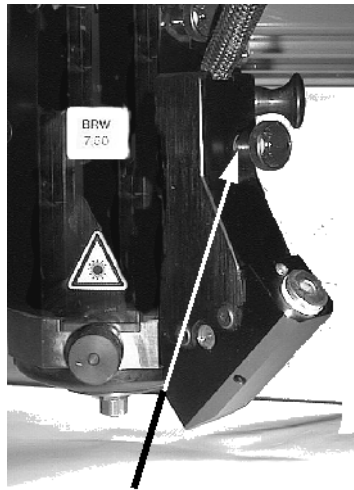
Only fit the Crossjet in the machining position when you want to use it. This prevents unnecessary soiling of the Crossjet.

The Crossjet should be kept in the park position when not in use.

### Note!

**If the CrossJet is fitted on the cutting head, and if tubes are machined using the steady rest for circular tubes, then the higher tension rollers on the driven steady rest must be removed without fail (see. Fig. «3.5 -2 » Rotary axis).**

Fig.3.10-1 Crossjet on the Z-axis



Move the crossjet against the nubs, and fix with the screw

### 3.10.1 Applications

	<b>⚠ WARNING</b>
	<p>Oil vapors can ignite spontaneously in the laser beam or on the hot work piece. Use only the correct oil. Further information can be found under "Supplier documentation".</p>

The Crossjet should be used for steel and aluminum with a thickness of 6 mm upwards. With these thicknesses, the oil mist prevents molten material from sticking to the surface of the work piece. The Crossjet is activated by pressing the [Sf2] button on the keyboard in the «Work» menu.

**3.10.2 How it works**

The Crossjet is fitted with air and oil connections. A mist of oil and air is sprayed onto the work piece before piercing. The film of oil on the surface of the work piece reduces the adhesion of the slack that escapes upwards during piercing. The thickness of the oil film depends on the flow rate, the nozzle diameter and the duration of the spraying process.

**3.10.3 Cross blow**

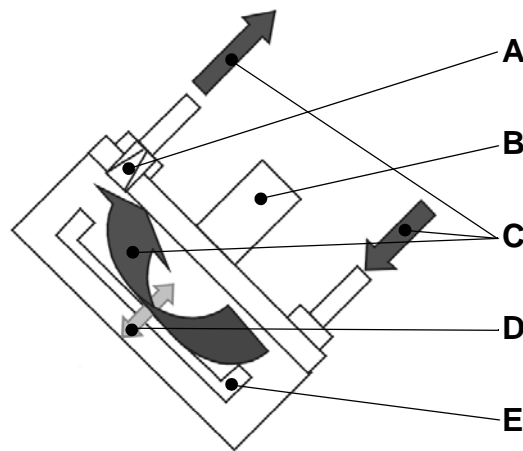
After piercing, a jet of compressed air blows away sideways the material coming off the top surface, thereby reducing its adhesion to the work piece and nozzle. «Cross blowing after piercing» is activated by pressing the [Sf2] button on the membrane keyboard in the «Work» menu.

**3.10.4 Water jet spray (optional)**

This is attached to the tactile detection device and is used for cooling the material.

## 3.11 Bypos (option)

Fig.3.11-1 BYPOS mirror with mount



- A. Aperture
- B. Pressure transducer
- C. Water circulation
- D. Deformation of the mirror
- E. BYPOS mirror

In machines with flying optics, the focal point varies over the working area of the machine. The greater the distance between the output coupler in the laser and the lens in the cutting head, the lower the focal point. The reason for this is the natural divergence of the laser beam. This results in different cutting qualities over large work areas.

An adaptive optics system (BYPOS) can be used to keep the focal parameters constant irrespective of outside influences such as the variable distance between focusing lens and laser in machines with **“flying optics”**, or even to control these parameters according to the respective processes and work pieces.

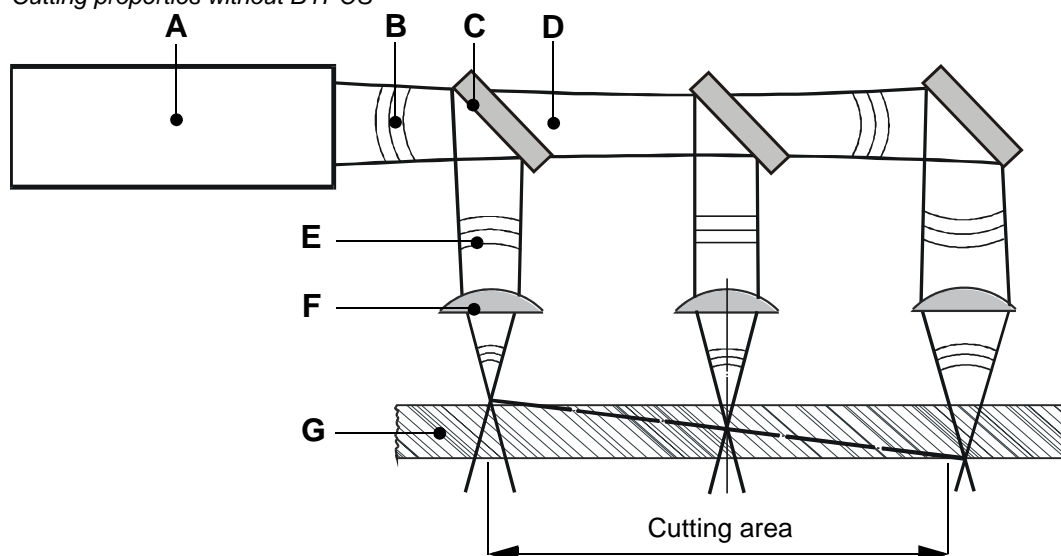
Bystronic uses a deformable mirror as its adaptive optics system, designed so that the mirror surface ensures constant optical properties during long-term use. The deformable mirror provides a 90° deflection along the Z-axis. The mirror surface is deformed by cooling-water pressure. A pressure booster station connected into the cooling circuit increases the water pressure to 14 bar. The electronic control system controls and monitors the pressure of the flowing cooling water in the mirror via a proportional (solenoid) control valve and a pressure sensor on the mirror.

The pressure booster station is fitted with a heater that can set the temperature of the BYPOS circuit in laser cutting machines having two cooling circuits. In machines with just one circuit the heater must be switched off.

### 3.11.1 Cutting properties without Bypos

Over the cutting area, the focal position moves down as a function of the beam length between laser and lens.

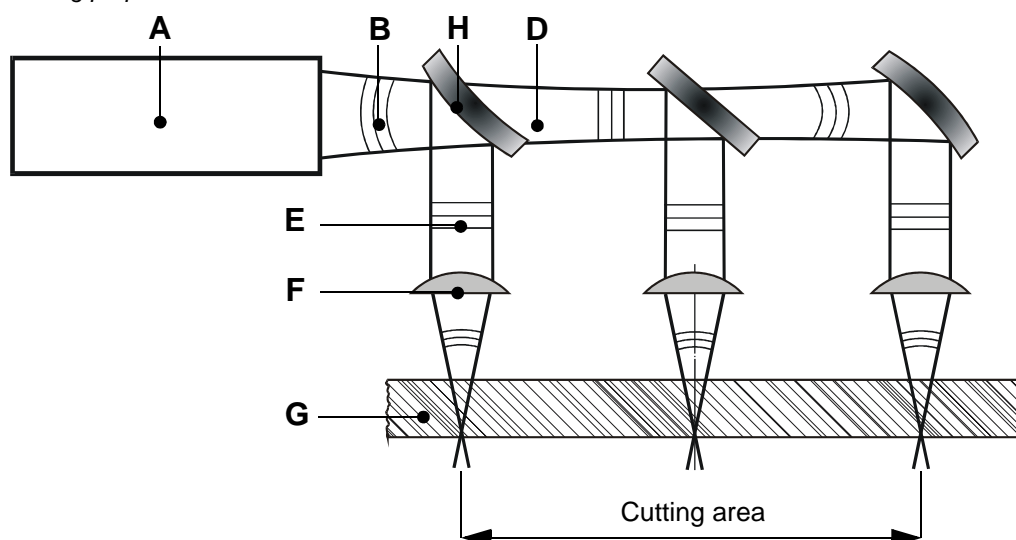
Fig.3.11-2 Cutting properties without BYPOS



### 3.11.2 Cutting properties with Bypos

The focal position remains constant over the entire cutting area.

Fig.3.11-3 Cutting properties with BYPOS



- A. Laser module
- B. Curved wave front
- C. Flat mirror
- D. Beam
- E. Variable wave front

- F. Lens
- G. Work piece
- H. Distorted mirror
- I. Flat wave front



### 3.11.3 Operating Mode 0

Fig.3.11-4 Operating mode 0



Legend:

- A. Mirror deformation
- B. Beam length

The defined mirror deformation remains constant over the entire cutting area irrespective of the beam length. The focal position is not automatically corrected in this operating mode. The correction must be done manually at the cutting head. The setting for the focal position must be found from the relevant cutting parameters.

For a mirror deformation of 0µm, the adaptive mirror is flat. The technically feasible adjustment range lies between -40 µm and +40µm. This means that the focal point can be moved by about 20mm.

If the operating mode is tested by firing into a Plexiglas cube, the mirror deformation must definitely be set to 0µm.

#### 3.11.3.1 Parameters for operating mode 0

The following parameters must be entered under "Setup values Adaptive optics 1" in the "Setup" menu:

Fig.3.11-5

Setup Einzelner Auftrag	
Einrichtungswerte Adaptive Optik 1	
Einrichtungswert: 0-Fix 1-Fokuskorrektur 2-Fokuskorrektur+Fokusslage	Wert   Einheit
Fester Spiegelhub zu Betriebsart=0	0 µm
Kennlinie Strahlänge 1	400 mm
Kennlinie Spiegelhub 1	0 µm
Kennlinie Strahlänge 2	1400 mm
Kennlinie Spiegelhub 2	-0.7 µm
Kennlinie Strahlänge 3	2400 mm
Kennlinie Spiegelhub 3	-1.2 µm
Kennlinie Strahlänge 4	3400 mm
Kennlinie Spiegelhub 4	-1.8 µm
Kennlinie Strahlänge 5	4400 mm
Kennlinie Spiegelhub 5	-2.5 µm
Hub/Fokussänderung Optik 3.75	8 µm/mm
Fokusslage Schneidkopf Optik 3.75	3 mm
Hub/Fokussänderung Optik 5.0	6.6 µm/mm
Fokusslage Schneidkopf Optik 5.0	2 mm
Hub/Fokussänderung Optik 7.5	3.3 µm/mm
Fokusslage Schneidkopf Optik 7.5	7 mm
Hub/Fokussänderung Optik 10.0	1.1 µm/mm
Fokusslage Schneidkopf Optik 10.0	5 mm

Operating mode (constant)=0

Fixed mirror deformation= Xµm

The fixed mirror deformation is normally set to 0.

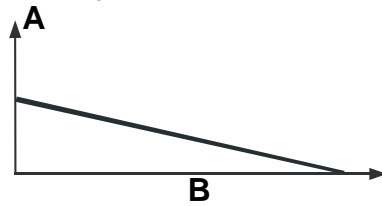
**Other values have no effect in this operating mode.**

### 3.11.4 Operating mode 1

The mirror deformation is varied as a function of the beam length. This relationship is fixed by a characteristic curve. The characteristic curve is defined by 5 mirror deformations at 5 different points along the length of the beam path. These mirror deformations are measured in cutting tests at the corresponding beam path lengths, and saved as parameters in "Setup". The 7.5" cutting head and 8mm stainless steel sheet should be used for these cutting tests.

In operating mode 1, the focal position for different types and thicknesses of sheet is not set automatically. This is possible in operating mode 2.

Fig.3.11-6 Operating mode 1



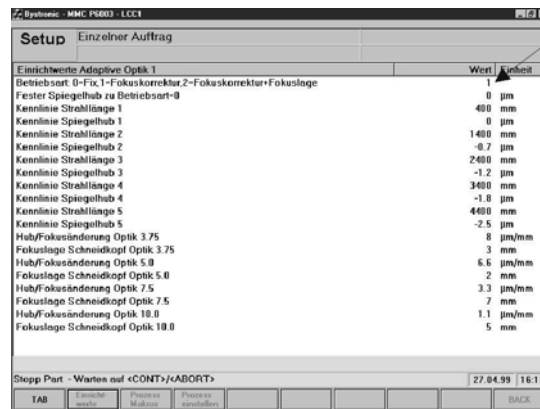
Legend:

- A. Mirror deformation
- B. Beam length

#### 3.11.4.1 Parameters for operating mode 1

The following parameters apply to operating mode 1:

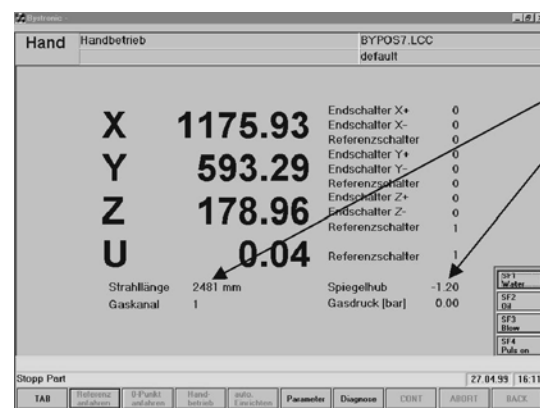
Fig.3.11-7



Operating Mode = 1

(In this operating mode, the value “Fixed mirror deformation” is irrelevant)

The data for defining the characteristic curve (5 interpolation-point pairs: beam length / mirror deformation) are set at the factory. After changing a lens or Bypos mirror, it may be necessary to measure the cutting-test values again using the following procedure.



For correct calculation of the beam length, the machine must first move to the reference point.

The current beam length and the mirror deformation calculated from this (set value) can be followed in the “Hand” menu as the cutting head moves.

A valid characteristic curve must exist before operating mode 1 can be used.

The total deformation is computed from the position-dependent characteristic value (characteristic curve) plus an OFFSET dependent on the characteristic data. The calculation is performed automatically.

### 3.11.4.2 Measuring the curve

The following requirements must be met before it is possible to measure the characteristic curve:

- The optical components and beam guidance system must be in perfect condition
- Material: stainless steel 8mm (preferably: 1.4301)
- 7.5" cutting head
- Test piece bypos\_t.lcc (is saved under C:\Abnahme\BTL ....) If this file is not present, this part must be produced on site according to the supplement bypos\_t.lcc.

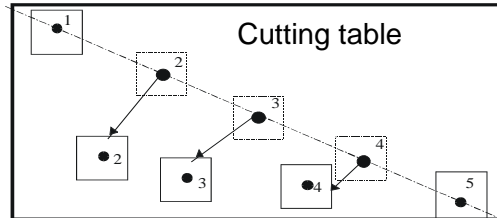


1. Select operating mode 0 and deformation 0 (flat mirror)
2. Moving to reference position
3. Move to curve point 1 (minimum beam length – see table below)
4. Cut test piece and correct focal point at cutting head until an optimum cut is obtained. One should aim for the **lowest possible focal position** for which there is still no hard burr.
5. Move to curve point 5 (maximum beam length)
6. Cut the same test piece without adjusting the focal length at the cutting head. Instead correct the focal length by changing the parameter "Fixed mirror deformation for operating mode 0". Larger negative deformations result in a higher focal position, and vice versa. Adjust parameter until an optimum cut is obtained.
7. Joining these two corner points gives a straight line as the characteristic curve. The deformation values for the intermediate points are interpolated and saved in the "Setup" menu Characteristic curve: beam length/mirror deformation 1-5. Calculation is as follows: the deformation determined at point 5 is divided by the number of intermediate points, in this case five.
8. Select operating mode 1. (Instead of the fixed mirror deformation, the CNC now imports the deformation calculated from the characteristic curve, which can be checked under Mirror deformation in the "Hand" menu.)
9. By making test cuts at the intermediate points, the characteristic curve in operating mode 1 can be checked and improved if necessary (by correcting the deformation of the corresponding point to adjust the focal position).

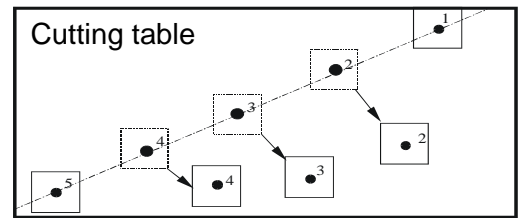
The beam length defines the position in which the test cut must be made. The beam length alone is not enough to specify the position on the cutting table. Thus the sheet for the test cut does not have to lie exactly on the table diagonal. The test cuts can be made on the table diagonals or in other positions by shifting the sheets, as

illustrated in the diagram below. The current length of the beam path can be read in the “Hand” menu.

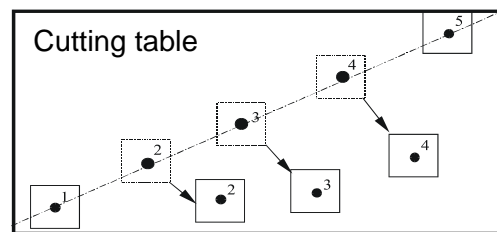
Beam input - left



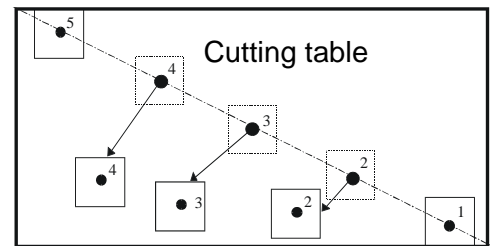
Beam input - right



Beam input - lower left



Beam input - lower right



### 3.11.4.3 Centering the characteristic curve

In a very few cases it is necessary to center the characteristic curve. This should be done when the mirror deformation at point 5 amounts to more than  $\frac{1}{4}$  of the total mirror deformation.

By changing the deformation value of each characteristic-curve point by the same amount, the curve can undergo a parallel shift. This means the characteristic curve can be centered around the zero value for large deformation variations. However, this correction must be compensated for at the cutting head. The conversion factors necessary for this can be found in the “Setup” menu, “Setup values adaptive optics 1”.

The characteristic curve is measured with the cutting head. For a different head (e.g. 5”), or after a lens change, one only needs to re-determine the focus zero position and the focal position for the relevant sheet thickness.

#### NOTE



*The curve that is derived is valid for all focal lengths.*

The beam lengths are then listed for the various machine sizes for which the mirror deformations can be measured.

#### TIP



*The values measured can vary from machine to machine because of differing beam-path ventilation.*

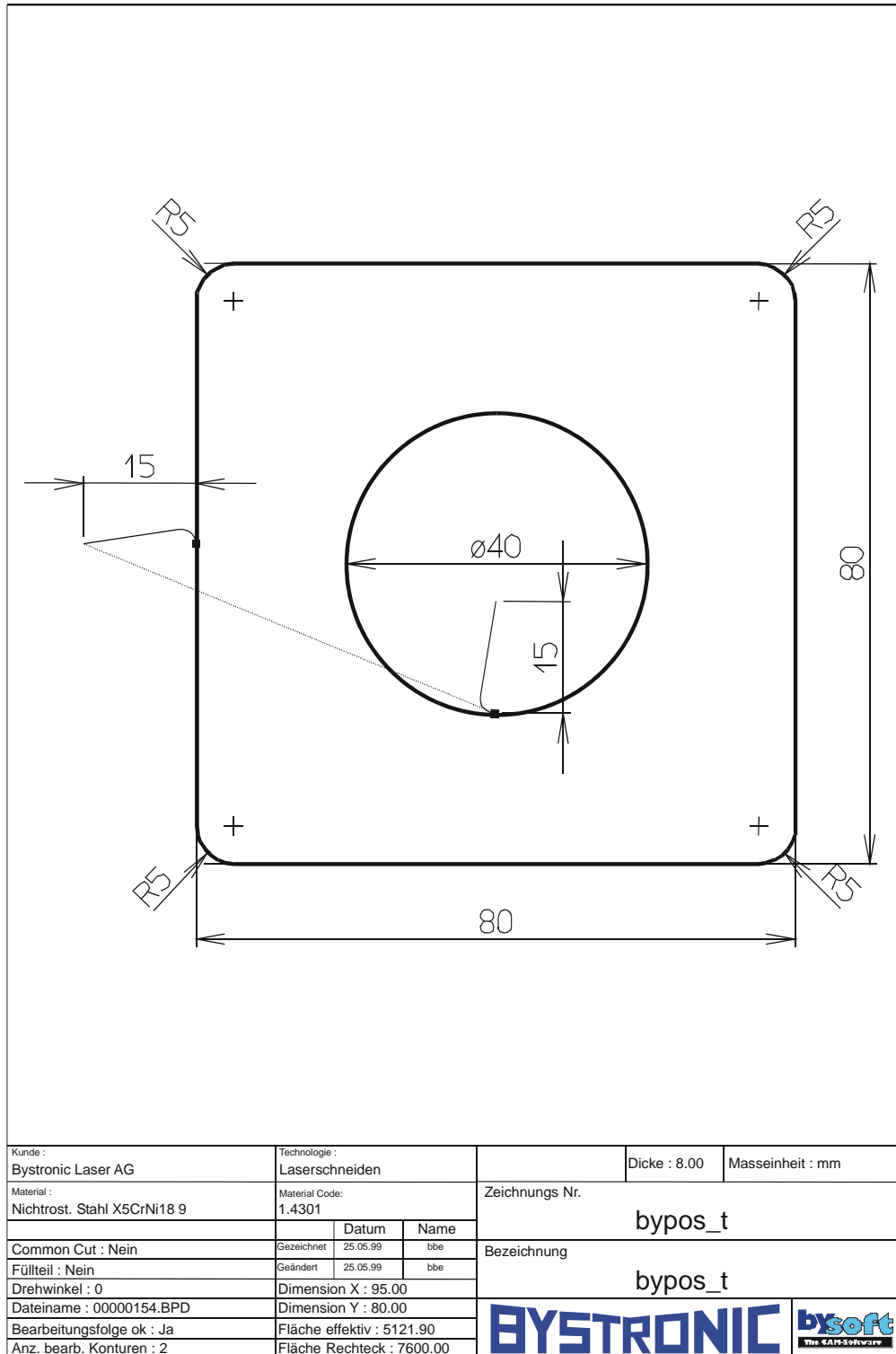
The characteristic curve may need to be modified after a lens change in the resonator (especially the output coupler).

## 3.11.4.4 Distribution of beam-length points

Machine size	Characteristic curve points	1	2	3	4	5
2512	Beam length (mm)	600	1200	2000	2800	3600
3015	Beam length (mm)	600	1400	2400	3400	4400
3204	Beam length (mm)	600	1450	2300	3150	4000
4015	Beam length (mm)	600	1700	3000	4300	5600
4020	Beam length (mm)	600	1800	3200	4600	6000
4025	Beam length (mm)	600	2300	3800	5200	6800
6504	Beam length (mm)	600	2250	3900	5550	7200
6520	Beam length (mm)	600	2600	4600	6600	8600
6525	Beam length (mm)	600	2700	4800	6900	9000
6530	Beam length (mm)	600	2800	5000	7200	9400

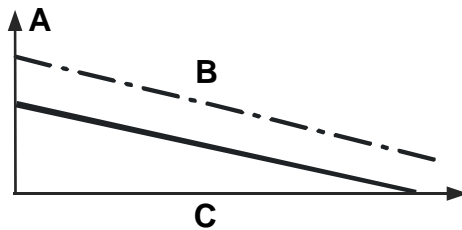
### 3.11.4.5 Test piece bypos\_t.lcc

Fig.3.11-8 Bypos test piece



### 3.11.5 Operating mode 2 (default mode)

Fig.3.11-9



- A. Mirror deformation
- B. Characteristic curve
- C. Beam length

The presence of a valid characteristic curve for operating mode 1 is a requirement for operating mode 2. In operating mode 2 the focal position, which is otherwise only for information purposes in the cutting parameters, is adopted as a parameter. In this mode, the focal position no longer needs to be adjusted manually at the cutting head when the work piece is changed, but is adjusted automatically by the adaptive optics. The total deformation is computed from the position-dependent characteristic value (characteristic curve from operating mode 1) plus an OFFSET dependent on the characteristic data. The OFFSET is calculated automatically as:

$$\text{OFFSET} = [\text{Deformation/Change in focal length}] - (\text{Focal length} + \text{Nozzle clearance} - [\text{Focal length cutting head}])$$

The two machine parameters dependent on the focal length:

- Deformation/Change in focal point
- Focal position Cutting head

are factory set and saved in the “Setup” menu.

#### NOTE



*These values must not be changed without careful consideration.*

Parameter	Wert	Unit
Einrichtung Adaptive Optik 1	2	
Betriebsart: B-Fix 1-Fokuskorrektur 2-Fokuskorrektur-Fokussage		
Fester Spiegelschub zu Betriebsart-6	0	µm
Kennlinie Strahlänge 1	400	mm
Kennlinie Spiegelschub 1	0	µm
Kennlinie Strahlänge 2	1400	mm
Kennlinie Spiegelschub 2	9.7	µm
Kennlinie Strahlänge 3	2400	mm
Kennlinie Spiegelschub 3	-1.2	µm
Kennlinie Strahlänge 4	3400	mm
Kennlinie Spiegelschub 4	-1.8	µm
Kennlinie Strahlänge 5	4400	mm
Kennlinie Spiegelschub 5	-2.5	µm
Hub/Fokussänderung Optik 3.75	13.2	µm/mm
Fokusslage Schneidkopf Optik 3.75	2	mm
Hub/Fokussänderung Optik 5.0	5.8	µm/mm
Fokusslage Schneidkopf Optik 5.0	2	mm
Hub/Fokussänderung Optik 7.5	3.3	µm/mm
Fokusslage Schneidkopf Optik 7.5	7	mm
Hub/Fokussänderung Optik 10.0	1.7	µm/mm
Fokusslage Schneidkopf Optik 10.0	7	mm

Operating Mode = 2

Do not adjust these values!



### 3.11.5.1 Working in operating mode 2

Follow the procedure below to work in operating mode 2:

- It is assumed that the reference focal length is known for the cutting head. If not it must be found.
- Select operating mode 2 (as described above).
- Set “Focal position Cutting head optics 7.5” / 5” (from Setup) on the cutting head. Once the cutting heads are correctly set, no further changes need to be made to them.
- Import the cutting plan and the cutting parameters. Here it is essential that the focal length in the cutting parameters tallies with that for the cutting head, otherwise the focal point is calculated incorrectly.
- Check or replace the cutting nozzle. If several jobs need to be processed automatically one after the other, then the largest of the specified nozzles must be used. Additional parameter adjustments may consequently be necessary. For example, when widely differing sheet thicknesses are cut in automatic mode.
- Center the cutting nozzle, then start the cutting process.

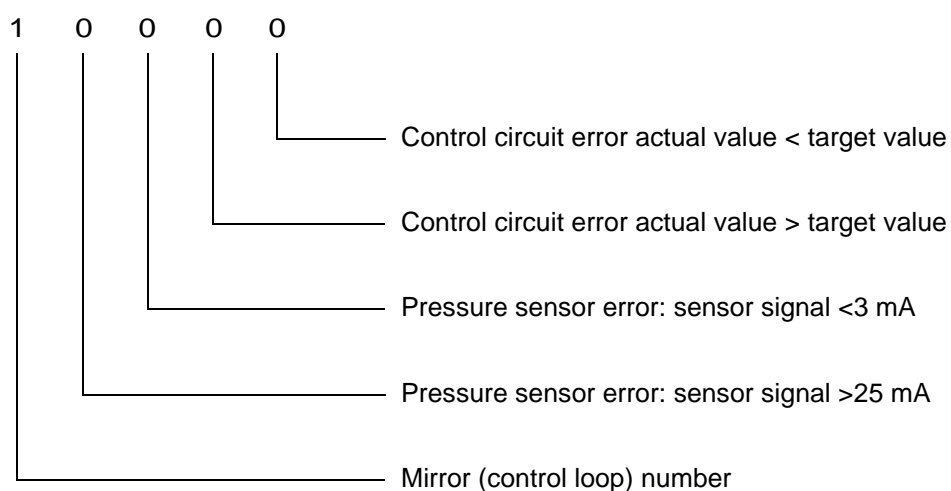
### 3.11.6 Bypos error messages

When the machine is ready for operation, the sensor and control monitoring system provides four error bits for diagnosing possible faults.

Error no.	Description	Cause
11	Control loop error: Actual value < target value	<ul style="list-style-type: none"> <li>• Flow controller or output stage faulty</li> <li>• Proportional valve not being actuated</li> <li>• Inlet value for the controlled variable too low for the set value.</li> <li>• Sensor is faulty or not connected</li> <li>• Can arise with Error 13.</li> </ul>
12	Control loop error: Actual value > target value	<ul style="list-style-type: none"> <li>• Flow controller or output stage faulty</li> <li>• Proportional valve fully open</li> <li>• Faulty sensor</li> <li>• Can arise with Error 14.</li> </ul>
13	Pressure sensor error: sensor signal <3 mA	<ul style="list-style-type: none"> <li>• Faulty sensor</li> <li>• Break in wiring to sensor</li> </ul>

Error no.	Description	Cause
14	Pressure sensor error: sensor signal >25 mA	<ul style="list-style-type: none"> <li>Faulty sensor</li> <li>Signal and supply line for sensor shorted together</li> <li>Sensor overloaded by the control variable.</li> </ul>

As of CNC P6104, Bypos error messages are displayed according to the following system:



Errors are displayed with a 1 at the appropriate position (error code 10000 means normal functioning, i.e. no error). Several errors at once can be indicated with this coding scheme.

# C4 CHAPTER

## **Operating and display elements, operating modes**

In this chapter you will learn more about the operating and display elements on the laser machine. An overview gives a brief description of the various buttons and keys. The different modes that can be used for operating the laser machine are also explained.

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### 4.1 Introduction

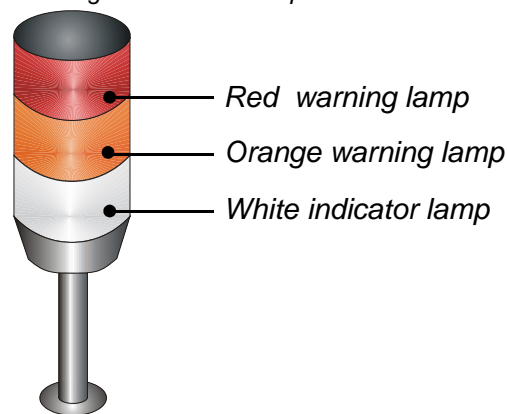
This chapter describes the warning signals and operating elements on the machine.

### 4.2 Warning signals

#### 4.2.1 Warning and indicator lamps

The warning lamps are mounted on the MCS cabinet. They show at a glance the current operating status of the laser.

Fig. 4.2 -1 *Warning and indicator lamp*



##### 4.2.1.1 Red warning lamp

If the red warning lamp is illuminated, the shutter is open and the laser beam is being emitted from the laser. If the lamp is off then the shutter is closed.

If the red warning lamp is flashing, the laser is in Service mode (laser class 4). Service mode is in force when the laser cover is open. Service mode tasks are described in the chapter «4.4 Operating modes».

##### 4.2.1.2 Orange warning lamp

If the orange warning lamp is illuminated, the high voltage to the laser is switched on and the laser is operating.

##### 4.2.1.3 White indicator lamp

The white indicator lamp indicates low pressure in the gas supply. This indicator enables the gas supply to be swapped to the reserve bottle before machining is stopped automatically by the controller because of insufficient gas supply. The gas controller (MCS cabinet) indicates which gas caused the white lamp to come on. (The green operating indicator light for the gas concerned is off).

## 4.3 Operating and display elements

### 4.3.1 Emergency stop button

There are 3 «Emergency stop» buttons on the laser machine enabling the machine to be switched off in the event of danger.

#### 1. PPC operating terminal

Fig. 4.3 -1 *Emergency stop on operating terminal*



#### 2. Hand-held controller

Fig. 4.3 -2 *Hand-held controller Emergency Stop*



#### 3. MCS cabinet

Fig. 4.3 -3 *Emergency stop on MCS cabinet*



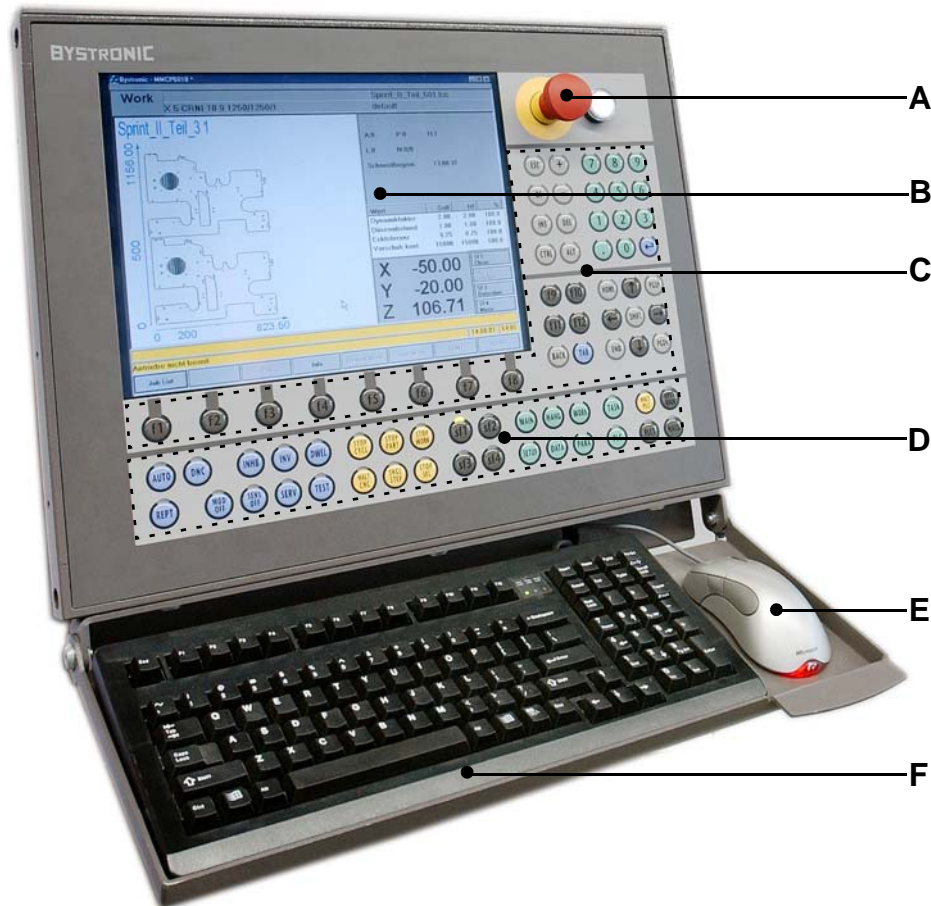
After an «Emergency stop» all reset buttons on the PPC and on the MCS cabinet go out. The following messages are displayed:

MMC Work menu	MCS cabinet display	Handling Operation
1. «Wait for Abort» 2. press after «Abort» 3. «External Emergency stop»	«Emergency Stop»	«Emergency stop active: deactivate»

The way in which an «Emergency stop» operates, and the procedure for restarting the machine, is described in the "Emergency stop" section of Chapter 3.

### 4.3.2 PPC operating terminal

Fig. 4.3-4 Operating terminal user interface



The operating terminal comprises:

- Emergency Stop and Reset button (A)
- TFT screen (B)
- Membrane keyboard area (PC functions) (C)
- Membrane keyboard area (machine functions) (D)
- Optical PC mouse (E)
- PC keyboard (F)

The latter has a "touch screen" design, Each program interface can be operated by touching the corresponding button or menu display on the TFT screen. The screen resolution must be at least 800 x 600 pixels.

#### 4.3.2.1 Switching status of buttons

When a button is illuminated, its command is activated.

**4.3.2.2 Automatic activation of functions**

The following buttons are automatically activated when a cutting plan is started:

- <DWEELL>
- <STOP SEL>
- <SENS OFF > (only if active during last job)
- <STOP CYCL>

When starting up the MMC, the relevant function keys SF1 to SF4 will be activated depending on what equipment the machine has (e.g. Crossjet) and on the setting in the SETUP configuration menu.

**4.3.2.3 Self-locking operation**

If you activate the buttons <AUTO> to <HEAD>, then the relevant function will remain active until you press the button again in order to deactivate it.

- If you deactivate one of the buttons, then the relevant function will remain deactivated until you press the button again in order to activate it.
- Active buttons are deactivated automatically after all jobs have been processed and the axes are back in the reference position.

**4.3.2.4 Key groups**

Common features of the buttons <HALT CNC>, <STOP CYCL>, <STOP PART>, <STOP WORK> und <STOP SEL> are summarized under the heading <STOP>.



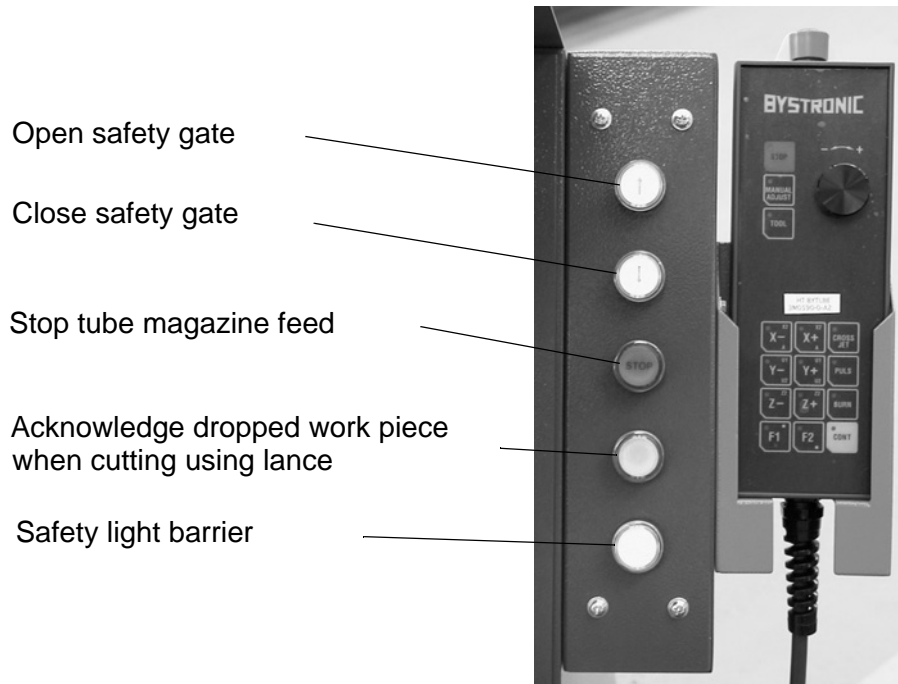
### 4.3.2.5 Summary of the PPC machine keyboard

Some of the buttons are assigned different meanings for individual functions. The standard functions are listed in the table below.

Button	Description
<F1>	F1 - F8 function keys for operating the machine software
<AUTO>	Automatic import of cutting plans and process parameters
<DNC>	Activate connection to a higher-level PPS
<INHB>	Move to programmed reference point (see < INHIBIT REF> )
<INV>	Work through cutting plan in reverse order
<DWELL>	Enable braking and acceleration during cutting
<REPT>	Work through engraving parameters first and then process parameters (e.g. to remove protective foils from sheet)
<MOD OFF>	Switch off modulation
<SENS OFF>	Switch off detection inside the < Sensor OFF> field
<SERV>	Press once = Move to service position Press twice = Automatic nozzle cleaning performed and then the cutting plan is completed
<TEST>	Work through cutting plan with cutting head raised and without laser beam
<STOP CYCL>	Stop before processing a new cutting plan. The automatic tube loader does not load a new tube
<STOP PART>	Stop before the next part
<STOP WORK>	Stop before and after a contour (before and after raising the cutting head)
<HALT CNC>	Stop the machining process
<SNGL STEP>	Work through plan in single steps (geometry element)
<STOP SEL>	Programmed stop to machining sequence (M01)
<SF1>	SF1 - SF4 Function keys (assignment depends on MMC Menu)
<MAIN>	MMC Main menu
<MANUAL >	Manual operation and diagnosis
<WORK>	Work through cutting plan
<SETUP>	Machine setup values
<DATA>	Editor for cutting plans and process parameters
<PARA>	Edit active parameters in the < Work> menu
<TASK>	not assigned
<PLC>	not assigned

Button	Description
<HALT PLC>	not assigned
<OPEN DOOR>	not assigned
<PLC1>	not assigned
<HEAD>	not assigned
<ESC>	Exit a dialog window without accepting the data
<BS>	(Back Space) Delete last character entered
<ENTER>	(Carriage Return) Acknowledge input
<PGDN>	Next screen page / Jump to end of block
<PGUP>	Previous screen page / Jump to start of block
<BACK>	Back to previous menu screen
<TAB>	Switch between the various dialog boxes using TAB key
Cursor keys	Move selection on screen in corresponding direction

### 4.3.3 Additional operating buttons



### 4.3.4 Hand-held controller

The hand-held controller is used for setup and adjustment tasks and for test cuts to determine parameters.

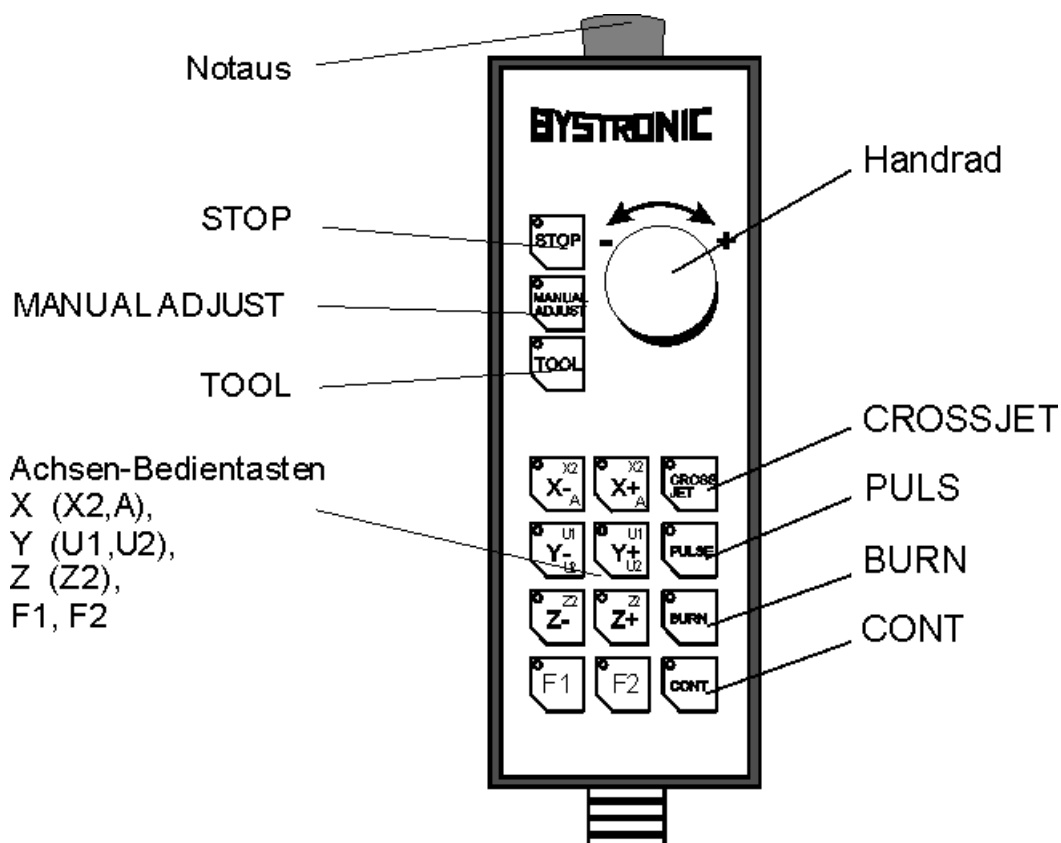
To activate the hand-held controller, select <HAND>, "Manual operation" or "Auto. setup".

The emergency stop buttons < STOP> and <CONT> are always enabled, regardless of whether or not you are in the <Hand> menu.

#### Brief description of buttons on the hand-held controller.

Button	Description
<BURN>	opens shutter and holds open whilst pressed down
<CONT>	Acknowledge button (continue)
<CROSSJET>	Crossjet functions
<MANUAL ADJUST>	Holding down this button enables fine positioning using thumb-wheel
<PULS>	Single pulse: Open shutter for selected period of time
<STOP>	Software stop: Stops all axis drives. Not an Emergency stop!

Fig. 4.3 -5



Button	Description
<F1>	Additional button (2 <sup>nd</sup> ) up
<F2>	Additional button (2 <sup>nd</sup> ) down
<U1+>	Rotates rotary axis counterclockwise, manual feed
<U1->	Rotates rotary axis clockwise, manual feed
<U2+>	Rotates rotary axis (steady rest) counterclockwise, manual feed
<U2->	Rotates rotary axis (on steady rest) clockwise, manual feed
<X+>	Moves away from zero point in X-direction, manual feed
<X->	Moves towards zero point in X-direction, manual feed
<X2+>	Moves the feed unit away from zero point in X-direction, manual feed
<X2->	Moves the feed unit towards zero point in X-direction, manual feed
<Y+>	Moves away from zero point in Y-direction, manual feed
<Y->	Moves towards zero point in Y-direction, manual feed
<TOOL>	activated (LED on)
<Z +>	Raises tool, capacitive sensing enabled, and closes assist-gas valve
<Z ->	Lowers tool, capacitive sensing enabled, and opens assist-gas valve
<TOOL>	deactivated (LED off)

Button	Description
<Z +>	Raises tool, capacitive sensing disabled
<Z ->	Lowers tool, capacitive sensing disabled
Thumb-wheel	Fine positioning of the axes

### 4.3.5 MCS cabinet

The MCS cabinet controls are described in Chapter 4 of the «BYLASER 3000» Operating Manual.

### 4.3.6 Fault messages

System and fault messages are displayed in the «MMC» and «Handling Operation» program in the yellow status-and error-message bars.

## 4.4 Operating modes

There are three operating modes that can be used when working with BYTUBE in Normal mode.

- **Hybrid**
- **Conventional (Byflex)**
- **Flat**

The machine is in Normal mode when

- the machine is correctly assembled,
- all covers and protective fences have been correctly fitted,
- the machine is switched on,
- all safety devices are reset,
- cutting plans and parameters have been imported,
- and the machining process has been started.

One can switch from one operating mode to another in the Setup menu. Hybrid operating mode = 1, Conventional operating mode = 0. Flat operating mode is enabled/disabled in FMS Handling.

The following axes and labels are relevant for operation and practical work.

### 4.4.1 HYBRID operating mode

Axis	Description
A	Travel unit with lance or support
X,Y,Z	Machining unit
U2	Plate holding rotary unit (steady rest) and four-jaw chuck
X2, U	Feed unit with gripper with rotary axis

Tubular sections with maximum external diameter of 170 mm can be cut in the HYBRID operating mode.

Bytube works with the tube loader. The U- and U2-axes are in use.

The cutting head moves in the Y- and Z-direction. The work piece moves along the X2-axis.

When cutting square and rectangular tubular sections, the X2-, Y- and Z-axes are active. When cutting circular tubes, the X2- and Z-axes are active.

The U2 rotary axis is fitted with the driven steady rest for cutting square and rectangular tubular sections.

Different cross-sections require suitably sized clamping jaws (steady rest) plus matching support plates and/or support rollers (located on tube-loader pillar rests).

Tubes are supported by a steady rest consisting of two solid vees able to move in opposing directions. Various sizes of vees are available.

### NOTE



*It is not possible to repeat an aborted cutting plan in Hybrid mode. This command key has therefore been disabled in the software.*

#### 4.4.2 CONVENTIONAL operating mode (Byflex)

In the Conventional operating mode (Byflex), the tube or the section is clamped in the four-jaw chuck in the lifting plate (U2) and a tailstock, i.e. the tube is placed directly in the machining area.

Tube magazine, pillar controller, steady rest and travel unit are not in use.

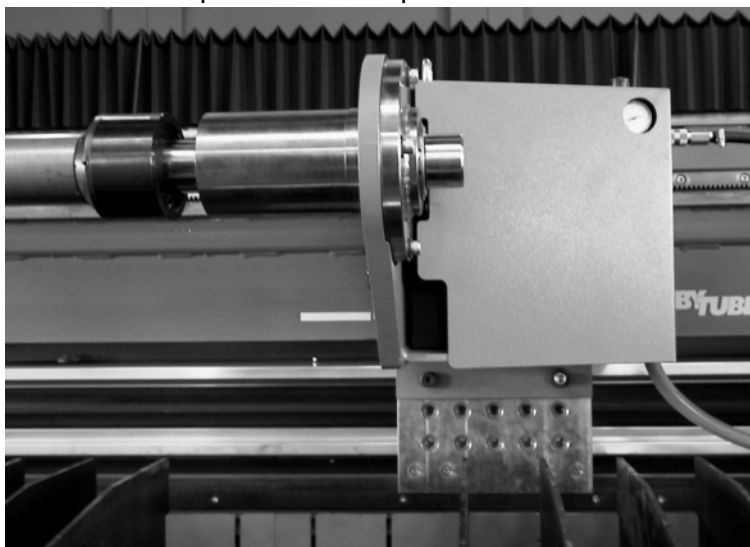
Fig. 4.4 -1 Four-jaw chuck in Conventional operating mode



Tubular sections with a maximum external diameter of 320mm and a maximum weight of 400kg can be cut.

The cutting head moves along the three axes X, Y and Z.

Fig. 4.4 -2 Tailstock nose piece with clamped tube



The tailstock is fixed mechanically in the required position. The travel unit is positioned as close as possible to the travel unit in manual operation, so that the compressed-air supply to the tailstock can be connected. The tube is clamped pneumatically via a foot pedal.

Tubular sections weighing more than 150 kg must be supported on rollers in a steady rest.

#### 4.4.3 FLAT operating mode

Bytube also has a limited capability for cutting flat sheets. For this mode, a table is placed on the base frame, and the sheets placed on the table grating.



In order to prevent the cutting head from colliding with the calibration plate or cleaning brush, the table must not be placed too far forward.

For Flat operation, "Conventional mode" must be selected in Setup, and "Flat cutting" selected under Setup in the Main menu.




### 4.4.4 Service mode

The machine is in Service mode when the machining sequence in Normal mode has been interrupted by the operator or by a third party. The reason for the stop makes no difference, whether for adjustment and checking tasks, loading and unloading or cleaning and maintenance work.

The machine enters Service mode at the moment when non-contact safety devices (e.g. light barriers) are crossed, the safety gate is opened or permanent safety devices are removed.

Normal mode is restored when the machine is once more ready for use, the safety devices are reset and the process is started up.





## CHAPTER

### Commissioning

Installation and commissioning are performed by Bystronic personnel or under the supervision of Bystronic. For this reason the “Commissioning” chapter is not included in the Operating Manual.

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**5. Commissioning..... 1**



## CHAPTER

### Operation

This chapter describes the operation of the laser cutting machine, and how to operate it safely. It also provides information on setting up and adjusting the laser cutting machine, as well as its various functions. The most important parameters for optimizing cutting are also explained.

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## **6.1 Introduction**

### **6.1.1 Safety regulations**

The Owner, operator and works mechanic must know the contents of Chapter 2 "Safety regulations" in order to avoid personal injury or damage to property when working with the Bytube machine.

### **6.1.2 Requirements to be met by personnel performing the disposal**

Relevant training of the operator includes participation in a training course by Bystronic Laser AG. The machine owner is responsible for ensuring the operator has the correct level of training.

The owner and operator shall ensure that no one is put at risk by the use of the Bytube laser cutting machine.

The operator is responsible in particular for the following points:

- Operation in Normal mode
- Cleaning and inspection
- Responding immediately to faults in accordance with regulations
- Keeping third parties out of the machine danger zone.

## 6.2 Operation of the system

### 6.2.1 Checks before switching on

Check the following points before starting the laser cutting machine:

- Safety equipment and emergency-stop devices are fitted and in working order.

*Operating elements relevant to personal safety are:*

- *EMERGENCY STOP*
- *Enable light barrier*
- *Open safety gate*
- *Close safety gate*
- *Stop Tubemagazine and chuck*

- All emergency stop buttons are reset.
- The machine and its components show no signs of external damage or faults.
- Compressed air is connected, pressure and quality meet technical specification.
- Laser gas bottles are connected and reducing valves are open, pressure and quality meet technical specification.
- Assist-gas bottle is connected and the reducing valve is open. As long as no assist gas is ready at the gas control, the high voltage stays locked during start-up.
- The key-operated switch on the MCS cabinet is set to «POWER» .
- The cooling unit and extraction-system power switches are on.
- There is no 3 ½ inch floppy disk in the A drive of the PPC (PPC cannot boot automatically if there is a disk in the drive).

## 6.2.2 Starting up the machine

Follow the four steps below to start the machine:

1. Open the gas supply
2. Open the compressed-air supply
3. Switch on the power supply
4. Press the Reset button on the PPC

### 6.2.2.1 Opening the gas supply

Open the reducing valves on the bottles containing assist gas ( $O_2$ ,  $N_2$ ), on the bottles containing laser gas ( $He$ ,  $CO_2$ ,  $N_2$ ) and on the compressed-air supply.

### 6.2.2.2 Switching on the power supply to the resonator and machine

The power supply to the whole system is switched on using the machine main power switch on the left side wall of the control cabinet. This switch can be locked in the <OFF> position, and must be switched to the <ON> position to start up the machine.

Fig. 6.2 -1



### 6.2.2.3 Pressing the Reset button on the PPC

The resonator is started automatically.

### 6.2.2.4 Switching on the resonator manually

In order to start the resonator, the key-operated switch on the MCS cabinet (laser) must be set to <ON> (position 1). The following prompt appears on the display..->RESET.

(The text BTL ... and P..-0.. varies according to the type of laser and program version used by the customer).

```
XXXXXX LASER DC BTL 3000 XXXXXX
XX BYSTRONIC AG   P02-03B  XX RESET
```

Now press the reset button above the key-operated switch. The <RESET> function sets the safety circuits to a defined state. Keep the reset button depressed for at least

three seconds to allow the control system to check all safety functions. The prompt <VACUUM ON?> appears in the display as the start-up message after the restart.

CURRENT	0	POWER	0	PRESS	1000
VACUUM ON?	SHUTTER UNLOCKED				

The resonator can be started up in step mode or automatically. To start the resonator up automatically, press the <ON> button on the keypad. The <Step> button must be disabled. The resonator is then started up automatically. The following message appears on the display once start-up is complete

CURRENT	14	POWER	400	PRESS	160
LASER READY SHUTTER UNLOCKED					

### NOTE



*The laser must reach the operating temperature before you start cutting. The operating temperature is reached when the power display stays permanently at the set power.*

#### 6.2.2.5 Peripheral equipment

- The cooling unit is also connected via the main power switch.
- The exhaust-air filter unit has a separate supply
- If the orange light on the laser cabinet is on, the machine is ready for use.

### 6.2.3 Shutting down the machine manually

#### 1. Shutting down the resonator

Press the <OFF> button on the keypad of the MCS cabinet (laser). This switches off the high voltage, turboblower and vacuum pump. The system is flooded with nitrogen to approximately ambient atmospheric pressure.

CURRENT	0	POWER	0	PRESS	155
RUNNING FLOOD SHUTTER UNLOCKED					

Flooding takes several minutes. After flooding has finished, the following display appears:

CURRENT	0	POWER	0	PRESS	990
VACUUM ON? SHUTTER UNLOCKED					

Only continue with the shutdown procedure once this display appears. (A new start-up cycle would also be possible now).

Turn the key to the left to position 0. Take out the key. All displays go out. The complete laser is powered down.

#### 2. Shutting down the Panel PC

In the MMC, use the <MAIN> key on the MMC keypad to go to the start page of the MMC software, and press <Shut down> in the lower menu field to shut down the MMC and the computer.

Do not switch off the power supply to the Panel PC until the following message appears on the screen: "You can switch off the computer now".

#### 3. Switching off the peripheral equipment

- Switch off the main power switch on the left of the control cabinet
- Close the compressed air supply
- Close the reducing valve on the assist-gas and laser-gas supply

### 6.2.4 Shutting down the machine automatically

The relevant setting can be made in Setup under the heading "Set-up Laser". See "Setup Parameters" chapter.

If the appropriate value has been entered, the software on the PPC can be closed. If the resonator is flooded, the machine can be shut down using the main power switch.

There are two other options for shutting down the machine automatically.

1. Shutting down after a defined time (parameter: "Switching off after:" in the MMC Setup)
2. Shutting down after a fault

## 6.2.4.1 Shutting down after a defined time

The machine is shut down:

- once the job list has been worked through
- once the cutting head has moved to the reference position
- and once the shutdown time specified in the MMC Setup has elapsed.

The STL controller switches the following components off in the order shown:

<b>immediately:</b>	<ul style="list-style-type: none"> <li>– Laser high voltage off</li> <li>– Laser blower off</li> <li>– Laser system flooded with nitrogen</li> </ul>
<b>after 1 minute:</b>	<ul style="list-style-type: none"> <li>– Exhaust air filter switched off</li> </ul>
<b>after 5 minutes:</b>	<ul style="list-style-type: none"> <li>– Cutting gases switched off</li> <li>– Compressed air switched off</li> </ul>
<b>after 10 minutes:</b>	<ul style="list-style-type: none"> <li>– Cooling unit compressor switched off</li> <li>– Cooling unit fan switched off</li> </ul>

## 6.2.4.2 Shutting down after a fault

The machine is shut down automatically after the following faults:

- Machine fault
- System error
- Incomplete loading process
- Incomplete removal process
- Light barrier interrupted

The STL controller shuts down the machine automatically after 60 minutes have elapsed. Shutdown can be prevented if the fault is rectified within this period. The shutdown procedure follows the sequence given in "Shutting down after a defined time"

## 6.2.5 Start-up after automatic shutdown

### NOTE



*Before starting up the machine, the time parameter in the MMC\_Setup must be reset to zero.*

After an automatic shutdown, the resonator must be re-started manually.

In order to re-start the resonator, press the reset button above the key-operated switch. The <RESET> function sets the safety circuits to a defined state. Keep the reset button depressed for at least three seconds to allow the control system to check all safety functions. The prompt <VACUUM ON?> appears in the display as the start-up message after the restart.

CURRENT	0	POWER	0	PRESS	1000
VACUUM ON? SHUTTER UNLOCKED					

The resonator can be started up in step mode or automatically. To start the resonator up automatically, press the <ON> button on the keypad. The <Step> button must be disabled. The resonator is then started up automatically. The following message appears on the display once start-up is complete

CURRENT	14	POWER	400	PRESS	160
LASER READY SHUTTER UNLOCKED					

**NOTE**

*The laser must reach the operating temperature before you start cutting. The operating temperature is reached when the power display stays permanently at the set power.*



## 6.3 Using the Panel PC

### 6.3.1 Starting the software

The software is started as follows:

1. Switch main switch on
2. This starts Windows NT
3. RS-View together with the Transport project and the MMC are started up automatically.
4. The root menu "Main" appears on the screen
5. You can switch back and forth between the RS-View and MMC programs by pressing the [Alt] and [Tab] keys together.

### 6.3.2 General information

The MMC software controls the cutting process of the laser machine, The MMC is a program with which the CNC controller can be displayed and changed.

The laser machine is operated via the following six main menus, which can be selected on the PPC operator terminal using the buttons with the same names.

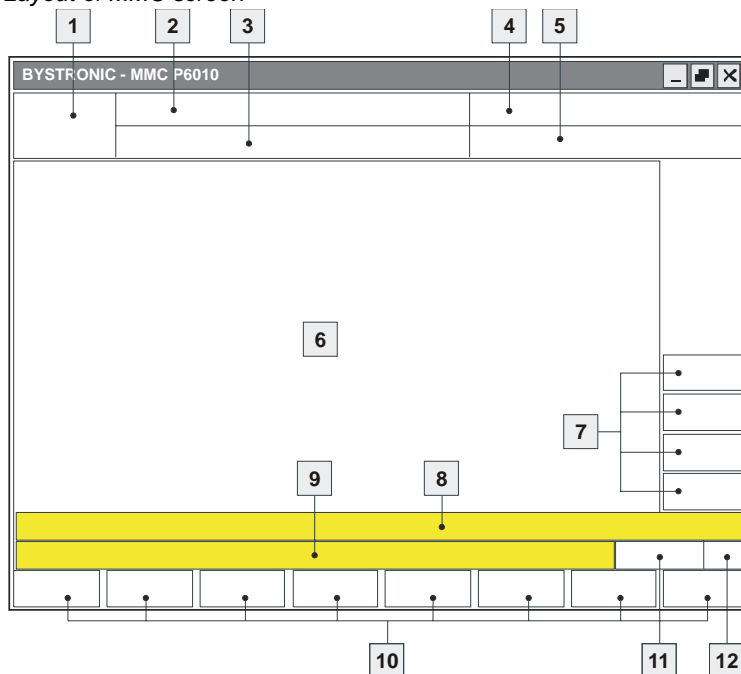
#### 6.3.2.1 Summary of the MMC menus

<b>MAIN</b>	Main screen at MMC start-up User logon and logoff, Windows NT4 operating system shutdown, machine configuration.
<b>WORK</b>	In this menu NC programs are selected, cutting parameters loaded and cutting plans executed; it also displays system messages.
<b>MANUAL</b>	It is possible to operate the machine manually in this menu. The diagnosis of any pending errors is also implemented here.
<b>PARAM</b>	Active process parameters are loaded in this menu. Changes can be made here and the data saved under the same or a new name.
<b>DATA</b>	An NC program can be created, edited and displayed graphically in the DIN Editor in this menu.
<b>SETUP</b>	Setup value settings are made in this menu. Access to these data is only possible on the < EXPERT> access level.

### 6.3.3 Layout of MMC screen

The MMC screen interface contains the following elements:

Fig. 6.3 -1 Layout of MMC screen



1.	<b>Menu</b>	This field shows which menu you are in. Labels match machine keyboard: <MAIN>, <WORK>, <MANUAL>, <PARAM>, <DATA>, <SETUP>
2.	<b>CNC operating mode</b>	Displays current operating state of the machine (e.g. individual job, automatic mode, manual mode, test mode, etc.)
3.	<b>Information on material</b>	Name and dimensions of current material
4.	<b>NC program</b>	File name of current cutting plan
5.	<b>Parameter file</b>	File name of current process parameters
6.	<b>Application window</b>	different displays according to menu
7.	<b>LED function keys</b>	Designation of LED function keys SF1 – SF4 on the machine keyboard; enabled in WORK and MANUAL
8.	<b>Comment line</b>	NC program comments are displayed as information for the operator.
9.	<b>System messages</b>	Status and error messages for the machine.
10.	<b>Function keys</b>	Designation of the function keys S1 – S8 on the machine keyboard, different assignments depending on the menu.
11.	<b>Date</b>	Displays today's date
12.	<b>Time</b>	Displays the current time

## 6.3.4 Manual cutting process

The manual cutting process is the usual way of starting a cutting process.

### 6.3.4.1 Reading in cutting plan



1. Press the <WORK> button on the terminal.
2. In the «Work» menu press the [f1] key or the «Job List» button.
3. In the «Job List» sub-menu press the [f1] key or the «Job/SPL» button. The «Add NC program» dialog window appears.
4. In this dialog box you can select the jobs that you want to import. Follow the instructions below:
  - Select the drive (1st column)
  - Select the directory in which the jobs are located (2nd column)
  - Select the jobs/files that you want to cut (3rd column)  
(Multiple selection possible using the «Shift» or «Ctrl» keys).
5. Confirm the selection by clicking on «OK». All the selected jobs will be entered in the «Job List».
6. If the Job List contains more than one job, then you can change the order in which they are performed using the "Prioritize" button.  
The jobs in the Job List are processed from top to bottom.

#### NOTE



*For further information on the "Add NC program" dialog and on the "Job List" sub-menu please see the MMC Online Help.*

### 6.3.4.2 Assigning cutting parameters to a job



1. In the «Job List» sub-menu select the first job that has not yet been assigned a parameter file.
2. Press the [f2] key or the «Select param.» Button. The «Load parameter file» dialog window appears.
3. You can select the cutting parameters for the job in this dialog. To do this proceed as in Point 4. Only one parameter can be assigned to each job. When selecting the parameter take into account which laser is being used and which version of the CNC controller is present.
4. Confirm the selection by clicking on «OK». The parameter is assigned to the selected job. Jobs with "default" next to them in the «Parameter file» column use the parameter file that was assigned to the job before them.

#### 6.3.4.3 Starting the cutting process

1. Use the >BACK> button to switch back to the «Work» menu. In the “Work” menu the job to be cut is displayed in the graphic window.
2. Press the [f6] key or the «Start work» button. The current job with the parameter assigned to it is read into the CNC. The status message «STOP Cycle - Wait for <CONT>/<ABORT>» appears.

#### NOTE



*Press the [F4] key or the «Info» button in the «Work» menu to check that the cutting data such as focal length of cutting head, nozzle type, material thickness, etc. are correct.*

3. What you do next depends on the operating mode:

#### 6.3.4.4 Starting the cutting process, "Hybrid" mode

- Insert the support rollers or vees on the pillar rests of the tube loader
- Grippers must be adjusted to suit the tubular section.
- Select the correct steady rest and adjust accordingly
- Select the "Auto" function in RS-View "Manual". Tube loading then proceeds automatically.
- In the MMC Setup, define whether cutting is being performed with the lance or tray
- Select the "Hybrid" operating mode in the MMC Setup

#### 6.3.4.5 Starting the cutting process, "Conventional / Byflex" mode

- Insert the mechanical chuck
- Fit the tailstock
- For heavy, long tubes insert additional support
- Select the "Conventional" operating mode in the MMC Setup

#### 6.3.4.6 *Starting the cutting process, "Conventional / Flat" mode*

- Fit the table or support surface (a maximum width of 400 mm can be cut)
- Select "Flat cutting" in RS-View Setup
- Select the "Conventional" operating mode in the MMC Setup

**Press the [f5] key or the «CONT» button to start the cutting process.**

Depending on which stop buttons are selected (>STOP CYCL>, <STOP PART>, <STOP WORK>, <HALT CNC>, <STOP SEL>), you are prompted to enter the appropriate confirmation in the status bar with «<CONT>/<ABORT>» to continue with the next program step. The stop keys are used for checking the cutting process before or after certain program steps. An explanation of the individual stop functions can be found in the MMC Online Help.

### 6.3.5 MMC menus

You can find basic information on the MMC in the "MMC Introductory Training" manual. This chapter describes any differences that apply specifically to the BYTUBE application.

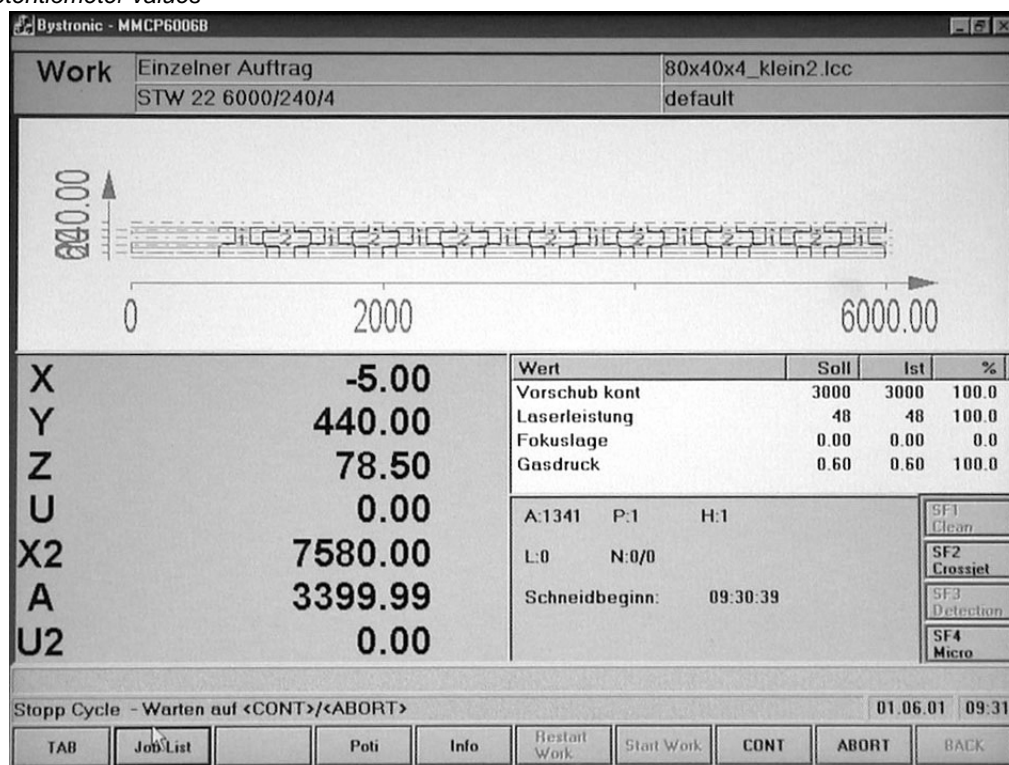
#### 6.3.5.1 Main

Main screen at MMC start-up User logon and logoff, Windows NT operating system shutdown, machine configuration.

#### 6.3.5.2 WORK

In this menu NC programs are selected, cutting parameters loaded and plans processed; display of system messages.

Fig. 6.3 -2 Potentiometer values

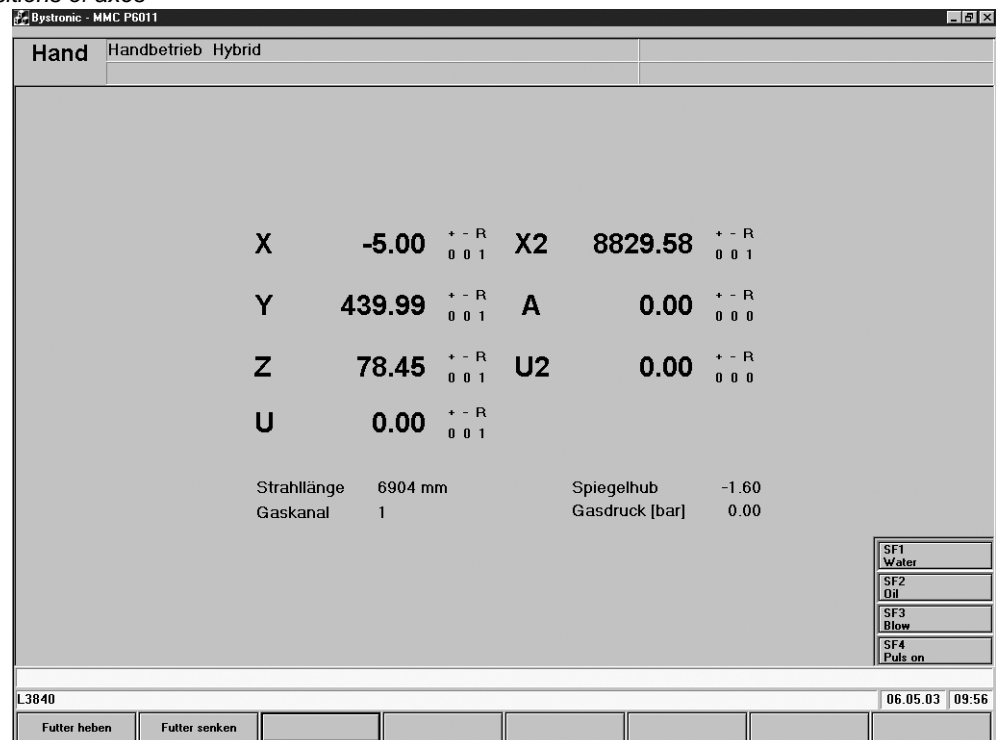


The values assigned in SETUP to the four potentiometers can be read here.

#### 6.3.5.3 MANUAL

It is possible to operate the machine manually in this menu. It also includes a fault diagnosis facility for any outstanding faults.

Fig. 6.3 -3 Positions of axes



When used in production, the positions can be monitored using the display above, which shows the following axes:

- X: Machining unit X-axis (longitudinal direction)
- X2: Feed unit X2-axis (longitudinal direction)
- Y: Cutting carriage (sideways)
- Z: Cutting head (vertical)
- U: Rotary axis of the gripper (feed unit)
- U2: Rotary axis on the lifting plate (steady rest/chuck)
- A: Position of the travel unit

The buttons at the bottom of the window are provided for manual operation of the tube loader and steady rest.

Buttons	Explanation
Pillar rests reference	Move all pillar rests to the reference point
Pillar rests down	All pillar rests are lowered
Pillar rests up	All pillar rests are raised
X pillar rest up	Each pillar rest is raised individually
X pillar rest down	Each pillar rest is lowered individually
Pillar rests radius	Move the pillar rests to the REQUIRED position
Open steady rest	The steady rest is opened

Close steady rest	The steady rest is closed
Raise chuck	Lifting plate moves up into top limit of travel
Lower chuck	Lifting plate moves down into bottom limit of travel

#### 6.3.5.4 **PARAM**

Active process parameters are loaded in this menu. In addition, changes can be made and the data saved under the same or a new name. Potentiometers can be assigned to four parameters, which can be displayed and varied.

Assign pot 1

Assign pot 2

Assign pot 3

Assign pot 4

Select Param

Save Param.

The individual windows in which the parameters can be set are documented in the "MMC Introductory Training" manual. These are:

Material / Tool data

Parameters, Continuous mode

Special parameters

Pulse mode parameters

Engraving mode parameters

CW macro parameters 1 / 2

Cutcontrol parameters

Additional information



## 6.3.5.5 DATA

An NC program can be created, edited and displayed graphically in the DIN Editor in this menu. You can also edit the parameters in the Parameter Editor or create new ones.

TAB

Edit

Graphic

Entry in Job List

Select NC prog.

Save NC prog.

BACK

Please refer to the Online Help for more information.

## 6.3.5.6 SETUP

Setup value settings are made in this menu. Access to this data is only possible at the < EXPERT> level.

TAB

Setup values

Process macros

Process setup

BACK

Fig. 6.3 -4 Setup values

Einrichtwerte Bytube		Wert	Einheit
X Achse: Arbeitsposition Hybrid		80	mm
X2 Spannfutterbreite		0	mm
Lichtschraken-Abstand		860	mm
Grenze Lünette öffnen (Position)		350	mm
Kollisionsgrenze Profilrohr		300	mm
Kollisionsgrenze Rundrohr		130	mm
X2 Entsorgeposition Profilrohr		301	mm
X2 Entsorgeposition Rundrohr		120	mm
<b>Bytube</b>			
Lichtschrake vorhanden: [0=aus,1=ein]		1	
Futter spannen: [0=aussen, 1=innen]		1	
Mit Lanze: [0=aus,1=ein]		0	
Mit Schale: [0=aus,1=ein,2=Ende pos,3=schneiden pos]		0	
Mit Gegenhalter [0=aus,1=ein]		0	
Lade kurze Rohre: [0=aus,1=ein]		0	
X2 Achse: Geschwindigkeit Futter spannen Pos.		4000	mm/min
X2 Achse: Futter spannen Position		7500	mm
X2 Achse: Futter spannen Position kurz		2950	mm
X2 Achse: Stützen ab Vorlauf		800	mm
Stützenhöhe Offset		0	mm

Antriebe verriegelt 23.10.02 08:41

TAB Einrichtwerte Prozess Makros Prozess einstellen BACK

**6.3.5.7 Bytube setup values**

<b>X-axis: Working position, Hybrid mode</b>	Distance of nozzle from reference point
<b>X2 chuck width</b>	If a chuck with relatively long jaws is fitted, this dimension must be entered
<b>Light barrier distance</b>	Distance from the zero point to the light barrier (virtual light-barrier distance). The distance that the tube moves forwards depends on the value entered here. For instance, if a value 100 mm larger is set, then the first waste part is longer. This is particularly important for parts cut at an angle.
<b>Open limit of end support (position)</b>	Position of work piece at which the steady rest is opened. This value applies to the machining of circular tubes.
<b>Collision limit tubular section / Collision limit circular tube</b>	Distance from zero point back to collision limit. Applies when cutting tubes, typical value 270mm. The distance must always be set so that one cannot drive into the steady rest with the X2 axis.
<b>X2 Disposal position tubular section / X2 Disposal position circular tube</b>	After cutting the last piece, the chuck moves close enough to the steady rest to allow a leftover piece to be pushed out. This disposal position can be defined here. The value for circular tubes can be reduced, but is 250 mm for rectangular tubes.
<b>Raise chuck / Lower chuck</b>	The lifting plate is now controlled by the CNC. In order to raise the plate, the machine must be in Hybrid mode and the X2-axis sitting in the reference position. The command is performed in the second Shift menu using "Raise chuck" / "Lower chuck".

**6.3.5.8 Bytube settings**

<b>Light barrier fitted [0/1]</b>	Enable or disable light barrier for detecting tube. Tube length must match that in cutting plan.
<b>Chuck clamping: [0=external, 1=internal]</b>	For large tube diameters the tube is clamped from inside. The direction of the clamping action of the jaws can be set here.
<b>With lance [0/1]</b>	A 1 must be entered here if a lance is being used

<b>With tray [0=off, 1=on, 2=end pos. 3= cutting pos.]</b>	<p>0: Entering a 0 means that no tray is being used.</p> <p>1: The tray moves into the parked position and waits until the material is present. Then the tray (in lowered position) moves to the center (of gravity) of the work piece to be cut, is raised again and stops. The first cut/severance cut drops down onto the conveyor. (The tray tips up without material.) As soon as the part has finished being cut, it is taken by the gripper and discarded in the disposal position.</p> <p>2: The tray moves into the parked position and waits until the material is present. Then the tray (in lowered position) moves to the center (of gravity) of the work piece to be cut and waits until the first cut piece has dropped off. Then the tray moves under the tube and stops. Before the last cut (part finished), the tray returns to the center of gravity. Once the part has finished being cut, it is taken by the gripper and discarded in the disposal position.</p> <p>3: The tray moves with the center of gravity.</p>
<b>With tailstock [0=off, 1=on]</b>	A 1 must be entered here if a tailstock is being used
<b>Loading short tubes [0/1]</b>	If tubes of length 2m are placed in the tube loader, then they must be placed against the right end stops. This is set with a 1.
<b>X2 axis: Chuck speed to clamping pos.</b>	Defines the speed at which the chuck moves to the specified position.
<b>X2 axis Chuck clamping position</b>	Defines the position at which the chuck clamps a long tube.
<b>X2 axis Chuck clamping position short</b>	Defines the position at which the chuck clamps a short tube that has been placed against the right-hand end stop of the tube loader.
<b>X2 axis: Pillar rests down, forward</b>	Defines the distance between chuck and pillar rest at which the pillar rest is lowered when the chuck moves forward.
<b>Steady-rest height offset</b>	The offset can be used to adjust the steady-rest height to the ideal axis height according to the tube diameter.

### 6.3.5.9 A-axis

Fig. 6.3 -5 A-axis setup values

The screenshot shows the 'Setup' screen for a Bystronic MMCP6006C machine. The title bar indicates 'Bystronic - MMCP6006C \*'. The main window is titled 'Setup Hybrid'. Below the title, there is a table of parameters for the A-axis. The parameters are listed in the left column, and their values and units are in the right columns. The parameters include: Schalen Laenge (660 mm), Schalen Position (110 mm), Schalen Offset (100 mm), Lanze Laenge (400 mm), Lanze Position (120 mm), Lanze Offset (0 mm), Entsorgepositionen zu Lanze und Schale (3000 mm), Bahnhofpositionen (2500 mm), Entsorgepositionen 1 (2000 mm), Entsorgepositionen 2 (2500 mm), Entsorgepositionen 3 (3000 mm), Spez. Schale (60000 mm/min), Schalen Geschwindigkeit (60000 mm/min), Bytube Betriebsart (1), Schale kippen: [0=aus, 1=ein] (1), Betriebsart: Konventionell=0, Hybrid=1 (1), and Lünette U2 beim Rohrladen öffnen 0=nein 1=ja (0). At the bottom, there is a status bar with 'Antriebe verriegelt', a date/time display '23.10.02 08:39', and several buttons: TAB, Einricht.werte, Prozess Makros, Prozess einstellen, and BACK.

A Achse	Wert	Einheit
Schalen Laenge	660	mm
Schalen Position	110	mm
Schalen Offset	100	mm
Lanze Laenge	400	mm
Lanze Position	120	mm
Lanze Offset	0	mm
<b>Entsorgepositionen zu Lanze und Schale</b>		
Bahnhofpositionen	3000	mm
Entsorgepositionen 1	2500	mm
Entsorgepositionen 2	2000	mm
Entsorgepositionen 3	2500	mm
Entsorgepositionen 4	3000	mm
<b>Spez. Schale</b>		
Schalen Geschwindigkeit	60000	mm/min
<b>Bytube Betriebsart</b>		
Schale kippen: [0=aus, 1=ein]	1	
Betriebsart: Konventionell=0, Hybrid=1	1	
Lünette U2 beim Rohrladen öffnen 0=nein 1=ja	0	

Antriebe verriegelt 23.10.02 08:39

TAB Einricht.werte Prozess Makros Prozess einstellen BACK

<b>Tray length</b>	The length of the tray mounted on the travel unit. The tray is used for collecting the work piece or the waste.
<b>Tray position</b>	This value specifies the position of the tray. The position is measured from the front edge of the travel unit to the front edge of the tray.
<b>Tray offset</b>	Tray position compensation. Distance from start of tray to rotary axis
<b>Lance length</b>	Length of the lance. Measured from the front edge of the travel unit to the lance mount.
<b>Lance position</b>	Position of the lance.
<b>Lance offset</b>	Lance position compensation. Distance from lance tip to rotary axis
<b>Disposal positions for lance and tray</b>	
<b>Station positions</b>	This position is the starting point for the travel unit or the intermediate position during operation.
<b>Disposal positions 1 - 4</b>	The 4 disposal positions can be used to define points at which parts or waste can be discarded.

<b>Tray spec.</b>	
<b>Tray speed</b>	The tray speed is the speed at which the travel unit moves back with the tray. The speed must be selected to ensure that a work piece does not fall off when the travel unit accelerates.
<b>Bytube operating mode</b>	
<b>Tip tray [0=off, 1=on]</b>	Tipping of the tray can be enabled or disabled.
<b>Operating mode Conventional=0, Hybrid=1</b>	The operating modes must be defined. 0 is selected for manual loading and conventionally clamped work piece. Hybrid operating mode (1) is selected for automated loading by the tube loader.
<b>Steady rest U2 closed for tube changeover</b>	<p>This function is enabled to prevent a leftover tube being tipped up at tube changeover. The next tube pushes the leftover tube along with the steady rest closed. This prevents a leftover tube from tipping up and colliding with a new tube pushing it along.</p> <p>This function must be enabled during machining of the first tube, otherwise the tube moves into the closed steady rest at the start.</p>

### 6.3.6 PLC - Handling Operation

The main window is the entry point into the tube handling software.

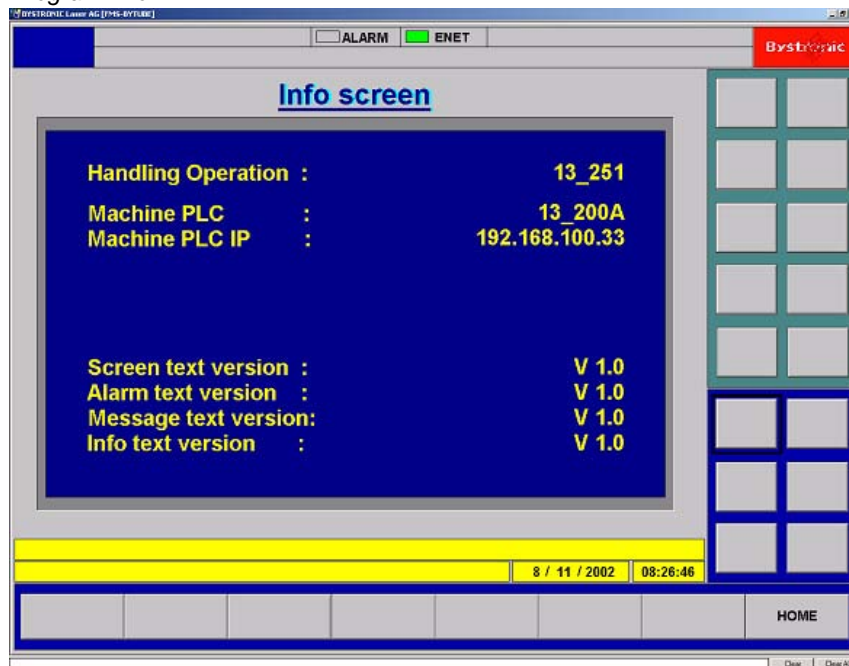
Fig. 6.3 -6 *Main window*



The submenus are accessed from the Main menu. Some of the menus are access protected with a login procedure. It is possible to switch between different cell modules within the submenus.

The "Info" window provides information on the software and version.

Fig. 6.3 -7 *Program Info*



<b>Main</b>	Root screen which opens when the software is started.
<b>Hand / Manuall</b>	Manual operation of the various tube-handling elements
<b>Setup</b>	Settings fro the configured components
<b>Configuration</b>	Configuration of the modules fitted
<b>Login/Logout</b>	Entry to / exit from password-protected areas of the software
<b>Exit</b>	Exits the software
<b>Alarm</b>	Alarm-message handling
<b>Home</b>	Back to start page

### 6.3.6.1 Hand/Manual menu

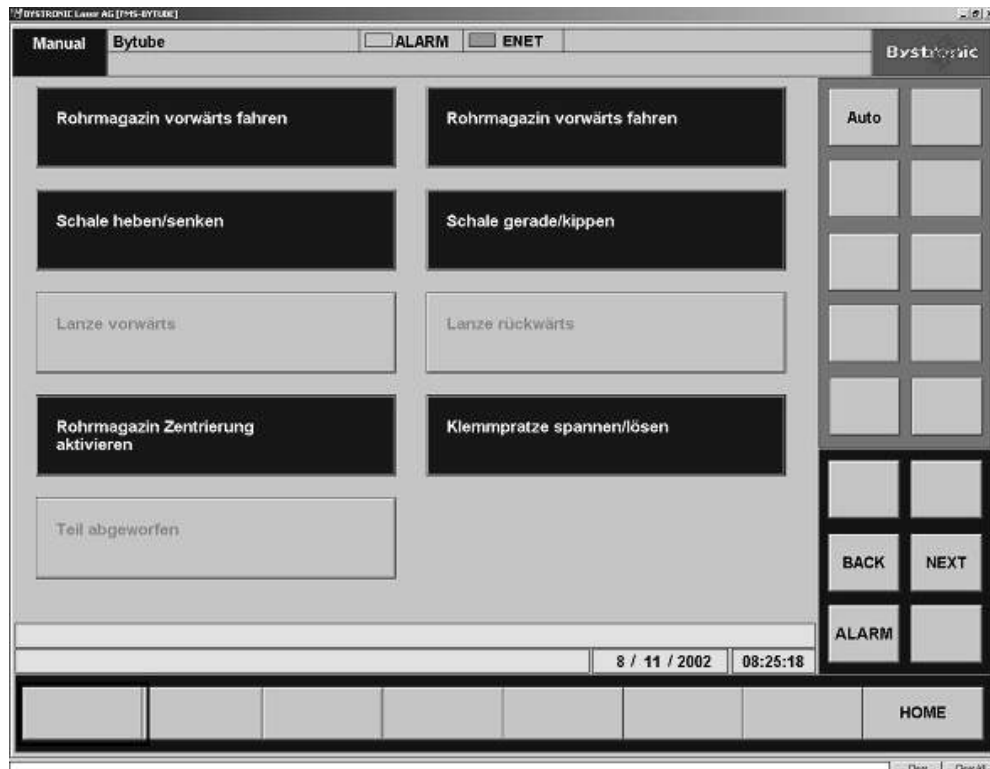
The tube loader is operated using the "Manual" menu.

<Next> scrolls to the next page.

<Alarm> signals a triggered alarm.

<Home> takes you back to the start page.

Fig. 6.3-8 Hand/Manual menu



As the buttons indicate, various functions of the tube loader and tools can be enabled.

- The tube-loader chain moves forward.
- The tube-loader chain is put into reverse.

- Tray can be raised or lowered.
- Tray can be placed in a tipped or level position.
- Square and rectangular sections can be centered.
- The clamping brackets are closed / released.
- The lance is moved forwards or backwards.
- If the machine does not automatically detect a part being discarded, this can be confirmed manually.
- The <Auto> button is used to initiate the loading process.

Fig. 6.3 -9 Hand / Manual menu, 2nd page



In this menu one can

- raise or lower the chuck.

If the machine is set up for the "Conventional" operating mode, one can

- clamp or release the tailstock.

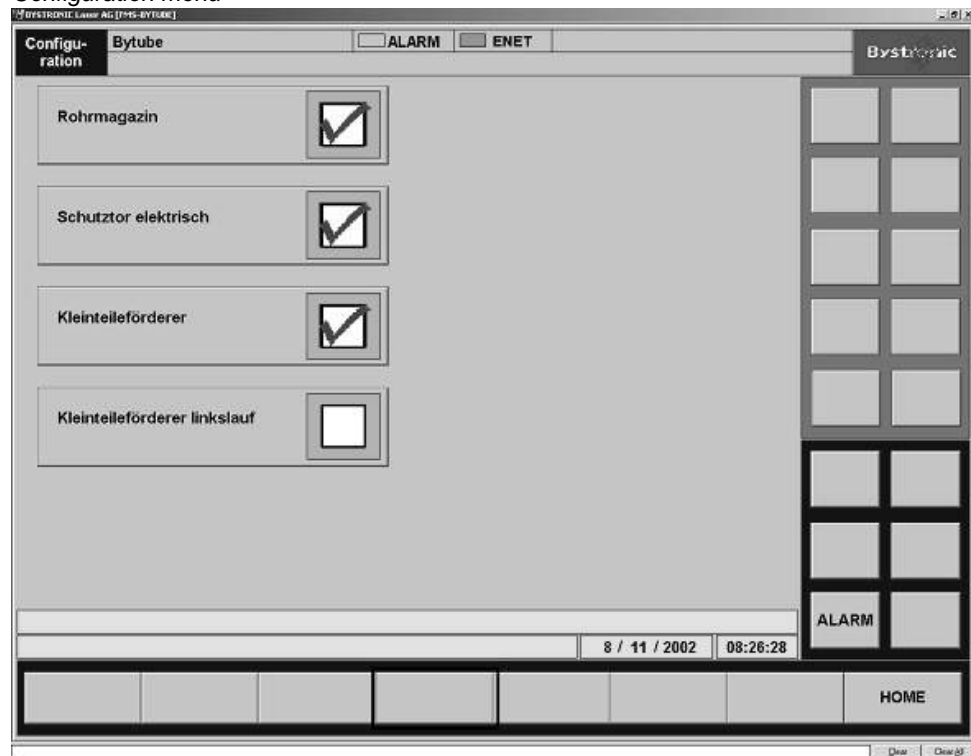
The small-parts conveyor is

- moved forwards and backwards. The time displayed on the "small-parts conveyor forward" button indicates how long the small-parts conveyor continues running after cutting.



## 6.3.6.2 "Configuration" menu

Fig.6.3-10 Configuration menu

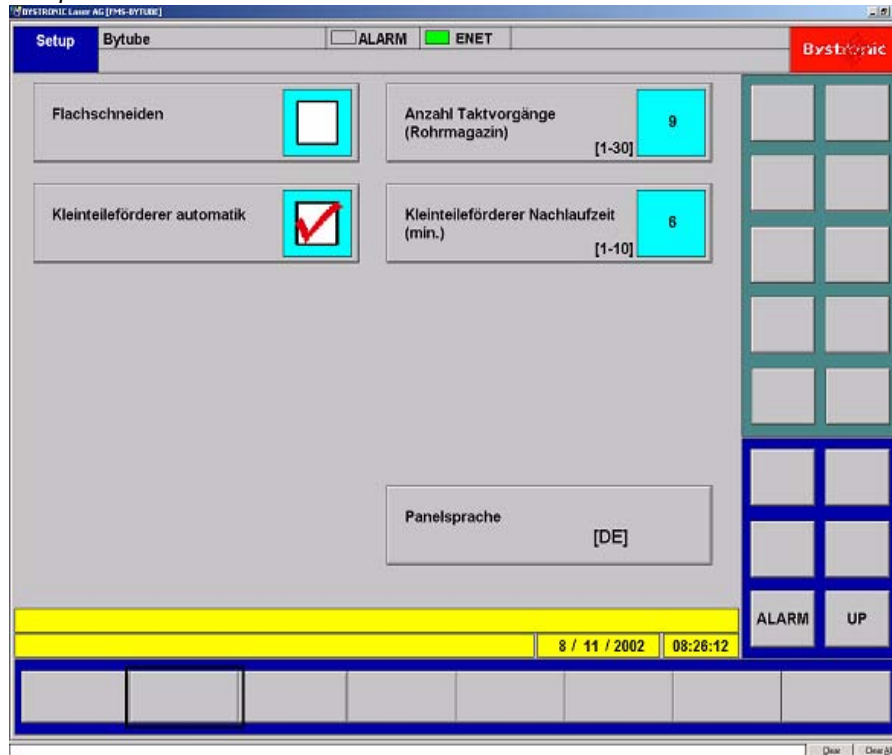


In the **"Configuration" menu** one can select whether

- a tube magazine is in use
- the safety gate is electrically connected
- the small-parts conveyor is fitted
- and whether the small-parts conveyor is running counter-clockwise.

### 6.3.6.3 “Setup” menu

Fig.6.3-11 Setup menu



In the “**Setup**” menu one can

- prepare the machine for flat cutting
- enable automatic operation of the small-parts conveyor
- enter the number of positioning steps to be made by the tube magazine before it stops. The number can be set between 1 and 30.
- set the time the small-parts conveyor continues to run, between 1 and 10 minutes.

### 6.3.7 “Emergency Stop” alarm messages

Activating the [Emergency stop] button disconnects all electrical loads from the power supply. This does not apply to the controller or the dust extraction system (filter) if fitted.

The "Emergency Stop" alarm message appears on the screen.

In order to bring the system back into a defined status after an emergency stop, proceed as follows:

1. Rectify the problem
2. Reset the Emergency stop button
3. Switch off laser controller (MCS)
4. Press the Reset button on the STL control cabinet (button must light up).
5. Switch on the laser controller (LCS); see “Laser Operating Manual”
6. Start up the laser and begin the machining process

Enable light barrier

The light barrier protects against access to the danger area of the tube loader. If the light beam is interrupted, the drives of the transport systems in question are disconnected from the supply. The programmable controller stores the last program step.

The following states are indicated by the lamp coming on:

#### **Lamp flashing:**

The light barrier circuit has been interrupted. Controller issues prompt to press the enable button.

#### **Lamp lit:**

The light barrier circuit is in working order and active.

### 6.3.8 Status fields

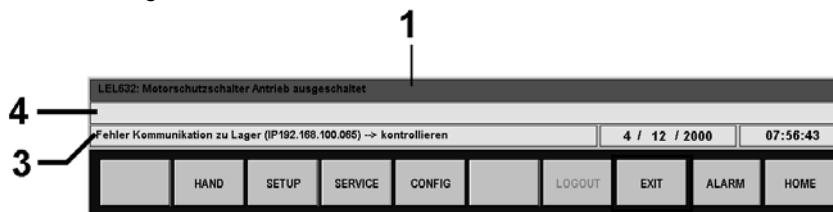
Alarm and machine messages are treated differently.

#### 6.3.8.1 Machine messages

The messages provide information about the instantaneous status of the machining process. Information concerning the commands that follow immediately thereafter are displayed for further processing. The current machine status is displayed in field (3) and the current machining process in field (4).

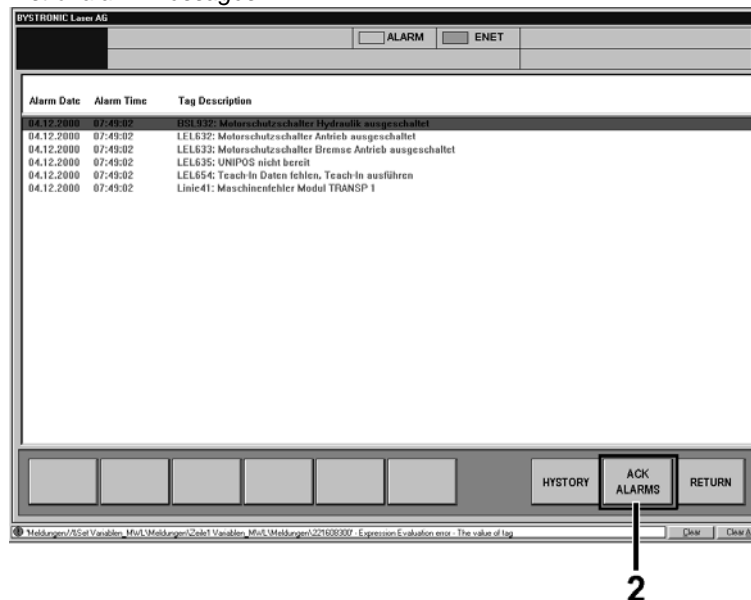
#### 6.3.8.2 Alarm messages

Fig.6.3-12 Alarm message



Any faults are shown on the display (1) in plain text . Pressing the [ALARM] button displays the list of all errors.

Fig.6.3-13 List of alarm messages



If there are several errors, they can be shown in a list and deleted using the button [ACK ALARMS] (2).

Alarm messages (1) are triggered by an erroneous controller state.

Different colors for the error messaging are used to indicate the severity of the cause.

Tab. 6.3-1

Alarm messaging color	Meaning
red	current, active alarm message which shuts down the machine.
violet	acknowledged alarm message that is still active and is stopping machine operation
blue	unacknowledged alarm message that does not cause an immediate break in machine operation.

If a fault occurs, then it triggers an alarm message. All automatic processes and manual operation in the relevant module are stopped. After the problem is fixed and the alarm has been acknowledged, operation can continue.

## 6.4 Layout of the MMC Online Help facility

### General information

An OnlineHelp facility is installed with the MMC software. The Help facility contains the description of each of the MMC functions. It is installed in the same language as that used in the MMC. The Help files are located in the MMC root directory. The file name is "HELPLCC\_\*.hlp", where the \* stands for the language version.

### 6.4.1 Opening the Help facility

Fig. 6.4 -1 *Help dialog in the «Main» menu.*

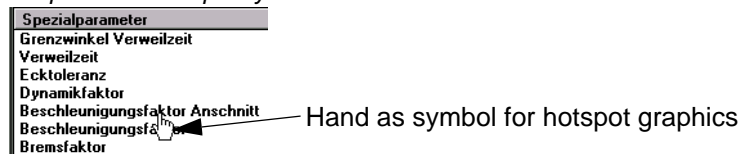


You can open the Help facility from the MMC user interface using the «SHIFT-F1» hotkeys. The Help facility is context sensitive; «SHIFT-F1» retrieves the Help topic relating to whichever menu page or dialog window is open in the MMC. A screenshot appears with Help text. If the displayed text or screenshot is larger than the displayed area of the screen, then you can scroll using the scrollbars on the right and bottom of the window.

You can also open the Help facility by selecting the Help file in the Windows user interface.

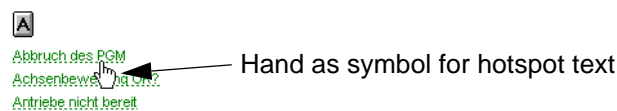
## 6.4.2 User guidance

Fig. 6.4 -2 Graphic with hot-spot symbol



Most graphics have hidden hotspots. A "hotspot" refers to an active element in this screen. If you move the mouse cursor over an area containing a background "hotspot", the mouse cursor becomes a hand. Clicking with the mouse then opens the associated Help text or jumps to the relevant Help page.

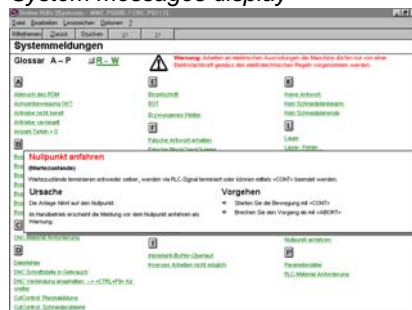
Fig. 6.4 -3 Text as hotspot



If a screen text is displayed in green then it contains a cross-reference or "hotspot". Clicking on the «Related topics» option opens a dialog box containing similar or related terms.

## 6.4.3 System messages

Fig. 6.4 -4 System messages display



You can display explanations of «System and error messages» that appear in the MMC status line by pressing the «System messages» button in the six main menus of the Online Help. This opens a glossary of the messages. Clicking on the message opens the associated explanation.

#### 6.4.4 Search for terms

There are 3 options for searching for specific topics or terms within the Help facility. Clicking on the «Help topics» button opens a dialog window containing the tabs "Contents, Index, Search".

##### Contents:

The «Contents» page is the same as a table of contents. Clicking on the main topics opens a sub-list from which you can jump to the Help topics.

##### Index:

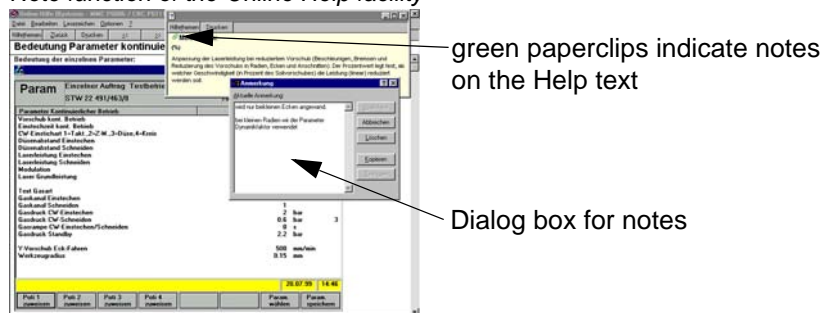
The Help topic being sought is accessed by entering the search term in the top input line and clicking on the entry that appears in the search result.

##### Search:

The «Search» function can be used to find words or terms anywhere in the Help facility.

#### 6.4.5 Note function of the Online Help facility

Fig. 6.4 -5 Note function of the Online Help facility



The Online Help facility includes an option for saving additional information or personal notes on specific entries. To do this, open the Help window to which you want to add certain notes. Right-click in this window to open a dialog box. Click on the «Notes» option. This opens a dialog box in which you can add personal notes or comments to the selected Help dialog box. Save the note you have made. A green paperclip appears above the Help topic to indicate that there is a note attached to this topic.

#### 6.4.6 Limitation in the "DIN-EDITOR" menu page

Using the «SHIFT-F1» hotkeys to open the Help facility is only possible in the MMC software. The DIN-EDITOR should be considered as a separate program, however, so the Help facility cannot be opened from here using «SHIFT-F1». The quickest way of accessing the DIN-EDITOR Help topic is to click on the «EDITOR» button in the «DATA menu» Help topic.



## 6.5 Assist gases

Nitrogen (N<sub>2</sub>) and oxygen (O<sub>2</sub>) are used for laser cutting.

### 6.5.1 Assist gas quality

The gas quality has a crucial impact on the cut quality. Nitrogen affects the quality of the cut surface. The following table shows the relationship between quality grade and oxide formation on the cut surface.

Gas type	Quality	Purity [Vol. %]	Proportion nitrogen + argon (N <sub>2</sub> +Ar) / [ppm]	Proportion of water (H <sub>2</sub> O) / [ppm]	Cut surface
Oxygen O <sub>2</sub>	<b>3.5*</b>	≥ 99.95	≤ 500	≤ 5	Oxide formation
			Proportion of oxygen (O <sub>2</sub> ) / [ppm]	Proportion of water (H <sub>2</sub> O) / [ppm]	
Nitrogen N <sub>2</sub>	<b>2.8</b>	≥ 99.8	≤ 500	≤ 20	oxide free, slightly yellow
Nitrogen N <sub>2</sub>	<b>3.5*</b>	≥ 99.95	≤ 100	≤ 10	oxide-free, not guaranteed shiny
Nitrogen N <sub>2</sub>	<b>4.5</b>	≥ 99,995	≤ 10	≤ 5	oxide-free, guaranteed shiny
Nitrogen N <sub>2</sub>	<b>5.0</b>	≥ 99,999	≤ 3	≤ 5	absolutely oxide-free, guaranteed shiny

\*Values recommended by Bystronic

### 6.5.2 Gas consumption

The gas consumption is heavily dependent on the pressure and the nozzle used.

#### Oxygen with K-nozzles (low-pressure cutting)

Fig. 6.5 -1  $O_2$  with K-nozzles, Resolution 0-6 bar  
[m<sup>3</sup>/h] Gas consumption

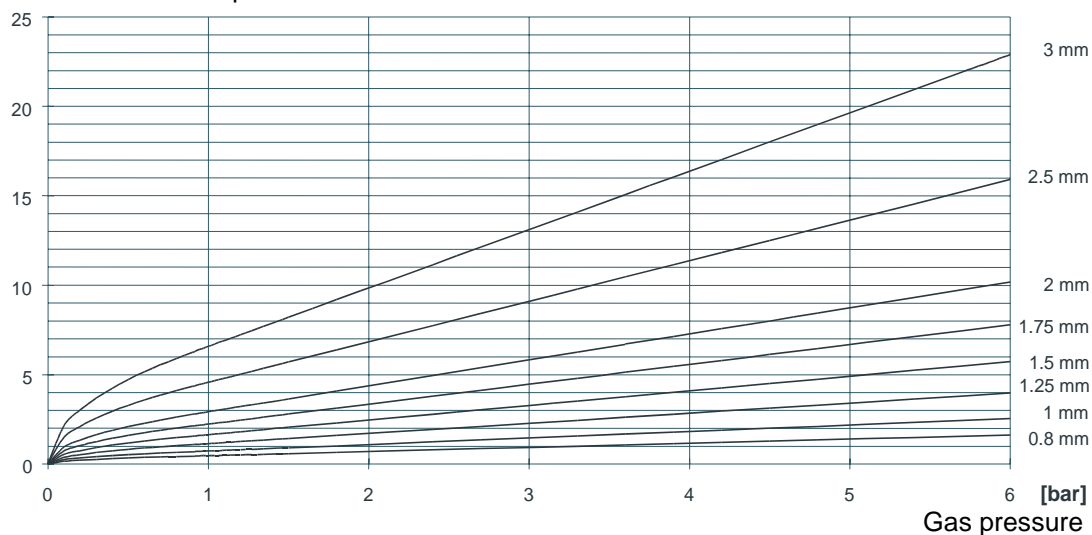
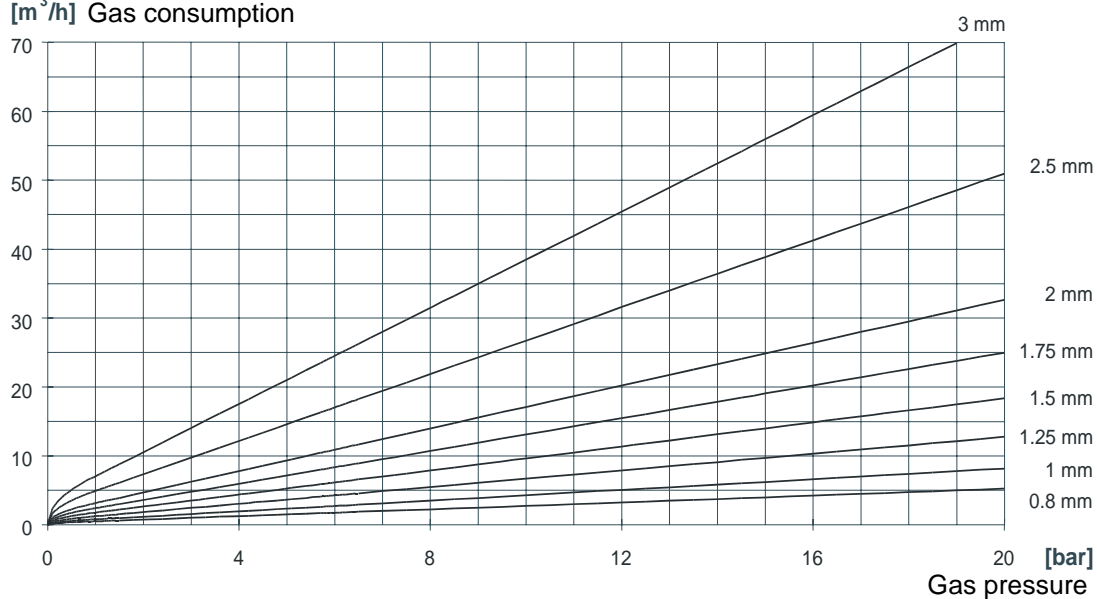


Fig. 6.5 -2  $O_2$  with K-nozzles, Resolution 0-20 bar  
[m<sup>3</sup>/h] Gas consumption



### Nitrogen with HK-nozzles (high-pressure cutting)

Fig. 6.5 -3  $O_2$  with HK-nozzles, Resolution 0-6 bar  
[m<sup>3</sup>/h] Gas consumption

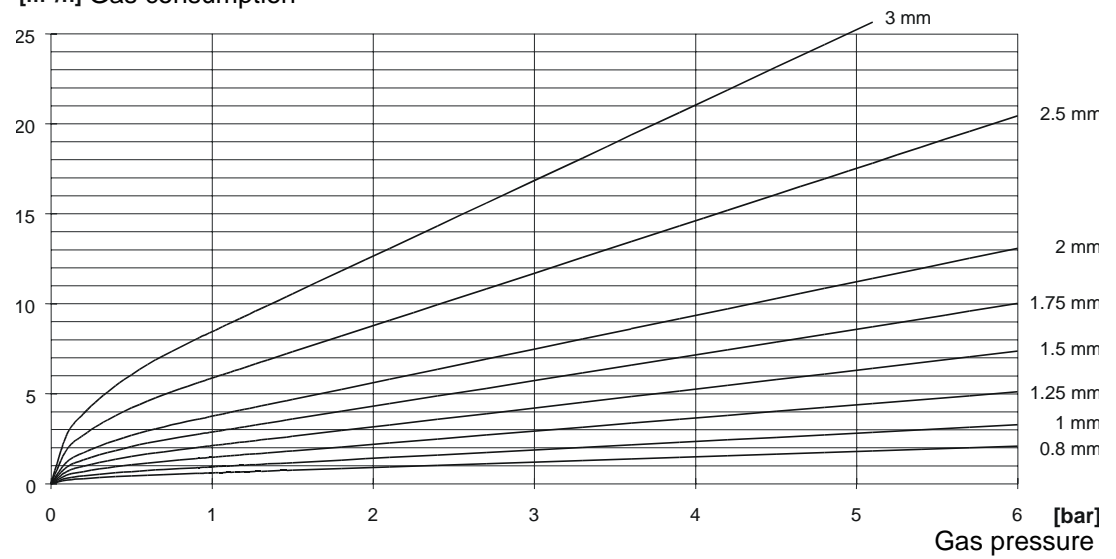
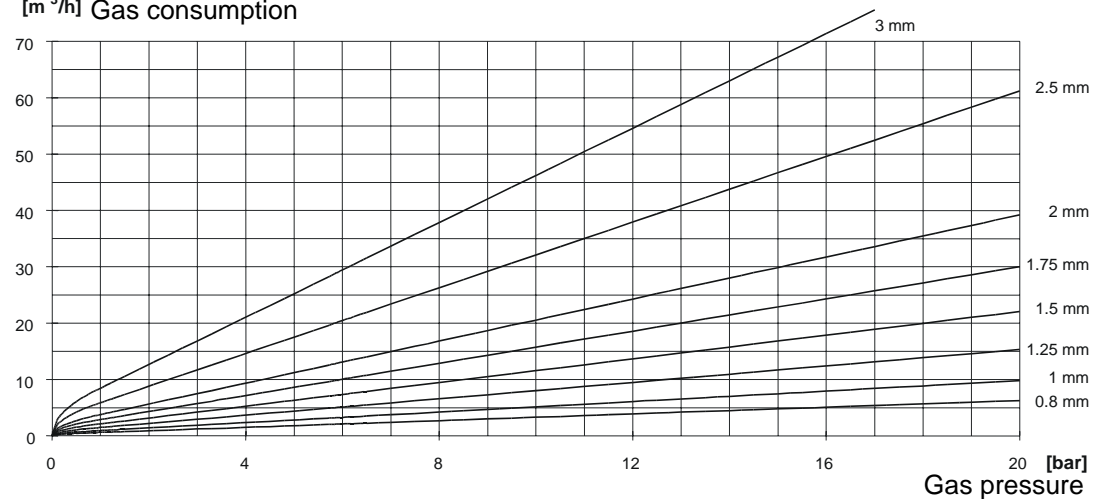


Fig. 6.5 -4  $O_2$  with HK-nozzles, Resolution 0-25 bar  
[m<sup>3</sup>/h] Gas consumption



### Nitrogen with K-nozzles (low-pressure cutting)

Fig. 6.5 -5  $N_2$  with K-nozzles, Resolution 0-6 bar  
[m<sup>3</sup>/h] Gas consumption

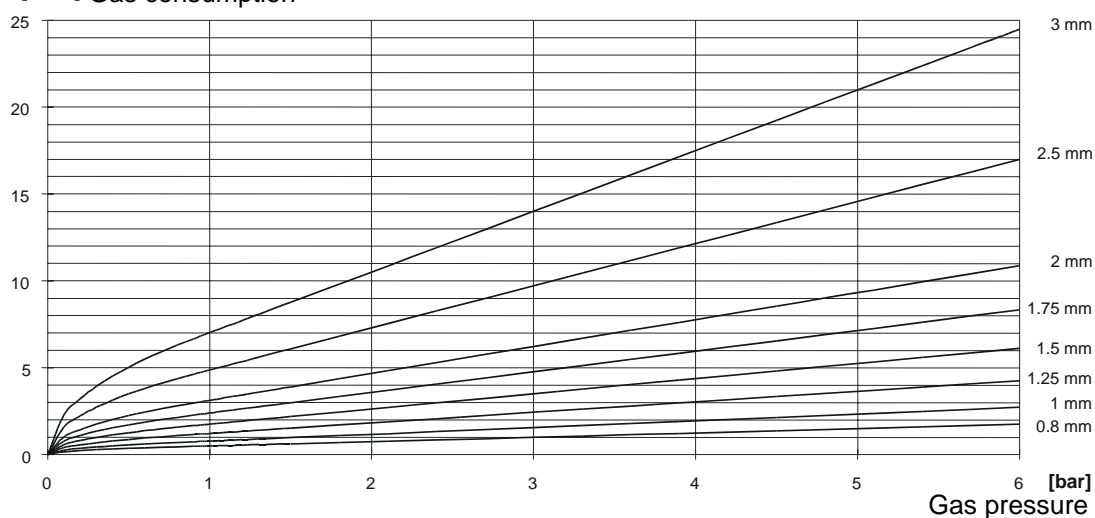
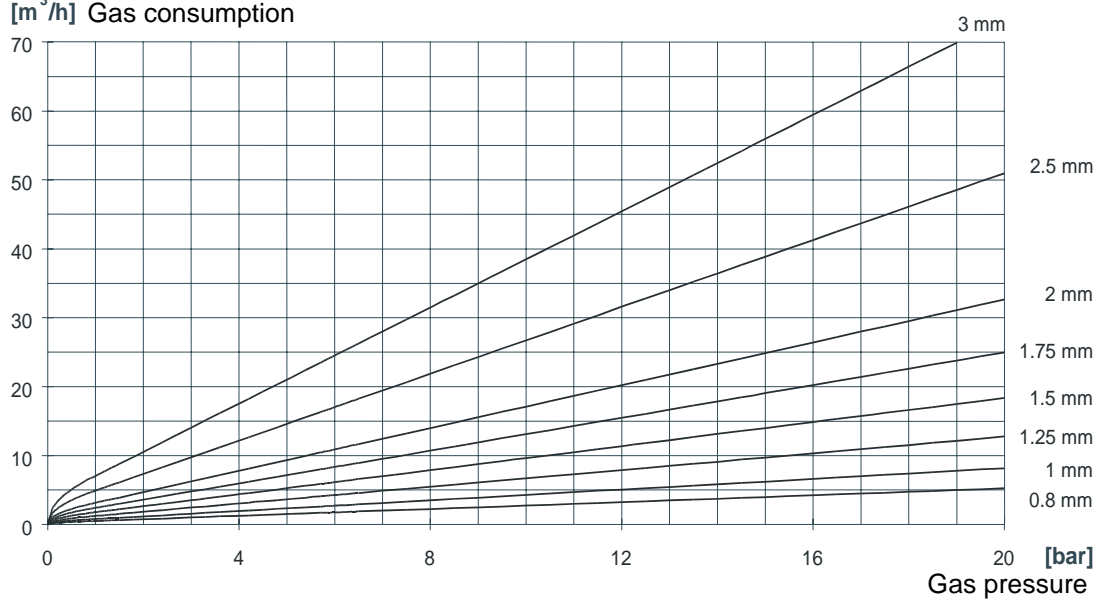


Fig. 6.5 -6  $N_2$  with K-nozzles, Resolution 0-20 bar  
[m<sup>3</sup>/h] Gas consumption



### Nitrogen with HK-nozzles (high-pressure cutting)

Fig. 6.5 -7  $N_2$  with HK-nozzles, Resolution 0-6 bar  
[m<sup>3</sup>/h] Gas consumption

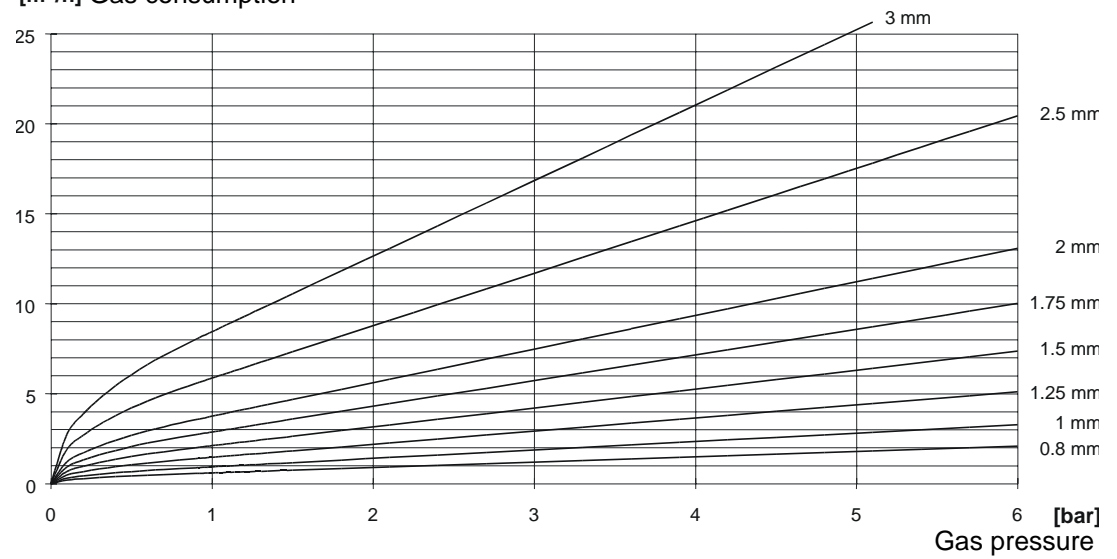
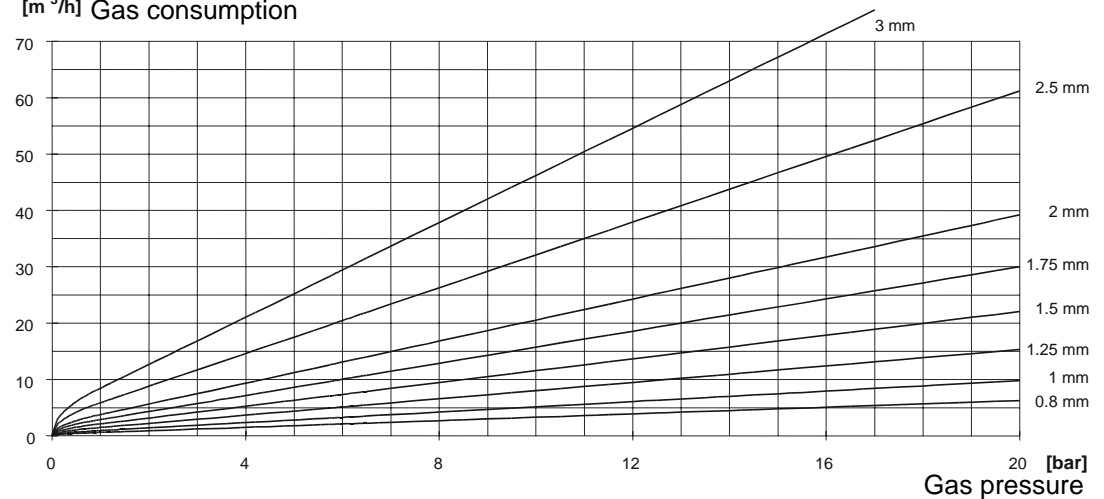



Fig. 6.5 -8  $N_2$  with HK-nozzles, Resolution 0-25 bar  
[m<sup>3</sup>/h] Gas consumption



### 6.5.3 Bottle replacement

	<p style="text-align: center;"><b>⚠ CAUTION</b></p> <p>Secure gas bottles in place. Put safety caps on unconnected bottles.</p>
---	---

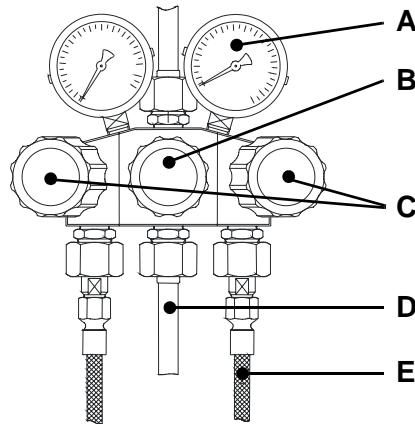
The assist-gas bottles can be replaced during operation. Make sure that you replace bottles carefully and cleanly to avoid dirt entering the gas pipeline.

#### General notes

- Never empty the bottles completely. Always return the bottles with a residual pressure of at least 1 atmosphere above atmospheric pressure.
- When changing bottles, make sure that you use the correct gas quality. Never use a lower gas quality than specified.
- The machine stops if the assist gas runs low. The MMC displays the error message «GAS JET ERROR».
- The machine stops if the laser gas runs low, and the laser excitation is switched off. The MMC displays the error message «GAS MIX ERROR» (in the MCS controller) or "Gas error" (in LaserView).
- Use «Reset» (laser controller) or «Abort» (CNC controller) to clear the error messages on the laser controller once the cause of the error has been removed.

### 6.5.4 Assist gas fittings

Fig. 6.5 -9 Fitting for assist-gas connection



A.	Manometer
B.	Reducing valve
C.	Stop valve
D.	Gas controller base pipe connection
E.	Bottle connection

### Replacing assist-gas bottles during operation



1. Check that the stop valve (C) (full bottle) is closed.
2. Close the reducing valve (B). Counter-clockwise, 0 bar)
3. Slowly open the bottle valve (full bottle).
4. Close the stop valve (C) (empty bottle) and open the stop valve (C) (full bottle).
5. Set reducing valve (B) to 15 bar (for oxygen) or 25 bar (oxide-free cutting). (max 28 bar)
6. Close bottle valve (empty bottle).
7. Remove empty bottle from the cabinet and fit with safety cap. Insert new bottle and secure in place.
8. Open bottle valve to the new bottle briefly to blow out any accumulated dirt. Caution: Pressure 200 bar! (Protect eyes) Connect bottle.

#### NOTE



*The bottle valves should be closed if the system is to be out of operation for a prolonged period (> 8 hours). Otherwise, if gas leaks through valve faces, pressure builds up that can destroy the pressure control valve in the cutting carriage.*

## **6.6 Setting up and adjustment**

### **6.6.1 Cutting head**

#### **6.6.1.1 *Remove the cutting head***

The head needs to be removed

- if the work-piece material or thickness requires a suitable focal length.
  - if the nozzle and lens need to be checked because of declining machining quality.
1. Move the axes until you can reach the cutting head comfortably.
  2. Open the safety door.
  3. Hold the cutting head in one hand and undo the two clamping levers with the other.
  4. Turn the cutting head over to prevent dust reaching the lens. Put the cover over the aperture. (If the aperture is not covered, dirt can get on the lens. This dirt may then be heated by the laser beam once the head has been refitted, causing damage to the lens). Store the cutting head either with the nozzle pointing downwards or horizontally.

#### **6.6.1.2 *Fitting the cutting head***

Take the cover off the cutting head. Use one hand to place the cutting head in the retaining ring. Press it evenly against the holder until you have fixed it with the clamping levers.

### **6.6.2 Changing the nozzle**

The nozzle needs to be changed

- if another nozzle is required according to the parameter set.
  - if because of declining machining quality the nozzle has been found to be damaged.
1. Clean the nozzle and nozzle body externally.
  2. Unscrew the nozzle by hand in a counter-clockwise direction. If the nozzle is too tight to move, use a ring spanner.
  3. Screw in the nozzle required. Only tighten the nozzle by hand.
  4. Fine adjustment of the nozzle centering must be performed whenever a nozzle is changed.





### 6.6.3 Fine adjustment of nozzle centering

Fine adjustment of the centering is necessary after

- poor cutting results (whiskering on one side of the work piece)
- coarse adjustment
- changing a nozzle

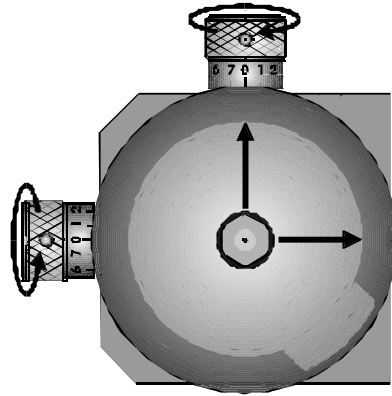
If the selected material requires a change in the focal position, then the focal point must be moved before fine adjustment of the centering.

1. On the MMC, select "Setup", "Setup Laser".
2. Enter 1% for "Laser power single pulse"
3. Enter a "Pulse length" of about 20-100 ms
4. Enter a "Delay time, shutter open/closed" of 400 ms
5. Affix a strip of transparent adhesive tape onto the nozzle of the cutting head.
6. Switch to <Manual> "manual operation"

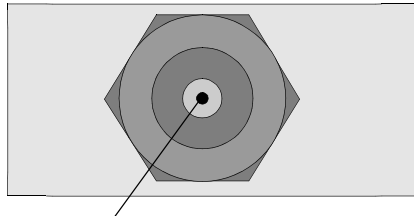
	<div> <b>WARNING</b></div> <p><b>Laser class 4.</b> <b>Invisible laser radiation. Avoid exposing eyes or skin to direct or stray radiation. Wear protective glasses.</b></p>
---	--

7. Close safety gate
8. Select <PULS> on the hand-held controller
9. Open safety door
10. Using a mirror held under the nozzle, check whether the hole burnt into the adhesive tape is positioned exactly in the center of the nozzle aperture
11. If necessary, center the nozzle in the relevant direction using the centering screws
12. Repeat steps 5-10 until the laser beam is fired exactly through the center of the nozzle

Fig. 6.6 -1 Nozzle with centering screws

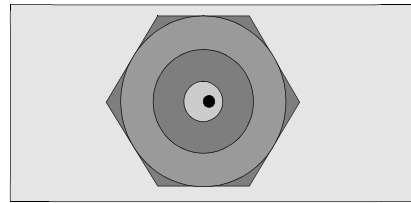


centered



Nozzle aperture laser burn hole

Centering required



Correction: Move nozzle to right

**NOTE**

*The centering screws move the nozzle, not the burn hole. The screws have right-hand threads, i.e. turning clockwise moves the nozzle towards the screw, while turning counter-clockwise moves it away from the screw.*

**NOTE**

*Optimum cutting quality is to a large extent dependent on a properly centered nozzle. If the nozzle is off-center, the laser beam can hit the nozzle and be deflected. For this reason care should be taken to center the nozzle accurately.*

12. Exit Manual operation, close safety gate.

#### 6.6.4 Nozzle cooling

When machining reflective materials (aluminum, stainless steel), the nozzle is heated by the reflection. This also applies to steel of thickness 6mm or more. This can have a negative effect on the capacitive detection (nozzle clearance distance changes).

The nozzle can be cooled with air. You can set the pressure using an adjustment knob. The blue adjustment knob is located on the front of the carriage.

Nozzle cooling also prevents fumes soiling the cutting head when cutting steel.

### 6.6.5 Adjust jet clearance

Determining the parameters

A suitable nozzle clearance and focal position are required for different materials and work-piece thicknesses. A set of parameters for the most frequently used materials is included in the machine. When determining the nozzle clearance and focal position for other materials, use the parameter set for a similar material as starting point.

If you have changed the lens, carry out a calibration before setting the nozzle clearance and focal position.

For a focal position of 0, the focus lies on the work-piece surface. Focal positions above the work-piece surface are given a negative sign, while focal positions below the work-piece surface (in the work piece or below the work piece) have a positive sign.

### 6.6.6 Adjusting the focal position

One turn of the tenths scale corresponds to a 6 mm height adjustment, i.e. one subdivision equals 2/10 mm.

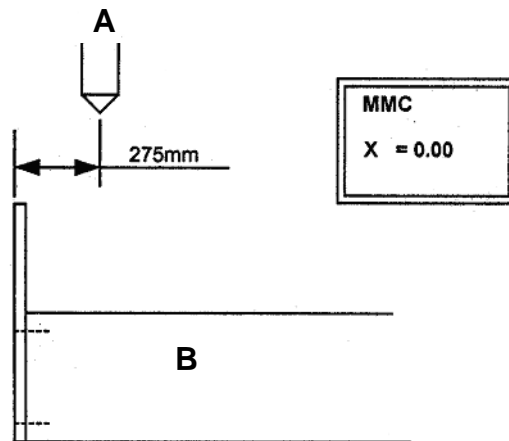
1. Turn the focus adjustment ring until the slide piece is right at the top. The zero mark is now visible on the millimeter scale and the adjustment ring. This corresponds to the maximum top focal position.
2. Turn the focus adjustment ring in the positive direction until the zero mark appears again. This corresponds to position 0 on the adjustment ring and 6 on the millimeter scale. Another complete turn of the focus adjustment ring produces another 6mm adjustment, i.e. 12mm in total, which can be read off on the millimeter scale again. Another turn goes to 18mm.
3. Read off the intermediate values on the tenths scale. For example the figure 0-40 means that, starting from the position 0 and turning downwards, 40 must appear on the tenths scale on the adjustment ring.
4. Find the required nozzle clearance from the "Work", "Info" menu (for example nozzle clearance 0.7mm). Start from the focal position noted on the label on the head (e.g. 0-40). Add the required nozzle clearance to the value on the label (e.g.  $40 + 7 = 47$ ) and set this value on the adjustment ring.
5. Find the required focal position for the work piece from the "Work", "Info" menu (e.g. focal position 5 mm, i.e. 5mm in the material).
6. Add this value to the value on the adjustment ring (e.g.  $47 + 50 = 97$ ). The value of 97 means we are in the 2nd range, i.e. between 6 and 12mm. The focus adjustment ring is therefore turned beyond the 2nd zero mark (6mm) to the difference of 3.7 mm, i.e. to subdivision 37.

### 6.6.7 Setting the reference points on the Bytube CNC

Certain rules need to be followed for the settings. These basically relate to setting the reference points X, X2 and A axes. It is important to know here, that all reference dimensions, and hence all dimensions derived from the reference points, depend on the X (default X) axis. For example, if the reference dimension for the X-axis is changed, then the position values for the A- and X2-axes are no longer correct. Thus it is imperative to make the X-axis settings first.

#### 6.6.7.1 X-axis reference

The reference dimension for the X-axis must be set so that when  $X = 0.00$  mm the machine stands 275 mm from the outer edge of the first plate screwed onto the machine frame. This value must be optimized between the risk of collision and material wear and the length of leftover tubes.

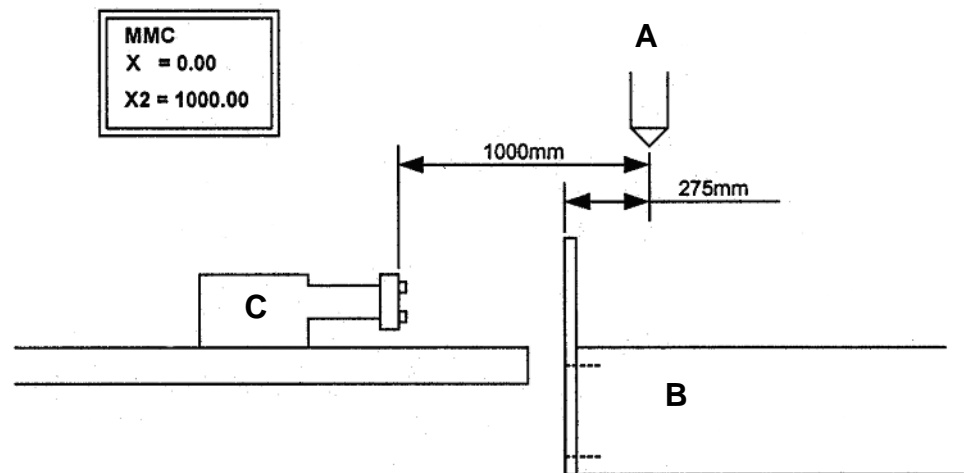


- A. Cutting head at  $X = 0.00$
- B. Machine frame

#### 6.6.7.2 X2-axis reference

The reference dimension for the X2 axis must be set so that the head of the gripper lies directly under the nozzle of the cutting head when both axes display 0.00. This position is only theoretically possible however. Thus the X2-axis should be positioned at 1000mm and the X-axis at 0.00mm (on the display). It must be possible to measure this distance of 1000mm, i.e. distance and displayed value must match (displayed in Hand / Hybrid X2). The distance is measured from the front face of the gripper base without jaws fitted.

This value can be set in the menu Main / Config HW / X2-axis reference

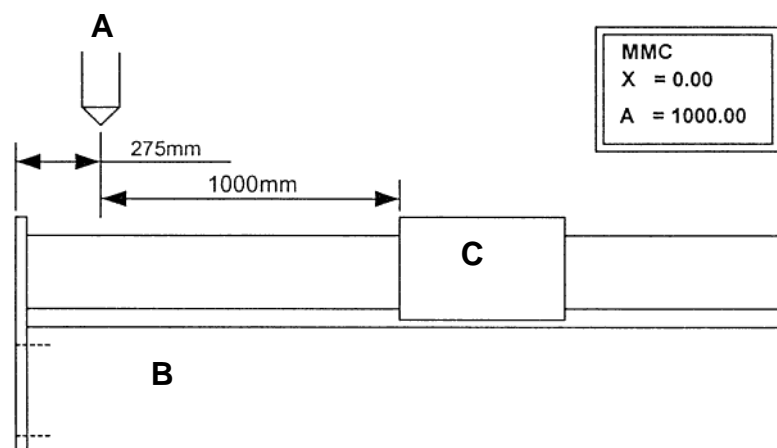


- A. Cutting head at X = 0.00
- B. Machine frame
- C. X2-axis with gripper

### 6.6.7.3 Reference A-axis

The reference dimension of the A-axis must be placed at the zero point of the X-axis. To do this the A-axis can be positioned at 1000mm and the X-axis at 0.00mm (on the display). It must be possible to measure this distance of 1000mm.

This can be changed in Main / Config HW / A-axis: Reference



- A. Cutting head at X = 0.00
- B. Machine frame
- C. A-axis

**6.6.7.4 Collision limits X2-axis**

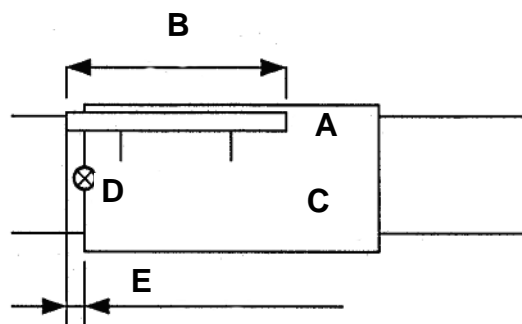
The collision limits of the X2-axis for circular, square and rectangular hollow sections depend on the components that are fitted, such as clamping jaws, steady rest and chuck. The collision limits must be found on the machine, with the aim of generating minimum waste while ensuring collision-free operation.

Can be set in Setup / Hybrid.

**6.6.7.5 Tray on the A-axis**

The sketch below illustrates the tray Setup. The offset value is used for making slight corrections.

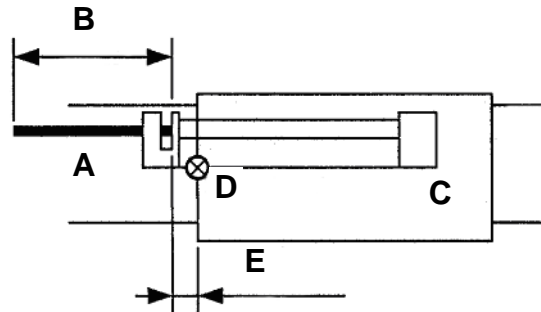
This value can be set in Setup / Hybrid / A-axis.



- A. Tray
- B. Tray length
- C. A-axis
- D. Zero point A-axis
- E. Tray position

## 6.6.7.6 Lance on the A-axis

The sketch below illustrates the lance Setup. The offset value is used for making slight corrections.



- A. Lance
- B. Lance length
- C. A-axis
- D. Zero point A-axis
- E. Lance position

## 6.7 Process parameter make-up


The required cutting quality can only be achieved with optimized process parameters.

Process parameters for the most frequently cut materials are supplied on the hard disk of the machine controller or on diskette. When the machine is delivered, the latest parameter files for your controller version are copied to the panel PC.

The process parameters for a specific operating mode are grouped in a file with a characteristic file name.

To load process parameters:



- press the  key
- select the «Job List» function or press the [f1] key
- selecting the «Select param» function or pressing the [f2] key.
- Select the desired parameter file and load it by selecting the «Open» function.

### NOTE



*The parameters provided by BYSTRONIC are guides. The conditions required for achieving optimum cutting results are summarized in chapter 12, Cutting technology.*

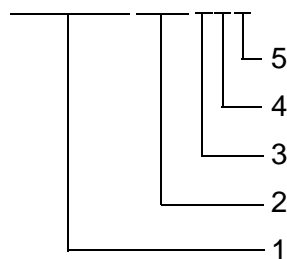


## 6.7.1 File naming conventions

File names contain five parameters:

1. Material number using DIN convention
2. Material thickness + surface treatment
3. Machine type
4. Lens (focal length)
5. Process or assist gas

**WWWWWSSS.B5P**



### 6.7.1.1 Material ID in compliance with DIN standard

Systematic numeric identification of materials according to DIN 17007.

The seven-digit material number consists of:

- Principal material group
- Type number
- Suffix

### 6.7.1.2 Principal material groups

- 0 = iron, iron alloys, cast iron
- 1 = steel and cast steel
- 2 = heavy metals excluding iron
- 3 = light (non-heavy) metals
- 4 – 8 = non-metal materials
- 9 = unassigned code

### 6.7.1.3 Type numbers

For the type numbers of principal groups 0 and 1, the first two digits indicate the type categories. The next two digits of the type numbers are counters. Type numbers are essentially formed on the basis of their chemical composition of the materials or their origin.

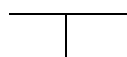
#### 6.7.1.4 Suffixes

The suffixes stand for special characteristics such as type of melt or cast, heat treatment and cold forming.

It was not possible to take the suffix into account in the BYSTRONIC file names. Only the first five digits are used for the material identifier.

#### 6.7.2 BYSTRONIC material ID based on DIN standard

WWWWWSSS.B5P



The letters "WWWWW" stand for the first five digits of the DIN material designation.

#### 6.7.2.1 Principal group 1: Steel and cast steel

This group covers all steels including cast steel. The first two digits in the type numbers indicate the type categories. The next two digits are counters, which bear no relation to the carbon or alloy content.

Ordinary steels and quality steels	
1.00	Commercial and ordinary grades
1.01-1.02	General structural steels
1.03-1.07	Quality steels, unalloyed
1.08, 1.09	Quality steels, alloyed
1.90-1.99	Special grades

Unalloyed high grade steels	
1.10	Steels with special physical characteristics
1.11-1.12	Structural steels
1.15-1.18	Tool steels

Alloyed high grade steels	
1.20-1.28	Tool steels
1.32, 1.33	High-speed steels
1.34	Wear-resistant steels
1.35	Roller bearing steels
1.36-1.39	Ferrous materials with special physical characteristics
1.40-1.45	Stainless steels
1.47, 1.48	Heat-resistant steels
1.49	High temperature materials
1.50-1.84	Structural steels

Alloyed high grade steels	
1.85	Nitriding steels
1.88	Hard alloys

## 6.7.2.2 Principal group 2: Non-ferrous metals

2.000-2.1799	Copper and copper alloys
--------------	--------------------------

## 6.7.2.3 Principal group 3: Light metals and their alloys

3.0000-2.4999	Aluminum and alloys
3.5000-3.5999	Magnesium and alloys
3.7000-3.7999	Titanium and alloys

In principal groups 2 and 3, the four-digit type numbers indicate the composition, classified according to base metals, type and amount of the alloy constituents.

### 6.7.3 Material thickness

WWWWWSSS.B5P



These digits indicate the material thickness in tenths of millimeters.

If the material thickness is less than 10 mm, the first character "S" can designate the surface treatment:

*Designations for surface treatments*

- E** = anodized
- F** = hot galvanized
- K** = plastic coated (film)
- L** = painted
- R** = flying piercing (fast piercing)
- V** = electro-galvanized
- X** = flying piercing with plastic-coated film
- Y** = flying piercing of hot-galvanized sheet
- Z** = flying piercing of electro-galvanized sheet

(Example "SSS" **E09** = work-piece thickness 0.9 mm, anodized).

#### NOTE



*Surface finishing can impede cutting (composition of paint components or thickness of coating), thus requiring adjustment of parameters.*

### 6.7.4 Machine type, work-piece support, laser type

WWWWWSSS.B5P



This character stands for the machine type.

Code	Machine type	Laser type	Size
<b>A</b>	BYSTAR	BYLASER 3000	3015
<b>B</b>	BYSTAR	BYLASER 3000	4020 & 4025
<b>E</b>	BYSPEED	BYLASER 4400	3015
<b>F</b>	BYSTAR	BYLASER 4400	4020
<b>H</b>	BYSPRINT	BYLASER 2200	2512 & 3015
<b>R</b>	BYTUBE	BYLASER 3000	3204 & 6504
<b>W</b>	BYSPRINT	BYLASER 3000	3015
<b>X</b>	BYSTAR	BYLASER 4000	3015

Code	Machine type	Laser type	Size
Y	BYSTAR	BYLASER 4000	4020 & 4025
Z	BYSPEED	BYLASER 40S	3015

### 6.7.5 Lens

WWWWWSSS.B5P

└ This character stands for the lens used.

Code	Focal length
5	5"
7	7.5"

### 6.7.6 Process and assist gases

WWWWWSSS.B5P

└ This character stands for the process and the assist gas

Code	Process
O	Cutting with oxygen
A	Cutting with nitrogen
A	Cutting with argon
L	Cutting with compressed air
P	Pulsed cutting

### 6.7.7 Coding of process parameter file names

Example:

*Code for process parameter file name*

1 0 3 3 2 X 5 0 . A 5 O

**Assist gas:**      **O** = oxygen      **N** = nitrogen      **P** = pulsed cutting  
                          **L** = compressed air      **A** = argon

**Cutting head:**      **5** = 5"      **7** = 7.5

**Laser machine:**

<b>A</b>	=	BYSTAR 3015	BYLASER 3000
<b>B</b>	=	BYSTAR 4020, 4025	BYLASER 3000
<b>E</b>	=	BYSPEED 3015	BYLASER 4400
<b>F</b>	=	BYSTAR 4020	BYLASER 4400
<b>H</b>	=	BYSPRINT 2512, 3015	BYLASER 2200
<b>R</b>	=	BYTUBE 3204, 6504	BYLASER 3000
<b>W</b>	=	BYSPRINT 3015	BYLASER 3000
<b>X</b>	=	BYSTAR 3015	BYLASER 4000
<b>Y</b>	=	BYSTAR 4020, 4025	BYLASER 4000
<b>Z</b>	=	BYSPEED 3015	BYLASER 40S

**Sheet thickness:**      Sheet thickness in 1/10 mm (e.g. 150 = 15 mm)

**Surface finish & machining type:**

<b>E</b>	=	anodized
<b>F</b>	=	hot galvanized (smooth finish)
<b>K</b>	=	plastic coated (film)
<b>L</b>	=	painted
<b>R</b>	=	flying piercing (fast piercing)
<b>V</b>	=	electro-galvanized
<b>X</b>	=	flying piercing with plastic-coated film
<b>Y</b>	=	flying piercing of hot-galvanized sheet
<b>Z</b>	=	flying piercing of electro-galvanized sheet

Sheets less than 10 mm thick: one letter specifies the surface treatment and the machining type.

**Material:**      DIN number of material

### 6.7.8 Constraints

#### Transferability of parameters between different machines of the same type

Conditions for transferring the parameters calculated by BYSTRONIC:

- machine properly calibrated
- beam quality as at first start-up
- focal length and nozzle as per parameter list
- machine and focusing lens in perfect condition
- laser gas quality as per specifications
- sheet surface free of scale (pickled, etched or polished)

#### 6.7.8.1 Influence of contour geometry

The parameters apply to shapes whose contour elements are larger than twice the sheet thickness (example: for a sheet thickness of 3 mm, parameters apply at and above 6 mm hole diameter, tooth length, etc.).

Various parameters need to be adjusted for complicated and tight contours.

Recognizing the key parameters for adjustment requires experience on the part of the machine operator.

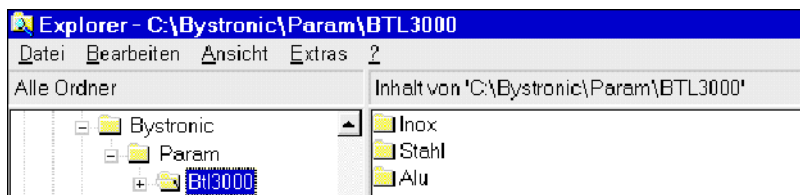
#### 6.7.8.2 Optimizing parameters

The parameters provided by BYSTRONIC are for recommended values. Materials with the same designation still differ in terms of composition within certain tolerances. Other differences are due to the type of casting and melt, heat treatment and cold forming.

The parameters have been selected so as to allow these materials to be cut despite these differences. If material quality and ambient conditions are constant, it may be possible to optimize these parameters still further. Optimization can increase the quality and economic efficiency of the machining process.

### 6.7.9 Parameter storage system

The control system does not set any conditions as to how parameter storage is organized. Parameters can therefore be stored according to the company's specific needs. We recommend the following directory structure



- Save the parameters that you have determined yourself. One option is to rename the existing PARAM directory. Select the date up to when you worked with the existing parameters as the new name for the existing directory. e.g. 30\_03\_2002.
- Create a new path called PARAM.
- In Explorer, copy ....Param from drive C: or D: to C: Copy
- Delete from the hard disk those parameter files that you no longer need. (e.g. Directory Laser 40 plus sub-directories if you are working solely with Laser 30).



## 6.8 Adjusting process parameters

**Process parameters are parameters that have a direct effect on the cutting process. These production parameters are not optimized for maximum cutting rate but for process reliability.**

The parameters supplied by Bystronic are optimized for cutting particular materials. Nevertheless, it can be the case that these parameters result in unsatisfactory cutting results. The requirements and procedure to be followed in order to improve the cutting result in such a situation are described below.

### 6.8.1 General information

There are numerous laser cutting parameters, some of which are mutually dependent. We only list here the 5 main parameters that can be used to optimize cutting quality:

- Focal position
- Laser power
- Gas pressure
- Feedrate
- Nozzle distance

The adjustments to parameters described here only apply to simple contours such as straight lines.

#### NOTE



*The cutting quality is only evaluated for a straight cut in the X+, X-, Y+, Y- axis direction. Interpolated cut directions such as radii, diagonal cuts or initial cuts are not included.*

*How to modify parameters for complex contours such as sharp corners, radii, small contours, initial and final cuts and holes is explained in Chapter 12, Cutting Technology.*

### 6.8.2 Reasons for adjusting parameters

- Differences in alloys
- Tolerance variation in the sheet thickness
- Different qualities of surface finish
- Different composition of material
- Large temperature differences in the material used  
(Reference temperature = +20°C)

### 6.8.3 Requirements for adjusting parameters

The following conditions must be met in order to obtain a good cut quality by adjusting the main parameters:

- Laser machine and laser must be in perfect condition.
- The lens in the cutting head must be in perfect condition (see Chapter 7, Maintenance).
- The cutting head and nozzle must match the specifications in the parameter file.

#### Preliminary steps

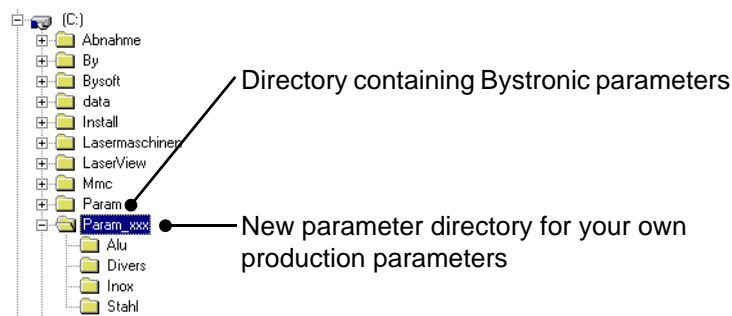
Before you start adjusting parameters for the material to be cut, we recommend that you create a directory for modified parameters. The parameters supplied by Bystronic are saved in the directory «C:\Param».

Follow the instructions below:



1. Save the modified parameters in a second directory containing the sub-directories.

Fig. 6.8 -1 Example directory for modified production parameters



2. Save the parameters that you want to change in the directory for the material concerned.



*Once you have adjusted the parameters, we recommend printing them out using the «Paramview» program from the «Bysoft 6 Toolbox», and keeping them in a folder. We also recommend keeping the test piece.*

### 6.8.4 Procedure for optimizing cutting parameters

Before cutting new material, carry out a cutting test. If problems arise with the cutting quality, these can be rectified by adjusting the Bystronic parameters. Bystronic provides dedicated cutting plans for adjusting and testing cutting parameters (except for BYTUBE). These are held on the PPC in the «Handover» folder under the Laser type concerned. Use the "Test\_large.lcc" cutting plan. This part includes all four cuts in the X and Y direction.

To optimize the cutting quality:



1. Place the material that you want to cut on the shuttle table and move this into the machining area.
2. Import the cutting plan "Test\_large.lcc" into the «Job List» menu and assign to this cutting plan the relevant material parameter file that you want to use for cutting. (See Chapter 6, Operation). Use the parameter file that you saved for this purpose in the directory for personal parameters (see chapter «6.8.3 Requirements for adjusting parameters»).


#### NOTE



*Use the guidance in Chapter 12, Cutting Technology to assess the cut made in your part having below-par cut quality. Find out what cut-optimization steps are needed from the list of possible causes and suitable remedial action. If more than one option is given, follow the order below.*

#### Order in which to adjust the cutting parameters

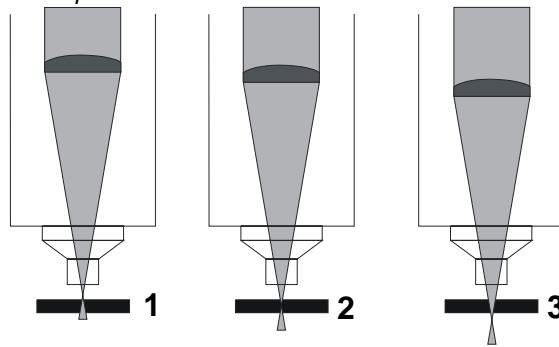
	Cutting with O <sub>2</sub>	Cutting with N <sub>2</sub>
1	Focal position	Focal position
2	Laser power	Gas pressure
3	Gas pressure	Feed ± 10% OK
4	Feed ± 10% OK	Laser power
5	Nozzle distance	Nozzle distance

3. Only cut one part from the cutting plan for each cutting test. To do this, press the  button on the PPC operating terminal. The program stops after cutting a part. Press «Cont» to cut further parts, «Abort» to terminate.
4. Repeat the cutting tests with the amended parameters until you achieve a good cutting result.
5. Save the amended parameter in the menu «Param» with key [f8]. Make sure that you save the modified parameter file in its own directory (see "Preliminary steps" in chapter «6.8.3 Requirements for adjusting parameters»).

### 6.8.5 Focus position

The focal position refers to the position of the cutting point at which the diameter of the laser beam is at its minimum and thus there is maximum power density. The focusing of the laser beam is generated by the lens in the cutting head. Depending on the material, the focal point during cutting is either on (1), in (2) or below (3) the work piece.

Fig. 6.8 -2 Focal position of the laser beam



The focal position depends essentially on the cutting gas used.

Gas type	*Laser cutting type	Focal position
O <sub>2</sub>	Burn cutting	Focal position in upper area of material
N <sub>2</sub>	Laser cutting	Focal position in lower area of material
No gas	Sublimation cutting	Focal position depends on material thickness and beam quality

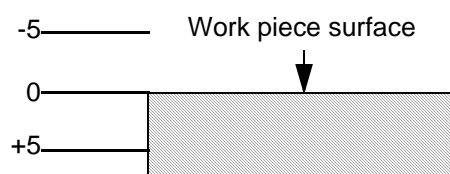
\* For information on the laser cutting types please see Chapter 12, Cutting technology.

To change the focal position, proceed as follows:



1. Press the **PARA** key. Mark the parameter «Focal position» on the page «Characteristics Material / Tool».
2. Enter the new value on the numeric block of the PC keyboard. A higher value moves the focal position down, a lower value moves it up. The value "0" corresponds to the material surface.

Fig. 6.8 -3 Change of focal position




3. Confirm by clicking on OK.

### 6.8.6 Gas pressure

To change the gas pressure, proceed as follows:




1. Press the  key. Mark the parameter «Gas pressure CW cutting» on the page «Parameters continuous operation».
2. Enter the new value on the numeric block of the PC keyboard. With oxygen, a higher value results in a higher cutting temperature and a rougher cut surface. For nitrogen, the material is blown out more strongly and cooled more.
3. Confirm by clicking on OK.

### 6.8.7 Laser power

To change the laser power, proceed as follows:




1. Press the  key. Select the parameter «Laser power cutting» on the page «Parameters continuous mode».
2. Enter the new value on the numeric block of the PC keyboard.
3. Confirm by clicking on OK.

### 6.8.8 Feed

To change the feed, proceed as follows:




1. Press the  key. Select the parameter «Feed cont. operation» on the page «Parameters continuous operation».
2. Enter the new value on the numeric block of the PC keyboard.
3. Confirm by clicking on OK.

### 6.8.9 Nozzle distance

To change the nozzle clearance, proceed as follows:



1. Press the  key. Mark the parameter «Nozzle distance cutting» on the page «Parameters continuous operation».
2. Enter the new value on the numeric block of the PC keyboard.
  - Nozzle distance < 1mm
    - Nozzle wear and soiling increase
  - Nozzle distance > 1mm
    - Cutting quality decreases
    - Lower nozzle heating with plasma cutting
3. Confirm by clicking on OK.

## 6.9 Process parameters

**Prior to machining, a cutting plan file and a process parameter file are imported into the CNC. The «Param» menu only provides access to the process parameters present in the CNC.**

This chapter describes the most important process parameters. Additional process parameters are described in the MMC Online Help.

### 6.9.1 Focal length: 5.0 / 7.5

Focal length of the focusing lens (inches)

### 6.9.2 Type of nozzle

Nozzle specification (e.g. HK 10)

### 6.9.3 Focal position

Position of the focal point in the material (mm)

### 6.9.4 Gas channel cutting

Selection of gas type for the «Cutting» process.

### 6.9.5 CW piercing mode

#### 1 = Tactile

This piercing mode is mainly used with thin sheets (steel/stainless steel).

**Advantage:** Nozzle & lens protection, short piercing time

**Disadvantage:** Piercing holes are slightly larger than from «Nozzle distance piercing»

The laser power is increased from 0% to «Laser power piercing» as soon as the signal «sensor on sheet» (15mm above surface of sheet) is generated. At the same time, the speed is adjusted to «Piercing speed» (5000mm/min). With the «Piercing tactile» option, highly reflective materials may set up reflections that will destroy the adaptive mirror (option).

## 2 = Z dimension

This piercing mode is mainly used for thick sheets (steel > 6mm).

**Advantage:** Nozzle and lens protection, flat piercing cups and short piercing time. The incident laser beam, not being 100% focused, results in considerable heating of the sheet surface. This causes increased absorption of the laser beam. The «lifting height, nozzle» should be at least 40 mm.

### Special application:

Piercing in film-coated sheets. The foil at the piercing point is melted away or melted on and can therefore no longer bubble up. The «Lifting height, nozzle» should be at least 40 mm.

The laser power is increased as soon as the head begins to descend from the Z-dimension height. If the current position does not lie at the height given by the Z dimension, the Z-axis moves to the Z dimension (define the Z dimension in «Special parameters», «Lifting height, nozzle»).

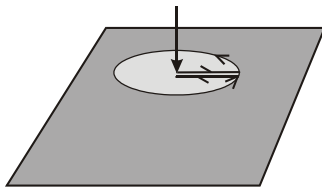
With «Piercing from Z dimension», highly reflective materials may set up reflections that will destroy the optical components.

## 3 = Nozzle

The laser power is not increased until the «Nozzle distance, piercing» is reached.

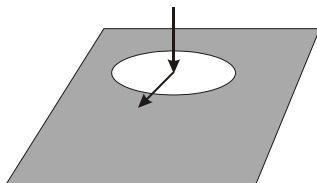
## 4 = Circular piercing

Fig. 6.9 -1



After piercing, a circle of diameter 2 mm is cut around the piercing point and back to the center, at half the speed of the «Feed cutting» feed rate. The hole created makes the subsequent initial cut easier. Circular piercing can only be enabled in CW mode. Set the piercing time to zero if necessary.

Fig. 6.9 -2



The circle and subsequent initial cut into the contour are cut in the relevant operating mode. The position within the cut hole is not suitable for readjustment of the nozzle clearance. Avoid readjustment of the clearance by selecting the same nozzle distance in the parameters for piercing and cutting. If you select different operating modes for the circular piercing and for the contour, ensure that both parameter records contain the same nozzle distance settings.



### 6.9.6 Laser power piercing

Laser power during the piercing time (as a percentage of the rated power of the laser) (%).

### 6.9.7 Nozzle distance, piercing

Distance between the nozzle and the work piece during piercing (mm).

### 6.9.8 Gas pressure CW piercing

Gas pressure during piercing. A pressure higher than 10 bar for the low-pressure gas channel 1 results in «Warning ! parameter error» (**bar**).

### 6.9.9 Nozzle distance, cutting

Distance between the nozzle and the work piece during machining (**mm**).

### 6.9.10 Laser power cutting

Laser power (as a percentage of the rated power of the laser) when cutting in normal operating mode with the standard feed rate (%).

### 6.9.11 Acceleration factor, lead-in

In the event of difficult lead-in conditions after piercing, this parameter can achieve higher process reliability. If the lead-in (initial cut) acceleration is less than 0.1 and below the «Acceleration factor, contour», the initial cut is made without modulation (**m/s<sup>2</sup>**).

- enabled for standard piercing
- disabled for engraving, welding, pre-burning, Common Cut (M18) and also when a value of 0 is set for «piercing time»

### 6.9.12 Gas ramp piercing / cutting

Ramp from piercing pressure to cutting pressure during lead-in. This parameter is used in oxide-free cutting. The correct pressure depends on the cutting feed rate, and is increased linearly after normal or circular piercing (s).

The gas ramp is only applied if

- the value for the piercing time is > 0
- both piercing and cutting is in CW mode
- the same gas has been selected for piercing and cutting
- the piercing pressure is lower than the cutting pressure

### 6.9.13 Gas pressure CW cutting

Gas pressure for the «Cutting» process. Pressures higher than 10 bar in gas channel 1 are not permitted and result in «Parameter error» (**bar**).

### 6.9.14 Feed, continuous wave mode

Standard feed rate for CW mode (active between machine functions M4 and M5). When a plan is copied from the MMC to the CNC, the value of the "F" address is copied from this parameter (if present, this value must appear in block G29, otherwise this value is not active) (**mm/min**).

### 6.9.15 Dynamic Factor

The maximum feed rate when cutting radii is calculated by the controller using the formula below. This value is compared with the standard feed rate. The smaller value of the two is chosen as the actual feed rate.

- $V$  (max. dyn. feed rate) =  $900 \times Df \times \sqrt{R \times \Delta S}$  [mm]
- **Df**:dynamic factor [-]
- **R** :radius [mm]
- **ΔS**:chordal deviation [mm]/1000

If you are cutting small-radius contours, the dynamic factor should be optimized using trial cuts.

The table indicates the smallest radius that can be cut at the standard feed rate. (Chordal deviation 10μm). For smaller radii, the feed rate is reduced accordingly.

## Radius table


Feed rate	Dynamic factor										
[mm/min]	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3
1000	1.37	0.77	0.49	0.34	0.25	0.19	0.15	0.12	0.10	0.09	0.07
2000	5.49	3.09	1.98	1.37	1.01	0.77	0.61	0.49	0.41	0.34	0.29
3000	12.35	6.94	4.44	3.09	2.27	1.74	1.37	1.11	0.92	0.77	0.66
4000	21.95	12.35	7.90	5.49	4.03	3.09	2.44	1.98	1.63	1.37	1.17
5000	34.29	19.29	12.35	8.57	6.30	4.82	3.81	3.09	2.55	2.14	1.83
6000	49.38	27.78	17.78	12.35	9.07	6.94	5.49	4.44	3.67	3.09	2.63
7000	67.22	37.81	24.20	16.80	12.35	9.45	7.47	6.05	5.00	4.20	3.58
8000	87.79	49.38	31.60	21.95	16.12	12.35	9.75	7.90	6.53	5.49	4.68
9000	111.11	62.50	40.00	27.78	20.41	15.63	12.35	10.00	8.26	6.94	5.92
10000	137.17	77.16	49.38	34.29	25.20	19.29	15.24	12.35	10.20	8.57	7.31
11000	165.98	93.36	59.75	41.50	30.49	23.34	18.44	14.94	12.35	10.37	8.84
12000	197.53	111.11	71.11	49.38	36.28	27.78	21.95	17.78	14.69	12.35	10.52

### 6.9.16 Modulation

Adjustment of the laser power to suit reduced feed rate (acceleration, braking and reduction of the feed rate in radii, corners and initial cuts). The percentage defines the speed (as a percentage of the standard feed rate) at which (linear) reduction of the power is to commence (%).

### 6.9.17 Tool radius

The tool radius equals half the width of the cutting gap. Measure the width of the cutting gap in test cuts. As the sides of the cutting gap are not exactly parallel in the vertical direction, the depth of measurement must be defined for larger sheet thicknesses. The value can be entered to 2 decimal places. This parameter is active if the G functions G41 / G42 (tool compensation left / right) are contained in the plan (mm).

	<b>⚠ CAUTION</b>
	The minimum gas pressure must never fall below 1.5 - 2 bar (protection of lens). An excessively high gas pressure results in unnecessary gas loss on the positioning paths

## 6.10 Hand-held controller

The hand-held controller is a flexible extension to the PPC operator terminal. It is connected to the CNC controller by a cable. The two functions most commonly performed with the hand-held controller are described below.

### 6.10.1 Separating cuts

Severance cuts made with the hand-held controller are used for removing off-cuts or leftover tube sections.

#### NOTE




*Always make separating cuts using the parameter belonging to the material to be cut.*

To perform a separating cut using the hand-held controller:



1. In the MMC go to the «Hand» menu. Press the «Manual operation» button or the <f3> key. The hand-held controller is enabled and the <TOOL> button illuminated.
2. Move the cutting head to the reference position by pressing the «Move to reference» button. Calibrate the sensing mechanism on the calibration plate using the hand-held controller.
3. Press and hold the <Z-> button to calibrate. Wait until the cutting head has lowered itself onto the calibration plate for the second time and you can hear cutting gas escaping.
4. Release the <Z-> button. The cutting head remains lowered.
5. Press the <Z+> button to raise the cutting head.
6. Use the X and Y buttons to move the cutting head to the position on the sheet where the separating cut is required.
7. Press the <Z-> button to lower the cutting head. Wait until the cutting head has lowered itself to the nozzle clearance distance and then release the button.
8. Switch the laser on by pressing the <BURN> button. The laser remains on as long as the <BURN> button remains pressed. Use the U or Y buttons to move **immediately** in the required direction for separating the tube or tubular section.

9. After separating the off-cut, release the <BURN> button **immediately** to switch off the laser, then press the <Z+> button to raise the cutting head.

	<b>⚠ CAUTION</b>
	<p>Make sure that the cutting head is always lowered during cutting, otherwise strong reflections can arise that may damage the cutting nozzle.</p> <p>Always move the cutting head immediately after pressing the &lt;BURN&gt; button, otherwise the laser may damage the lower tube wall or machine components.</p>

### 6.10.2 Shifting the origin of the cutting plan

The origin of the cutting plan is offset in order to be able to cut parts at any position in the machining area. The main applications are:

- Use of leftover sheets
- Cutting without edge detection
- Material not located at the machine origin.

#### NOTE



*Only use the origin-offset function for cutting single parts, not for whole cutting plans. There is a risk that the machine would move beyond the existing sheet or into the end-stops if the cutting plan extended beyond the sheet as a result of shifting the origin.*

To offset the origin of the cutting plan:



1. Load the cutting program and run using «Start work». The <STOP PART> and <HALT CNC> buttons must be activated (yellow LED must light up).
2. In the Work menu, use the «Cont» button to confirm the messages in the yellow status line until the message «Stop at origin – wait for <Cont>/<Abort>» appears. The cutting head moves to the machine origin (zero point).
3. Switch to the Hand menu and press the «Manual operation» button.
4. Use the X and Y buttons on the hand-held controller to move the cutting head to the required position.
5. Switch to the «Work» menu and press the «Cont» button to start the cutting process.

## 6.11 Special functions

### General information

Special functions are tools which make working with the laser cutting machine easier in certain situations.

### 6.11.1 Crossjet

Crossjet prevents slag generated when the laser beam pierces the material from adhering to the surface of the work piece.

The base position for the Crossjet is the parked position.

Fig.6.11-1 Crossjet in parked position.

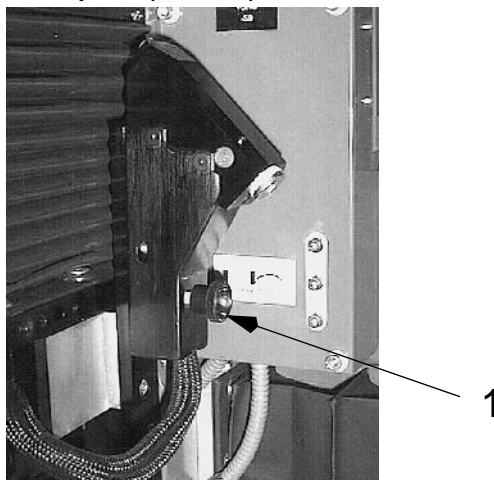
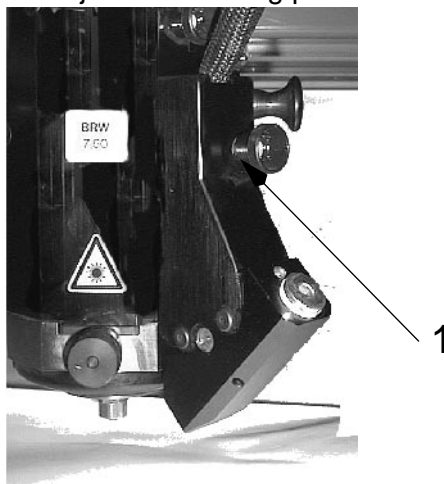


Fig.6.11-2 Crossjet in machining position



1 Move in the Crossjet on the nubs, and fix with screw

Only fit the Crossjet in the machining position when you want to use it. This prevents unnecessary soiling.

#### 6.11.1.1 Registering the crossjet

If a Crossjet is mounted on the Z-axis, this must be registered in the MMC menu «Main», «Service», «Config. CNC» MMC menu by activating the «Crossjet» checkbox.

Crossjet is enabled by pressing the [SF2] button on the keyboard in the «Work» menu.

#### NOTE



*Crossjet can only be enabled with the [SF2] button if the parameter «Oil-mist time before piercing» has a value greater than zero.*

The Crossjet has the following operating modes:

- Oil mist
- Cross blow.

#### 6.11.1.2 Oil mist

The oil mist consists of oil and air, and is sprayed onto the work piece before piercing. The film of oil on the surface of the work piece reduces the adhesion of the slack that escapes upwards during piercing.

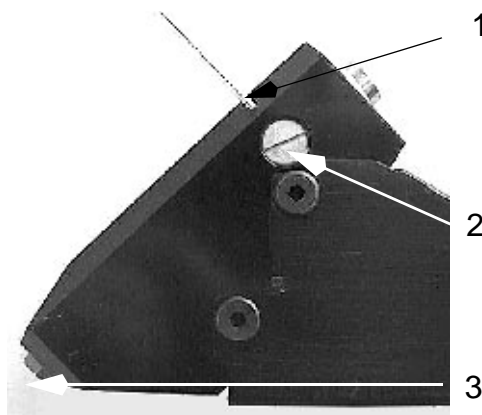
	<b>⚠ CAUTION</b>
	<p>Risk of fire</p> <p>Oil vapors can ignite spontaneously on the laser beam or on the hot surface of the work piece. Only use the correct oil and only in the dosage required for the job.</p>

The length of the spraying process is set in the MMC in the «Param», «Special Param» menu using the «Oil mist before piercing» parameter.

The oil mist is not active before piercing in pulse operation or before piercing after «Lowered positioning».

The thickness of the oil film depends on the flow rate, the nozzle diameter and the length of the spraying process.

Fig.6.11-3





- 1.) Retaining screw
- 2.) Set-screw
- 3.) Jet

You can regulate the flow rate using the set-screw. First undo the retaining screw. The flow rate is set to "fully open" in the factory setting.

#### 6.11.1.3 *Transverse blowing*

Transverse blowing can be switched on and off in the MMC using the «Transverse blowing after piercing» parameter in the «Work» menu, «active param.», «Special parameters». To control the duration of the cross-blowing, use the «Delay time before processing» parameter in the «Work», «Active param.», «Laser parameters CW mode» menu.

#### 6.11.1.4 *Manual controller*

Take Crossjet from the parked position to the machining position.

Move to the reference point. In the "HAND" menu, choose "Auto. setup". The machine then moves to the zero point.

Activate the hand-held controller and press <Z-> to lower the head.

Use SF2 or SF3 (Oil, Blow) to select Crossjet functions, which are enabled in manual operation and during automatic setup using the <CROSSJET> button on the hand-held controller. Settings and operating modes.

#### NOTE



*If Crossjet is fitted, note that the distance between cutting head and chuck must be changed by the size of the fitted Crossjet attachment.*

*Collision risk!*

### 6.11.2 Edge detection

Edge detection is used when the sheet is not lying on the machine zero point when cutting flat parts (operating mode Conventional / Flat). Edge detection enables better use of the sheet. Process reliability is higher. The zero point and angle of the sheet are measured by edge detection.

#### NOTE



*Edge detection is possible with both capacitive detection and CutControl.*

The sheet (work piece) is only detected in the Y-direction. The X-direction is blocked to prevent a collision with the clamping jaws, which means that not all the options are available.

#### NOTE



*For edge detection to work with BYTUBE, "flat-part machining" mode must be enabled.*

Select edge detection



1. MMC «Setup» menu, «Edge detection setup values».
2. «Detection 0=off, 1=X, 2=X/Y, 3=X/Y/angle» parameters
3. Select **2**, to detect the sheet once in the Y direction. Use this option if the sheet is located correctly in the X direction and at the correct angle.
4. Select **3** to detect the sheet twice in the Y-direction. The two measurements are used to determine the position and the angle of the sheet in the Y-direction. Use this option if the sheet is located correctly in the X direction.

#### 6.11.2.1 Edge detection types

The detection modes have the following meaning:

##### **0 = off**

No edge detection

##### **1 = X**

Detection of the origin in the X-direction. Fastest detection mode. Use if the sheet has been pushed correctly into the stops in the Y direction.

##### **2 = X/Y**

Detection of the origin in the X- and Y-direction. Used if the sheet is already positioned squarely with respect to the axes.

##### **3 = X/Y/Angle**

Detection of the origin in the X- and Y-direction and computation of the skew angle  $\alpha$ . Used if the position and angle of the sheet need to be found.

### 6.11.2.2 *Edge detection with CutControl*

Detection using CutControl is more accurate than detection using capacitive sensing.

- During capacitive sensing, the cutting head moves approx. 5 mm beyond the edge of the sheet.
- The cutting head moves rearwards until the laser beam touches the edge of the sheet.
- The next sensing section is moved to.

Select Edge detection with Cut Control:



1. MMC «Setup» menu, «Edge detection with CutControl set up values»
2. Parameter «Detection with CutControl: 0=off, 1=on»
3. Select **1** to enable edge detection with CutControl.


### 6.11.3 Service functions

Service functions are functions for checking and servicing the machine before or during the cutting process. The service functions are only active if the <SERV> button has been enabled.

The following service functions are available:

- Move to service point
- Nozzle cleaning
- Calibration

#### 6.11.3.1 Move to service point

Press the  button to move to the service point. The machine moves to the service point when next told to Stop or Halt.

This function makes the cutting head move to a defined position in the machining area. The position of the service point can be fixed in the «Setup» menu, «Machine setup values», «X/Y axis: Service point».

The service point can be used for maintenance work in the machining area and for replacing the cutting head.

#### 6.11.3.2 Nozzle cleaning

The «Nozzle cleaning» function is a sub-function of «Move to service point» and is executed by pressing the < sfl> key or the <Clean> button in the «Work» menu.

This function causes the nozzle on the Z-axis to be passed repeatedly across the brush on the shuttle table. Nozzle cleaning removes dirt, deposits and splashes of metal that have become attached to the nozzle as a result of the cutting process. You can set the number of cleaning actions using the parameter «Number of cleaning passes» in the menu «Setup», «Nozzle cleaning set-up values».

You can also specify in this menu whether automatic nozzle cleaning should be performed at the end of the cutting plan and after a certain number of cuts into the sheet. The sensing mechanism is re-calibrated after nozzle cleaning.

#### 6.11.3.3 Calibration

The «Calibration» function is a sub-function of «Move to service point» and is also executed by pressing the < SENS OFF> button twice.

## 6.11.4 CutControl

Chapter 3.9 «Cut Control (option)» describes the «CutControl» design and operation.

### NOTE



*CutControl cannot be used with an NK nozzle*

### 6.11.4.1 Working with CutControl

Before using CutControl, the system must be in a fault-free condition.. The cut quality and parameters must be correct. (see chapter «6.8.4 Procedure for optimizing cutting parameters»).

Cutting using CutControl:



- In the «Setup» menu parameters, set «CutControl 0=off/1=on» to 1.
- The calibration threshold for the material to be cut is needed. From CNC software version P6110 onwards, calibration thresholds are determined and saved in the cutting parameters. Cutting can proceed immediately with these values without needing to find the thresholds manually. During production, you should measure the calibration threshold as a check, and make a change to the cutting parameter file if necessary.
- CutControl is ready for use. The cutting plan can be started.
- CutControl stays enabled until the parameter «CutControl 0=off/1=on» is set to 0 in the Setup menu, or the calibration value is set to 0 in the cutting parameters. In principle, CutControl can be switched on in Setup and switched on and off using cutting parameters. This means that CutControl can be switched on and off in automatic mode. When cutting materials that are not monitored by CutControl, the CutControl must be switched off.

#### 6.11.4.2 Measuring the calibration threshold

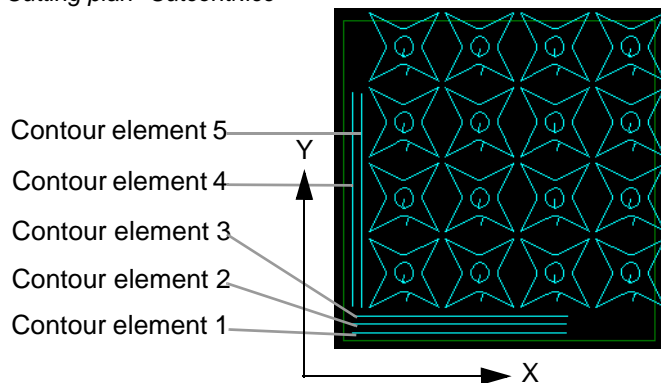
The calibration threshold is measured during a good cut in cutting or manual operation. In the cutting mode, the calibration threshold can be determined using the "Cutcontr.LCC" cutting program. This cutting program is stored on the PPC in the directory "C:\Abnahmen\Lasertyp\....".

Measure the calibration threshold as follows:



- Load and run the "Cutcontr.LCC" cutting plan
- During the cutting of the contour elements 1-5, the parameter «Calibration during cutting: 0=off; 1=on» must be set to 1 in Setup. This activates the calibration process. After about 2 seconds, the mean value is displayed on the bottom line to the right. This is the calibration threshold.

Fig.6.11-4 Cutting plan "Cutcontr.lcc"



The contour elements are cut as follows:

Contour element	Cut direction
1	X+
2	X+
3	X-
4	Y+
5	Y-

The calibration thresholds will be different in each cutting direction (see table in chapter «6.11.4.3 Guideline values for Calibration thresholds»). The mean value should be formed from the values for the contour elements 2-5. in order to take into account the directional dependence. The mean value must be entered in the parameter «Calibration threshold Gas channel 2» and saved.

This calculated value normally does not vary significantly under identical optical conditions, and so only needs to be checked occasionally during the course of production. The calibration threshold can vary sharply if cutting parameters change, or lenses become splashed or mirrors soiled. CutControl can still operate correctly over a very broad tolerance range (See table in chapter «6.11.4.3 Guideline values for Calibration thresholds»).

CutControl operation can be checked during cutting of the star shapes (see chapter «6.11.4.4 CutControl functional check»).

If a different material or a known sheet with a different surface finish is being cut, a new calibration value must be determined.

After calibration, or if cutting is stopped prematurely, the setup value is automatically reset (=0).

If the calibration is performed with a cutting head without CutControl, a calibration threshold <10 appears. Values <10 are ignored by the CNC controller, and thus handled as for disabled CutControl

### 6.11.4.3 Guideline values for Calibration thresholds

Material thickness [mm]	Focal length	Stainless steel N <sub>2</sub>	Nozzle	Structural steel N <sub>2</sub>	Nozzle
1	5"	250-450	Hk15	250-450	Hk15
2	5"	250-450	Hk15	250-450	Hk15
3	5"	250-450	Hk17	250-450	Hk17
4	7.5"	200-450	Hk17	350-450	Hk20
5	7.5"	250-500	Hk20	400-700	Hk25
6	7.5"	350-500	Hk25	450-1000	Hk25
8	7.5"	600-1100	Hk25	1100-1400	Hk30
10	7.5"	850-1150	Hk30	-	-
12	7.5"	700-900	Hk30	-	-

### 6.11.4.4 CutControl functional check

The functioning of the CutControl can be checked by using the "Cutcontr.LCC" test program. This cutting program is stored on the PPC in the directory "C:\Abnahmen\Lasertyp\....".

Perform the following steps to check the operation of CutControl:



1. Load a stainless-steel sheet, 10mm thick, onto the machine (BYLASER 3000)
2. Enable CutControl in the «Setup» menu.
3. Load the cutting plan "Cutcontr.LCC"
4. Load the cutting parameters
5. Perform a test cut by hand to check the cut quality
6. Start the cutting plan "Cutcontr.LCC"
7. The calibration threshold can be checked using the first five contour elements (see chapter «6.11.4.2 Measuring the calibration threshold»)

CutControl operation can be checked during cutting of the star shapes. If CutControl is functioning correctly, the system reacts in the following way at the points of the stars:

- If the laser beam fails to cut through (welding), the cutting head stops, moves back and cuts slowly over the welding bead and then accelerates back to the original speed.
- If only the blue plasma flame is produced (it is still cutting through), the speed of the cutting head reduces until the plasma flame goes out and it then accelerates to the normal cutting speed.

Both types can be repeated or combined. Where slow cutting is being carried out, a burr is produced. If the machine reacts during plasma formation or when the beam breaks away, CutControl does not then function. An error is present.



## 6.11.5 Microjoints

Microjoints prevent cut parts from tilting or falling down (see chapter 12.7.5 «Microjoints»).

### NOTE



*With BYTUBE, the microjoint functions are only available for circular-tube machining (rectangular-tube machining with microjoints is not provided).*

The following types of microjoints are possible:

- **Automatic microjoints** (enabled at the laser machine)
- **Programmed microjoints** (programmed in Bysoft and enabled at the laser machine)
- **Weld joints** (programmed in Bysoft and enabled at the laser machine)

### 6.11.5.1 Automatic microjoints

You can set automatic microjoints in your cutting plan.

To set microjoints:



1. In the menu «Setup», «Set-up values microbars», select the function «2=automatic».
2. Use the values for “Critical parts...” to specify the minimum and maximum range at which a microjoint is set automatically. These functions are only enabled for «2=automatic». This function also takes into account the microjoints programmed in Bysoft. Further information on «Microjoint setup values» can be found in the MMC Online Help.
3. Switch to the «Work» menu and press the «SF4» button. This enables the «Microjoints» function.

### 6.11.5.2 Programmed microjoints

Programmed microjoints are programmed as «Microjoints» in Bysoft and are already included in the LCC file (M80).

To enable the microjoints:



1. In the menu «Setup», «Set-up values microbars», select the function «1=on». All microjoints programmed in Bysoft are enabled. Further information on programming microjoints in Bysoft can be found in the **Bysoft** Online Help.
2. Switch to the «Work» menu and press the «SF4» button. This enables the «Microjoints» function.

### 6.11.5.3 Weld-joints

Welding frames are programmed in Bysoft as «Microjoint» and are already included in the LLC file (M80). Unlike the microjoint, the weld joint must be programmed as close as possible to the center of the contour, as the weld joint is placed on the cutting clearance of a previously cut contour. Weld-joints are used mainly when cutting sheets greater than 4mm in thickness, where the thickness of the material makes it difficult or impossible to break out the part.

To enable weld-joints:



1. In the menu «Setup», «Set-up values microbars», select the function "3=weld joint". Further information on «Weld-joint setup values» can be found in the **MMC** Online Help.
2. Switch to the «Work» menu and press the «SF4» button. This enables the «Weld-joint» function.

## 6.11.6 Restart Work

<RESTART WORK> allows you to continue processing the aborted cutting plan at any position you choose. Examples of abort situations:

- Scheduled interruption
- Power failure
- Stop because of error message (see chapter «6.14 Fault, error and system messages»)

### NOTE

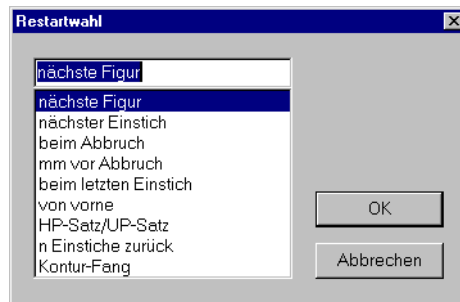


*Restart WORK is not available in the "Hybrid" operating mode.*

### 6.11.6.1 Restart selection

Various restart types are possible depending on the abort condition.

Fig.6.11-5 Restart mode selection window



A <Restart Work> can be issued after every<Stop Part>, <Stop Work>, <Abort> or <Halt>. Then instead of moving to the reference position, the machine positions itself directly at the restart point.

The status of all function keys on the machine keyboard prior to the abort is restored with a Restart. Exceptions are <AUTO>, <DNC>, <SERVICE> and <HALT>, which remain disabled for safety reasons, and must be selectively set again after the Restart.

Selecting restart mode	Description
<b>next shape</b>	Start machining from the next figure
<b>next piercing</b>	Start machining from the next piercing
<b>at stop point</b>	Start machining from the abort position
<b>mm before stop point</b>	Start machining 1-999mm before the abort position. All the program steps needed to machine this path may no longer be held in the internal memory. If this is the case then machining restarts at the first program step still stored. If 0 is entered for the distance then this is equivalent to "Restart at stop point". If the machine stops during withdrawal at the end of the cut, withdrawal is repeated (even if unnecessary).
<b>at last piercing</b>	Start machining at the last piercing point without piercing action. The piercing time is not taken into account
<b>from start</b>	Start machining from the beginning of the cutting plan (G51)

Selecting restart mode	Description
<b>MP block / SP block</b>	By entering the block number within the main program and sub program the restart can take place at any point in the cutting plan. This means it is possible to skip contours, contour sections or even complete figures that have not yet been cut.
<b>n piercing points back</b>	Start machining at the given number of piercing points before the abort point.
<b>Contour lock-on</b>	Start machining after positioning the cutting head in manual mode. On selecting the <Contour lock-on> option the machine moves into the waiting position. The operator must then position the cutting head in manual mode as close as possible to the required restart point for resumption of cutting. After acknowledgement with <Cont>, the controller moves at right angles to the next contour and continues working through the cutting plan from this point onwards.

#### 6.11.6.2 Limitations

##### All restart options:

- A restart is only practical up to the last cutting plan displacement of a figure. For figures prior to this displacement an offset results or the wrong restart point or no restart point is found.
- A restart is only possible in the same cutting process; it cannot extend into another process. Thus for instance a restart can only be performed within the Cutting or Preburning process. It is not possible to switch to preburn from cutting using a restart function.

##### Contour lock-on:

- When restarting in the contour, the <Sensor off> field around the withdrawal point is ignored
- <On-the-fly cut start and end> is only possible again from the next contour onwards.
- The computing time to pick the contour can be considerable in the case of large cutting plans or imprecise restart positions.

## 6.12 Parameter setup

This menu is displayed by pressing the «Setup» button. The «SETUP» menu contains the setup values for the machine, laser, edge detection, microjoints and any other options. The menu contains several pages which can be scrolled through using the «Page Up» and «Page Dn» keys.

### 6.12.1 Machine setup values

#### **Feed with manual operation, head up:**

*(mm/min)*

Feed rate for rough positioning in manual mode, head in reference position.

#### **Feed with manual operation, head down:**

*(mm/min)*

Advance for fine positioning and for machining in manual mode, head lowered. Active while you press «Z-». If you also press «BURN», the rate automatically switches to the value for «Feed, continuous wave mode» from the process parameters.

#### **Feed reference:**

*(mm/min)*

Advance rate for moving to reference position. This feed rate is limited to 30 m/min in order to minimize the stress on the guides when stopping.

#### **Feed positioning:**

*(mm/min)*

Advance rate when positioning, during automatic setup and when moving to zero point. This feed rate is limited to 130 m/min by the drive. This feed rate is not active in manual operation.

#### **Positioning acceleration:**

*(mm/s<sup>2</sup>)*

This value applies to the X- and Y-axes within the displayed value range.

#### **Dimensional units, plan:**

**2 = MM**

Units in mm

**3 = INCHES**

Units in inches. A plan dimensioned in inches is converted to mm for machining (the display is still in inches however). In extreme cases this conversion can cause rounding errors.

**Type of calibration****1 = 1. piercing**

Calibration at first piercing point in plan

**2 = reference**

Calibration at reference point

**3 = specific position**

Calibration at defined position

**X-axis: Specific position:**

(mm)

X-dimension for defining the specific calibration position

**Y-axis: Specific position:**

(mm)

Y-dimension for defining the specific calibration position

**X-axis: Setup points:**

(mm)

Separation of setup points in X-direction. This value is required for aligning the laser beam (auto. setup).

**Y-axis: Setup points:**

(mm)

Separation of setup points in Y-direction. This value is required for aligning the laser beam (auto. setup).

**X-axis: Service point:**

(mm)

Distance of the service point from the machine zero point.

**Y-axis: Service point:**

(mm)

Distance of the service point from the machine zero point.

**X-axis: Start coordinate:**

(mm)

Distance of the cutting plan origin from the machine zero point. If the plan contains a G51 address, "X-axis: start coordinate" is ignored.

**Y-axis: Start coordinate:**

(mm)

Distance of the cutting plan origin from the machine zero point. If the plan contains a G51 address, «X-axis: start coordinate» is ignored.

### **Tube radius:**

(mm)

Default value for tube radius for rotary axis cutting. The controller reads the actual tube radius from the cutting plan in order to compute the Y coordinate in rotary movements.

### **Minimum lifting-off height between figures:**

(mm)

This setup value defines the lift-off height when positioning between two figures. This improves process reliability.

### **Max. positioning distance at low lifting height:**

(mm)

This value limits the positioning distance with no or only low lift-off height. If the value «Max. positioning distance at low lifting height» is exceeded, then the head is raised to the «Minimum lifting-off height between figures» at the exit cut. The limit only applies to cutting flat parts but not to tubes. Lowered positioning is disabled for this distance. For flying end-of-cut, the head is raised to the lift-off height between shapes during positioning. This also applies to the flying start-of-cut, with the proviso that the initial cut is long enough for lowering the head. The parameter is static, and is read only at the start of an NC program. Any change during cutting has no effect.

### **Detection:**

#### **0 = off**

Cutting without height detection. The tool is positioned to the absolute height required. The height is calculated from the current parameters:  
abs. height = material thickness + nozzle distance

#### **1 = on**

Cutting with height detection

### 6.12.2 Setup value, auto shutdown

**Switching off after:****0=off**

The auto shutdown system is enabled as soon as a value greater than zero is entered.

**Condition**

- all cutting plans finished
- cutting head in reference position

**NOTE**

*Before starting up the machine, the parameter must be reset to zero.*

**Unload:****0 = off****1 = on**

Only enabled if a loading/unloading device is fitted.

### 6.12.3 Laser setup values

**Laser:****0 = off**

Switches the laser off and remembers the previous switch setting (1-3)

**1 = standby**

Follow cutting plan but without laser, e.g. for test purposes

**2 = on**

Laser powered up manually

**3 = automatic**

With this setting the laser is powered up automatically after switching on the main switch on the machine.

**Pulse width, single pulse:***(ms)*

Pulse length of a single pulse. This value is required when measuring the focal position and centering the nozzle.

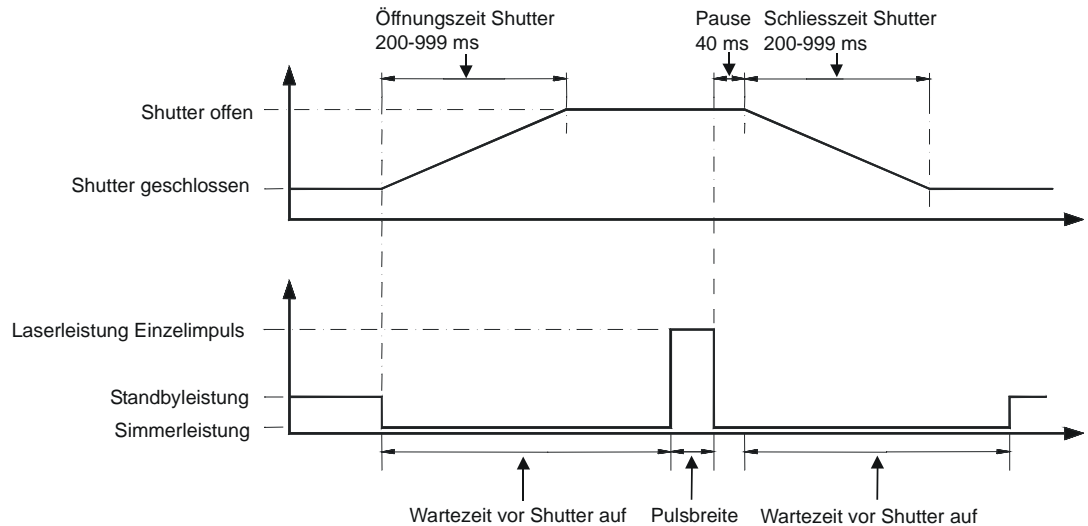
**Laser power single pulse:***(%)*

Laser power of a single pulse. This value is required when measuring the focal position and centering the nozzle.



### Delay time, shutter open/closed (BYSTAR / BYSPRINT / BYTUBE): (ms)

Delay between the shutter opening and the laser power being increased from the base power to the specified value (piercing, cutting, pulse). This delay is needed for opening / closing the shutter. It depends on the air pressure present. Find out for your machine the minimum value for this parameter by increasing it in steps at low pulse power and comparing the burn hole at each step. Maximum burn hole indicates the shutter is fully open (See nozzle centering).



### Delay time before lowered positioning: (ms)

Delay between exit cut and positioning action. This is needed when positioning without raising the head. The laser power is reduced during this time to a level where an engraving mark is no longer left during positioning.

#### 6.12.4 Purge gas setup values

**Minimum purging pressure after change of gas type:**

(bar)

If the gas channel is changed in the various process steps, the gas pressure of the purge gas can be set. The purging process is also performed after a change in cutting gas initiated by a process macro.

**Minimum purging time after change of gas type:**

(s)

If the gas channel is changed in the various process steps, the purge time for the purge gas can be set. The purging process is also performed after a change in cutting gas initiated by a process macro.

**Gas depressurization waiting time after purging:**

(s)

For a purging process after changing the gas type, a delay can be set as the «Gas depressurization waiting time after purging» in the «Setup» menu to allow the gas pressure to drop after purging.

**Pre-purging time after interruption:**

(ms)

A pre-purging operation can be performed after any interruption in cutting, to protect the lens. The gas type and pressure are the same as those for the subsequent piercing action.

#### 6.12.5 Edge detection setup values

Determining the position of the work piece when cutting flat parts by detecting the edge of the work piece:

- No need to align sheet with the positioning stops
- Lower wear on the support grating for heavy sheets
- No scratch marks on the sheet

It is assumed that the size of the sheet is at least as big as the plan dimensions (G29).

The start of the detection path is set by a distance given in the «Sensor allowance» parameter (see diagram). The controller uses the detected edge points to work out the sheet origin, and, depending on the value of the «Detection» parameter, also the angle of the sheet with respect to the axes. It places the corner point of the cutting plan (G51) on the computed origin of the sheet, and rotates the plan ready for machining if the angle has been computed.

The «X- and Y-axis start coordinate» parameters from «Set-up Machine» are ignored, as is any origin offset given with the address G51 in the cutting plan.

**Detection process**

1. Moving to reference position
2. Calibrate the detection system
3. Detect edges
4. Move to plan origin

If high detection accuracy is required, then ensure that sheets are used with edges that are as vertical as possible. If «INHIBIT» is enabled then the origin is only found for the first sheet. The angle and the origin offset are retained.

**Detection:****0 = off**

No edge detection

**1 = X**

Detection of the left edge only in the X-direction. Fastest detection mode. Used when loading from the sheet table, assuming that the sheets are pushed against the end stops.

**2 = X/Y**

Detection of the origin in the X- and Y-direction. Use if the sheet is already correctly located at the correct angle relative to the axes.

**3 = X/Y/Angle**

Detection of the origin in the X- and Y-direction and computation of the skew angle. Used if the position and angle of the sheet need to be found.

**Sheet loading (BYSPEED / BYSTAR / BYSPRINT):**

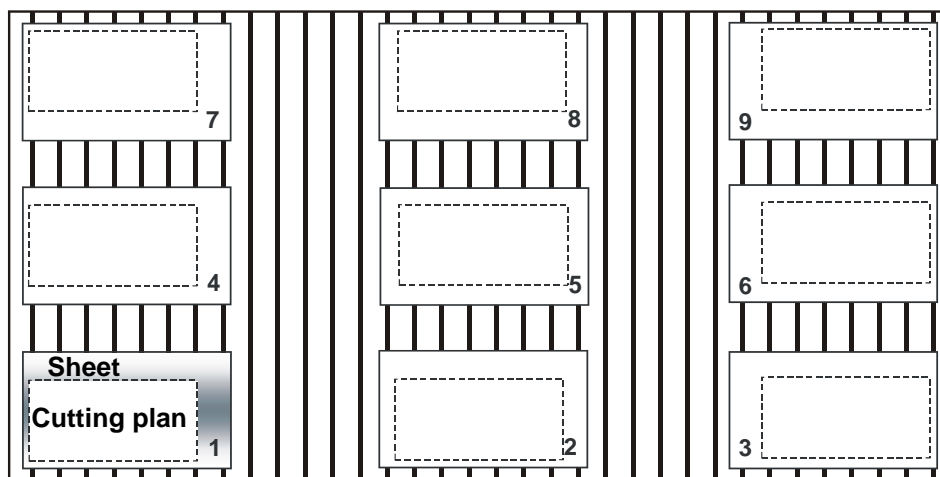
A configuration value for Material request to transport system (PLC) results in material data for placing a new sheet being forwarded from the MMC via the CNC.

When a Material request to transport system (PLC) is enabled, an X- and Y- start coordinate must be added as a G51 block. With edge detection enabled, the coordinates are calculated from the setup and the configuration (PLC) according to the type of sheet loading. The Sheet store and Material request to PLC configurations can only be selected if the CNC is fitted with the necessary 2nd DIOCOM.

With edge detection enabled, a sheet can be placed in any corner or in the middle of the cutting table. The lower left corner of the sheet is always detected.

Number	Loading	Number	Loading
1	front left	6	center right
2	front center	7	rear left
3	front right	8	rear center
4	center left	9	rear right
5	center center		

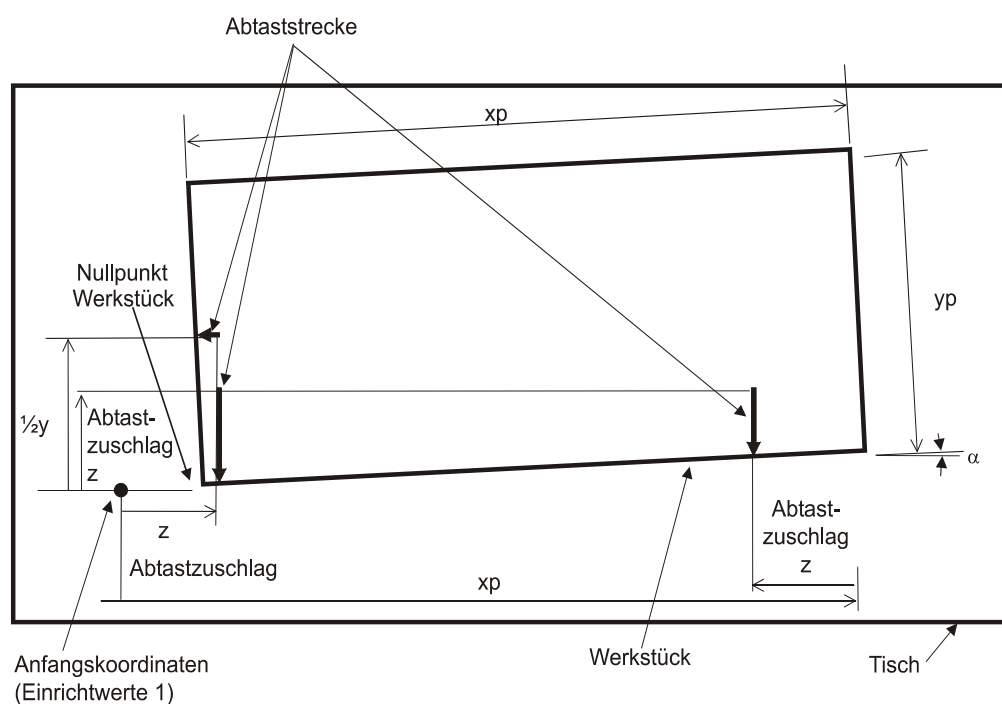
### Cutting table



### Sensor allowance:

(mm)

Detection starts over the work piece and moves towards the edge (sensing path). The sensor allowance  $z$  includes the positioning tolerance of the sheet stack and the loading tolerance. The value must be less than the plan dimension G29.



## **X-distance, scanning device:**

(mm)

Since at the edge of the work piece only half the nozzle is lying over metal, the capacitance changes. This parameter contains this offset that arises when detecting the edge (see handover report for default value).

This parameter can also be used instead of an edge distance if the cutting plan does not include an edge offset (in address G52).

## **Y-distance, scanning device**

(mm)

Analogous to X offset above.

## **Scanning feed:**

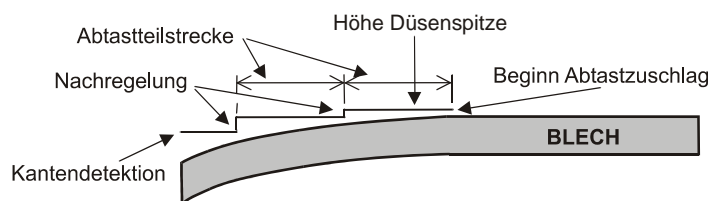
(mm/min)

Maximum permitted speed during detection. The lower the speed the higher the detection accuracy.

## **Detection step length:**

(mm)

Length of steps between which capacitive detection readjusts the nozzle clearance. Readjustment allows sheets with down-turned edges to be detected. The special case of "No readjustment" is assigned to the value 0.



For efficient production, the sensor allowance should be as small as possible, the detection feed rate (scanning feed) as high as possible and the detection step length as long as possible. Carry out tests to find optimum values.

## **Sampling tolerance (0= no check points):**


(mm)

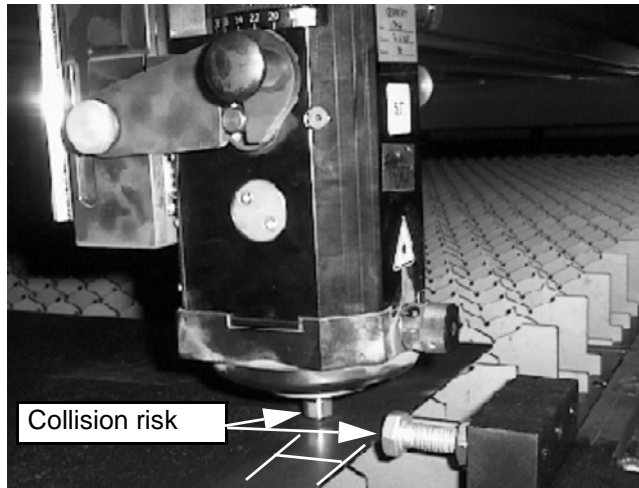
Edge detection with check points is enabled by the Setup value «Sampling tolerance (0=no check points)».

An additional point in both the X- and Y-direction is then detected and compared with the measured edge taking into account the position. If one of the check points deviates by more than the detection (sampling) tolerance then the detection process is repeated with the detection positions shifted slightly.

After 3 failed attempts, detection is terminated with «Warning:.. inaccurate detection». After displaying the warning for 5 seconds, the cutting plan is worked through using the most accurate detection.

This procedure applies to detection of the origin as well as detection of shapes.

	<p style="text-align: center;"><b>⚠ CAUTION</b></p> <p>Danger when using edge detection with thin sheets</p>
---	--



Distance (20 mm min.)

If edge detection is performed near an end stop on the cutting table then there is a risk of the cutting head colliding with the end stop.

Therefore make sure when performing an edge detection that the sheet is at least 20 mm from the stop. This makes sure that the cutting head does not collide with the stop during edge detection.

## 6.12.6 Set-up values microbars

Microjoints (microbars) prevent:

- cut figures tilting or falling out during automatic sheet removal.
- cut figures tilting during lowered positioning
- melting loss at the exit cut when cutting stainless steel

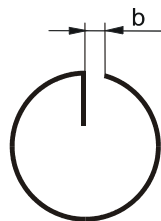
### Function:

#### 0 = off

No microjoints. Any microjoints programmed in the cutting plan are ignored.

#### 1 = on

Microjoint only as auxiliary function in cutting plan: M80 before M5 at any point between two geometry elements. This means more than one microjoint is possible per contour. The geometry element before M80 is cut shorter by an amount given by the joint width  $b$  (see diagram).



#### 2 = automatic

The controller automatically sets exactly one microjoint per cut for shapes where the X-dimension lies between «X-dimension minimum» and «X-dimension maximum»: the controller generates one microjoint before each exit cut by terminating the cutting action prematurely.

#### 3 = Weld joint

A weld joint is set instead of a microjoint. This parameter must be enabled before starting on the cutting plan. The «weld joint» function is primarily designed for thick sheet steel, where the thickness means that these parts cannot be removed, or only with difficulty, if microjoints are used.

### Critical parts: X-dimension max...:

(mm)

Only enabled for "2 = automatic". If you are setting microjoints merely to prevent tilting, then microjoints for X-dimensions greater than twice the spacing of two grating bars are superfluous. The value 0 means that the direction is still not taken into account.

**Critical parts: X-dimension min.***(mm)*

Only enabled for "2 = automatic". Parts smaller than «X-dimension minimum» count as small parts (cut-outs) that will not be machined further and are therefore to be removed by the small-parts conveyor.

If you want to prevent the small parts from tipping up or being left in place, then the value must be less than the spacing of two grating bars.

**Critical parts: Y-dimension max.***(mm)*

Only enabled for "2 = automatic". The value 0 means that the direction is still not taken into account.

**Critical parts: Y-dimension min.:***(mm)*

Only enabled for "2 = automatic". Parts smaller than «Y-dimension minimum» count as small parts (cut-outs) that will not be machined further and are therefore to be removed by the small-parts conveyor.

The material-dependent parameters of the microjoint function («microjoint width», «piercing mode after microjoint») are described in the «Special parameters» menu.



### 6.12.7 Setup values, Weld joint

Microjoint welding complements microjoint cutting. Mixed mode operation of microjoint cutting and welding is not possible. Microjoint welding is possible for a laser power of 2.4 kW and above. Welding can be performed with oxygen or nitrogen.

#### **Welding with oxygen. (Structural steel)**

The surface of the material is heated up and melts in the cutting gap. A weld point is formed of approximate size 6-8mm. Useful material thicknesses are 4-12mm.

#### **Welding with nitrogen: (Stainless steel and structural steel with N2)**

The surface of the material is heated up and melts in the cutting gap. A weld point is formed of approximate size 2-3mm. Useful material thicknesses are 4-8mm.

The same gas type should be used for welding as for cutting, otherwise the long purge times will reduce the advantages of welding.

You can define the parameters for microjoint welding using «Setup values, Weld joint». Microjoint welding is enabled under «Setup», «Set-up values microjoints», «Function: 3= weld joint». Weld points are programmed using (M80/M81 microjoint).

#### **Nozzle distance:**

(mm)

Nozzle clearance at the weld position

Default values: (in mm)

O<sub>2</sub>: 50

N<sub>2</sub>: 8

#### **Cutting clearance offset into waste part:**

(mm)

The weld point can be shifted from the center of the cutting gap into the waste piece by entering a displacement value. This minimizes damage to the cut part caused by the weld point on its surface.

Default values: (in mm)

O<sub>2</sub> 0.8

N<sub>2</sub>: 0

#### **Gas channel:**

Weld gas type. Welding can be performed with oxygen or nitrogen.

#### **Gas pressure:**

(bar)

Gas pressure during welding

Default values: (in bar)

O<sub>2</sub>: 0.2

N<sub>2</sub>: 0.1

**Laser power:**

(%)

Laser power during welding

Default values: (in %)

Laser:	2.4	3.0	4.0
O <sub>2</sub> :	100	85	60
N <sub>2</sub> :	45	35	25

**Weld time:**

(s)

Time spent by the laser beam making the weld point on the material

Default values: (in s)

Laser:	2.4	3.0	4.0
O <sub>2</sub> :	0.5	0.4	0.4
N <sub>2</sub> :	1	1	1

**Overcut:**

(mm)

The overcut is the cutting distance traveled beyond the programmed weld joint before the laser makes the weld joint.

Default values: (in mm)

O<sub>2</sub>: 25N<sub>2</sub>: 6**Reset distance before interrupt:**

(mm)

Restart point before welding interruption

Default values: (in mm)

O<sub>2</sub>: 0N<sub>2</sub>: 0**Acceleration factor:**(m/s<sup>2</sup>)

Acceleration factor when starting up in the cutting gap

Default values: (in m/s<sup>2</sup>)O<sub>2</sub>: 3N<sub>2</sub>: 3

### **CW gas ramp:**

(s)

CW gas ramp when starting up in cutting gap

Default values: (in s)

O<sub>2</sub> 0

N<sub>2</sub>: 0

## **6.12.8 Nozzle cleaning setup values**

### **Manual initiation of nozzle cleaning**

Enable «Service» and if applicable «Halt» to initiate this function. Once the service position has been reached, the cleaning process can be started by selecting the «Service» function again.

### **Number of cleaning passes**

The nozzle is cleaned by traveling x number of times over the brass brush. The cutting gas is shut off during the cleaning process. The nozzle is recalibrated on the calibration plate after cleaning.

### **Clean at end of cutting plan:**

**0 = off**

The nozzle is not cleaned at the end of the cutting plan.

**1 = on**

The nozzle is cleaned at the end of the cutting plan, before moving to the reference position.

### **Clean after x pierces:**

**0=off**

The nozzle is not cleaned while working through a cutting plan.

**»0=on**

The nozzle is cleaned after performing the number of piercing actions specified in the parameter.

### **Distance Z-reference - cleaning height:**

(mm)

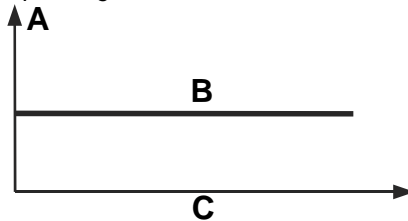
This value is used to define how far the cutting head is lowered from the reference position in order to clean the nozzle.

### 6.12.9 Setup values, adaptive optics 1

#### Operating mode (BYSPEED):

##### 0=Fixed: (Service mode BYSPEED)

Fig.6.12-1 Operating mode 0



- |    |                      |
|----|----------------------|
| A. | Mirror deformation   |
| B. | Characteristic curve |
| C. | Beam length          |

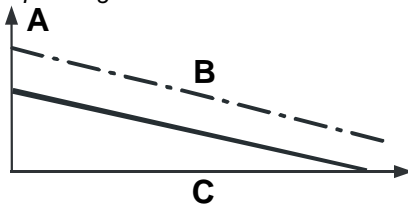
The defined mirror deformation remains constant over the entire cutting range irrespective of the beam length. The focal position is not automatically re-corrected in this operating mode.

A mirror deformation of  $0\mu\text{m}$  for the adaptive mirror corresponds to a flat mirror. The technically feasible adjustment range of  $-40\mu\text{m}$  to  $+40\mu\text{m}$  moves the focal point by about 20mm.

If the operating mode is tested by firing into a Plexiglas cube, the mirror deformation must definitely be set to  $0\mu\text{m}$ .

##### 1=Focus correction+Focal position: (Default mode BYSPEED)

Fig.6.12-2 Operating mode 1



- |    |                      |
|----|----------------------|
| A. | Mirror deformation   |
| B. | Characteristic curve |
| C. | Beam length          |

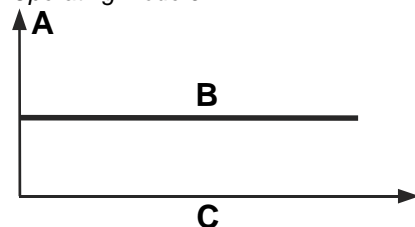
A valid characteristic curve must exist before operating mode 1 can be used. In operating mode 1, the focal position, which normally appears in the cutting parameters merely for information purposes, is adopted as a parameter. In this mode, the focal position no longer needs to be adjusted manually at the cutting head when the material is changed, but is adjusted automatically by the adaptive optics. The total deformation is calculated from the position-dependent characteristic-curve value (characteristic curve) plus an OFFSET. This offset is a function of the characteristic values for focal length, focal position and nozzle distance, which are obtained from the given cutting parameter file. The calculation is performed automatically.

## Operating mode (BYSTAR / BYSPRINT / BYTUBE):

### 0 = Fixed

The mirror deformation specified by the parameter «Fixed mirror lift for operating mode= 0» is adopted.

Fig.6.12-3 Operating mode 0



Legend:

- |    |                      |
|----|----------------------|
| A. | Mirror deformation   |
| B. | Characteristic curve |
| C. | Beam length          |

### NOTE

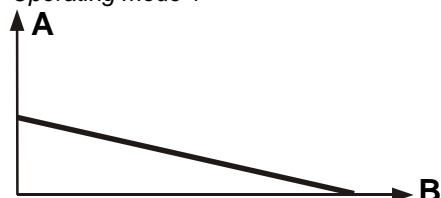


*No characteristic curve is followed.*

### 1 = Focus correction

In operating mode 1, mirror deformation correction is used to compensate over the cutting range for the variation in focal position as a function of beam length. These mirror deformations are saved in the five characteristic curve points.

Operating mode 1



Legend:

- |    |                    |
|----|--------------------|
| A. | Mirror deformation |
| B. | Beam length        |

### NOTE



*Follows the characteristic curve*

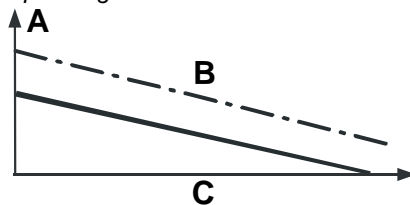
### 2 = Focus correction + focal position

In operating mode 2, the «cutting head focal position» (focal length) parameter (dependent on cutting head) given in the «Adaptive Optics set-up values» (Setup) merely needs to be added manually to the focal point reference position (focal position at nozzle tip) at the cutting head. All necessary settings and corrections are then performed by the CNC.

**The CNC takes into account the following values:**

- «Focal length» from the cutting head characteristic data?(Param menu)
- «Focal position» from the cutting head characteristic data?(Param menu)
- «Nozzle distance» from the currently enabled parameter set (Param menu)
- «Deformation/focus change» lens ... (Setup menu)
- «Cutting head focal position» lens... (Setup menu)
- Mirror deformation to be generated online from characteristic curve (Setup menu)

Fig. 6.12 -4 Operating mode 1



Legend:

- |    |                      |
|----|----------------------|
| A. | Mirror deformation   |
| B. | Characteristic curve |
| C. | Beam length          |

**NOTE**

*Follows characteristic curve + focal point corrected*

**Fixed mirror deformation for operating mode = 0:**

This value is used to define the fixed mirror deformation for operating mode 0, for servicing purposes. A negative deformation (< 0mm) produces a concave mirror, a mirror deformation of 0mm generates a flat mirror and a positive deformation (> 0mm) creates a convex mirror.

**Characteristic curve:**

The characteristic curve is used to compensate for variations in the position of the focal point (dependent on the beam property) over the whole cutting range. The Maintenance folder contains more precise details on how to calibrate this compensation curve. The beam length begins 400 mm outside the effective cutting range. Five points on the characteristic curve are taken at regular intervals along the whole beam path. Points 2, 3, 4 and 5 are obtained by applying mirror deformation correction to the focal position characteristic of point 1.

**Focal length default setting (BYSPEED):**

(mm)

In order to be able to generate the whole range of focus positions required (dependent on the focal length) using mirror deformation, the negative mirror deformation range must also be included. The «Focal length default setting» is only relevant in operating mode 1.

**Lift/Focus change (BYSTAR / BYSPRINT / BYTUBE):***( $\mu\text{m}/\text{mm}$ )*

This parameter is defined by the type of adaptive mirror used and by the focal length chosen. It is used by the CNC in operating mode 2, to convert all values dependent on the focal position (mm) into a deformation in mm.

**Focal position cutting head (BYSTAR / BYSPRINT / BYTUBE):***(mm)*

In order to be able to generate the whole range of focus positions required (dependent on the focal length) using the mirror deformation, the negative mirror deformation range must also be included. This is done by adding this value to the cutting head reference position. The CNC compensates for this by less deformation. The «Focal position cutting head» parameter is only effective in operating mode 2.

**6.12.10 Cut Control setup values****Process monitoring:**

CutControl monitors the cutting process in CW normal mode. Piercing, pulsing, engraving, pre-burning and macros are not monitored. Monitoring starts after the initial cut and/or after start-up following a «HALT», and ends before the exit cut. Cutting-process parameters such as modulation, corner feed rate etc. are not taken into account. Any change in a CutControl value is only enabled at the next monitoring cycle, which can be forced by «HALT» or a calibration process.

Process monitoring is based on the light emitted from the work piece. The emitted light is detected via a mirror by three detectors. The mirror and the detectors are mounted in the sliding piece of the cutting head. The cutting heads are labeled with a CutControl label.

**CutControl applications**

CutControl is used for the following materials and thicknesses:

- Stainless steel 1-12mm thick
- Steel 1-6mm thick

**Measuring the calibration threshold**

The calibration process is initiated during a good cut in cutting or manual operation by setting the parameter «Calibration during cut» in the «Setup» menu to 1. During calibration, a signal is detected every 20ms and summed to obtain an average value. After a short time (about 2 seconds), the controller displays the average value on the right of the same line. This is the calibration threshold for the material concerned. The value can be measured several times for checking purposes. This value must then be entered manually in the parameter «Calibration threshold Gas channel 2» in the «Param» menu. This calculated value normally does not vary significantly, and so only needs to be checked occasionally.

If a different material or a different surface finish is being cut, then a new calibration value must be measured.

After calibration, or if cutting is interrupted, the setup value is automatically reset (=0).

**NOTE**

*CutControl cannot be used with an NK nozzle*

**CutControl: 0=off, 1=on:**

Cutting with/without CutControl

**Calibration during cutting: 0=off, 1=enable:**

Measuring the base signal for a good cut in cutting or manual operation.

**Guideline values for Calibration thresholds for Bystar, Bysprint und Bytube**

Material thickness [mm]	Focal length	Stainless steel N <sub>2</sub>	Nozzle	Structural steel N <sub>2</sub>	Nozzle
1	5"	250-450	Hk15	250-450	Hk15
2	5"	250-450	Hk15	250-450	Hk15
3	5"	250-450	Hk17	250-450	Hk17
4	7.5"	200-450	Hk17	350-450	Hk20
5	7.5"	250-500	Hk20	400-700	Hk25
6	7.5"	350-500	Hk25	450-1000	Hk25
8	7.5"	600-1100	Hk25	1100-1400	Hk30
10	7.5"	850-1150	Hk30	-	-
12	7.5"	700-900	Hk30	-	-

**Calibration threshold gas channel 1 ( O<sub>2</sub> ), and 2 ( N<sub>2</sub> ) (display only):**

Measured base signal of a good cut with gas channel 1 / 2 . Calibration thresholds cannot be overwritten. They are used for displaying the values found from calibration. These values must be entered manually in the parameters and saved.



### 6.12.11 Setup values for edge detection with CutControl

More accurate edge detection is achieved by using CutControl. When CutControl is employed, the following steps are performed in addition to capacitive edge detection:

- After capacitive edge detection the machine moves approximately 5 mm beyond the edge of the sheet.
- The laser is switched on with «Detection laser power» and «Detection gas pressure»
- The laser is moved backwards until the laser beam touches the sheet edge
- The machine stops in this position and saves the detected reading found using Cut Control
- The machine travels to the next edge detection location

**Detection with CutControl:**

(0 = off, 1 = on)

Edge detection with Cut Control on/off

**Detection feed rate:**

(mm/min)

Feed rate during detection

**Detection nozzle distance:**

(mm)

Optimum nozzle distance for an accurate signal

**Detection Gas channel:**

Gas type for detection

**Detection Gas pressure:**

(bar)

Gas pressure during detection

**Detection Laser power:**

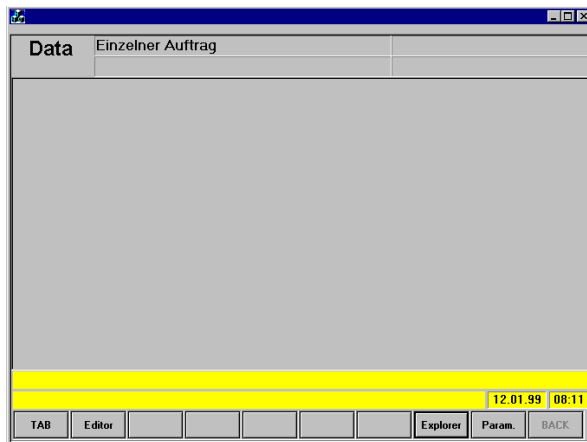
(%)

Percentage laser power during detection

**Detection level:**

Minimum signal level for sheet detection. An error can arise if the detection point lies on a support grating.

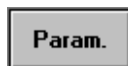
## 6.13 DATA menu



This menu is displayed by pressing the <Data> button



Pressing the <Editor> button opens the Editor program DinEdit.

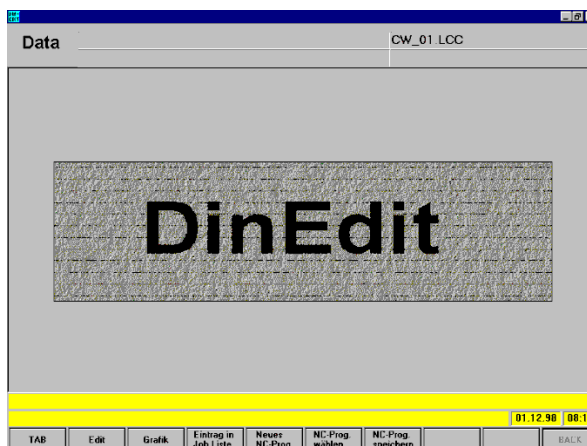


Pressing the <Data> button opens the Parameter Editor. This tool allows you to import a process parameter file, edit process parameters or create a personal process parameter file.



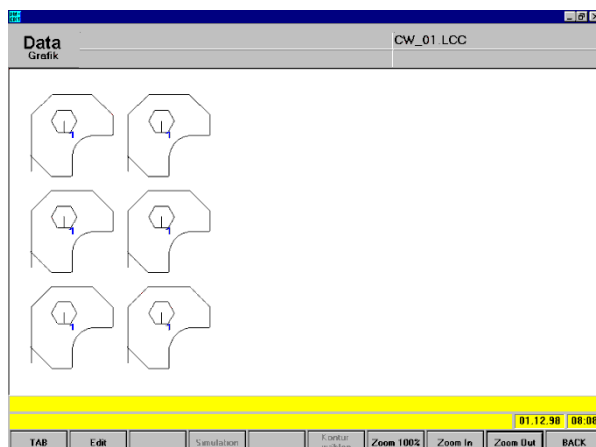
Pressing the <Explorer> button opens Windows Explorer.

### 6.13.1 Editor (DinEdit)



The <S1> button opens the <DinEdit> program, a standalone editing program. To highlight that this program is not the MMC, its start-up screen displays a graphic with the label "DinEdit". A cutting plan can be displayed graphically or as NC code.

## 6.13.1.1 DATA graphic



The cutting plan currently selected or being edited is displayed graphically. The <Graphic> application displays the cutting plan in full.

### Simulation

(Not enabled yet)

### Select contour

(Not enabled yet)

### Zoom function

The zoom functions <Zoom in>, <Zoom out> and <Zoom 100%> are displayed in the toolbar when the DinEdit program is started. The size of the graphic can also be changed from the PC or machine keyboard using the <+>/<-> buttons.

### Zoom in

Enlarges the screen contents currently displayed.

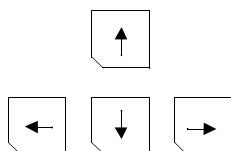
### Zoom out

Reduces in size the screen contents currently displayed.

### Zoom 100%

The screen contents are set to the default size.

### Move



The on-screen graphic can be moved both horizontally and vertically using the arrow keys on the machine or PC keyboard.

### Entry in Job List

A modified cutting plan must be saved. After saving, the <Entry in Job List> button is enabled in the toolbar. Pressing this button inserts the cutting plan directly in the Job List.

**New NC prog.**

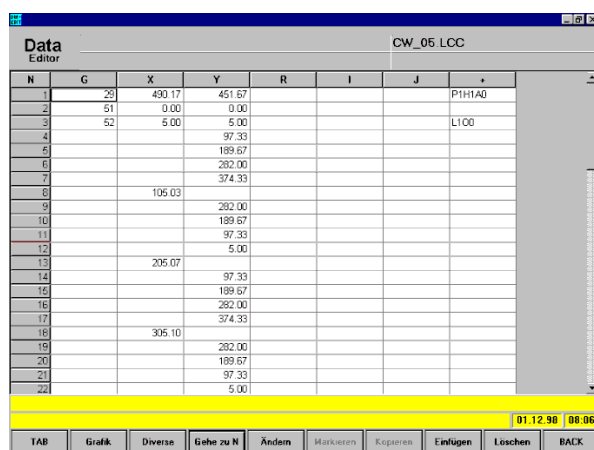
This function opens an empty editing window for creating a new cutting plan.

**Select NC prog.**

A dialog box opens in which you can browse through all the drives, directories and files, optionally selected by file extensions, in order to select an NC program for editing.

**Save NC prog.**

NC programs, with any modifications, can be saved under the same name or a new name.

**6.13.1.2 DATA Editor**


N	G	X	Y	R	I	J	+
1	29	430.17	451.67				P1H1A0
2	51	0.00	0.00				
3	52	5.00	5.00				L100
4			97.33				
5			189.67				
6			282.00				
7			374.33				
8		105.03					
9			282.00				
10			189.67				
11			97.33				
12			5.00				
13		205.07					
14			97.33				
15			189.67				
16			282.00				
17			374.33				
18		305.10					
19			282.00				
20			189.67				
21			97.33				
22			5.00				

01.12.98 08.06

TAB Grafik Diverso Gehe zu N Ändern Markieren Kopieren Einfügen Löschen BACK

The Editor allows you to edit and create values, comments and, if applicable, parameter file details in the NC program via the CNC or PC keyboard. The Editor works as a standalone program and can only be started when the MMC is running. It is divided into six address columns.

**Addresses**

The editor works on the basis of the code blocks.

The G functions are preparatory functions.

Columns X and Y contain coordinates. Column R is reserved for radii.

When you close the editor, the plausibility is checked automatically. You yourself, however, must check whether the data entered can also be worked through in practice. Look out in particular for

- typing errors in the numbers for the M functions and G functions
- modified positioning data that causes the axes to hit the end stops.

Check the edited plan using <GRAPHIC>, to highlight any obvious (typing) errors in the graphic.

**"N" address**

Consecutive line numbering. The lines are renumbered if a line is inserted.

**"G" address**

The table below shows the authorized numbers and their meaning. The numbers can be overwritten and deleted. Missing address numbers are inherited.

**"X" and "Y" address**

Coordinates or dimensions. These values can be overwritten, deleted or inherited.

**"R" address**

Circle, corner or tube radius. These values can be overwritten, deleted or inherited.

**"I" and "J" address**

Center of circular arcs. The values can be overwritten, deleted or inherited. The program only jumps to these columns if a radius or circular arc has not been specified.

**"+" address**

Auxiliary functions. A number of different auxiliary functions are possible depending on the G functions. These appear in one line in the order entered and in the same column, with letter and value. These values can be overwritten, deleted or inherited.

**Go to N**

This function is used to jump to a specified N address number.

**Modify**

The data in the currently selected field can be changed.

**Marking**

(Not enabled yet)

**Copy**

(Not enabled yet)

**Insert a new data record**

Editing function for inserting a block.

Inserts an empty block at the required position.

**Delete**

Editing function for deleting a block.

The blocks from line number Nxxxx to Nzzzz are deleted.

**Divers**

This function contains the zoom functions and a function for updating the line numbers.

**Zoom 100%**

The screen contents are set to the default size.

**Zoom in**

Enlarges the screen contents currently displayed.

**Zoom out**

Reduces in size the screen contents currently displayed.

**Updating of the N-Code**

The line numbers of a modified NC program are listed in ascending order.

### 6.13.1.3 Table of defined addresses

Code	Meaning	Format	Units
<b>A</b>	Job number	05	
<b>C</b>	Angle of rotation of figure in degrees	+0320	(degrees)
<b>F</b>	Feed rate during interpolation	05	(mm/min)
<b>G</b>	Preparatory function (G address or G function)	02	
<b>H</b>	Number of program passes	05	
<b>I</b>	X coordinate of circle center point	+ 0520	(mm)
<b>J</b>	Y coordinate of circle center point	+ 0520	(mm)
<b>L</b>	Subprogram number	03	
<b>M</b>	Auxiliary function	02	
<b>N</b>	Block number	06	
<b>O</b>	Rotation code (0=0°, 1=90°, 2=180°, 3=270°; only after G52)	03	
<b>P</b>	Program number (main prog.) / Figure number (subprog.)	05	
<b>Q</b>	Piercing time different from parameter	0210	(s)
<b>R</b>	Radius	0520	(mm)
<b>S</b>	Macro no.		
<b>U</b>	Rotation coordinate	+ 0320	(degrees)
<b>X</b>	X coordinate (main prog.) / X dimension (subprog.)	+ 0520	(mm)
<b>Y</b>	Y coordinate (main prog.) / Y dimension (subprog.)	+ 0520	(mm)
<b>Z</b>	Z lift-off height different from parameter	0520	(mm)

#### NOTE

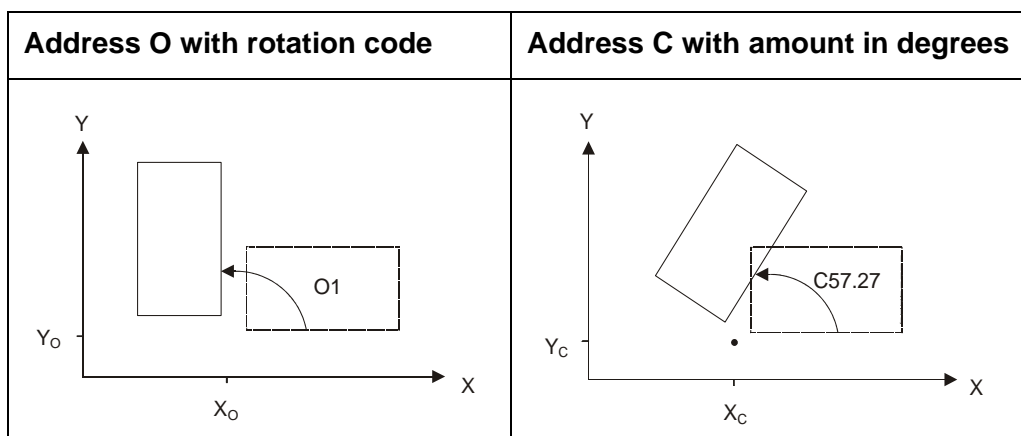


*If you have selected Inches for the dimensional units under <SETUP>, <Machine setup values>, the format for addresses I, J, R and X, Y, Z (+) reads 0430 inches.*

Address contents not included in the table are not defined and are ignored by the controller. Thus unexpected results can occur with typing mistakes.

No practical applications for the address Q are currently known of for the Bystronic machines.

The Bytube software module in Bysoft calculates Z for the additional lift-off height prior to tube rotation. The calculated Z dimension depends on the tube dimensions.



#### 6.13.1.4 G functions

- For those assigned addresses enclosed in brackets, the controller adopts the default value if you have not entered any numerical values from the keyboard.
- For all other assigned addresses, numerical values must be entered from the keyboard, otherwise machining may be terminated in some circumstances (Error message "memory error").
- Entering the address M is optional.

#### Notes on the individual functions

For address G0, the controller takes the feed rate from the <Positioning speed> parameter.

For addresses G1 to G3, the controller takes the feed rate from the Cutting, Engraving or Welding parameters depending on the machining mode (G10 – G12).

It computes the actual feed rate from this set value, taking into account

- <Acceleration factor>
- <Dynamic factor> and <Corner tolerance>, if these parameters are enabled

For address G11 (Engrave) and M16 (Reduced power), the controller uses fixed values for the following special parameters, irrespective of the defined values:

Critical angle dwell time	<b>175</b>
Corner tolerance	<b>0.08</b>
Acceleration factor	<b>1</b>
Acceleration factor, lead-in	<b>1</b>



## Summary of G functions

The following list summarizes the G functions.

### 6.13.1.5 Table of G functions

Code	Assigned addresses	Description
0	XY (U)(Z)	Positioning
1	XYM	Straight path
2	XYRM	Circular arc, clockwise (start, end and radius)
3	XYRM	Circular arc, counterclockwise (start, end and radius)
2	XYIJM	Circular arc, clockwise (start, end and center)
3	XYIJM	Circular arc, counterclockwise (start, end, center)
4	M	Machine command without moving the axes (e.g. G0 X50 Y100 G4 M1)
(10)	S	Cutting (default value, only include in program when switching back from engraving or welding). A process macro is enabled when G10 is used with S1 or S2.
11		Engraving
12		Welding
(17)		Machining of work pieces in the XY plane (default value, only include in program when switching back from rotary axis)
20		Machining circular tubes using the rotary axis
23		Machining rectangular tubes using the rotary axis
28	XYL(P)	Start of subprogram for single figure
29	XY(P)H(A)(F)(Q)	Start of main program (X and Y are required for edge detection)
40		Tool-radius compensation off
41		Tool-radius compensation left
42		Tool-radius compensation right
51	XY(R)(U)(Z)	Coordinate of main program origin
52	XY(R)(Z)LO(T)C	Coordinate of subprogram origin (referred to the origin of the main program), O and C are mutually exclusive
85	XYRU	U-axis, corners, no X movement or proportional movement  (R is the calculated rounding radius, U is the destination plane)

Code	Assigned addresses	Description
86	XYRU	U-axis, corners, approaching at an angle, leaving straight  (R is the calculated rounding radius, U is the destination plane)
87	XYRU	U-axis, corners, approaching straight, leaving at an angle  (R is the calculated rounding radius, U is the destination plane)
98		End of subprogram
99		End of main program

### 6.13.1.6 M functions

Code	Meaning	Validity	Action before or after G function
1	Scheduled interrupt if <STOP SELECT> is enabled	block	after
4	Machining on	global	before
5	Machining off	global	after
6	Lowered positioning on	global	before
7	Lowered positioning off	global	after
8	Cooling water on	global / on the fly	before
9	Cooling water off	global / on the fly	after
10	Sensing off	global	before
11	Sensing on	global	after
12	Pulsed mode, cutting on	global	before
13	Pulsed mode, cutting off	global	after
14	Pulsed mode, piercing on	global	before
15	Pulsed mode, piercing off	global	after
16	Reduced power	M4 to M5	before
17	Dwell	block	before
18	Piercing without piercing time, taking into account the parameter <Gas ramp, CW piercing/cutting> and <Acceleration factor, lead-in>	block	before
19	Interrupt auxiliary signal on	block	before
20	Interrupt auxiliary signal on	block	after
21-28	Bysmart deposit locations		
30,32	User functions, enable	block / on the fly	before
31, 33	User functions, enable	block / on the fly	after
40, 42	User functions, acknowledgement	block	before
41, 43	User functions, acknowledgement	block	after
50, 52	User functions, acknowledgement / <CONT>	block	before
51, 53	User functions, acknowledgement / <CONT>	block	after
80	Microjoint		after

### 6.13.1.7 Validity of M functions

#### **Block**

The function is active for the block containing the function.

#### **global**

The function is active from the block containing the "On" command up to the block containing the "Off" command.

#### **on the fly**

The function is coupled to an external signal that can also be received while a G address is being executed (see next section "User functions" for an example).

#### **User functions**

The user functions are provided for coordinating customized processes and devices with laser machine operation.

Numerous different applications are conceivable, but just a few examples are given below as illustration:

#### **enable**

These functions work in a similar way to the functions "Cooling water on/off" (M8 and M9)

- In combination with blocks G1 to G3, these M functions work on the fly. M numbers that are even work before the block, odd numbers after the block.
- Before M4, after M5 and in combination with G4, these M commands work statically.

Example of the use of an on-the-fly M function: A clamping device for a welding task is fitted with proximity switches in order to prevent collisions with the machining head. If the head approaches, the clamping device is released, if it moves away again, clamping is applied.

#### **Acknowledgement**

These functions work in a similar way to "Interrupt auxiliary signal".

They always cause an interrupt in the machining process. Machining is resumed once the acknowledgement signal is received. If necessary during cutting, the cut is interrupted and the head raised. M42/43 cause the tool to be raised first to the maximum Z-dimension.

Example of the use of an M function with acknowledgement: External drill. The drill outputs the acknowledgement signal on completing the drilling action.

#### **Acknowledgement or <CONT>**

These functions work in a similar way to "optional stop", but are dependent on <STOP SELECT>.

They always cause an interrupt in the machining process. Machining is resumed once the acknowledgement signal is received or if you press the Acknowledge button. If necessary during cutting, the cut is interrupted and the head raised. M52/53 cause the tool to be raised first to the maximum Z-dimension.

Example of the use of an M function with acknowledge or <CONT>: External quality control of unattended machining using temperature measurement. If the maximum temperature is exceeded, machining is interrupted until you press acknowledge.



**6.13.2 Explorer (Windows Explorer)**

The Windows 95 Explorer is started from this toolbar. It is used in particular for copying, moving, renaming, locating and deleting files. Familiarity with Windows is assumed.

**6.13.3 Param. (Parameter Editor)**

Parameters can be created, edited and saved using this tool. These do not have any effect on the cutting process in hand, however. This data is not sent to the CNC.

## 6.14 Fault, error and system messages

	 <b>WARNING</b>
	<p>In accordance with electrical engineering regulations, work must only be undertaken on the machine's electrical equipment by specialist electricians.</p>

### 6.14.1 System error status

The system error status indicates faults or system errors; the system is not ready for operation.

System message	Cause	Procedure
Controller not ready	Intermediate circuit voltage can no longer be switched on.	Check fuse switch F2 Reset CPU
Drives not ready	Servo failure.	Turn off machine and turn it back on.
Emergency off external	One of the < EMERGENCY STOP> buttons has been activated The machine safety circuit is open	Turn the mushroom-head button to release it, switch the resonator control off with the key-operated switch and press < RESET> on the PPC
Drives locked	Safety gate open Key-operated switch turned to left	Close safety gate Turn key-operated switch to the right

### 6.14.2 System warnings

The system warnings indicate faults or system errors; the system is ready for restricted operation.

System message	Cause	Procedure
Lubricant container empty	The central lubrication container is empty. No lubrication cycle taking place.	Fill lubricant container
Lubricating cycle timeout	Lubrication cycle taking too long.	Test drive and reset CNC
Delay motor temperature too high	Motor protection. <STOP WORK> is set automatically or after a while <Halt>. 'Stop before...' cannot be cleared with <CONT>.	Wait until motor cools down and continue by pressing <CONT> or cancel by pressing <ABORT> and move to reference.

System message	Cause	Procedure
Warning: Bypos error	An adaptive lens error in Mode 0=Fix only causes this warning and no Emergency stop.	Emergency operation. After correcting the Bypos error activate Mode 1 or 2.
Warning: inaccurate sampling	The required accuracy was not achieved in edge detection with check points. In subsequent machining the values with the smallest deviation are used.	Machining is automatically resumed after a 5 second pause. The process can be terminated during this interval if the required tolerance is not achieved.
Gas warning	Difference between existing and required gas pressure is less than 1 bar.	Check gas supply and replace gas bottle concerned.
W-axis warning:frequency outside tolerance	The free-running frequency of the capacitive W axis control does not lie in the expected frequency range before calibration.	Call Bystronic Customer Services
Warning: park crossjet	The crossjet is in its operating position, although not currently in use.	Park crossjet
CutControl: plasma formation	The CutControl has detected plasma	Adapt parameters (not essential)
CutControl: cutting problems	The CutControl has detected cutting problems (plasma).	Adapt parameters, clean head (not essential)
PLC transport fault	Operating with sheet store: The PLC (SPS) transport system is reporting an error with transportation of sheets to and from the store	Correct the transport system fault.

### 6.14.3 Waiting states

Waiting states either terminate themselves, are terminated by the PLC signal or can be ended by pressing < CONT> .

System message	Cause	Procedure
Waiting for stops	Mechanical stops (where they exist) are being retracted.	
Waiting for material	Continuing with machining without automatic table interchange	Continue machining by pressing < CONT> Cancel machining by pressing < ABORT> Press < MatPos> on the console
Waiting for stacking	Operating with BYSORT, stacking plan is being transferred.	In the case of repeated transfer errors the process can be cancelled by pressing < ABORT> .
Waiting for cutting data	Controller is waiting for the NC program.	
Move to reference	Machine moving to reference In manual mode this message appears as a warning before the machine moves to reference.	Start the movement by pressing < CONT> Cancel the procedure with < ABORT> .
Move to zero point	Machine is moving to zero point. In manual mode this message appears as a warning before the machine moves to zero point.	Start the movement by pressing < CONT> Cancel the procedure with < ABORT> .
Optional stop M01	The machine is standing at a stop that has been scheduled using M1, if the < STOP SELECT> function is activated.	Continue machining by pressing < CONT> Cancel machining by pressing < ABORT>
Waiting for additional signal M19/M20	The machine is standing at a scheduled stop. (M19/20, M40 - M53) Clear via PLC or manually.	Continue machining by pressing < CONT> Cancel machining by pressing < ABORT>
Restart seam detection	Tube handler is trying to detect seam.	only with optional tube handler
Wait for upper seam detector	Seam detector is being raised	only with optional tube handler
Wait for end of laser manual operation	The laser is still in manual mode at Start Work, or when enabling CNC manual operation	Switch laser to CNC operation using laser controller.



System message	Cause	Procedure
Wait for laser to be ready	The laser is still powering up at Start Work, or when enabling CNC manual operation	Wait or terminate Start Work with <ABORT>. Manual operation is not possible without laser functions

### 6.14.4 Interruptions (Stop)

Interruptions, stops are triggered using the machine keyboard and must always be cleared by pressing <CONT>, external <CONT> or <ABORT>

System message	Cause	Procedure
Stop service	This message appears when the axes are standing in the service position.	<CONT> to continue or <ABORT> to terminate
Interruption stop	This message appears when the axes are standing still due to a <HALT>.	<CONT> to continue or <ABORT> to terminate
Stop cycle	This message appears before each sheet in the reference position.	<CONT> to continue or <ABORT> to terminate
Stop part	This message appears when the axes are standing at the zero point of the next part.	<CONT> to continue or <ABORT> to terminate
Stop work	This message appears when the axes are standing still before or after the next step in the work.	<CONT> to continue or <ABORT> to terminate
Stop at zero point	This message appears if <HALT> was initiated during <Stop Cycle>. The axes stop at the zero reference point of the cutting plan.	The zero reference point can be offset in manual operation. <CONT> to continue or <ABORT> to terminate
Stop at contour lock-on	This message appears after a restart with contour lock-on, as a prompt to move to the restart point manually.	After selecting the restart point: <CONT> to continue or <ABORT> to terminate
Single step	This message appears when the program is being worked through in single steps (program line by line)	<CONT> to continue or <ABORT> to terminate

### 6.14.5 Confirmations

Confirmations are protective measures for man and machine and must always be cleared by pressing <CONT>, external <CONT> or <ABORT>.

System message	Cause	Procedure
Forced continue	Confirmation by pressing <CONT> of:  Waiting for material  Optional stop M01  Waiting for additional signal M19/M20	<CONT> to continue or <ABORT> to terminate
Inverse work not possible	If the entire plan has been created as a single figure then the INVERS key cannot be used.	Program individual figure segments as sub-programs
Axis movement OK?	Confirmation of movements in manual mode:  Moving to reference position  Moving to zero point  Axis movements in auto. Configuration	<CONT> to continue or <ABORT> to terminate

### 6.14.6 Emergency stop

Emergency stops terminate cutting and manual mode. They have to be cleared by pressing <ABORT>. A Restart is possible in certain cases.

System message	Cause	Procedure
Emergency off internal	<STOP> has been activated the machine's safety circuit has tripped	Press <ABORT> on the MMC.
Emergency off external	one of the <EMERGENCY STOP> buttons has been activated the machine's safety circuit has tripped	Turn the mushroom-head button to release it, switch the resonator control off with the key-operated switch and press <RESET> on the PPC.
Stop, point of aim beyond cutting zone	The target of the positioning process displayed is outside the cutting range. (e.g. manual movement)	Cancel and Restart from the beginning.

System message	Cause	Procedure
Stop by laser	Laser not ready	<p>Resonator pressure switch has triggered</p> <p>Cooling water flow rate too low</p> <p>Wait for «Laser Ready» on the laser controller display or, if you do not need the laser, switch it off using the key.</p> <p>Check compressed air supply</p> <p>Check cooling system</p>
Stop by crash	<p>There has been contact between the nozzle and the sheet, or the nozzle is dirty</p> <p>The tactile ring sensor has come off.</p>	<p>Check the nozzle distance, clean the nozzle.</p> <p>Replace the ring sensor.</p>
Stop by limit switch X+	Limit switch X+ has been overshoot, machining aborted (e.g. due to coordinates outside work surface)	Clear with <ABORT>, restart not possible. Move away from the limit switch in manual mode.
Stop by limit switch X-	Limit switch X- has been overshoot, machining aborted (e.g. due to coordinates outside work surface)	Clear with <ABORT>, restart not possible. Move away from the limit switch in manual mode.
Stop by limit switch Y+	Limit switch Y+ has been overshoot, machining aborted (e.g. due to coordinates outside work surface)	Clear with <ABORT>, restart not possible. Move away from the limit switch in manual mode.
Stop by limit switch Y-	Limit switch Y- has been overshoot, machining aborted (e.g. due to coordinates outside work surface)	Clear with <ABORT>, restart not possible. Move away from the limit switch in manual mode.
Stop by limit switch Z+	Limit switch Z+ has been overshoot, machining aborted (e.g. due to position outside work surface)	Clear with <ABORT>, restart not possible. Move away from the limit switch in manual mode.
Stop by limit switch Z-	Limit switch Z- has been overshoot, machining aborted (e.g. due to position outside work surface)	Clear with <ABORT>, restart not possible. Move away from the limit switch in manual mode.
Stop by axis limitation, bridge	The bridge has crashed and interrupted the safety circuit.	Move the bridge by hand out of the limit position (mechanical knob-operated switch). Then reset the CPU and bridge servo.
Stop by axis limitation, carriage	The carriage has crashed and interrupted the safety circuit.	Move the carriage by hand out of the limit position (mechanical knob-operated switch) Then reset the CPU and carriage servo.

System message	Cause	Procedure
Stop by gas jet error	The existing gas pressure is lower than required	Clear with <ABORT> and change the gas bottle concerned.
Stop since crossjet not in position	The crossjet has been torn off	Clear with <ABORT> and change the crossjet..
Stop due to W-axis frequency error	The frequency of the capacitive W axis control is too low. The lowering operation has been terminated.	Clear with <ABORT> and check the cutting head for moisture in particular.
Stop because controller not ready	PLC (CNC) is no longer ready (fault)	Clear with <ABORT>
Stop because drives not ready	Servo failure.	Turn off machine and turn it back on.
Stop by safety circuit failure	Safety gate open Key-operated switch turned to left	Clear with <ABORT> and check the safety gates and the key-operated switch.
Stop by Watchdog, stop - fail	An axis is moving or was moved when safety circuit open.	Turn off machine and turn it back on.
Stop by Watchdog, CNC - fail	A software error caused CNC to crash.	Turn off machine and turn it back on.
NC-Stop: error at switching over to virtual machine 01 - 03:	The switchover to another virtual machine is only possible at the reference and outside cutting or manual mode.	Clear with <ABORT> and move the machine to reference.
01 = CNC at cutting 02 = CNC in manual mode 03 = CNC not in reference pos.		
Stop by plausibility test ...	During machining the actual and target values of the position of the axes are compared before each movement. If the current position deviates by more than 5 mm from the coordinates of the plan then machining is aborted. A faulty sensor, card or software could be the cause.  The axis/axes responsible and the location are also given.	Check the cutting plan  Call Bystronic Customer Services. A restart is only possible under certain circumstances.
... in X at approaching reference ... in Y at approaching reference ... in X/Y at approaching reference ... in X at zero point ... in Y at zero point		

System message	Cause	Procedure
... in X/Y at zero point ... in X at piercing in ... in Y at piercing in ... in X/Y at piercing in ... in X at piercing out ... in Y at piercing out ... X/Y at piercing out		
Stop by plausibility test in Z, sensor off inadequate	An attempt has been made to cut rectangular tubes with < Sensor off> .	Start from the beginning with sensor activated (Setup).
Stop by plausibility test in Z, not calibrated	Lowered without previous calibration. System error!	Recalibrate Call Bystronic Customer Services
Stop by plausibility test in Z, stopping distance too little	The calculated braking distance is greater than the current lifting height Causes: Axis is incorrectly configured Detection frequency fault	Call Bystronic Customer Services to check the configuration. In general operation is no longer possible.
Stop by plausibility test in Z, material detected at reference	Detection frequency fault. Causes: mechanical damage to cutting head poor assembly Moisture in the plug connections	Call Bystronic Customer Services
Stop from CutControl: no sheet edge detected	When using Cut Control for accurate edge detection, no edge could be detected in the area of previous capacitive detection.	Check Cut Control head and detection setup, and repeat procedure.

### 6.14.7 Aborting a cutting process

Cutting process cancellations have to be cleared by pressing <ABORT>. A restart is never possible.

System message	Cause	Procedure
No beginning of cutting plan	Faulty plan	Correct the cutting plan in BYSOFT or in the data editor Read in the plan again
No end of cutting plan	Faulty plan	Correct the cutting plan in BYSOFT or in the data editor Read in the plan again
Invalid subprogram number	Faulty plan	Correct the cutting plan in BYSOFT or in the data editor Read in the plan again
Cutting plan dimensions too large	Faulty plan	Correct the cutting plan in BYSOFT or in the data editor Read in the plan again
Converted cutting plan too large	LCC file too large	Divide the cutting plan up and read it in again
Faulty cutting plan structure	Error in precalculation of the processing sequence due to a reading error or a data error in the plan.	Correct the cutting plan in BYSOFT or in the data editor Read in the plan again
Incremental buffer overflow	Software fault	Inform Bystronic Customer Services
Flat cut: chuck in working position	A plan for flat machining was started, although the chuck is still installed. The operation is interrupted.	Terminate the start procedure with <ABORT>.
Tube cut: chuck swivelled away	A plan for rotary machining was started, although the chuck is not yet installed. The operation is interrupted.	Terminate the start procedure with <ABORT>.
Sheet count = 0	The value for the letter H in plan is 0. Machining is interrupted.	Modify the number of runs in <Job Detail> under <Job List> and send the program to the CNC again (modification also possible using the "H" code under <DATA> or BYSOFT).
Shuttle table active	During machining the <Waiting for material> position was skipped either intentionally with <CONT> or as a signal error. However the release test showed that the <Shuttle table active> signal is still displayed.	Terminate machining with <CONT> or <ABORT> and start machining process again. A restart is not possible.

### 6.14.8 Adaptive lens error

Adaptive lens errors terminate cutting and manual mode. They have to be cleared by pressing <ABORT> . A Restart is possible in certain cases.

System message	Cause	Procedure
Bypos: Timeout during transmission	The BYPOS is not switched on The serial link is broken The SERCOM is not adjusted to the adaptive lens	Switch the adaptive lens on Check the serial link Call Bystronic Customer Services
Bypos: UART parity error	There is a fault with the serial link	Check the serial link Call Bystronic Customer Services
Bypos: Protocol error	Poor serial link (a message has been wrongly communicated three times) CNC and adaptive lens have gone out of phase	Check the serial link Faulty manipulation, start the process again from the beginning
Error of the Bypos control	Internal error in the adaptive lens. Transfer or status errors of the adaptive lens bring about an Emergency stop	Clear this error message with <ABORT>. A detailed error message then appears so that conclusions can be drawn about the exact cause. Call Bystronic Customer Services
Bypos voltage 1/2 not ready	The Bystronic Bypos device is not ready or has failed	Call Bystronic Customer Services

### 6.14.9 Transport system error

Transport system errors can occur when operating with sheet store connected. They lead to termination of the cutting operation. They usually have to be cleared by pressing <ABORT> . A restart is never possible.

System message	Cause	Procedure
PLC transport fault, serial number	The transport system is signaling a general fault.	Check the transport system.
PLC transport sequence error, serial number	The transport system is acknowledging a «transport to» with an incorrect sequence number.	Unload the shuttle tables and start the cutting operation again.

### 6.14.10 MMC DNC error message

Some of the DNC messages have a modular structure. Two text blocks may appear one after the other in the system line. First there is a supplementary text (if one exists). The DNC error always comes at the end.

System message	Cause
Time-Out	During communication the time limit for receiving a character was reached.
EOT	During communication the EOT control character was received unexpectedly.
File error	The MMC cannot create, read or write temporary file, which the MMC needs to do for temporary data storage.
Unknown DNC-Error	An unknown error occurred during communication.
DNC interface in use	The requested COM port is already in use for another DNC communication application.
PGM aborted	Data transfer/upload terminated by the MMC with EOT.
No answer	Receiver (e.g. CNC) not responding to the ENQ call.
Wrong answer received	The first six characters of the response from the receiver (e.g. CNC) do not match the response format.
Wrong character received	Unexpected characters were received during DNC protocol (e.g. wrong control character during protocol)
Wrong Block Check number	The calculated block checksum does not equal the received checksum.
Wrong block assign	Assignment of block size, number of blocks and start block for program download is wrong. Calculated start point in file is larger than the file itself.
DNC connection retention. --> <CTRL+F9> to continue	The MMC could not establish a connection with the CNC at start up, and is now running OFFLINE. No data transfer with the CNC is possible. If the CNC is re-enabled, communication with the CNC can be resumed using the key combination < CTRL+F9> . An MMC restart is recommended.



### 6.14.11 MMC supplementary text to DNC error messages

The supplementary texts are optional and solely indicate the activity for which the error arose. The supplementary texts are generated and managed by the MMC.

System message	Cause
Delete NC-Programm	Delete error for NcProgram command.
Material Request to PLC	Error when sending the material request to the stock system (PLC)
Material Request to CNC	Error when sending the material request to the CNC
Error when sending NC program	Error when sending an NC program to the CNC.
Parameterfile	Error when sending the parameter file to the CNC.
Store	For a laser machine with stock system: Error when reading the stock status from the stock system (PLC).

### 6.14.12 Laser status

Actual laser status during laser power up, operation and flooding

LCS/LASCON3 status	MCS/SSI status	Cause
Laser status: Reset ok Laser status: apply vacuum Laser status: fill with gas Laser status: start turbine Laser status: switch on energizing	Laser status: LASER OFF Laser status: RUNNING VACUUM Laser status: RUNNING GAS Laser status: RUNNING BLOWER	Status information when powering up the laser (progress display)
Laser status: hand mode	Laser status: LOCAL	Laser being controlled manually
Laser status: flood	Laser status: RUNNING FLOOD	Additional information during switch-off

### 6.14.13 Laser errors

The status conditions below only lead to an emergency stop during cutting and if there is a collective error

LCS/LASCON3 status	MCS/SSI status	Cause
Laser error: compressed air, water	Laser error: WATER/AIR ERROR	The error is acknowledged on the laser controller concerned.  Refer to the laser controller specification for error details
Laser error: vacuum pump	Laser error: OVER CURRENT	
Laser error: inverter, turbine	Laser error: TUBE OUT	
Laser error: energizing	Laser error: GAS WARNING	
Laser error: gas warning	Laser error: GAS MIX ERROR	
Laser error: gas error	Laser error: ERROR HV DESK	
Laser error: service error		





The graphic features a large, stylized black letter 'C' on the left and a large black number '7' on the right. The '7' is positioned over a globe showing the continents of Europe, Africa, and Asia. A small, detailed image of a machine component, possibly a sensor or actuator, is placed on top of the '7'. Below the 'C' and '7', the word 'CHAPTER' is written in a large, black, serif font.

# C7 CHAPTER

## Maintenance

This chapter describes all the regular inspection and maintenance work on the machine that you can perform yourself after you have participated in a Bystronic Introductory Training Course. A maintenance table and logbook are provided to help you plan and perform this work.

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### 7.1 Introduction

#### 7.1.1 Safety regulations


This documentation forms the basis for the maintenance of the laser machine.

#### NOTE



##### Important

*Do not carry out any maintenance work on the machine until you have read the relevant chapter (incl. Safety)!*

	<b>⚠ WARNING</b>
	<p>Danger zone – keep away!</p> <p>Switch off the entire system before performing any inspection or maintenance work. Make sure that all components are disconnected from the power supply.</p> <p>Safeguard machine against unauthorized start-up.</p>

Always power down the machine for performing maintenance work. Protect the main switch with a padlock and store the key in a place inaccessible to unauthorized persons.

- Always power down all electrical or electronic components on which work is being carried out, to avoid danger of electrocution.
- Do not carry out work on gear units until components have cooled down, as there is a risk of burns.
- Always observe the manufacturer's safety instructions when handling operating resources, particularly gear oil, solvents and grease.

**7.1.2 Requirements to be met by personnel**

Personnel charged with maintaining the machine must have basic training. Maintenance personnel must be able to perform the following work:

- Operation of the machine control system
- Replacement and alignment of mechanical components
- Adjustments to mechanical and electrical equipment

The requirements of the maintenance personnel are differentiated into three levels.

**7.1.2.1 Operator**

The operator is responsible for daily cleaning and inspection work on the machine or system.

**7.1.2.2 Technical staff**

Technical staff are responsible for simple maintenance and inspection work on the machine or system. Work must be performed by trained personnel having attended Bystronic Laser AG's «Introductory operator training».

**7.1.2.3 Maintenance personnel**

Maintenance personnel must have basic professional training as electricians, mechanics etc.. The requirements to be met by maintenance personnel are high for safety reasons.

Maintenance can be performed either by BYSTRONIC's service personnel or the customer's own specially trained personnel. BYSTRONIC Laser AG offers special maintenance training for the customer's own maintenance staff.



Checks and maintenance tasks must be carried out at the intervals specified to ensure that the machine functions perfectly.

**⚠ WARNING**

Failing to observe the safety instructions in the operating manual may lead to danger to life and limb and damage to the machine.

**Damage occurring to the machine or system as a result of non-observance of the maintenance schedule is excluded from the provisions of the warranty.**

**TIP**

*Regular maintenance protects your machine from premature wear and increases its life. The result is maximum availability of your machine and minimal costs for wearing parts.*

## 7.2 Maintenance schedule

### 7.2.1 Tasks to be performed daily

Tab. 7.2-1

Tasks	Manual
<b>Laser module:</b> check for mechanical damage. Check warning lamp operating correctly.	See "Laser" Operating manual
<b>Laser controller:</b> check laser power and laser operating pressure	See "Laser" Operating manual
<b>Laser cabinet:</b> Check that warning lights are operating correctly Check "Shutter open" function Check "Laser ready" function	See "Laser" Operating manual
<b>Cooling unit:</b> check correct cooling-water temperature	Supplier documentation HYFRA PEDIA HT
<b>Cutting head:</b> Check lens for soiling, and possibly clean or replace Check that there are no leaks in the couplings Check cutting nozzle Clean cutting head (outside) Check that sensor working correctly ( <b>option</b> )	See "Cutting head" section

### 7.2.2 Tasks to be performed weekly

Tab. 7.2-2

Tasks	Manual
<b>Laser upper section:</b> inspect for soiling, corrosion and water leaks	See "Laser" Operating manual
<b>Laser module:</b> vacuum test	See "Laser" Operating manual
<b>Laser lower section, Deltech filter:</b> check for discoloration and possible replacement of filter	See "Laser" Operating manual
<b>Laser lower section, ultra-fine filter:</b> check for clogging, change if necessary	See "Laser" Operating manual
<b>Laser cabinet:</b> Check surge voltage protector viewing window	See "Laser" Operating manual
<b>Crossjet:</b> check oil level in the supply unit	See "Supply unit" section

<b>HERDING exhaust air filter:</b> Monitor cleaning compartment via rubber cap Acoustic and visual check of the blow off pulses Check operation of filter controller Empty dust collectors	HERDING supplier documentation
<b>Cooling unit:</b> Check air filter, clean or replace if necessary Clean air-cooled condensers	See "Laser" Operating manual Supplier documentation HYFRA PEDIA HT
<b>Collecting trays:</b> empty and clean trays <b>Pre-coating unit:</b> check for correct operation	- HERDING supplier documentation
<b>Ultrapac FILTER SYSTEM:</b> check LED display to see if filter change required	See "Supply unit" section ULTRAPAC supplier documentation
<b>Supply unit:</b> Check differential pressure display (pre-filter) Empty filter	See "Supply unit" section

### 7.2.3 Tasks to be performed monthly

Tab. 7.2-3

Tasks	Manual
<b>Control cabinet and laser:</b> all labels in place and legible	Operation
<b>Lower section of laser, turboblower (LEYBOLD):</b> check oil level	See "Laser" Operating manual
<b>Laser lower section, vacuum pump (SOGEVAC):</b> check oil level	See "Laser" Operating manual
<b>Laser lower section, Becker turbine:</b> Check temperature of turboblower bearings during operation Check LED display on BTC electronic monitoring panel (green range up to 60% O.K.)	See "Laser" Operating manual
<b>Laser:</b> Check contact pin of protective switch on shutter connection tube.	See "Laser" Operating manual
<b>Cooling unit:</b> Check water level in tank	See "Laser" Operating manual Supplier documentation HYFRA PEDIA HT

<b>Cooling unit / MINISTIL De-ionization unit</b> : check resin cartridge and change if necessary	See "Laser" Operating manual MINISTIL supplier documentation
<b>Beam path</b> : check machine optics, clean and adjust if necessary, check for leaks (bellows, seals)	See "Optics" section
<b>Carriage, bridge and Z-axis</b> : check limit and emergency switches working correctly	Design and operation
<b>Conveyor</b> : clean and lubricate the hinged-plate conveyor and sprocket	See "Conveyor" section
<b>"Simalube" grease cartridges</b> : check grease level	See "Tube loader" section
<b>Base frame</b> : check exhaust-air sector flaps are working correctly	-

## 7.2.4 Tasks to be carried out after 500 hours

Tab. 7.2-4

Tasks	Manual
<b>Laser lower section, vacuum pump</b> : first oil change	See "Laser" Operating manual

## 7.2.5 All tasks to be carried out after 500 hours

Tab. 7.2-5

Tasks	Manual
<b>Cooling unit</b> : Check air filter, clean or replace if necessary	See "Laser" Operating manual Supplier documentation HYFRA PEDIA HT
<b>Linear guides</b> : clean and lubricate	-
<b>Chain drive on safety gate</b> : clean and lubricate; check tension.	-

## 7.2.6 All tasks to be carried out after 1000 hours

Tab. 7.2-6

Tasks	Manual
<b>Laser lower section</b> : replace active charcoal filter	See "Laser" Operating manual

<b>Supply unit:</b> Replace active charcoal filter Replace pre-filter	See "Laser" Operating manual
<b>Cooling unit:</b> clean air-cooled condensers	See "Laser" Operating manual Supplier documentation Hyfra Pedia HT
<b>Cooling circuit:</b> clean secondary flow filter	See "Laser" Operating manual
<b>Tube loader:</b> grease nipples	See "Tube loader" section
<b>Carriage, bridge, Z-axis, base frame:</b> Inspect bellows for damage, replace if necessary Linear guides and rack-and-pinion: clean and lubricate	See "Linear carriage guide" section See "Rack-and-pinion" section
<b>Tools:</b> check, clean and grease if necessary	See "Tools" section
<b>HERDING exhaust air filter:</b> Check filter elements, deflector, walls of housing for wear Clean measurement line filter in the unfiltered gas and filtered gas compartment	HERDING supplier documentation
<b>Lance:</b> lubricate guides and spindle	

### 7.2.7 All tasks to be carried out after 2000 hours

Tab. 7.2-7

Tasks	Manual
<b>Slack in chains:</b> tighten chains if necessary	See "Tube loader" section
<b>Laser lower section, vacuum pump:</b> change oil	See "Laser" Operating manual

### 7.2.8 All maintenance tasks to be carried out every 3000 hours

Tab. 7.2-8

Tasks	Manual
<b>Linear guide and drive wheel:</b> grease with Molikote	See "Tube loader" section
<b>Cross-rod:</b> grease with Molikote	See "Tools" section

<b>Cooling unit:</b> change cooling water	See "Laser" Operating manual Supplier documentation Hyfra Pedia HT
<b>Laser lower section, vacuum pump (SOGEVAC):</b> Change exhaust filter	See "Laser" Operating manual
<b>Laser lower section, turboblower (LEYBOLD):</b> Oil change	See "Laser" Operating manual

### 7.2.9 All tasks to be carried out after 7500 hours

Tab. 7.2-9

Tasks	Manual
<b>Conveyor, gear motor:</b> change oil	See "Conveyor" section
<b>Ultrapac FILTER SYSTEM:</b> Change drying agent cartridge as indicated by LED display or after 7500 hrs Change pre- and post-filter as indicated by LED display or after 7500 hrs	See "Laser" Operating manual ULTRAPAC supplier documentation

### 7.2.10 Tasks to be carried out as necessary

Tab. 7.2-10

Tasks	Manual
<b>Control cabinet, Laser controller:</b> Check vacuum seal	See "Laser" Operating manual
<b>Beam path:</b> check machine optics, clean and adjust if necessary	See section "Replacing the deflecting mirrors" and "Cleaning the deflecting mirrors and lenses in the cutting head"
<b>Conveyor:</b> clean the hinged-plate conveyor and sprocket, check wiper	See "Conveyor" section
<b>Carriage, bridge, Z-axis and base frame:</b> Inspect bellows for damage, replace if necessary Clean and lubricate rack-and-pinions and guides	See "Linear carriage guide" section See "Rack-and-pinion" section
<b>Carriage and bridge, Z-axis, limit and emergency switches:</b> check operating correctly	Operation
<b>Lance:</b> clean	
<b>Collecting tray:</b> dispose of contents of collecting tray	See "Conveyor" section

## 7.3 Maintenance tasks

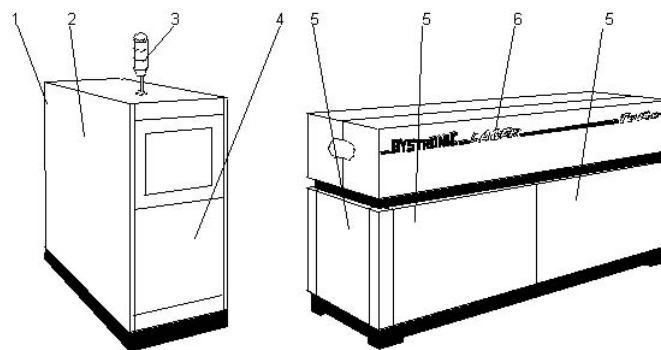
### 7.3.1 Safety devices

- Check the resonator daily for mechanical damage, and that the orange LASER READY warning lamp is working properly.
- Check the SERVICE MODE warning lamp whenever the machine is switched to service mode.
- Check monthly that the labels are in place and legible. The types of labels and their position are listed in the operating manual.

#### Position of the safety devices

The laser includes the following safety devices, all of which must be fitted and serviceable.

Fig. 7.3 -1 View of laser module and HV cabinet



- |   |   |
|---|---|
| <ol style="list-style-type: none"> <li>1. Rear doors of laser cabinet</li> <li>2. Two fixed covers on laser cabinet (right-hand side identical)</li> <li>3. Warning lamps</li> <li>4. Front doors of laser cabinet</li> </ol> | <ol style="list-style-type: none"> <li>5. Six service covers on laser lower section with sound insulation liners (rear side of laser identical)</li> <li>6. Two folding doors on resonator upper section, lockable with key (rear side of laser identical)</li> </ol> |
|---|---|

After maintenance work, refit all covers that you have removed. Lock the folding doors on the resonator upper section and remove the key.

Please refer to the Laser operating manual for more detailed information.

### 7.3.2 Machining axes

#### Inspection

Check the bellows at least every 1000 hours for burn marks or other damage. Replace if necessary.

Check the level of the "Simalube" grease cartridges monthly. Replace the empty grease cartridges.

#### Maintenance

Service the rack-and-pinion and the linear guide every 1000 hours.

#### Environmental protection in waste disposal

Replaced parts such as seals, solvents and oil must be disposed of according to the local waste disposal regulations and the environmental protection laws that apply in the country of use.

The mineral oils suggested by Bystronic can be reprocessed, depending on their degree of contamination and degradation. See also the manufacturer's specification.

### 7.3.3 Carriage linear guide

Fig. 7.3 -2



#### Required material

- Grease gun
- Motorex 190 EP grease (Bystronic order number 197 1661)



**Procedure**

1. Move to the zero point.
2. Disconnect machine from the power supply (switch off main power switch). Move the carriage by hand to the center of the bridge.
3. Start with any grease nipple. Each grease nipple must be lubricated with three shots of grease. During lubrication, the carriage must be moved 10 cm in each case (distributing the grease).
4. Move the carriage to and fro by hand.
5. Switch on the machine.
6. Check that the limit switches are working correctly: in manual mode, use the hand-held controller to move to all limit switches.

**7.3.4 Rack-and-pinion**

(Rack-and-pinion and linear unit beneath bellows)

1. Move to the zero point.
2. Disconnect machine from the power supply (switch off main power switch). Move the carriage by hand to the center of the bridge.
3. On the cutting-carriage side, loosen the four bellows. Undo the guard plates. Move the bellows away from the center of the bridge.
4. Remove any emergent grease and dirt with a clean cloth.
5. Clean the rack-and-pinion with petrol.
6. Clean the rack-and-pinion with a dry cloth.
7. Grease the rack-and-pinion with Molikote DX Paste (Bystronic order number 197 3609). Refer to the Supplier documentation in the maintenance manual for instructions for use and the safety datasheet.
8. Fit bellows and guard plates.
9. Move the bridge to and fro by hand. Check that working properly.
10. Switch on the machine.
11. Check that the limit and emergency switches are working correctly: in manual mode, use the hand-held controller to move to all limit switches.

The rack-and-pinions and linear guides of the tube loader must also be cleaned and greased.

### 7.3.5 Tools

#### Maintenance

Grease the nipples on the U2-axis plate, the steady rest and the A-axis travel unit every 1000 hrs. Undo the covers on the A-axis travel unit. Apply three shots of grease with the grease gun.

Grease the cross-rod for the U2 plate with Molikote DX Paste (Bystronic order number 197 3609) every 3000 hrs.

### 7.3.6 Tube loader

#### Inspection

Check the chains of the tube loader for slack every 2000 hrs. The chains should have a maximum slack of 1 cm.

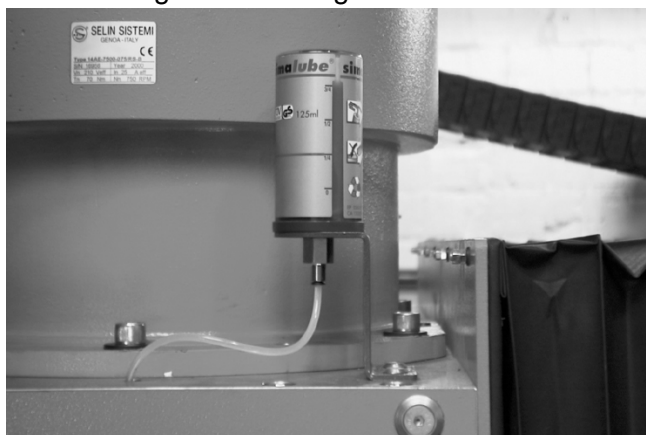
Check the level of the "Simalube" grease cartridges monthly. Replace the empty grease cartridges.

#### Maintenance

Check the grease nipples on the pillar rests every 1000 hrs. Move the carriage to reference position and activate the command "All pillar rests up". Apply three shots of grease with the grease gun.

Grease the linear guide and the drive wheel of the chuck with Molikote DX Paste (Bystronic order number 197 3609) every 3000 hrs.

Fig. 7.3 -3 "Simalube" grease cartridge



### 7.3.7 Cutting head

#### Inspection

Check the lens daily or as necessary for soiling, metal splashes or scratched surface; clean or replace the lens if necessary.

Close the input aperture with a cover to prevent dirt penetrating.


Check the cutting head daily for soiling.

Check the cutting nozzle daily for burn marks, splashes of material and circular nozzle hole.

### 7.3.8 Mirror types

Various mirrors, which seem identical externally, are used in Bystronic laser cutting machines. The type and properties of the mirrors can only be identified by the order number.

### 7.3.9 Cleaning the deflecting mirrors and lenses

	<b>⚠ CAUTION</b>
	<p>Handling optical components and parts.</p> <p>Optical components and parts are soiled or damaged by improper handling.</p> <p>Always wear disposable gloves when cleaning, replacing or checking the optical system. Make sure that the work place is clean.</p>

The lenses and mirrors have specially coated surfaces, so you need to store, clean and fit the optical parts with care. Damage to the vapor-deposited coating causes a reduction in beam quality.

Damage can occur in the following ways:

- by dirt being burnt on by the laser beam
- by dirt leaving scratches on the surface during cleaning

#### Aids required for cleaning:

Cleaning set part no. 4-09163 comprising:

- Lens cleaner (acetone) 100ml
- Lens polish 50ml
- Lens cleaning paper, 2 packs
- 1 bag cotton buds
- 1 bag cotton-wool pads
- Disposable gloves

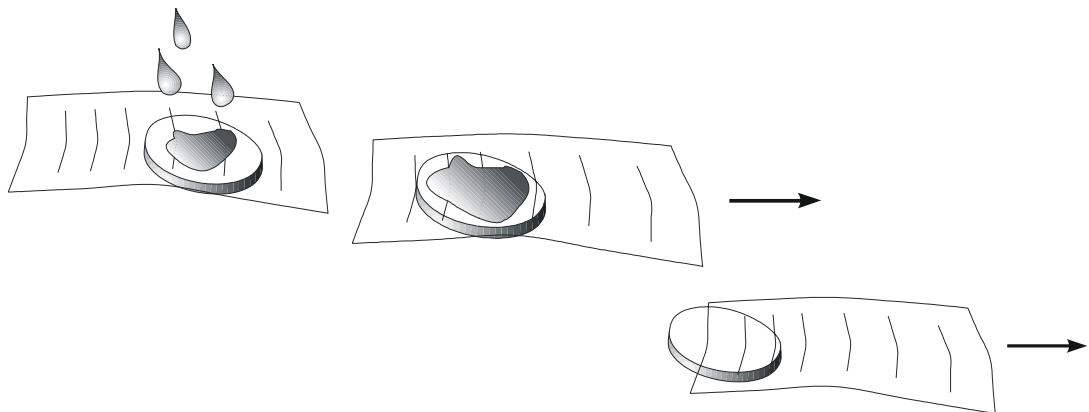
**NOTE**

- Never clean the mirror surface when it is dry.
- Never use compressed air to blow dirt off the optical parts as impurities in the compressed air will be shot into the mirror.
- Only use the lens cleaning cloths and cotton buds once, and keep them free from dust when storing.
- Keep the bottle of acetone clean, and always replace the lid.
- Wear gloves. Fingerprints left when inserting the optical components shorten their life.
- Set up the work place away from the laser so that no solvent vapors can get into the laser gas circuit.
- Check the labeling on the edge of the mirror and lenses. If the labeling has disintegrated then it must be reapplied.
- Replace the clean mirror immediately. Caution: observe mounting direction

**Cleaning after light soiling (stage 1)**

1. Remove the particles of dirt by blowing them off or use a new soft paintbrush.
2. Place a lens cleaning paper on the lens or mirror and add 2-3 drops of acetone using the pipette.
3. Wipe the lens cleaning paper slowly over the lens or mirror, avoiding smears and leaving a dry clean surface.

Fig. 7.3 -4



### Cleaning after heavier soiling (stage 2)

**NOTE**

- The lens polish is abrasive and not only removes dirt but also acts on the coating. If you polish for too long, too often or with too high a pressure, the coating can be removed and the optical characteristics changed!

1. Blow off the particles of dirt and make sure that all the particles are removed so that the surface is not scratched.
2. Using a fresh cotton bud dipped in lens cleaner, perform circular movements from the center outwards. Turn the cotton bud round once evenly in the process. Only apply light pressure, and if necessary repeat the process more than once with a fresh cotton bud each time.
3. When finished, clean the lens or mirror again with acetone and lens cleaning paper to remove any smears.

Fig. 7.3 -5



### Cleaning off stubborn dirt (stage 3)

If the lens is not clean enough after using the cleaning methods described above, the lens polish cleaning agent can be used.

1. Put some lens polish on a cotton-wool pad and polish the lens or mirror with circular movements from the center outwards.
2. Leave the polish to dry.
3. Take a new cotton-wool pad and remove the polish residues.
4. Then clean the lens or mirror with acetone and lens cleaning paper as described above. Inspect the lens or mirror carefully. No residues must be visible.
5. If the lens or mirror cannot be cleaned even by this method, or if you discover burns or damage to the coating, the element must be replaced.

### 7.3.10 Conveyor

The conveyor is also called the hinged-plate conveyor.

#### **Inspection**

Whenever the collecting tray is emptied, check the wiper for damage and that the tension spring is applying enough contact pressure.

#### **Maintenance**

Clean the chains monthly or as necessary and treat them with WKS chain spray (Bystronic order number 1972800).

Working with added cooling water:

Clean daily and oil with Anticorit BW 366 (Bystronic order number 1974615).

Working without added cooling water:

Clean at least monthly and oil with Anticorit BW 366

Change oil in gear motor according to supplier's instructions. Use only gear oil GEARSYNT 220 (Bystronic order number 1974002).



# C8

## CHAPTER

### Repair

The «Repair» chapter helps you to identify the causes of faults and to remedy them. It gives you advice on how to carry out the repairs.

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## 8.1 Introduction

### 8.1.1 Safety regulations

#### NOTE



#### Important

*Never perform any repair work on the machine without having read the relevant chapters (including safety section).*



#### ⚠ WARNING

It is not permitted to stay in the danger zone. Secure the system against unauthorized switchon.

Always power down the machine when performing repair work. Protect the main switch with a padlock and keep its key in a place inaccessible to unauthorized persons.

- Always power down all electrical or electronic components on which work is being performed
- Work on gear units may not be carried out until they have cooled down. as there is a risk of burns.
- Always observe the manufacturer's safety instructions when handling operating resources, particularly gear oil, solvents and grease.

#### Observe the following points concerning repair of the machine:

- Only the work described may be performed. Any work on the machine beyond these specified tasks is prohibited.
- Use only the tools and test equipment listed.
- Use only original BYSTRONIC spare parts.



#### ⚠ WARNING

Failing to observe the safety regulations may lead to danger to life and limb and damage to the machine.

**8.1.2 Requirements to be met by personnel performing the disposal**

Personnel charged with repairing the machine must have appropriate basic training. Repair personnel must be capable of the following tasks:

- Operation of the machine
- Repair to pneumatic and hydraulic systems
- Replacement and repair of mechanical components
- Adjustments to mechanical and electrical equipment

## 8.2 Troubleshooting

### 8.2.1 Troubleshooting schedule...

If operation is interrupted for unknown reasons, follows the schedule below:

1. Localize the fault.  
Is the fault mechanical or electrical? Is it a hardware or software fault (error message MMC/CNC/PLC)?
2. Identify the cause of the fault.  
Faults often lead to follow-up faults.
3. Frequency of fault  
Does the fault always occur, or do certain events trigger it?
4. Environmental conditions  
Check the machine:
  - Obstruction due to soiling, foreign objects, damage?
  - Power supply (supply voltage, compressed air) OK?
  - Ambient conditions, climate influences (e.g. heat, storm, etc.)?
5. Interference from other equipment (voltage spikes)?
6. Check the:
  - Illuminated PPC push-buttons and trip [emergency stop].
  - Sensors, limit switches, safety limit switches.
  - LEDs on the input and output modules.
7. Wiring and terminals  
Check installation for loose connections and disconnected wires.
8. Switches and settings  
Has an object been replaced ? Settings not correct?
9. Initialization  
Switch off the system completely and restart.
10. Supplier documents  
Other manuals may contain information on the fault and troubleshooting.
11. Telephone  
Call Bystronic Customer Services.

## 8.3 Repair

### 8.3.1 Chain tension

Overtightened chains load the drive unnecessarily and create increased wear. Chains that are too loose tend to skip teeth.

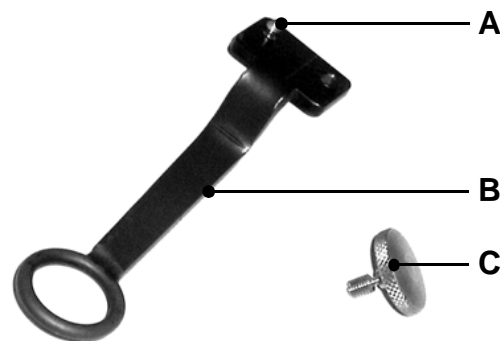
Check the chain tension monthly and re-tension as necessary.

### 8.3.2 Tactile detection

#### Break in tactile sensor

The sensor is positioned using the pin and fastened with the fastening screw. If the sensor breaks, either the pin or the fastening screw has broken off.

Fig. 8.3 -1 Tactile sensor with fastening screw



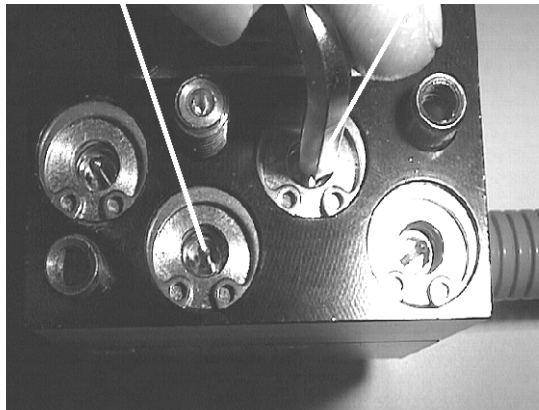
A.	Pin
B.	Ring sensor
C.	Fastening screw with predetermined breaking point

#### Remedying a sensor break

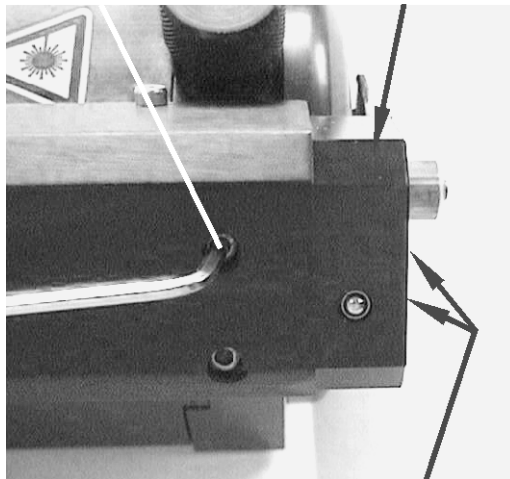


1. Interrupt the process by pressing <Abort>.
2. Go into the manual menu and raise the head with <Z+>.
3. Use the hand-held controller to move the bridge close to the safety gate.
4. Shut down machine and open safety gate.
5. Place the new sensor with the fastening screw on a clean table. Put the cutting head beside it.
6. Depressurize the pneumatic cylinder by briefly pressing the Allen key onto the top of the coupling.

Fig. 8.3 -2




7. Pull the head forward until the Allen screw becomes visible. Loosen both screws.





8. Undo both cheese-head screws and remove the head from the guide by hand
9. Remove head carefully from the guide. Head section can only be pulled forward 5 cm, as it is joined to the connection tube to the detection unit.
10. The rear side of the head is visible, and the broken-off part of the pin or fastening screw can be pushed or screwed out. For better access, the connection tube can be detached by turning the head and holding the connection tube.
11. Fit the connection tube again, and push the head into the guide. Retighten the four screws.
12. Check whether the head can move without touching the housing.
13. Fit sensor and tighten the fastening screw.
14. Check whether the sensor is in the center of the nozzle (visual check only). Turn the clip to the right side.

- 15.** Refit cutting head and connect electrical cables.
- 16.** Switch on machine and reference the tactile detection system (see Beam guidance system operating manual).

## 8.3.3 Cutting head

	<b>⚠ CAUTION</b>
	<p>Handling optical components and parts.</p> <p>Optical components and parts are soiled or damaged by improper handling.</p> <p>Always wear disposable gloves when cleaning, replacing or checking the optical system. Make sure that the work place is clean.</p>

### 8.3.3.1 Replacing the lens

 	<b>⚠ WARNING</b>
	<p>Toxic fumes can be emitted by thermal damage to a lens or severe scratching of a lens. In addition, slightly radioactive thorium fluoride is released.</p> <p style="text-align: center;"><b>Always wear a breathing mask and gloves when performing cleaning work. Avoid stirring up dust.</b></p> <p>Material that has come into contact with the broken lens or lens dust must be cleaned thoroughly or disposed of as hazardous waste.</p> <p>Damaged lenses must be returned to Bystronic.</p> <p>After cleaning, wash your hands thoroughly under running water.</p> <p>Further information can be found in the safety datasheets in the supplier documentation.</p>

#### NOTE



*The lens casing and clamping ring are adapted to suit the focal length of the lens. Note the labeling (5", 7.5") when assembling.*

*The clamping ring must be pre-tensioned, otherwise the lens will move when subject to thermal stress. Pre-tensioning the clamping ring too tightly may damage the lens. Therefore, make sure that you tighten the clamping ring with only slight pressure.*

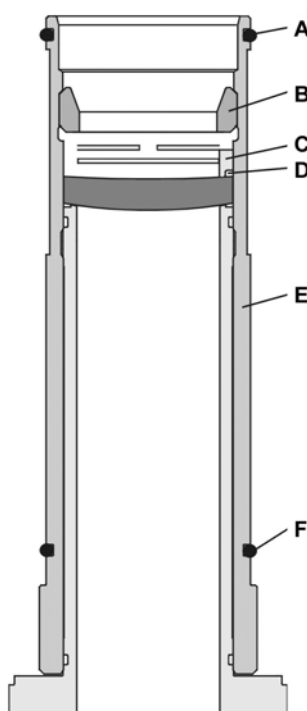
### 8.3.3.2 Tools required

- Lens key
- Plastic rod
- Lubrication set
- Cleaning set

### 8.3.3.3 Lens key and plastic rod



Fig. 8.3 -3 Cutting head



A. O-ring "b"

B. Nut

C. Clamping ring

D. O-ring "a" (**do not** grease)

E. Lens casing

F. O-ring "b"



1. Lay the cutting head on a clean surface with the Bystronic labeling facing up and with the nozzle to the back.
2. Undo the screws holding the lens mount in the cutting head.
3. Remove the lens casing from the cutting head using the lens key and place it on a clean surface with the clamping ring facing up.
4. Remove O-rings (F) and check for damage.

### NOTE



*If a damaged O-ring (F) has to be replaced by a new one, this must be lightly greased with "Syntheso Proba 270" (Bystronic order number: 1971659) before fitting. No residual grease should be visible.*

5. Clean lens key with compressed air.
6. Unscrew the nuts (B) with the lens key.  
The lens key is in two parts. The long end fits the 7.5" cutting head, and the short end the 5" head.
7. Turn lens casing through 90 ° and carefully lift off the lens casing. If the lens does not come away from the lens casing, press the lens down lightly from above with a cleaning swab inserted in the slide.
8. Clean lens according to the instructions in Chapter 7.4.2 «Lubrication, maintenance and cleaning tasks».
9. Check O-ring (D), replace if damaged.  
**Caution:** Do not grease this O-ring. Place clamping ring with fitted O-ring on the correct side on a clean surface.
10. Place lens on the O-ring. Make sure that the lens is placed on the O-ring with the curvature facing **up**.
11. Pull lens casing over the lens key and turn it all upside down.
12. Screw nut into the lens casing and tighten with the lens key, holding the lens casing with one hand and tightening firmly with the other hand on the key shaft in one action.

### NOTE



*If the clamping ring is properly pre-tensioned, the four slits in the middle are closed.*

13. Insert the assembled lens casing into the cutting head using the lens key.  
**Observe the correct direction of installation.**
14. Reinsert the assembled lens casing into the cutting head and tighten the six screws evenly.  
Don't use an offset Allen key, as the applied torque can be too great.

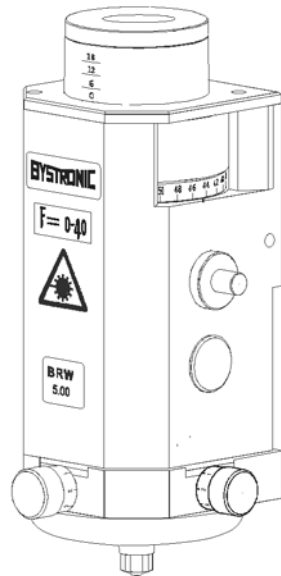
15. Insert the cutting head on the «Z-axis» and center the laser beam in the cutting nozzle (see chapter 6 «Changing the nozzle and centering the laser beam»).
16. Determine the focal position of the cutting head (only necessary after a change of lens, but not after lens cleaning).

#### 8.3.3.4 Calibration of the focal position

Determine the focal position after each lens change.

Each cutting head has a specific focal position. The value found should be recorded on the cutting head.

Fig. 8.3 -4



There are two different ways of finding the focal position:

#### First option: (Cutting)

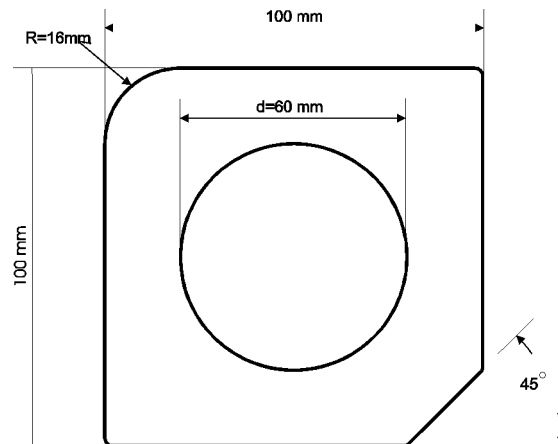


1. After a lens change, the old focal point can be set using the adjusting ring. Now perform fine-adjustment of nozzle centering (see Beam guidance system operating manual)
2. Place sheet (stainless steel  $\geq 3\text{mm}$ ) on table. Set up machine for oxide free (N<sub>2</sub>) cutting.
3. Do cutting tests and adjust the adjustment ring until the cutting quality is back to the original state. The optimum focal position can be found in this way.

- Do not select too complicated a contour for the cutting test.

*Example:*

Fig. 8.3 -5



- If a new focal position is obtained, this must be recorded on the cutting head.

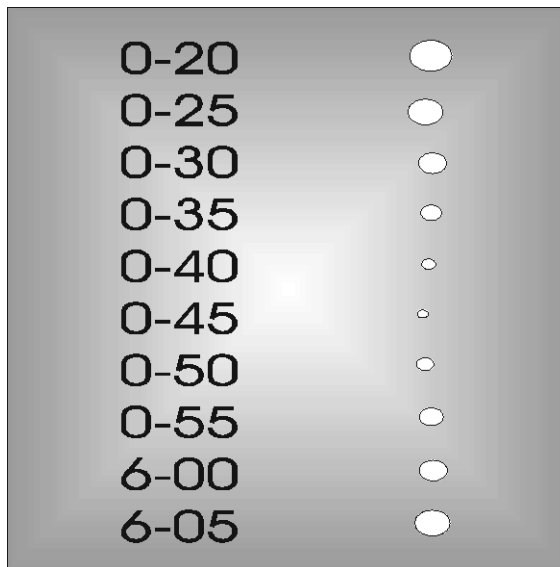
### Second option: (Single pulse)

Get a pad of self-stick post-it notes. (3M Post-it 76x76mm)



- Set the adjustment ring to the old value for the focal position.
- Insert new nozzle (e.g.: HK20) and center it.
- Use the adjustment ring to set a focal position 3mm higher.
- Now stick a Post-it note directly over the nozzle aperture.
- At the MMC controller, select <Setup>, and then "Set-up Laser". Now enter a "Laser power, single pulse" of 1%, and a "Pulse length" of 20-100ms.
- Now switch to the <Hand> menu and send a pulse using the hand-held controller. Make sure that the alignment hole is clean. If not, the pulse duration must be corrected.
- Move Post-it note and repeat action 6, after turning the adjustment ring 0.5 millimeters lower.


Fig. 8.3 -6



*The focal position is at 0-45*

8. Repeat this operation a number of times, until the smallest possible hole is found. It is advisable to use smaller steps, e.g. 0.2 millimeters, for the final optimization.
9. Write the focal position found on the head.  
(e.g. F= 6-10)

## 8.3.4 Beam guidance optical system

	<b>⚠ CAUTION</b>
	Handling optical components and parts.
	Optical components and parts are soiled or damaged by improper handling.

Always wear disposable gloves when cleaning, replacing or checking the optical system. Make sure that the work place is clean.



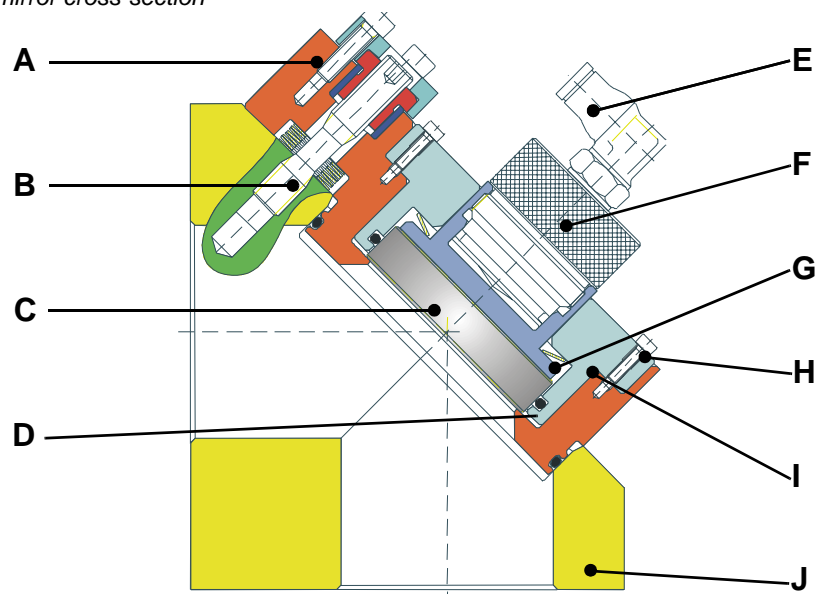
*Bystronic laser cutting machines have various mirrors, which appear identical externally. The type and properties of the mirrors can only be identified by the order number.*

### Replacing the deflection mirror



*On no account adjust the setting screws. Cooling water tubes must not be detached.*

Fig. 8.3 -7 Deflecting mirror cross-section



A.	Mirror support	F.	Cooler
B.	Set screw	G.	Pressure spring
C.	Deflecting mirror	H.	Mirror screws (x 4)
D.	O-ring	I.	Mirror mount
E.	Cooler connection	J.	Deflection vee



1. Switch machine off at main power switch, and safeguard against being switched on again.
2. Remove beam-path cover.
3. Unscrew four fastening screws on the mirror mounting (**H**) without detaching the coolant tubes.
4. Remove the mirror mounting (**H**) from the vee and turn it upside down so that the mirror faces up.
5. Press the mirror out of its mounting and out of the O-ring by pressing the cooler (**F**) upwards.
6. You can now hold the mirror on the side and remove it from the mounting.
7. Replace new or cleaned mirror. See chapter 7 «Lubrication, maintenance and cleaning tasks» for a description of how to clean the mirrors.

**NOTE**

*Hold the mirror from the side without soiling it with your fingers and insert it into the mounting. Use Kodak paper to press the mirror into the O-ring.*

8. Make sure that the mirror holder is absolutely clean before inserting the mirror mounting.
9. Position the mirror mounting correctly in the mirror holder. Tighten the fastening screws evenly.
10. Fit covers and switch on machine.
11. Before continuing work, a test shot must be fired to ensure that the beam deflection has not been changed.
12. To do this, insert the alignment tool for the Z-axis and fire at corner 4 on a cardboard plate.
13. Check centricity of the burn point.
14. If this is OK, you can commence cutting. For poor centricity, check the beam path.
15. After replacing or cleaning the deflecting mirror, the laser beam must always be re-centered in the nozzle (see chapter 6 «Changing the nozzle and centering the laser beam»).

**TIP**

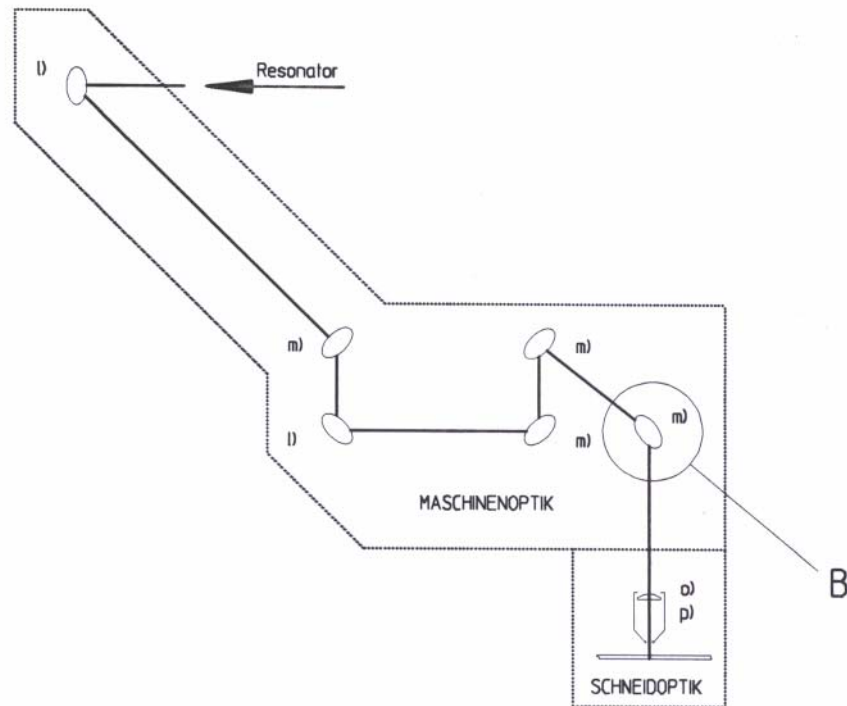
*When you replace a machine mirror, note down the position, date and hours of operation of the machine on the back of the mirror.*

### NOTE



*Repair work exceeding the scope of work described in the "Repair" chapter may only be performed by specially trained Bystronic experts. Contact our Customer Services department (see chapter "Repair service information").*


Schematic diagram of Bytube beam path



<b>m)</b>	Deflecting mirror
<b>l)</b>	90° deflection
<b>o), p)</b>	Lenses as per customer requirements

If the machine is fitted with Bypos, an adaptive mirror Bypos W is fitted in detail B, otherwise a deflecting mirror.

## 8.4 Converting a Bypos mirror to a flat mirror

	<b>⚠ CAUTION</b>
	Handling optical components and parts.
	Optical components and parts are soiled or damaged by improper handling.

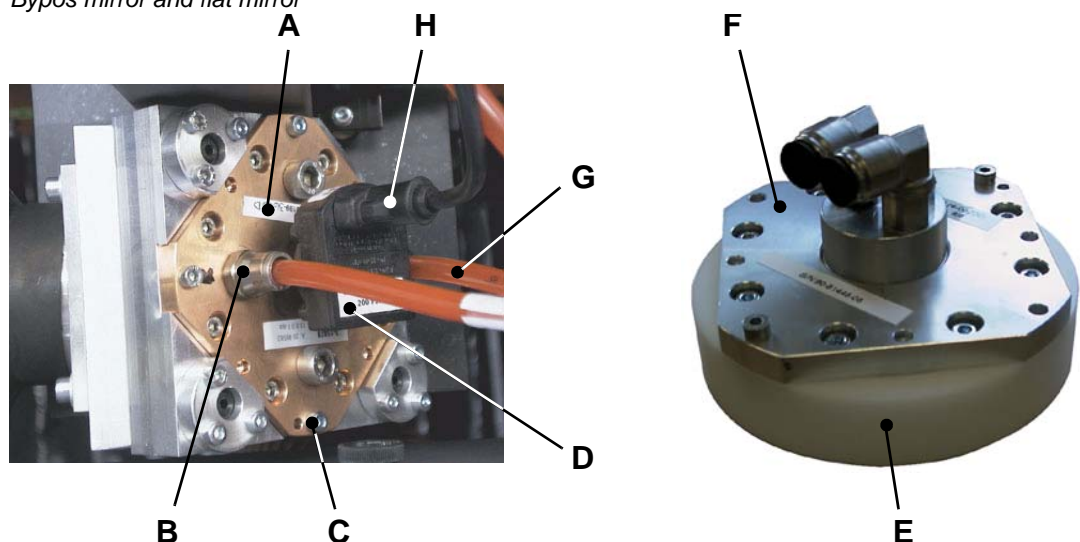
Always wear disposable gloves when cleaning, replacing or checking the optical system. Make sure that the work place is clean.

The flat mirror needs to be used if one of the following components fails:

- Bypos mirror
- Pressure sensor
- Proportional valve
- Pressure booster station
- Prescon card

Cutting can continue using the flat mirror as a temporary solution. If the Bypos mirror or the sensor fails then the whole mirror unit (including sensor) must be replaced.

Fig. 8.4 -1 *Bypos mirror and flat mirror*



A.	Bypos mirror	E.	Protective cap
B.	Cooling water return	F.	Flat mirror
C.	Fixing screws (4 off)	G.	Cooling water supply
D.	Pressure sensor	H.	Sensor cable connector



## 8.4.1 Conversion procedure



1. Shut down and switch off the complete system (resonator, machine, cooling unit).
2. Disconnect the sensor cable (**H**) in the cutting carriage.
3. Disconnect the cooling water supply (**G**) and return pipes (**B**) from the Bypos mirror.
4. Unscrew the fixing screws (**C**) (4 off).
5. Remove the Bypos mirror (**A**) and affix the protective cap.
6. Fit the flat mirror (**F**) and connect the cooling water supply and return pipes.

### NOTE



*Once the flat mirror has been fitted, the cooling-water circuit needs to be converted to suit the new circumstances.*

- To convert the cooling-water circuit when the pressure booster station is intact, please see «8.4.2.1 Conversion when pressure booster station intact»
  - To convert the cooling-water circuit when the pressure booster station is faulty, please see «8.4.2.2 Conversion when pressure booster station faulty»
7. Call in the site electrician, and switch off the motor safety switch labeled "Pressure booster in Bypos circuit" in the cooling-unit control box (see diagram in supplier documentation).
  8. Close the cover of the cutting carriage.

## 8.4.2 Commissioning after conversion carried out

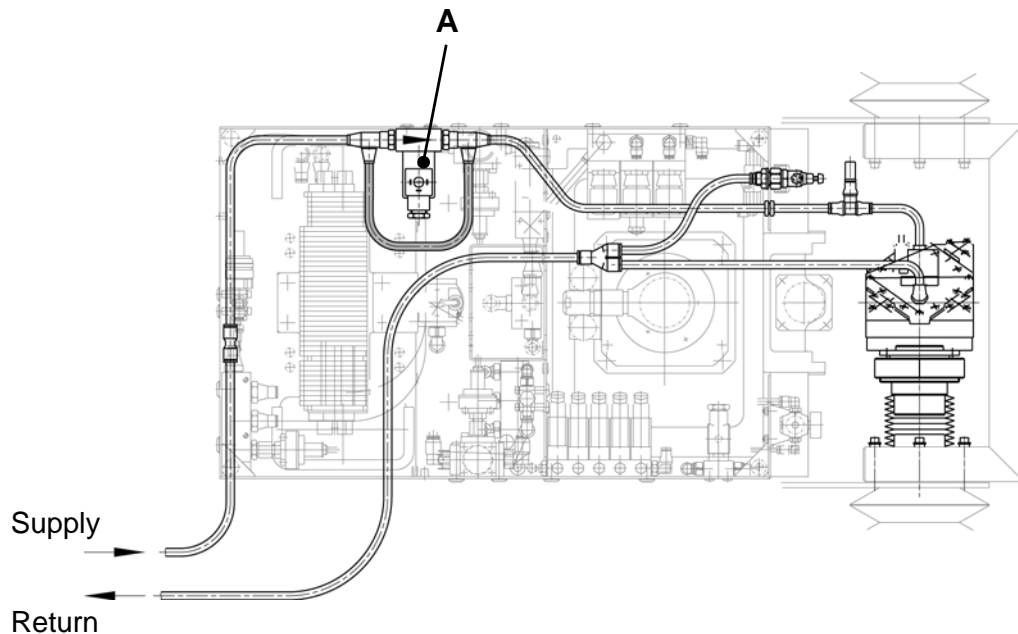


1. Start up laser cutting machine.
2. Check the position of the flat mirror using the alignment gauge, and align if necessary.
3. In the "Setup" menu, switch the Bypos operating mode to "0". Ignore any error message that may appear.
4. Before starting cutting, adjust the focal point manually (see «8.3.3.4 Calibration of the focal position»).

#### 8.4.2.1 Conversion when pressure booster station intact

If the pressure booster station is not faulty, once the flat mirror has been fitted the cooling-water circuit must be reconnected by bypassing the proportional valve (A).

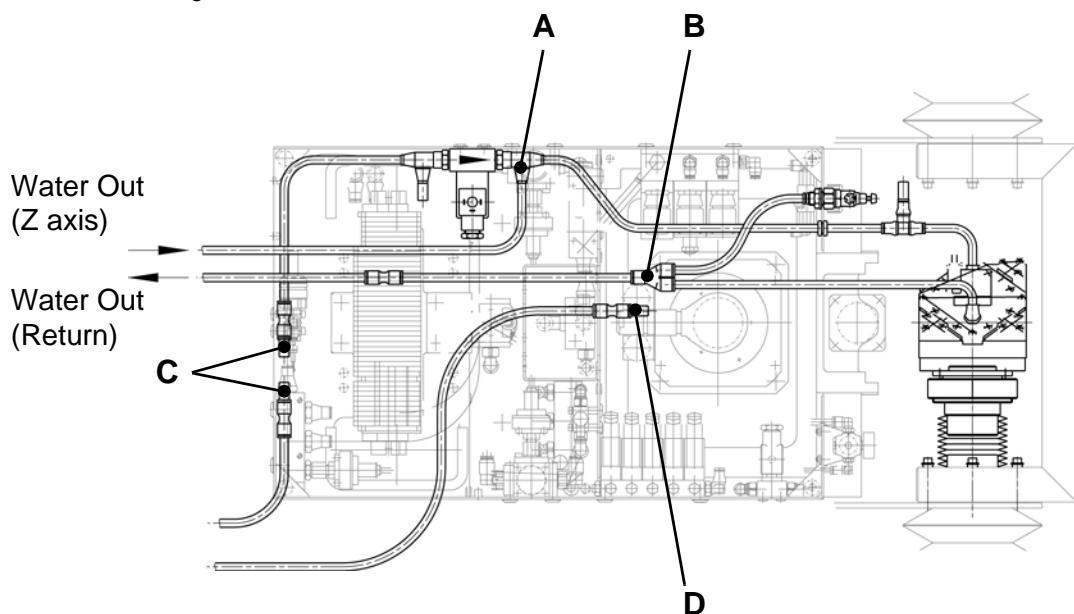
Fig. 8.4 -2 Bypassing the proportional valve



#### 8.4.2.2 Conversion when pressure booster station faulty

If the pressure booster station fails, the cooling-water return from the cutting head (Z-axis) must be fed into the cooling-water circuit for the flat mirror.

Fig. 8.4 -3 Converted cooling-water circuit

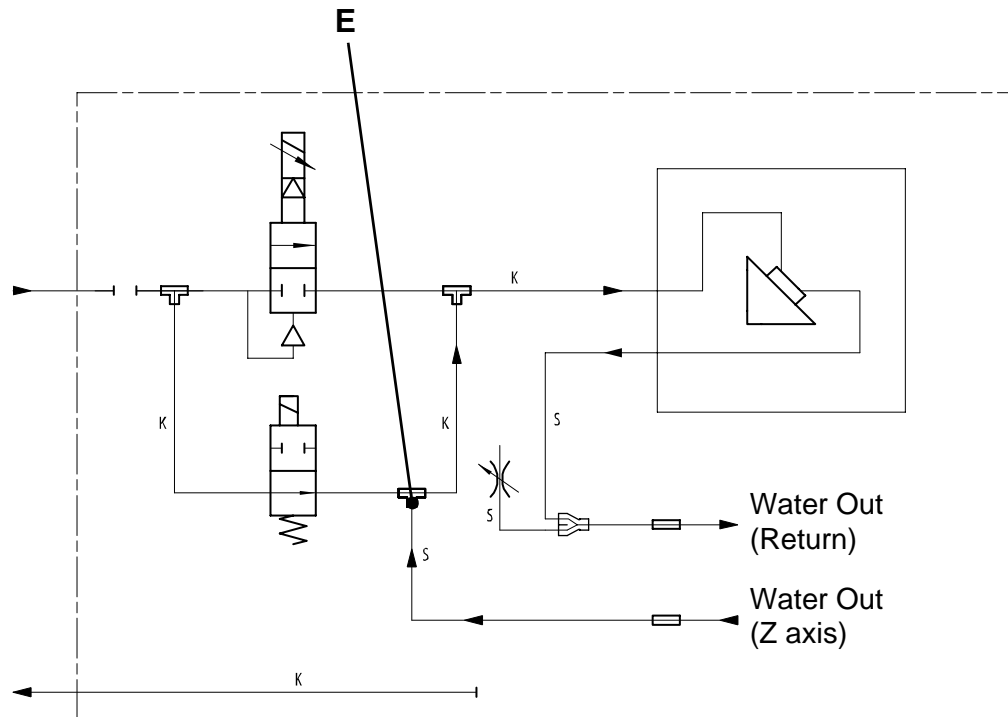




1. Disconnect the cooling water return (Z-axis – return from cutting head) at the coupling and connect to the plug-in connector (A) downstream of the proportional valve.

For model with tank heater: connect to the plug-in connector (E) downstream of the Bypass valve.

Fig. 8.4 -4 Converted cooling-water circuit for model with tank heater






2. Disconnect cooling-water return at Y-connector (B) .
3. Connect Y-connector to cooling water return (Z-axis – return from cutting head) using extension tube.
4. Disconnect the cooling-water supply (C) upstream of the proportional valve and blank it off using couplings with blanking plugs.
5. Also seal the cooling-water return pipe (D) with a coupling and plug.

## 8.5 Alignment

### 8.5.1 Alignment tools

Fig. 8.5 -1

Description	Applications
Alignment device for setting up optical beam expansion system	
Alignment device for setting up the mirror on the bridge axis. (3. deflecting mirror)	
Alignment device for setting up the mirror on the Z-axis (Bypos)	

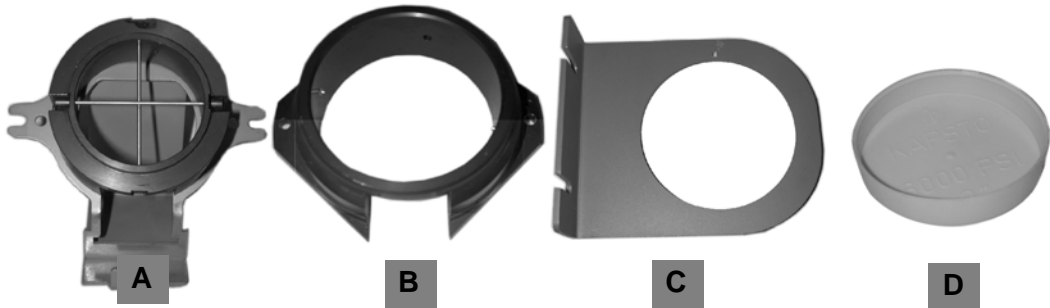
Description		Applications	
Alignment device for deflecting and adaptive mirrors			
			
A.	Alignment gauge	B.	Adapter ring
C.	Bracket	D.	Protective cap

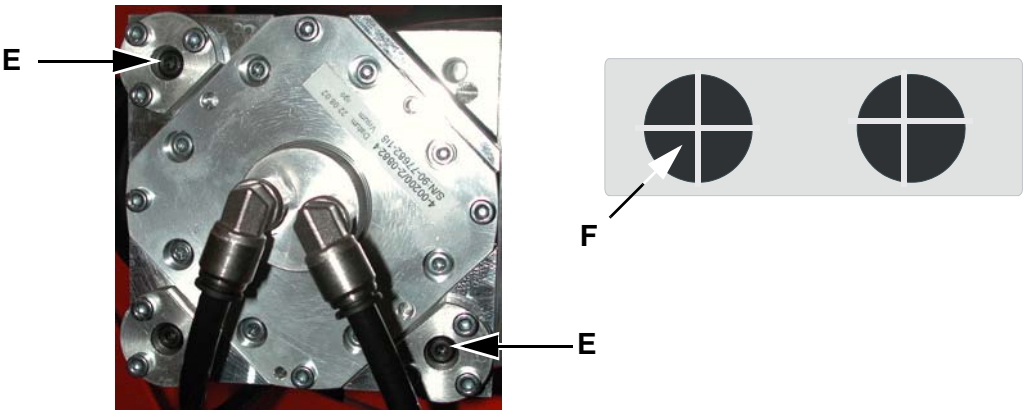
Fig. 8.5 -2

8.5.2 Alignment procedure

To obtain an optimum level of efficiency in laser cutting, all deflecting mirrors must be aligned and adjusted when commissioning the system for the first time. The deflecting mirrors also need to be aligned after changing an optical component, or if the cutting result is unsatisfactory.

When aligning, ensure that the laser beam is always in the center **F** of the alignment gauge. Use the screws **E** to make the adjustment. Fire with reduced power onto the plaster plate or paper strip.

Fig. 8.5 -3



*Optical components must be cleaned before assembly.*

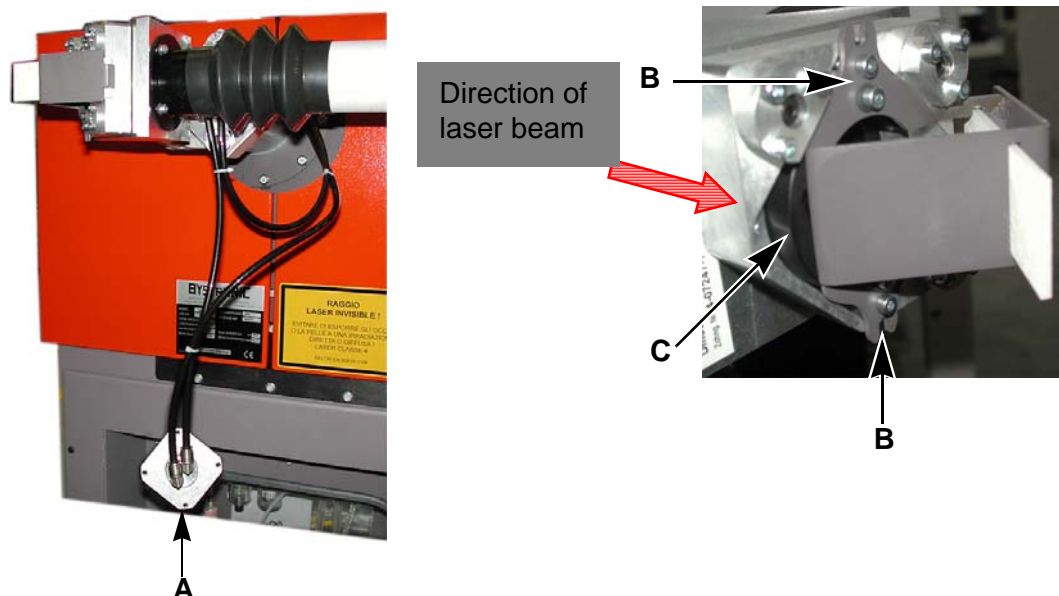
### 8.5.3 Alignment in beam divergence system

#### NOTE



*Only adjusted when there is extreme deviation along X beam path.*

Fig. 8.5 -4



1. Remove mirror holder **A**, take it out of the mirror mounting and let it hang down
2. Fix alignment gauge without adapter in the mirror mounting **C** using two screws **B**.

#### NOTE



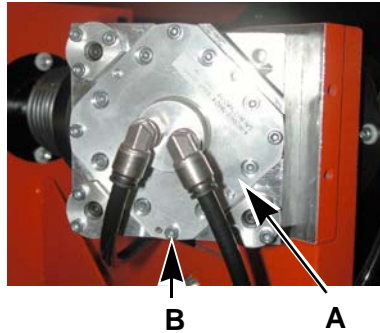
*During alignment, protect deflecting mirror from soiling with cap and masking tape.*

3. Fire a pulse of appropriate power

## 8.5.4 Alignment at deflecting mirror

The system must be re-aligned whenever the deflecting mirror is changed. The deflecting mirror in the X beam path is aligned using the targeting device on the bridge axis (3<sup>rd</sup> deflecting mirror).

Fig. 8.5 -5



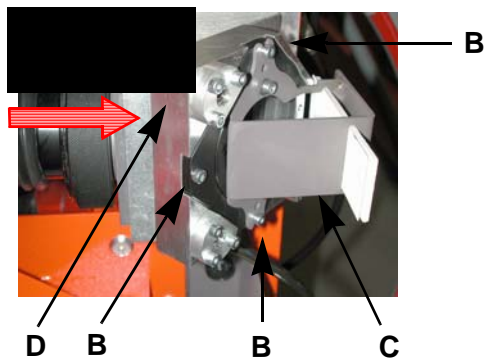
1. Undo the four screws **B** on the mirror holder **A**
2. Take mirror holder **A** out of the mirror mounting and let it hang down
3. Attach protective cap

### NOTE



*During alignment, protect deflecting mirror from soiling with cap and masking tape.*

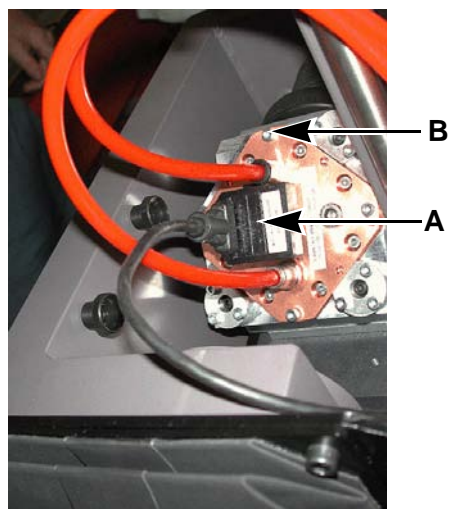
Fig. 8.5 -6



4. Fix alignment gauge **C** to mirror mounting **D** using the three screws **B**
5. Fire a pulse of appropriate power

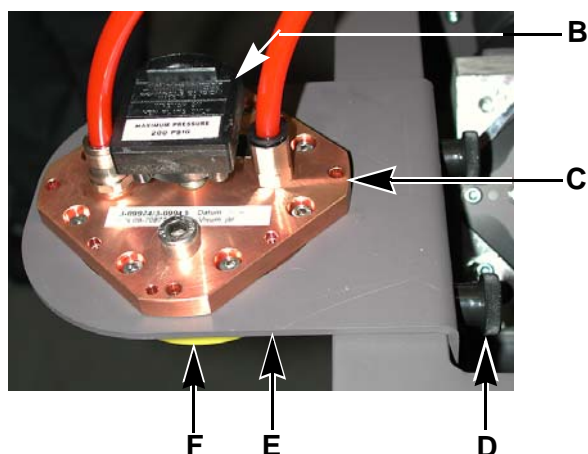
### 8.5.5 Alignment at Bypos-W

Fig. 8.5 -7



1. Remove screws **B** of the mirror mounting

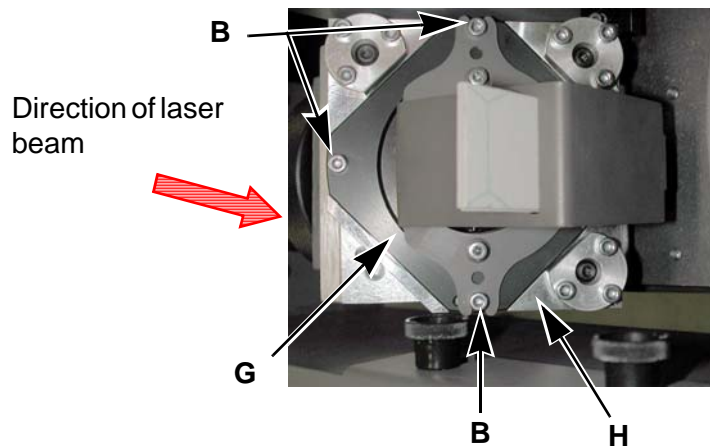
Fig. 8.5 -8



2. Fix bracket **E** onto the cutting bridge using the knurled screws **D**
3. Fit cap **F** on mirror
4. Fix mirror mounting **C** onto bracket using screw **B**



Fig. 8.5 -9



5. Fit alignment gauge **G** in the mirror holder **H** and fasten with three screws **B**



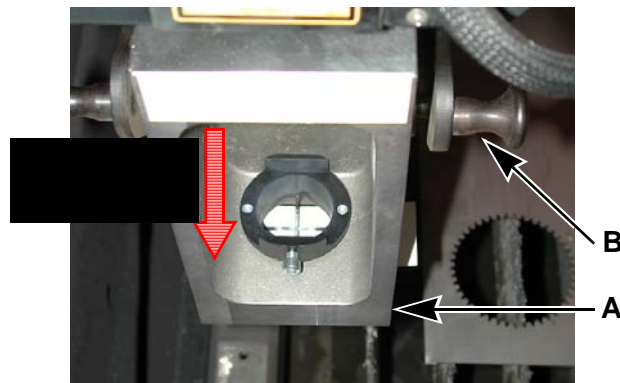
**TIP**

*If the vee is fitted incorrectly, the gauge stands up on the pin of the mirror holder and corrupts the result*

6. Fire a pulse of appropriate power

## 8.5.6 Alignment at cutting head

Fig. 8.5 -10



1. Remove cutting head
2. Mount alignment gauge for cutting head **A** using the two clamping levers **B**. If necessary lower using the Z-axis to enable simpler and more precise alignment.
3. Fire a pulse of appropriate power
4. Adjust mirror if necessary

## 8.6 Circuit diagrams, drawings

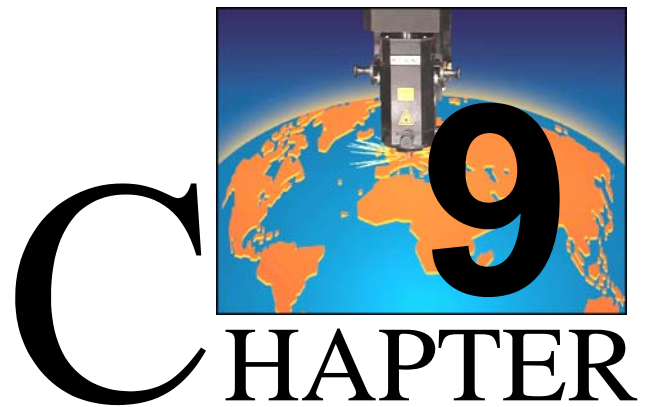
Circuit diagrams and drawings can be found in the spare parts catalogue and the «Equipment Diagram» folder.

## 8.7 Repair service information

Our Customer Service department is at your disposal in the event of problems. Please have the following information ready before you call:

- Company / Address
- Contact person
- Job number

For the contact address please refer to the details of **BYSTRONIC Customer Support** on page 4 at the beginning of this operating manual.



## CHAPTER

### **Decommissioning the system**

The chapter «Decommissioning the system» is not yet included in the operating manual.

## **Table of contents**

<b>9.</b>	<b>Decommissioning the system.....</b>	<b>1</b>
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# C10

## CHAPTER

### **Packaging, transport**

The chapter «Packaging, transport» is not available in the operating instructions. All work connected with packaging and transporting the machine or system is performed by the manufacturer's personnel.

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# C CHAPTER 11

## Disposal

The «Disposal» chapter provides information on disposal of the machine and its operating resources in accordance with environmental regulations. It also includes information on how to deal with spare components (e.g. replacement parts).

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### 11.1 Introduction

#### 11.1.1 Safety regulations

Always observe national regulations and standards for all components to be disposed of.

Also observe the manufacturer's regulations for operating resources and cleaning agents.

#### 11.1.2 Requirements to be met by operating personnel

Proper disposal must be performed by specially trained personnel.

### 11.2 Disposal

#### 11.2.1 Packaging

Dispose of packaging material used for delivery in accordance with national regulations and standards.

#### 11.2.2 Operating resources

#### NOTE



*Dispose of all operating resources in accordance with national regulations and standards.*

Gear oil and lubricants must be sent to a suitable treatment plant or disposed of as hazardous waste.

For all operating resources, observe the manufacturer's regulations. For further details please refer to the safety data sheets in the «Supplier Documents» folder in your machine documentation.

## 11.3 Components suitable for disposal

### 11.3.1 Material groups

**NOTE**

*Dispose of all materials in accordance with national regulations and standards.*

Metals and plastics must be separated and taken for recycling or disposal.

The machine and electrical control system must be taken apart and the component properly disposed of.

The machine contains the following materials:

- Steel castings
- Steel
- Nonferrous heavy metals (aluminum, copper)
- Rubber
- Plastics

The electrical control system contains the following materials and parts:

- Steel
- Plastics
- Nonferrous heavy metals (aluminum, copper)
- Protective varnish on circuit boards
- Electrical and electronic components
- Battery

## **11.4 Disposal centers, authorities**

### **11.4.1 Return to manufacturer**

The manufacturer takes back various components. This applies particularly to components replaced by repaired parts during the machine's service life.

### **11.4.2 Notification to authorities and manufacturer**

The manufacturer should be informed when you decommission the system.





## C12 CHAPTER

### **Cutting technology**

The «Cutting technology» chapter provides information on cutting with the Bystar laser machine. It includes basic advice on machining the raw material, and also provides information on special applications, coatings and alloys.

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## 12.1 Cutting with Bytube

*This chapter contains general advice on laser cutting, detailed in the sections from "Laser cutting procedure" onwards.*

The following points should be considered in particular in order to make optimum use of Bytube:

- Programming of parts
- Cutting parameters
- Production

When cutting tubes and sections, there are a larger range of variables to consider than when cutting flat sheets.

There are so many different possible values for tube dimensions, wall thicknesses, surface finishes and qualities that Bystronic cannot issue general cutting parameters.

A number of points need to be considered when adopting cutting parameters from flat-sheet cutting.

### 12.1.1 Adapting flat-sheet parameters to tube parameters

The tube thickness should be the same as the sheet thickness in question.

#### 12.1.1.1 For large circular tubes:

- Reduce the piercing power (the power can be reduced to as low as 60%)
- Set Nozzle distance, cutting to 1.2 mm
- Adjust focal position (when cutting tubes, the focal point needs to be slightly lower in practice)

#### 12.1.1.2 For small circular tubes:

- Reduce the piercing power (the power can be reduced by up to 60%), or pulsed piercing
- Minimize the 'Delay time before processing' or set to zero
- Set Nozzle distance, cutting to 1.2 mm
- Adjust focal position (when cutting tubes, the focal point needs to be slightly lower in practice than for cutting flat sheets)
- Reduce feed rate by 30...60%
- Reduce power by 50...80%
- Reduce gas pressure when cutting with O<sub>2</sub> (depends on material and surface finish of tube)

**12.1.1.3 For large rectangular tubes:**

- Reduce the piercing power (the power can be reduced to as low as 60%)
- Set Nozzle distance, cutting to 1.2...1.7 mm
- Adjust focal position (when cutting tubes, the focal point needs to be slightly lower in practice than for cutting flat sheets)
- Increase Y-feed move to corner to 4000...7000 mm/min
- Reduce gas pressure when cutting with O<sub>2</sub> (depends on material and surface finish of tube)
- Adjust modulation (normally 45...70%)

**12.1.1.4 For small rectangular tubes:**

- Reduce the piercing power (the power can be reduced by up to 60%), or pulsed piercing
- Minimize the 'Delay time before processing' or set to zero
- Set Nozzle distance, cutting to 1.2...1.7 mm
- Adjust focal position (when cutting tubes, the focal point needs to be slightly lower in practice than for cutting flat sheets)
- Reduce feed rate by 30...70%
- Increase Y-feed move to corner to 2000...4000 mm/min
- Reduce power by 50...80%
- Reduce gas pressure when cutting with O<sub>2</sub> (depends on material and surface finish of tube)
- Cut small geometries in pulsed mode
- Adjust modulation (normally 45...70%)

**12.1.1.5 Performance with sand-blasted surfaces**

- The cutting quality is reduced
- The gas pressure must be reduced

This information is based on internal cutting trials and should be seen as a guide to optimizing the cutting parameters. An important factor is the quality of the tube to be cut. At present it is still not possible to achieve the same qualities as are possible with flat cutting. This is why the parameters usually need to be adjusted.

**12.1.2 Recommendations for machining tubes and sections****12.1.2.1 General rules**

Tubes store the heat generated in piercing and cutting, and overheating must be prevented. Over-heated tubes distort and result in a poor cut quality. The latter can be prevented by

- using lances (See also the chapter "Design and operation")
- cooling the tubes using a flow of air in the tube and extracting air through the tube
- selecting a sensible cutting sequence when programming

**12.1.2.2 Cutting in conventional mode (Byflex)**

- Long tubes with small diameters/diagonals and thin walls must be supported to prevent deflection of the tube.

- The maximum diameter is 320 mm
- Long tubes with a large diameter/diagonal and thick walls require support as soon as end cuts are set. The axial tensioning of the tailstock is not sufficient to prevent the tube dropping down. Another option is to set programmed microjoints. This only works with circular tubes.

### Options

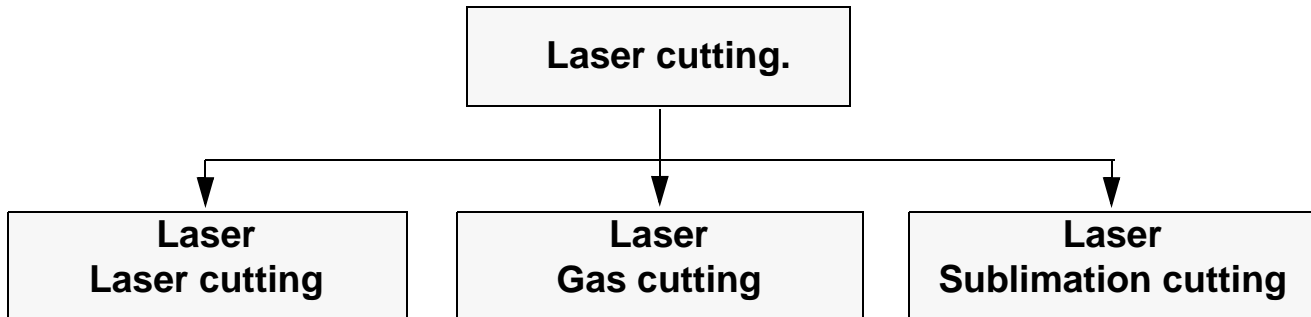
- **Microjoints**  
The microjoints prevent the tube dropping down when making severance cuts.
- **Weld-joints**  
Weld joints can be programmed in Bysoft.  
The values required in Setup for making the weld joints can be taken from flat machining.  
The advantage of the weld joint over the conventional microjoint is that it is not the same thickness as the wall of the tube being cut, but simply results in a weld point on the material surface. This property means it is easier to separate the tube later. If the weld joints are not sufficient, the tube must be supported.

### 12.1.2.3 Cutting in Hybrid mode

- In Hybrid mode the tubes are loaded automatically via the feed unit. The tubes can be up to 6500mm depending on the machine type (max. 12500 mm).
- Circular tubes can be cut using the circular-tube steady rest or using the driven four-jaw steady rest. The surface of the tubes is damaged less by the driven four-jaw steady rest. This applies particularly to aluminum tubes and tubes with surface treatments.
- Rectangular or square sections can only be cut using the driven four-jaw steady rest.
- The length of the leftover tube equals
  - for the driven four-jaw steady rest 300 mm
  - for the circular tube steady rest 170 mm
- The maximum diameter or longest diagonal that can be cut is 170 mm.

## 12.2 The laser cutting process

Basically, we can divide laser cutting into three areas:



### 12.2.1 Inert gas fusion laser cutting

In the fusion cutting process the work piece is melted locally and the melt is blown out by a gas jet (nitrogen  $N_2$ ). The material is only transported in the liquid phase, which is why the process is also called melt shearing.

The laser beam is admixed with a high-purity assist gas that blows the melted material out of the kerf but is not involved in the actual cutting process.

- Fusion cutting achieves greater cutting speeds than oxygen cutting or sublimation cutting. The evaporation energy required is generally far greater than the energy required to melt the material. In fusion cutting only a small part of the laser beam is absorbed.
- Maximum cutting speed rises with increasing laser power and decreases almost inversely proportionally to sheet thickness and fusion heat of the material. If laser power is sufficient, limiting factors are gas pressure in the cut and heat conduction.
- Fusion cutting is suitable for making oxide-free cuts in ferrous materials and titanium.
- The range of power flux density achieved by melting without causing evaporation is between  $10^4$  W/cm<sup>2</sup> and  $10^5$  W/cm<sup>2</sup> for steel.

### 12.2.2 Oxygen laser cutting

Oxygen laser cutting differs from fusion cutting in the use of oxygen as assist gas. The interaction of oxygen with the heated metal causes a reaction that heats up the material even more. As a result of this effect, depending on sheet thickness and laser power, this method of cutting can cut structural steel at speeds far greater than fusion cutting.

However, this process can lead to diminished cut quality compared to fusion cutting. The result may be wider cuts, increased surface roughness, deeper heat affected zones and diminished cut edge quality.

- Oxygen cutting is critical when cutting fine contours and acute geometries (risk of burn-off). However, the amount of heat input can be limited by pulsing.
- The laser power determines speed of cutting. If laser power is sufficient, limiting factors are available oxygen and heat conduction.

### 12.2.3 Laser sublimation cutting

In laser sublimation cutting, the material is evaporated in the cut. This requires very strong laser power.

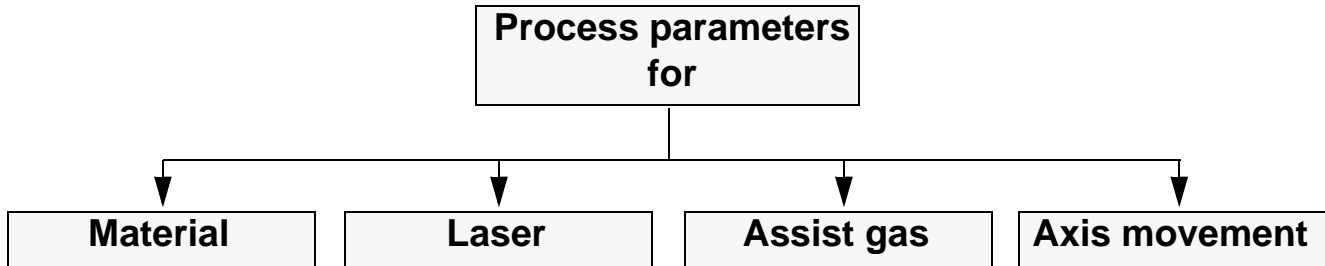
Sheet thickness must not substantially exceed the diameter of the beam otherwise the vapor created at the cut wall will condense and close the cut again. Therefore, this method is only suitable for applications where you must prevent the melt from being blown out. There are currently only a few applications for ferrous metals.

Exceptions are materials such as wood or special ceramics without a molten phase so that no recondensation of the material vapor can occur. It is also possible to cut much greater thicknesses of these materials.

- In laser sublimation cutting, optimum focusing depends on sheet thickness and beam quality.
- Laser power and evaporation heat only have little effect on the optimum focal position.
- Maximum cutting speed for a given material thickness is inversely proportional to the evaporation heat of the material.
- The necessary power density must be greater than  $10^8 \text{ Watt/cm}^2$  (Bystronic laser maximum  $1.5 \times 10^7 \text{ Watt/cm}^2$ ) and depends on the material, the depth of cut and the focal position of the laser beam.
- Maximum cutting speed for a given material thickness and sufficient laser power is limited by the gas jet speed.

#### 12.2.4 Cutting process

The cutting process means the interaction of the laser beam, the assist gas and the work piece.



The zone in which this process takes place is referred to as the cutting front or cut front. The laser power applied at the cutting front must heat up the material to the temperature required for phase transition of the material to melt and vapor.

The cutting front is a practically perpendicular surface heated and melted by the absorbed laser beam.

- In oxygen laser cutting, this melt zone is heated up further by the flow of oxygen blown into the kerf and reaches temperatures close to the melting point of the material. This causes strong vaporization and ablation of the material. At the same time, the assist gas jet blows out liquid material underneath the work piece.
- In fusion cutting the gas blows out the liquid material and protects the kerf from oxidization.

The molten zone continues to move in the direction of cutting. This ensures a continuous kerf.

Many important processes in laser cutting occur in this zone. Analyzing these processes provides important information on laser cutting. For example, it is possible to estimate cutting speed and explain the formation of characteristic striation marks.

### 12.2.5 Laser modes

Operating mode	Applications	Example
Continuous wave (CW)	Low-pressure cutting Normal cutting High-pressure cutting	Structural steel with O <sub>2</sub> Aluminum with N <sub>2</sub> Stainless steel with N <sub>2</sub> Continuous cutting produces a relatively fine cut
Modulation (MOD)	Cutting corners Acceleration and deceleration	With modulation activated, the laser output is adjusted to the axis speed. This prevents corners from getting burnt off.
Normal pulsed (NP)	Piercing Tight contours	Mild steel example: Small piercing point on contour (after microjoint) Small holes with minimum Ø ½ material thickness Fine contours

### 12.2.6 Gas parameters

- Gas type
- Gas pressure
- Nozzle diameter
- Nozzle geometry

Gas pressure and nozzle geometry affect the roughness of the cut edge and the creation of whiskers.

The amount of assist gas consumed depends on nozzle diameter and gas pressure.

- For low-pressure cutting applications gas pressure is up to 5 bar and up to 20 bar in the high-pressure range.
- The conventional cutting nozzle has a circular, conical aperture.
- Make sure that the distance between the nozzle aperture and surface of the material is as small as possible. The smaller the distance, the greater the volume of gas actually entering the kerf. Clearance distances typically range from 0.5 to 1.5 mm.

## 12.3 Materials

### 12.3.1 Material properties

The result of cutting the work piece can be a clean cut or a frayed cut edge with a burr.

The main factors influencing cut quality are:

- Alloy components
- Microstructure
- Surface quality
- Surface roughness
- Surface treatment
- Beam reflection
- Thermal conductivity
- Melting point
- Fusion heat
- Evaporation temperature

#### 12.3.1.1 Alloy components

These properties have a considerable influence on the materials' strength, specific weight, weldability, resistance to oxides and acids. Some major alloy elements of ferrous materials are: carbon, chrome, nickel, magnesium and zinc.

The higher the content of carbon, the less well the material can be cut (critical limit approx. 0.8% carbon). The following carbon steels can be cut well with the laser:

St 37-2, StW 22, DIN 1.203

#### 12.3.1.2 Microstructure

Generally speaking, the finer the grain of the material structure, the better the quality of the cut edge.

#### 12.3.1.3 Surface quality and surface roughness

If the surface has rusty spots or scales, the cut will be irregular and have many chips.

When cutting checker plate, select cutting parameters for the maximum thickness of the material. The checkers must always face down (reflection).



### 12.3.1.4 *Surface treatment*

Common surface treatments include zinc-coating, hot-galvanizing, varnishing, anodizing or foil coating.

- Depending on sheet thickness, zinc-coated sheets tend to form droplets below the cut.
- With varnished sheets, cut quality depends on the composition of the paint components.

Procedure for processing varnished sheets:

- Activate <REPEAT> on the CNC control unit
- For the first pass (G11) select a parameter set with reduced performance (etching) in order to pre-burn the surface treatment.
- For the second pass (G10) select the parameter set that corresponds to the material to be cut.

Foil-coated sheets are well suited to laser cutting. In order for the capacity scan to work smoothly and ensure optimal foil adhesion (avoiding bubbles), the foil-coated side should always face up on the work piece.

### 12.3.1.5 *Beam reflection*

Beam reflection of work piece surfaces depends on the base material, surface roughness and surface treatment. Some aluminum alloys are highly reflective (e.g. Anticorodal), as are copper, brass and stainless steel sheet.

### 12.3.1.6 *Thermal conductivity*

Materials with low thermal conductivity require less energy to melt than materials with high thermal conductivity.

For example, the energy required for stainless steel is less than for structural steel despite lower absorption at cutting temperature.

On the other hand, copper, aluminum and brass, for example, conduct a large amount of the heat generated by absorption of the laser beam. The heat is quickly conducted away from the focal point of the laser beam, thus making it harder to melt the material at this spot.

### 12.3.1.7 *Heat affected zone*

During laser cutting and laser welding changes may occur in the edge zones of the material being cut.

The following table contains guidelines for the size of the heat affected zone depending on the base material and its thickness.

Material thickness [mm]	Heat affected zone [mm]		
	St 37	Stainless steel	Aluminum
1	0.05	0.05	0.10
2	0.10	0.10	0.20
3	0.15	0.15	0.30
4	0.20	0.25	0.40
5	0.25	0.34	0.50
6	0.30	0.55	0.60
8	0.40	0.75	0.70
10	0.50	0.85	-
12	0.60	-	-

- In low-carbon steel and stainless steel there is little increase in hardness in the heat affected zone.
- In high-carbon steel (e.g. Ck60) hardening occurs in the edge zones.
- In hard-rolled aluminum alloys, the heat affected zone is slightly softer than the rest of the material.

### 12.3.2 Machining a range of materials

#### 12.3.2.1 *Structural steel*

This material can be cut with oxygen to produce good quality cuts. The laser is operated in CW mode. If the control changes the feed rate in tight contours, laser power is adjusted to axis feed rate by means of modulation.

When using oxygen as the assist gas, the cut edge is slightly oxidized. For sheet thicknesses up to 6 mm, high-pressure cutting with nitrogen as assist gas may also be used. In this case the cut edges are oxide-free.

Cut difficult contours and holes ( $\varnothing$  less than thickness of the material) in pulsed mode. This prevents sharp corners and thin joints from being burnt off.

- The greater the content of carbon in the steel, the more the cut edge will solidify and the greater the chance that sharp corners will be burnt off.
- Sheets with high alloy contents are more difficult to cut than sheets with low alloy content.
- An oxidized or sand-blasted surface will produce a far poorer cut quality.
- Color markings on the surface of the sheet have a negative effect on the cutting result.
- For sheet thicknesses of 12 mm and above, good results are achieved with laser sheet (e.g. Raex) and an oiled work-piece surface. The oil film reduces slag adhesion on the surface and considerably assists cooling. The oil film does not impair cutting results.
- Whenever possible, cut only fully killed steel. Contaminants in un-killed steel significantly impairs the cutting result. Dressing rollers and internal stress also affect suitability for cutting.

For smaller contours in sheet thicknesses of 15 and 20 mm we recommend fine-grain steel (e.g.: "Raex-250-Laser" from the Rautaruukki steel works, Raahe. This steel is made from a special melt with a maximum silicon content of 0.03% and a maximum carbon content of 0.012%. Tensile strength is 360-440 N/mm<sup>2</sup>. The ReH upper yield point equals at least 250 N/mm<sup>2</sup>. This steel has the following special features:

- no slag formation in laser cutting
- no warping of cut parts
- optimum edge behavior
- low spring-back

- good suitability for welding
- This steel is available in thicknesses of up to 30 mm

Cutting results with St 52-3 are inferior as it tends to chip and burr due to the viscous slag.

Observe the following guidelines in order to cut structural steel with a clean surface:

Si ≤ 0.04%:	preferable; cuts well with laser
Si < 0.25%:	possibly slightly reduced cutting properties
Si > 0.25%:	steel of limited suitability for laser cutting and thus inferior or irregular cutting results.

**NOTE**

*Tolerance as per DIN for steels up to St 52, Si is ≤ 0.55%. These figures are too imprecise for laser cutting.*

**12.3.2.2 Stainless steel**

Cut this material:

- With oxygen if one can tolerate oxidization of the cut edge
- With nitrogen in order to achieve oxide-free, burr-free cut edges that do not require clean-up.
- Depending on sheet thickness, high-pressure cutting with nitrogen at high laser power achieves comparable or even greater speeds than oxygen cutting.
- In order to be able to achieve burr-free cutting with nitrogen of stainless steel of thickness 5 mm or more over the entire table area, it is necessary to readjust the focal position. By averaging out the focal position and reducing speed it is possible to cut clean cuts, albeit with slight burring.
- With the BYPOS option it is not necessary to adjust the focal position manually.
- An oiled sheet surface improves piercing without reducing cut quality.

**For stainless steels select:**

- When cutting with oxygen: pulsed mode with reduced feed rate for sheet thicknesses of 5 mm and above.
- A much larger nozzle clearance distance for piercing than for cutting. A large nozzle clearance distance helps prevent splashes on the lens.

**NOTE**

*Only cut aluminum if the machine has a suitable device for absorbing reflections. Otherwise reflections can destroy the optical elements.*

#### 12.3.2.3 Titanium

Cut titanium sheets with nitrogen or argon assist gas. Cutting parameters are stored on the panel PC.

When cutting with oxygen, the cutting edge oxidizes and has a brown discoloration. A burr also forms on the underside of the sheet.

Cutting with argon achieves an oxide-free, clean cut edge without burr.

#### 12.3.2.4 Copper and brass

- Both materials are highly reflective and have high thermal conductivity.
- Brass can be cut with nitrogen up to 3 mm.
- Copper can be cut up to a sheet thickness of 3 mm; assist gas must be oxygen.

#### NOTE




*Only cut copper and brass if the machine has a suitable device for absorbing reflections. Otherwise reflections can destroy the optical elements.*

#### 12.3.2.5 Plastics

	<b>! WARNING</b>
	<p>Plastics must not be cut on BYSTRONIC laser cutting machines!</p> <p>The fumes given off on combustion are highly toxic. They cannot be completely removed by the extraction system.</p>

#### 12.3.2.6 Organic materials

	<div><b>⚠ DANGER</b></div> <p>There is a risk of fire when cutting organic materials (use nitrogen as assist gas).</p>
---	--

Wood, leather, cardboard and paper can be cut with the laser. The cut edge is charred (brown discoloration). The greater the feed rate, the less charring occurs. A clean cut cannot be guaranteed for glued wood because the glue layer breaks down in different ways depending on the type of glue.

#### 12.3.2.7 Other materials

Bystronic Customer Services can supply information on other materials.

### 12.4 Production

In order to maximize safety in production, we recommend testing parts separately with a greatly reduced cutting and positioning speed and by means of simulation in BYSOFT. Observe the following:

- Never position above a contour that is already cut.
- Observe direction of rotation during cutting and positioning
- No parts that rise up.
- Machine from right to left

#### 12.4.1 Sheets

When machining sheets of thickness 0.5-3 mm, special care must be taken to ensure that the sheets are good quality and are transported with care. Sheets should be flat and not warped. During storage, handling and transport, keep sheets flat and do not bend.

#### 12.4.2 Material surface

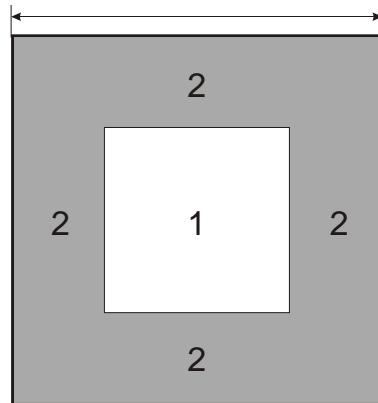
Material surface has a very significant influence on cutting results and cut quality.

Negative influences	Positive influences
<ul style="list-style-type: none"> <li>• Loose rolling skin</li> <li>• Rust</li> <li>• Scale</li> <li>• Uneven surface with troughs and irregularities</li> <li>• General soiling</li> <li>• Steel stamping, scrap marks</li> <li>• Color markings</li> </ul>	<ul style="list-style-type: none"> <li>• Fine, even surfaces with microscale</li> <li>• Sheet lightly oiled</li> <li>• Pickled sheets</li> <li>• Hot-rolled oiled sheets</li> <li>• Sandblasted and shot-blasted surfaces are only suitable to a limited extent but still better than rusty surfaces.</li> </ul>
Example: cheap ST52 sheet exposed to weathering.	Example: RAEX series sheets recommended by Bystronic.

### 12.4.3 Stresses

Cheap sheets generally have greater internal stress, and warp correspondingly in laser cutting. This stress is created during sheet manufacture.

Higher quality sheets have less internal stress. Often, stress may vary within one sheet. The greatest stress can be seen in the edge zones as a result of faster cooling. By means of careful nesting it is possible to achieve additional production reliability.



#### Area 1:

Little stress in the sheet. Parts subject to severe warping should be nested in this area. (e.g. long, thin strips)

#### Area 2:

More stress in the sheet. Uncomplicated parts not susceptible to warping should be positioned here.

### 12.4.4 Primers, varnishes, protective paints, zinc coatings

All these and similar surface treatments usually have a negative influence on cutting results. Oxygen and e.g. paint react in the kerf during cutting. This results in a very rough, frayed cut. Another problem is the difference in layer thickness in one sheet. Different thicknesses of protective coating cause errors in the capacitive detection.

#### Solutions:

Thicknesses up to 4 mm: Cut with nitrogen

Thicknesses > 4 mm: Etch off protective layer in the first pass.

#### NOTE



*Zinc-coated sheets are not suitable for pre-etching!*



#### 12.4.5 Alloy elements


Cutting quality and cutting performance depend on alloy elements. In steel, a greater content of Si creates a rough cut edge and increases slag formation and burring. Carbon contents > 0.16% can lead to poor results on sharp edges and small holes. Bystronic recommends laser sheets having controlled alloying constituents when working at the extreme sheet-thickness range.

	C content	Si content
RAEX 250	0,12%	0,01%
RAEX 420	0,13%	0,01%

#### 12.4.6 Oiling

Piercing splashes adhere less strongly on oiled sheets. This means that capacitate scanning is disrupted less. You can oil sheets in two ways.

- Working with Crossjet
- Buy oiled sheets
- Oil dry sheets manually

	<b>⚠ CAUTION</b>
	Do not use combustible oil. Always use welding protection oil (MOTOREX PROWELD 264 Bystronic order no. 8861850).

#### 12.4.7 Radii

Always avoid acute contours in laser cutting. It is much easier for the machine to cut a radius of e.g. 1...2 mm at all changes in direction. This has the following advantages:

- corners do not burn
- time gain thanks to continuous process
- clean laser part
- less risk of injury on the part

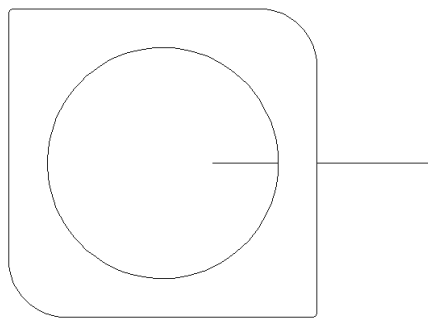
## 12.5 Programming

### 12.5.1 Piercing and initial cuts

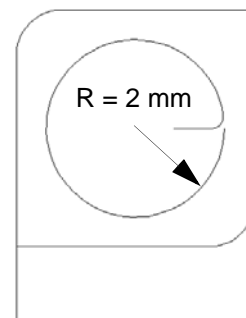
Piercing causes the sheet to heat up very strongly. Careful positioning of piercing points and adequate length of initial cuts can help prevent heat build-up.

Limit thickness sheet always requires a radius initial cut in order to ensure that the cutting process is as constant as possible.

Poorly located initial cuts



Well located initial cuts with additional radius initial cut



### 12.5.2 Piercing

Parameter values for the piercing process differ from cutting values.

#### 12.5.2.1 *Continuous wave piercing*

Advantage: fast piercing

Disadvantage: piercing crater.

#### 12.5.2.2 *Pulsed mode piercing*

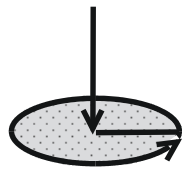
Advantage: small piercing hole.

Disadvantage: piercing takes a long time.

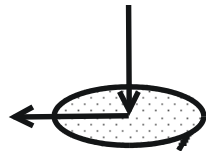
#### 12.5.2.3 *On-the-fly piercing during lowered positioning*

Use the parameters for «Flying start of cutting». These parameters ensure that the lens is protected against splashing.

### 12.5.2.4 Piercing with circular pierce in stainless steel and aluminum



1. After piercing, the machine cuts a 2 mm diameter circle with laser power.



2. Lowered positioning and approaching the contour through the start hole.

The hole is required in order to blow out the melt created during the approach and to initiate the cutting process.

### 12.5.2.5 Pulsed piercing on the contour

Pulsed piercing is used if piercing needs to be performed on the contour, or if the contour is very small and the piercing crater would impair the contour.

#### NOTE



*Sheet thickness in mm corresponds approximately to piercing time in seconds.*

If you need the cut-out part and the cut-out itself use «Pulsed mode piercing» (M14/15) directly on the contour.

### 12.5.3 Special piercing cuts in thick sheets

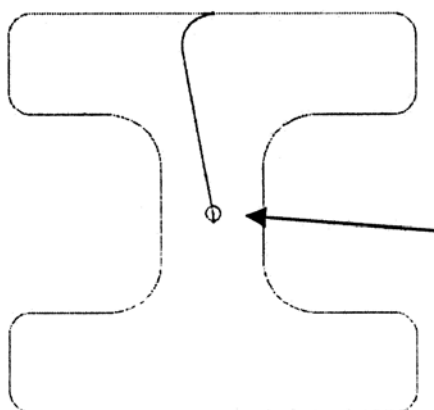
As laser powers increase it is possible to cut ever thicker materials. As a means of achieving optimum process reliability, the piercing procedure described below can be used to both increase reliability and reduce the minimum diameter that can be cut. Version 6 and above of the Technology Wizard supports special piercing cuts.

#### 12.5.3.1 Applications

Equipment	Thickness	Bylaser
Steel	18...25 mm	4000
Steel	18...20 mm	3000
Stainless	15...20 mm	4000

- if the hole is < sheet thickness
- tight, complex inner contours
- if the sheet is too hot and the cut quality gets bad

#### 12.5.3.2 Programming



1. Select the sheet thickness in the Technology wizard and set the technology automatically. Add macro 1 for small bores or contours depending on size.
2. For difficult contours, position the initial cut so as to maximize initial cut length.

3. Program a start hole at the end of an initial cut (for an inner contour).
  - Start hole radius in stainless steel = 1.25 mm
  - Start hole radius in Steel = 1.6 mm
4. Set technology automatically again. The start hole is pierced in pulsed mode and cut with macro 2.
5. Copy the start hole with technology to all ends of initial cuts where you want special piercing.
6. Delete the cutting sequence for the entire part.
7. Select cutting sequence manually.  
 Recommendation for steel: first cut all start holes, then cut the most difficult or the smallest contours (reduces the heat).

### 12.5.3.3 Cutting

1. Load program and cutting parameters.
2. Cut the cutting plan.

### 12.5.4 Initial cutting pane and end cutting pane for steel

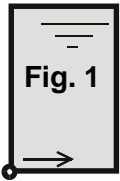
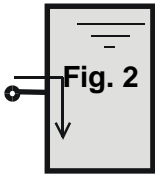
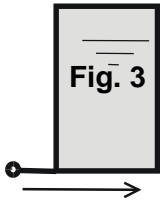
The technology wizard as of BYSOFT 6.2 greatly facilitates setting the initial cutting pane. The length and geometry of the initial cut are set automatically.

#### 12.5.4.1 Outer contour

Piercing is usually done in CW mode. This form of piercing is fast but makes a larger pierce than in pulsed mode. Therefore the pierce is usually located outside the contour (Figs. 2 and 3). The connecting line between the pierce and the contour is referred to as the initial cutting pane or initial cut for short.

A change in direction of the laser beam between the end of the initial cut and the contour appears as an irregularity on the work piece (Fig. 2). Therefore, if possible program the initial cut of the outside contour in the extension of a geometry element (Fig. 3).

However, program the initial cut perpendicular to a geometry element (Fig. 2) if you want to use the automatic round-off function or if you program a small inside contour in a sheet thickness greater than 10 mm (heat not carried away from initial cut when the cut is finished).

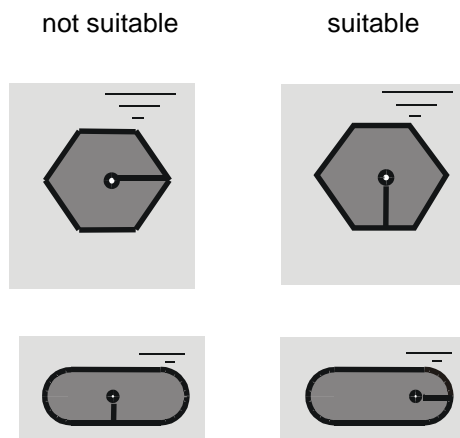
Parts requiring finishing	Small inside contours in thick sheet, corners with radii	Thin sheet, corners without radii
		
CW pierce on contour: Corner damaged	CW pierce outside contour Corner damaged	CW pierce outside contour. Move into contour in a line. No markings on the part

Program the initial cut as a stand-alone geometry element.

#### 12.5.4.2 Inside contour (cut-outs)

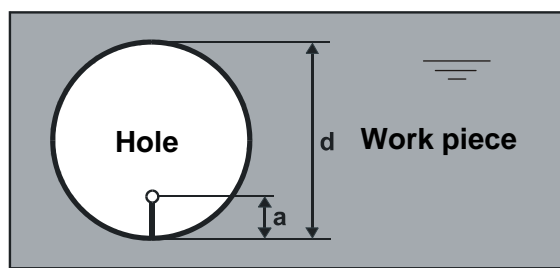
With small inside contours it is important that the heat input during piercing can flow off before cutting begins. Do not program the initial cutting pane in confined areas and at as large as possible an angle to the contour. This allows the heat to flow away more easily.

Fig.12.5-1 *small inside contours*



The length of the initial cut depends on sheet thickness and the diameter of the hole.

Fig.12.5-2 *Hole diameter*

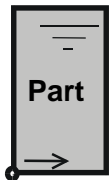
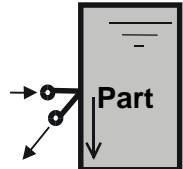
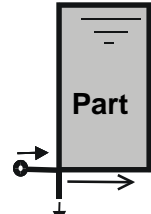


Sheet thickness [mm]	Hole diameter «d» [mm]	Initial cut length «a» [mm]
1...6	$d < 10$	from hole center ( $d/2$ )
	$d > 10$	5
8...12	$d < 20$	from hole center ( $d/2$ )
	$d > 20$	10
15...25	$d < 30$	from hole center ( $d/2$ )
	$d > 30$	15

### 12.5.5 Initial cutting pane and end cutting pane for stainless steel and aluminum

Piercing is usually done with oxide-free cutting in CW mode. In oxide-free cutting, the acceleration and deceleration paths must be outside the contour in order to avoid whiskers.

#### 12.5.5.1 Outer contour

poor	OK	good
		
<ul style="list-style-type: none"> <li>– CW pierce on contour</li> <li>– Corner damaged</li> </ul>	<ul style="list-style-type: none"> <li>– CW pierce outside contour</li> <li>– Point of cut-in and cut-out visible on contour</li> </ul>	<ul style="list-style-type: none"> <li>– CW pierce outside contour</li> <li>– Move into contour in a line</li> <li>– Markings on the part</li> </ul>

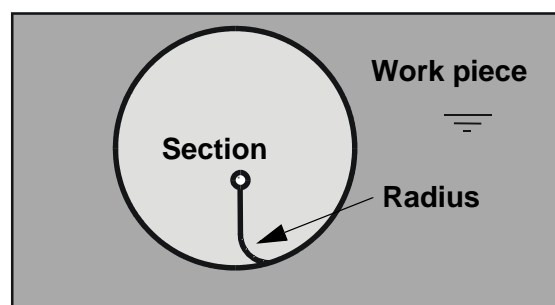
#### 12.5.5.2 Inside contour (cut-outs)

##### NOTE



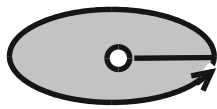
For holes and other cut-outs it is an advantage to program the transition from the initial cutting pane to the contour with a radius.

Fig.12.5-3 Inside contour cut-out

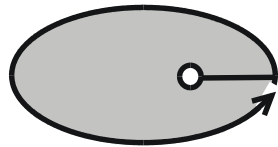




### 12.5.5.3 Initial cut length for cut-outs



Piercing in center of hole up to 30 mm hole diameter

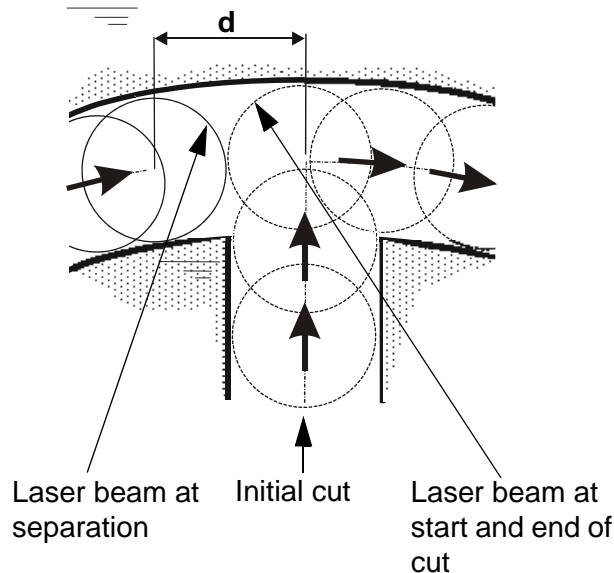


Length of initial cut depends on sheet thickness as of a hole diameter of 30 mm

### 12.5.6 Microjoints

Without microjoints, a cut-out is completely cut, i.e. when the cut is completed the laser joins the start of the cut again. However, separation of the material occurs before the geometric end of the cut by at least the width of the kerf (**d**):

Fig.12.5-4 *Part cut-out microjoint*

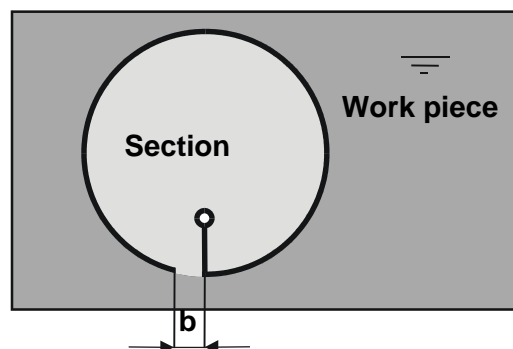


At this point the cut-out part already tilts and the laser beam hits the side of the tilting part causing heat erosion. The melt of this burn-out reflects the laser beam and causes more burn-out in the cut-out itself.

Use microjoints to avoid this burn-out. The CNC system has an automatic microjoint function.

Adding a microjoint causes the laser beam to switch off by distance (**b**) before the geometric end of the cut-out. The cut-out stays connected to the part and does not tilt off. Press the cut-out out of the part after cutting the plan or remove the cut-out with a rod magnet when the protective door is open. Set web width (**b**) at least as large as kerf width (**d**).

Fig.12.5-5 *Microjoint*



## 12.5.7 Corners

### 12.5.7.1 Cutting obtuse corners with radii

Avoid corners without radii wherever possible. Advantages of corners with radii over corner without radii:

- Axes are moved more dynamically
- smaller heat affected zone
- less burring
- time gain
- lower risk of damaging contour

Optimum rounding off radius:

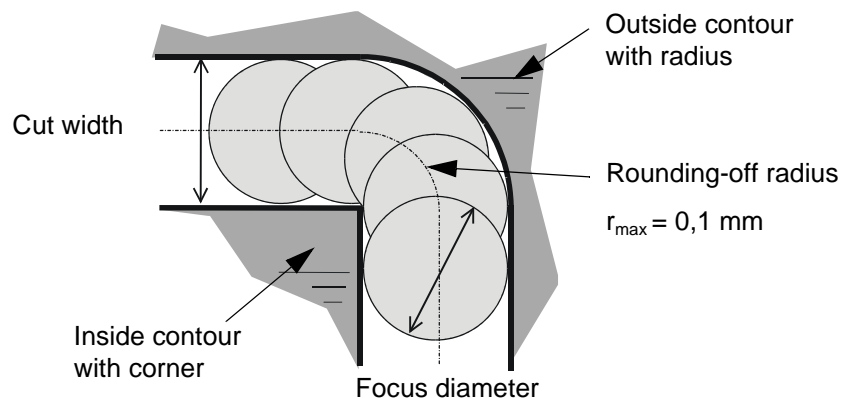
$R_{\text{optimum}}$  = sheet thickness in mm divided by 10, but not less than 1 mm.

Maximum radius, if a sharp corner is needed on the inner contour:

$R_{\text{edge}}$  = half cut width

This radius creates a sharp corner but the axes already move dynamically:

Fig.12.5-6 Radii in contours



### 12.5.7.2 Cutting obtuse corners with «corner tolerance»

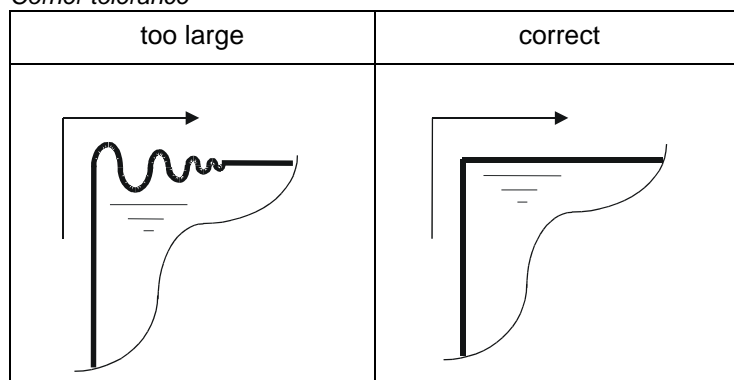
If you need a sharp corner on the outside contour for further processing, program the corner without a rounding-off radius.

#### NOTE



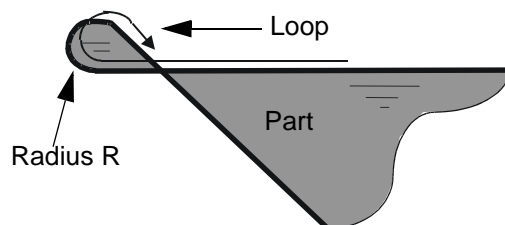
*If corner tolerance is too high, overshooting can occur.*

Fig.12.5-7 Corner tolerance



### 12.5.7.3 Acute corners in thin sheet with loops

Fig.12.5-8 Corner with loops



Cutting corners in thin sheet at high speed requires looping. This procedure has the following advantages:

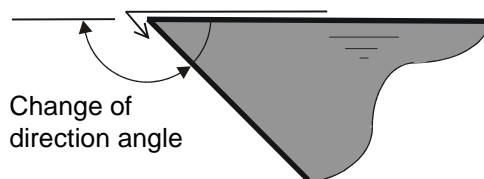
- the axes travel over a sharp corner with continuous change of direction
- the part itself is cut at constant speed
- prevents axis overshoot and additional burring
- reduces heat effect in the corner

### 12.5.7.4 Acute corners in thick sheet with the «dwell time» parameter

Cutting thick sheet with loops creates too much heat on the work piece. Therefore, use the «dwell time» parameter for thick sheet when cutting acute corners.

The machine moves into the corner and waits for the set «dwell time» before leaving the corner.

Fig.12.5-9 Critical angle dwell time



If you enter a value for the «dwell time» parameter, the machine decelerates and waits at every critical angle greater than the «critical angle dwell time» parameter set in the CNC.

### NOTE



*Where the angle on the wanted part is too small, the machine will automatically follow a small radius; thus the dwell time is no longer active.*

### 12.5.8 Pre-piercing

If you are cutting parts with lots of holes and openings or if small parts are tightly nested, Bystronic recommends pre-piercing.



- Use the BYSOFT 5.3 ByADD or Bysoft 6.0 Bywork software to add the pre-piercing functions to the LCC plan
- Pre-pierce whole sheet
- Clean off piercing splashes from sheet
- Let the sheet cool down if necessary
- Cut

### TIP



*Use a smaller nozzle for pre-piercing than for cutting. (e.g. K12 instead of K17). The piercing pressure must be doubled in order to prevent splashes on the lens. Pre-piercing considerably reduces the amount of heat introduced into the sheet. It also reduces the size of piercing holes.*

*After pre-piercing all the holes, the machine automatically moves to the zero point. Here you can conveniently change the nozzle.*

*Reset the «Gas pressure, pre-piercing» back to the original value and reduce the piercing time to 0.*

*This procedure allows you to cut holes and openings of 0.8 to 1.0 times the sheet thickness in normal thickness sheet without pulsing.*

### NOTE



*If the sheet heats up severely during cutting it expands. This can cause pre-punched holes to shift.*

#### Solution:

Reduce size of cutting area by dividing a large cutting plan (e.g. 1x2 m) into two small (e.g. 1x1 m) plans.

The thermal expansion problem means that you should only use multiple cuts to cut individual parts that have no tolerances.

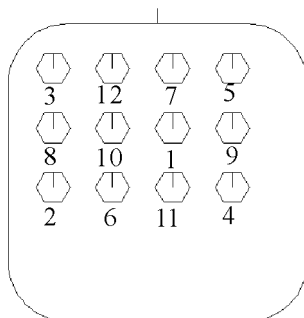
### 12.5.9 Cutting small parts

#### 12.5.9.1 with normal thickness

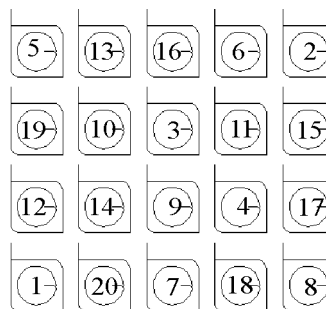
In order to be able to cut such parts with adequate process safety in production, observe the following guidelines:

- Use a radius (R) for all acute contours.  $R = \frac{1}{10}$  x sheet thickness, but at least 1 mm.
- Smallest openings (holes, slits) 1,2...1,5 x sheet thickness.
- Minimum web width 1,2...1,5 x sheet thickness.
- Minimum part spacing 1.0...1.5 x sheet thickness, but at least 10 mm in order to ensure reliable capacitive detection
- When cutting with tactile detection, parts spacing min.  $\frac{1}{2}$  ring diameter.
- Initial cut length 1 x sheet thickness, but at least 10 mm.
- Careful programming (cutting sequence in DIN part) in order to ensure optimum heat distribution in the part.
- Well thought-out nesting (cutting sequence of individual parts in the cutting plan). This ensures good distribution of heat in the cutting plan.

**Fig. individual part**



**Fig. cutting plan**



- The numbers indicate the cutting sequence.

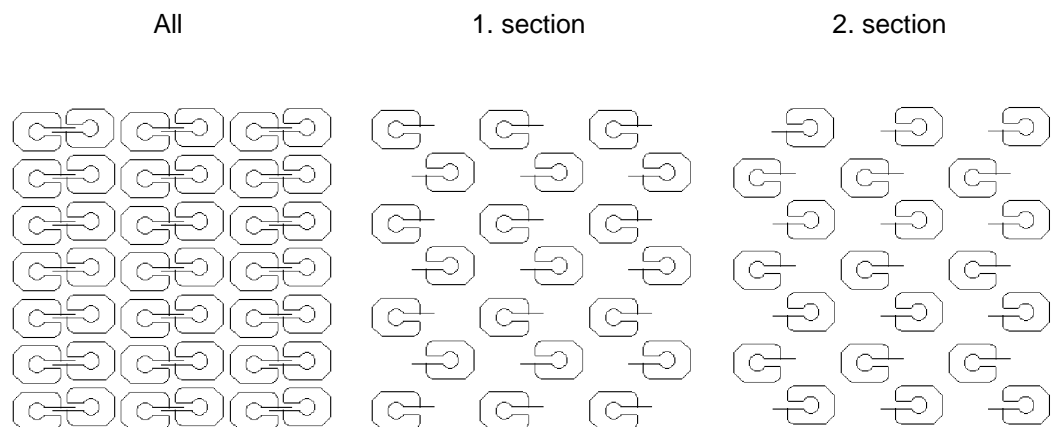
Exceeding guidelines may cause sheet overheating. First signs of overheating are indicated by rough cut surfaces, burnt contour cuts and melt not blown out.

### Example 1: Cutting in 2 passes

*Raex 250, thickness 15 mm*

Sheet dimension	x = 675 mm
	y = 689 mm
Parts dimension	x = 100 mm
	y = 80 mm
Shape spacing	x = -18 mm
	y = 17 mm

The complete cutting plan is divided into two new cutting plans. Only every second part is cut in the first plan (cut 1). Now you have to interrupt cutting until the temperature of the sheet drops below 40 °C. Only then can you cut the remaining parts (cut 2).



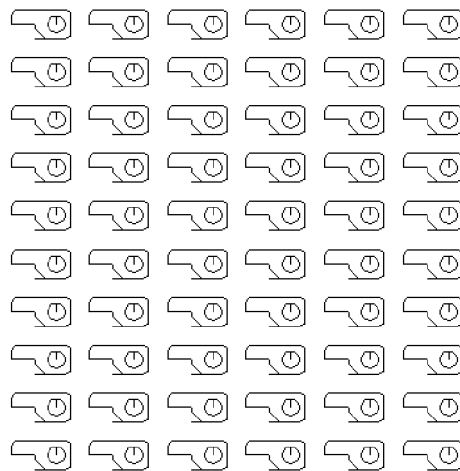
### Example 2: Cutting in 3 passes

*Raex 250, thickness 12 mm*

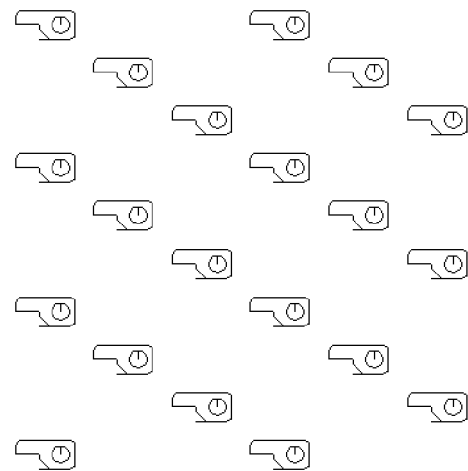
Sheet dimension	x = 477 mm
	y = 485 mm
Parts dimension	x = 62 mm
	y = 30 mm
Shape spacing	x = 20 mm
	y = 20 mm

The same procedure as with two passes only that every third part is cut in the first pass (cut 1). Now you have to interrupt cutting until the temperature of the sheet drops below 40 °C. Only then can you cut the second groups of parts (cut 2). The third cut is cut the same way as the second cut.

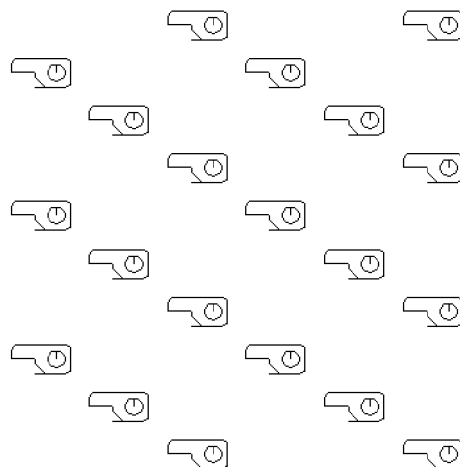
All



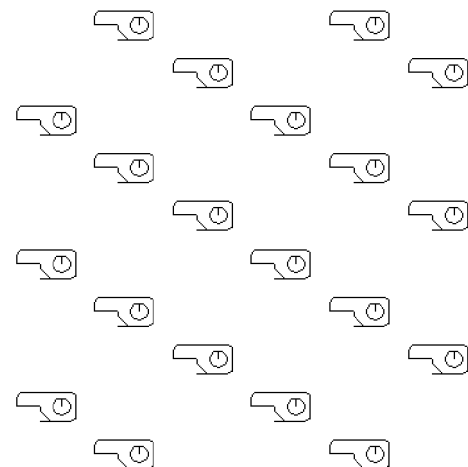
1. section



2. section



3. section





**12.5.9.2 With limit thickness**

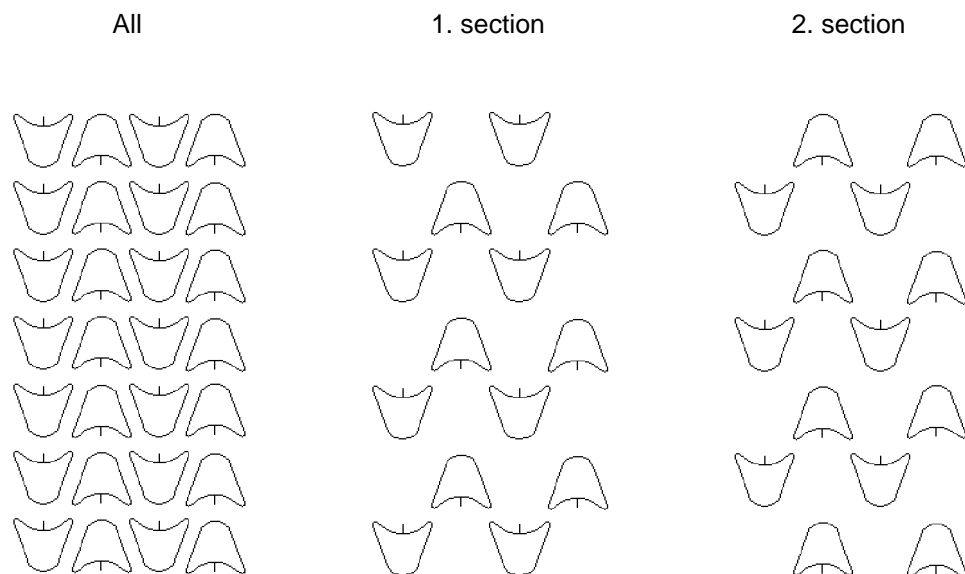
Observe the following guidelines:

- Use a radius (R) for all acute contours.  $R_{\min} = 1 \text{ mm}$
- Radius initial cut,  $R_{\min} = 1,0 \dots 3,0 \text{ mm}$
- Smallest openings (holes, slits)  $1,5 \dots 2,5 \times$  sheet thickness
- Minimum web width  $1,5 \dots 2,5 \times$  sheet thickness
- Minimum part spacing  $1,5 \dots 2 \times$  sheet thickness, but at least 15 mm
- Initial cut length  $1 \times$  sheet thickness, but at least 15 mm
- Careful programming (cutting sequence in DIN part, see example Fig. individual part) in order to ensure optimum heat distribution in the part
- Well thought-out nesting (cutting sequence of individual parts in the cutting plan, see example Fig. cutting plan). This ensures good distribution of heat in the cutting plan
- Possibly with etching

**Example 3: Cutting in 2 passes***Raex 250, thickness 18 mm*

Sheet dimension	x = 485 mm
	y = 960 mm
Parts dimension	x = 122 mm
	y = 110 mm
Shape spacing	x = -1 mm
	y = 30 mm

Only cut 1 and 2 when sheet temperature is less than 40 degrees.



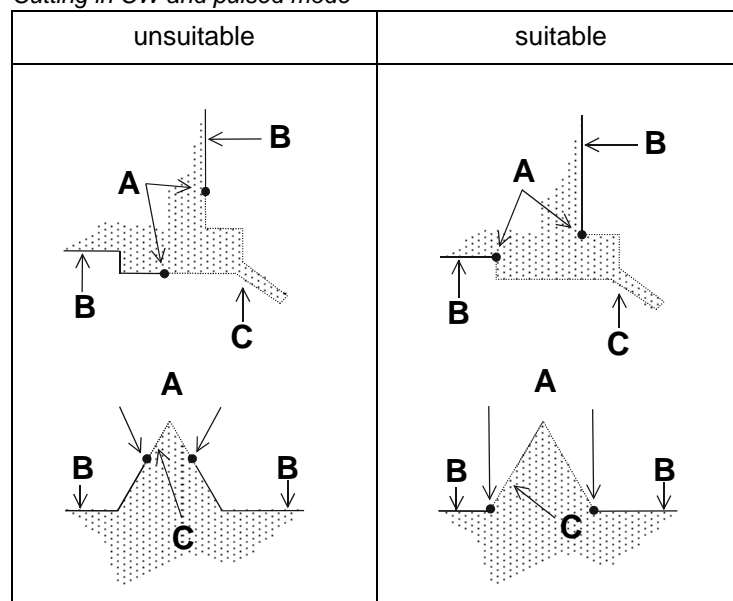
Despite the suggested measures, the necessary process reliability when cutting small parts may not be achieved in production at the limits of sheet thickness. Although the parts can be cut, they can only be cut as individual parts but not as a nested cutting plan. The operator's experience will decide where the limit is.

## 12.5.10 Pulsed mode cutting

Use laser cutting in pulsed mode for critical contours.

- Sheet thickness range 1 to 5 mm
- Cutting speed is approx. 5 to 10 x less than with CW laser cutting
- Sheets of thickness 1 to 6 mm are well suited to pulsed machining
- Sheets of thickness 8 to 5 mm can only be cut in pulsed mode if machine settings are optimum and laser power is sufficient. Rough grooves form and the "cutting" feed rate is low.
- Do not cut whole parts in pulsed mode.
- Set the switchover point from pulsed to CW cutting so that switchover takes place in a corner.
- Do not switch on straight lines or large contours as switching from one mode to another causes a small chip:

Fig12.510 Cutting in CW and pulsed mode



Legend:

- A. Switchover point
- B. CW cutting
- C. Pulsed cutting

### NOTE



*If possible switch pulsing on after CW cutting and not vice-versa. This improves transitions on the cut edge from CW cutting to pulsing.*

## 12.6 Definitions and limits

Cutting steel causes very high temperatures in the sheet. These are due to

- the laser beam
- the carbon (C) in the material assisting the melting process
- the assist gas (O<sub>2</sub>) supporting melting.
- other alloy components in the sheet

Applying heat and heat generation are therefore physical processes.

The heat applied can get so high that cut quality gets so poor that the melt is no longer blown out. The cut parts are useless.

These problems occur in different material thicknesses, part sizes, holes shapes and laser types.

These cutting instructions are intended to highlight potential cutting problems before they occur, and to show what is and is not possible.

The following definitions are required.

### 12.6.1 Definition of limit thickness / normal thickness

When cutting materials whose thickness lies in the limit-thickness region, the following points are crucial to maintaining constant results:

- Quality of material and gas
- Condition of lens and system
- Overall constancy of laser system

Limit thicknesses are material thicknesses at the limit of the cutting performance of the laser. All value below these limit thicknesses are normal thicknesses.

By taking account of these cutting instructions, materials can be cut on Bystronic laser cutting machines up to the following maximum limit thicknesses:

Max. sheet thickness in	Bylaser			
	2200	3000	4000	4400
Structural steel	12 mm	20 mm	20 mm	25 mm
Stainless steel	6 mm	10 mm	12 mm	20 mm
Aluminum	4 mm	8 mm	8 mm	12 mm

Smallest hole in	Bylaser			
	2200	3000	4000	4400
Structural steel with pulsed piercing	...10 mm: 0.8...1 x sheet thickness	...10 mm: 0.8...1 x sheet thickness	...15 mm: 0.6...1 x sheet thickness	...15 mm: 0.6...1 x sheet thickness
Structural steel with pulsed piercing/cutting	...10 mm: 0.5...0.8 x sheet thickness	...10mm: 0.5...0.8 x sheet thickness	...15 mm: 0.5...0.8 x sheet thickness	...15 mm: 0.5...0.8 x sheet thickness
Stainless steel with macro	0.5...2 x sheet thickness	0.5...2 x sheet thickness	0.5...2 x sheet thickness	0.5...2 x sheet thickness
Aluminum with macro	0.5...2 x sheet thickness	0.5...2 x sheet thickness	0.5...2 x sheet thickness	0.5...2 x sheet thickness
Various materials with macro	0.5...2 x sheet thickness	0.5...2 x sheet thickness	0.5...2 x sheet thickness	0.5...2 x sheet thickness
Stainless steel with CW	>2 x sheet thickness	>2 x sheet thickness	>2 x sheet thickness	>2 x sheet thickness
Aluminum with CW	>2 x sheet thickness	>2 x sheet thickness	>2 x sheet thickness	>2 x sheet thickness
Various materials with CW	>2 x sheet thickness	>2 x sheet thickness	>2 x sheet thickness	>2 x sheet thickness

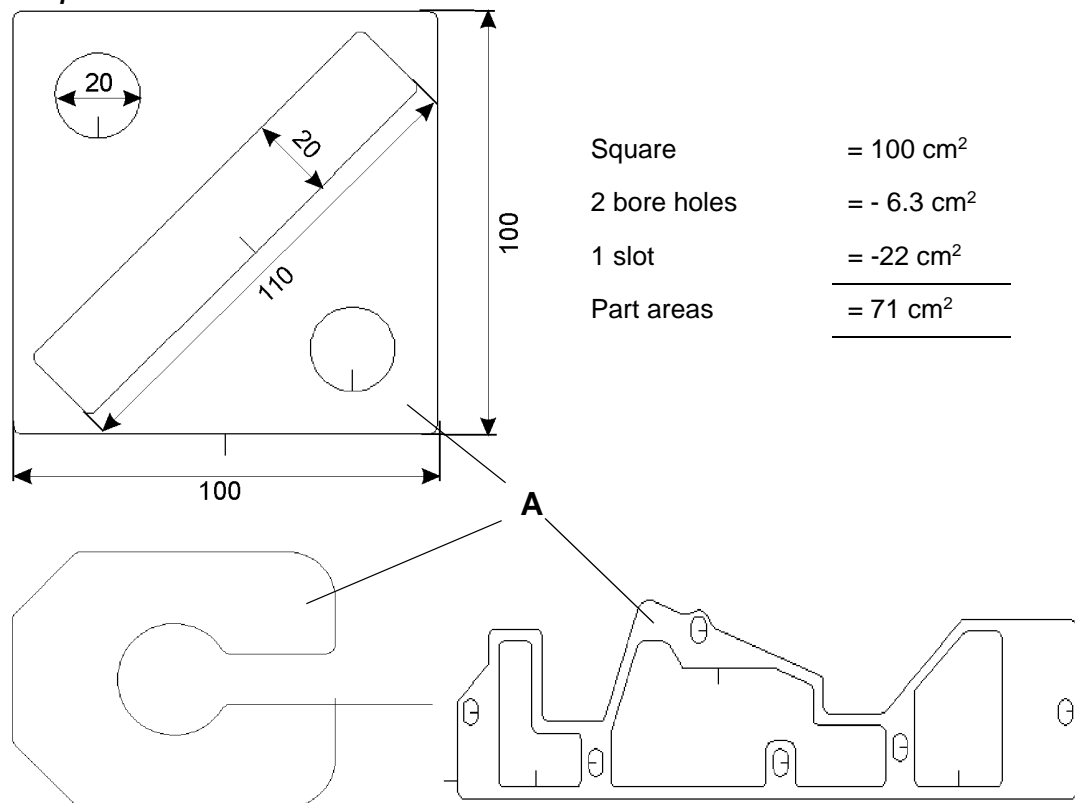
Flying piercing in	Bylaser			
	2200	3000	4000	4400
Steel (sheet thickness)	3 mm	3 mm	3 mm	3 mm
Stainless steel	3 mm	3 mm	3 mm	3 mm
Aluminum	3 mm	3 mm	3 mm	3 mm
Various materials	3 mm	3 mm	3 mm	3 mm

### 12.6.2 Definition of part area A

Bystronic defines the area of a geometric part according to the following criteria.

**Part area A =** area inside an enclosed outside contour. Bore holes, slits and openings are subtracted.

Fig.12.6-1 **Example:**



## 12.6.3 Definition of part size

Severe heat accumulation (build-up) above all occurs at limit thicknesses and with small parts. Allocation of part size depends on sheet thickness.

*Definition of part size as dependent on sheet thickness*

Thickness in mm	small parts	medium parts	large parts
15,0...20,0	A = 150	150 = A = 1350	1350 = A
12,0...14,9	A = 100	100 = A = 900	900 = A
8,0...11,9	A = 75	75 = A = 675	675 = A
4,0...7,9	A = 40	40 = A = 360	360 = A
2,0...3,9	A = 20	20 = A = 180	180 = A
0,5...1,9	A = 10	10 = A = 90	90 = A

Table applies to BYSTRONIC laser series.

If heat problems occur when cutting small part sizes up to max. 4 mm sheet thickness, you can cut with nitrogen (N<sub>2</sub>) instead of with oxygen (O<sub>2</sub>).

### Advantages:

- Nitrogen greatly cools the cut edge and the part
- Bright-finished metallic surface
- Very small heat-affected zone

Cutting parameters are similar to stainless steel sheets of the same thickness. Only feed rate needs to be reduced by 10 to 20%.

#### 12.6.4 Definition of web width and minimum web width

Hole separations, hole-to-outside-contour distance, and distances between contours are generally referred to as web width. The smallest distance inside a part is referred to as minimum web width.

Fig.12.6-2 *Example A*

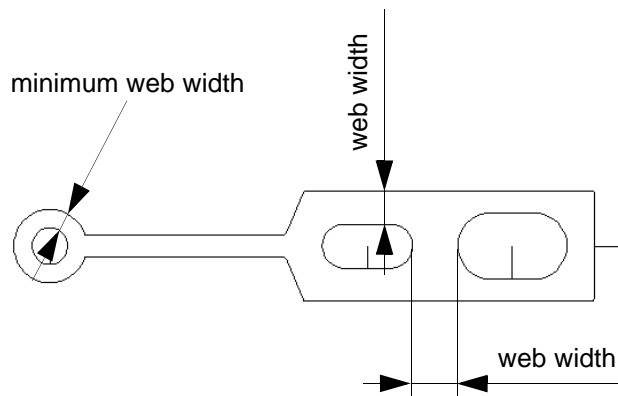


Fig.12.6-3 *Example B*

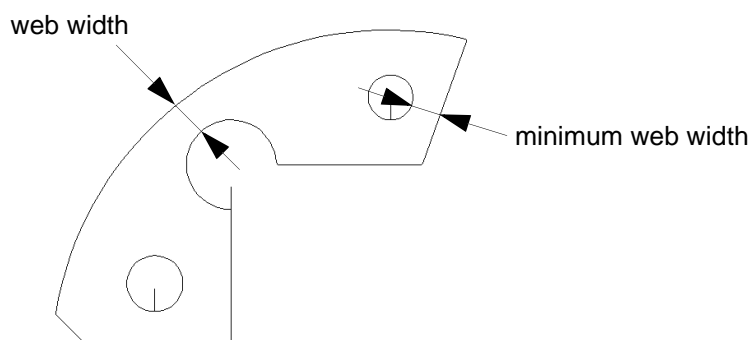
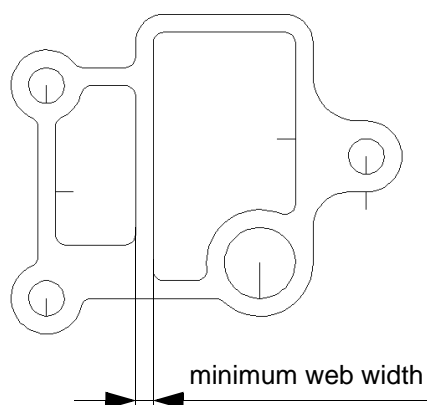


Fig.12.6-4 *Example C*





## 12.6.5 Part spacing

Part spacing is the minimum distance between two parts. Initial cuts outside the part belong to the part.

Fig.12.6-5 *Example A*

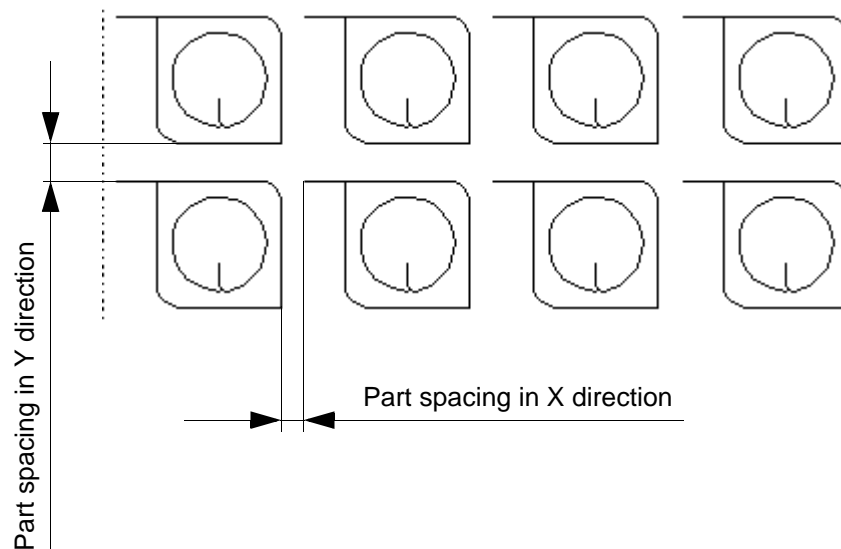
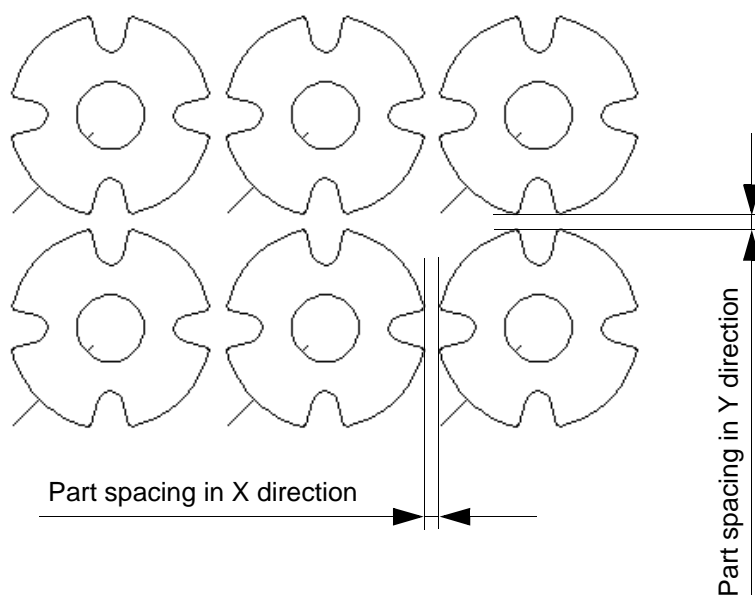


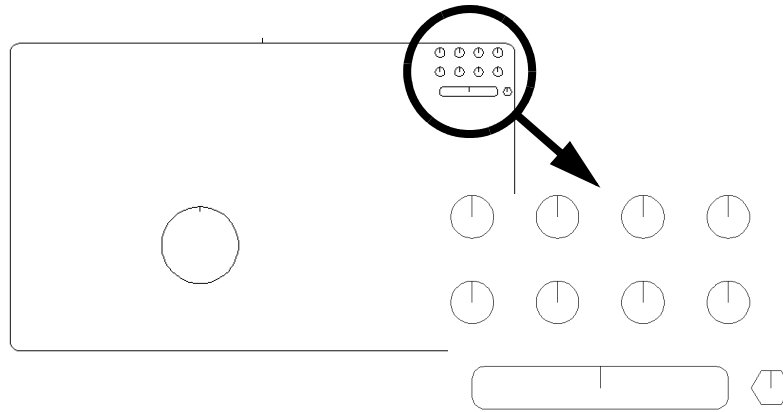
Fig.12.6-6 *Example B*



### 12.6.6 Master gauges

Large parts can also overheat partially if you are cutting narrow master gauges. Master gauges are subject to the same rules and definitions as individual parts.

Fig.12.6-7 *Example B*



The same rules and definitions apply as to individual parts.

### 12.6.7 Achievable parts accuracy

The tables shown are based on the DIN standard 2310 "Thermal Cutting", but have been extended to cover the Bystronic Laser AG laser machines. The specified tolerances are values obtained from practical experience of laser gas cutting and fusion cutting.

Thickness t [mm]	Part length L [mm]					
	0 < L < 10	10 < L < 100	100 < L < 300	300 < L < 1000	1000 < L < 2000	2000 < L < 3000
0,5 < t < 3	[+/-] 0,1	[+/-] 0,1	[+/-] 0,2	[+/-] 0,25	[+/-] 0,3	[+/-] 0,4
3 < t < 6	[+/-] 0,2	[+/-] 0,2	[+/-] 0,2	[+/-] 0,25	[+/-] 0,4	[+/-] 0,5
6 < t < 10	[+/-] 0,2	[+/-] 0,2	[+/-] 0,2	[+/-] 0,3	[+/-] 0,4	[+/-] 0,5
10 < t < 15	[+/-] 0,25	[+/-] 0,25	[+/-] 0,3	[+/-] 0,3	[+/-] 0,4	[+/-] 0,6
15 < t < 20	[+/-] 0,3	[+/-] 0,3	[+/-] 0,3	[+/-] 0,3	[+/-] 0,5	[+/-] 0,6

The following conditions must be met in order to achieve the tolerances above:

- Optimized cutting results, especially tool compensation (normally the Bystronic lens carrier parameters).
- The sheets must not heat up more than 20°C during laser cutting.
- When parts are measured, the flatness of the parts must be identical to the flatness of the cutting position.
- Internal stress of the sheets is not taken into consideration in the tables. Warps have a negative effect on the results.
- The superficial roughness must not influence the measurement.
- Measurements must not be performed on the contour at the starting point.
- Relevant measurements must only be performed on parts with bare edges.
- Good system conditions including all lenses.
- Measurement and analysis processes according to VDI/DGQ 3441

### 12.6.8 Unsuitable parts for production

These are usually small parts in limit thicknesses, although special geometries in normal thicknesses can cause problems.

#### Example 4

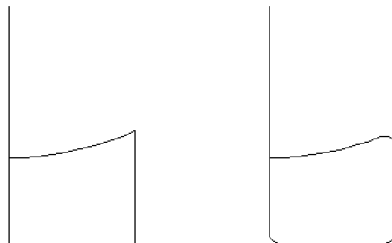
*Raex 250, thickness 20 mm*

Sheet dimension  $x = 88 \text{ mm}$

$y = 83 \text{ mm}$

Parts dimension  $x = 25 \text{ mm}$

$y = 17 \text{ mm}$



- Shape 1 without radii cannot be cut this way
- Shape 2 with  $R = 2 \text{ mm}$  can be cut as an individual part on certain conditions
- Parts of this size in limit thickness are unsuitable for production

## 12.7 Cutting process

### 12.7.1 Cutting structural steel

Start of cutting after piercing in continuous wave.

The following table lists guidelines for waiting time before cutting and for the acceleration factor to start cutting in continuous wave. During the set waiting time before cutting the heat created by piercing can dissipate in the work piece. This prevents large chips when the laser starts moving.

#### NOTE



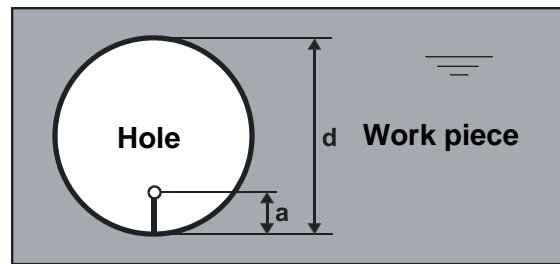
*For holes with a diameter smaller than sheet thickness, increase waiting time before cutting based on the following guidelines or pierce in pulsed mode.*

Sheet strength	Focal length	Waiting time before cutting		Acceleration factor
		Shape > sheet thickness	Shape < sheet thickness	
[mm]	[Inch]	[s]	[s]	Start-up
1	5"	0,1	0,1	1
2	5"	0,2	0,2	1
3	5"	0,2	0,2	1
4	7,5"	0,3	0,3	1
5	7,5"	0,3	0,3	1
6	7,5"	0,4	0,8	1
8	7,5"	0,5	1,2	1
10	7,5"	0,8	1,5	1
12	7,5"	0,8	2,0	1
*15	7,5"	0,8	2,5	1
*20	7,5"	1,0	3,0	1

\* These thicknesses cannot be cut with «Bylaser 2200».

### 12.7.1.1 Initial cuts for holes

Fig.12.7-1 Hole diameter



Sheet thickness [mm]	Hole diameter «d» [mm]	Initial cut length «a» [mm]
1...6	$d < 10$	from hole center
	$d > 10$	5
8...12	$d < 20$	from hole center
	$d > 20$	10
15...25	$d < 30$	from hole center
	$d > 30$	15

Also refer to the technology wizard in the BYSOFT programming software.

### 12.7.1.2 Hole roundness

You can influence hole roundness by changing the dynamic factor. If holes are cut out of round, set a smaller dynamic factor.

The dynamic factor depends on the type of machine, cutting feed and the laser.

### 12.7.1.3 Guidelines for the dynamic factor

Sheet strength [mm]	Bysprint	Bystar 3015	Bystar 4020/25	Byspeed	Bytube
1...3	1,0	0,8	0,5	1,8	0,8
4...0	0,8	0,8	0,8	1,5	0,5

For general information on programming initial cuts please see chapter «Initial cutting pane and end cutting pane for steel», while the chapter «Machining holes» contains tips on cutting holes.

### 12.7.1.4 Obtuse corners with «corner tolerance» parameter (quality cuts)

The following table contains recommended values for the «corner tolerance» parameter according to the laser machine. General information on cutting corners can be found in the chapter «Machining corners».

### 12.7.1.5 Corner tolerance guides [mm]

Sheet strength [mm]	Bysprint	Bystar 3015	Bystar 4020/25	Byspeed	Bytube
1...2	0,15	0,10	0,05	0,25	0,10
3...4	0,10	0,10	0,07	0,25	0,10
5...10	0,10	0,10	0,10	0,25	0,10

### 12.7.1.6 Cutting acute corners in thin sheet with loops

Sheet strength [mm]	Loop radius [mm]
1...5	3
6...10	4
12...20	5

### 12.7.1.7 Acute corners in thick sheet with the «dwell time» parameter

The following table contains guides for the «dwell time» parameter depending on sheet thickness. General information on cutting corners in thin sheets can be found in the chapter «Machining corners».

Sheet strength [mm]	Dwell time [ms]
1...12	100
13...15	200
16...20	500

### 12.7.1.8 Cutting thick sheet

General notes:

- Use the serrated grid; for critical parts consider shimming the sheet off the support grid.
- Spacing a of individual parts in the cutting plan: a = double sheet thickness.

#### 12.7.1.9 Piercing

- Oil the sheets. Oiling prevents piercing splashes from sticking on the surface of the sheet and does not have any negative effect on the cutting process.
- The Crossjet allows you to spray an oil mist. The oil mist is a mixture of air and oil. The oil mist cools the piercing point. The Crossjet function can be used to blow off piercing splashes. This prevents piercing splashes from sticking to the sheet.

Use the «Bywork» module of the BYSOFT programming software to specify the sequence of piercing thick sheet with numerous pierces (etching).

- All piercing is done before cutting the contours. This greatly reduces and distributes more evenly the heat input into the work piece.
- For etching, for example, you can also use a cutting head with an older lens. However, use a cutting head with an intact lens to cut the contours!
- After completion of the etching program, wipe any splashes off and continue cutting.

#### 12.7.1.10 Cutting

Make sure that the sheet temperature does not exceed 40°C otherwise cut edges may “chip”.

- Wait before starting to cut small holes until the pierce has cooled down («dwell time before cutting» parameter) or even use the etching program for sheet thicknesses 15...20 mm.
- Note geometric conditions when specifying the cutting sequence. Cut small holes and complicated contours before other contours.
- In a first pass, only cut every other part and then the remaining parts in a second pass.
- Interrupt cutting until the sheet has cooled down to less than 40°C if it still heats up to more than 40°C despite these measures.



## 12.7.2 Oxide-free cutting of stainless steel

### NOTE



*Assist gas is nitrogen!*

### 12.7.2.1 Start of cutting after piercing

After the set piercing time has expired, the machine starts moving at the set acceleration factor. Sheet thicknesses for which the entry “**yes**” is indicated in the “**Circular piercing required**” column additionally require a start hole.

### 12.7.2.2 Bylaser 2200

Sheet strength [mm]	Acceleration factor Start-up [-]	Circular piercing required
1...1,5	1	No
2...2,5	0,7	No
3	0,3	No
4	0,05	No
5	0,02	No

### 12.7.2.3 Bylaser 3000/4000/40s

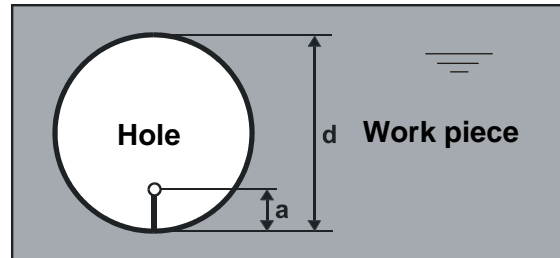
Sheet thickness [mm]	Acceleration factor start- up [-]	Circular piercing required
1	1	no
2	0,8	no
3	0,5	no
4	0,4	no
5	0,1	no
6	0,02	no
8...12	0,001	Yes
**15	0,001	Yes

\*\*Only for Bylaser 4000

**12.7.2.4 Initial cut for hole**

The length of the initial cut depends on sheet thickness and the diameter of the hole:

Fig.12.7-2 Hole diameter



Sheet thickness [mm]	Hole diameter «d» [mm]	Initial cut length «a» [mm]
1...6	$d < 20$	from hole center ( $d/2$ )
	$d > 20$	10
8...12	$d < 30$	from hole center ( $d/2$ )
	$d > 30$	15

**12.7.2.5 Hole roundness**

The same values apply to roundness of holes and the dynamic factor as for structural steel. See chapter «Cutting structural steel».

**12.7.2.6 Corner tolerance (quality cuts)**

The same values apply to corner tolerance as for structural steel. See chapter «Cutting structural steel».

**12.7.2.7 Processing with loops**

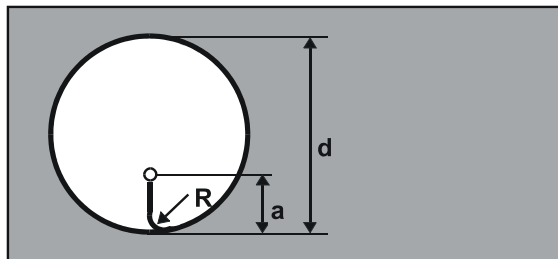
Loop size guides

Sheet strength [mm]	Loop radius [mm]
1...4	4
5	5
6	6
8	8
10	10
12	12

### 12.7.2.8 Inside contours (cut-outs)

For holes and other cut-outs it is an advantage to program the transition from the initial cutting plane to the contour with a radius.

Fig.12.7-3 Inside contour initial cut



Sheet thickness [mm]	Hole diameter «d» [mm]	Initial cut length «a» [mm]	Radius «R» [mm]
1...6	$d < 20$	from hole center ( $d/2$ )	1
	$d > 20$	10	1
8...12	$d < 30$	from hole center ( $d/2$ )	1
	$d > 30$	15	1

#### NOTE



*Assist gas is nitrogen!*

### 12.7.3 Oxide-free cutting of aluminum alloys

#### 12.7.3.1 Start of cutting after piercing

After the set piercing time has expired, the machine starts moving at the set acceleration factor. Sheet thicknesses for which the entry “**yes**” is indicated in the “**Circular piercing required**” column additionally require a start hole.

#### 12.7.3.2 Bylaser 2200

Sheet strength [mm]	Acceleration factor Start-up [-]	Circular piercing required
1	1	No
2...3	0,3	No
4	0,03	Yes

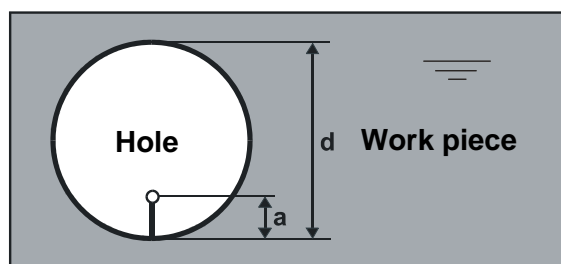
#### 12.7.3.3 Bylaser 3000/4000/40s

Sheet thickness [mm]	Acceleration factor start-up [-]	Circular piercing required
1	1	no
2	0,8	no
3	0,5	no
4	0,1	no
5	0,01	no
6...8	0,001	Yes

#### 12.7.3.4 Initial cut for hole

The length of the initial cut depends on sheet thickness and the diameter of the hole:

Fig.12.7-4 Hole diameter



Sheet thickness [mm]	Hole diameter «d» [mm]	Initial cut length «a» [mm]
1...6	d < 20	from hole center (d/2)
	d > 20	10
8...12	d < 30	from hole center (d/2)
	d > 30	15

### 12.7.3.5 Hole roundness

The same values apply to roundness of holes and the dynamic factor as for structural steel. See chapter «Cutting structural steel».

### 12.7.3.6 Corner tolerance (quality cuts)

The same values apply to corner tolerance as for structural steel. See chapter «Cutting structural steel».

Corner tolerance guides:

Sheet strength [mm]	Corner tolerance [mm]
1...5	0,1
6	0,08
8	0,06
10	0,04

### 12.7.3.7 Processing with loops

Loop size guides

Sheet strength [mm]	Loop radius [mm]
1...4	2
5...6	3
8...10	4

#### 12.7.4 Pulsed operation

In pulsed cutting, the laser power is always switched from "base power" to "cutting power" at a defined frequency. The energy introduced into the material causes heating and rapid melting of the material. A coaxial flow of gas assists the cutting process, removing the material from the cut gap.

The advantage of pulsed operation is that the necessary pulse peak power is present, but less heat overall is introduced into the material. This allows smaller holes and openings, plus difficult contours, to be cut with a better quality.

The ratio between pulse and pulse interval has a direct impact on the piercing time and the cutting feed rate. The cutting speed can be up to 10 times lower in pulsed mode than in CW mode. The piercing time in pulsed mode can be up to 10 times longer than in CW mode.

##### 12.7.4.1 Pulsed cutting

- The values for the default pulse parameters are found for holes whose diameters are half the material thickness maximum.
- Cutting sharp ends and corners without radii

##### 12.7.4.2 Pulsed piercing

- Piercing with lower heat input
- Piercing with minimum piercing craters.
- Piercing on the contour, so that both inner and outer part can be used

##### 12.7.4.3 Programming

Parts programming has a major impact on the results that can be achieved.

Use the Bysoft software to define the full machining technology. There are two ways of defining whether pulsed mode is used to cut/pierce contours:

- Manual: the programmer assigns the required process type to the individual contours.
- Automatic: using the Technology wizard. This contains the most important rules on how to machine which contour. This has the added advantage of reducing the programming time.

If only sections of a contour are to be cut in pulsed mode, then programming must ensure the minimum number of changeover points (pulsed mode/cutting mode).

Select the cutting sequence so that the difficult contours on a part are always cut first, i.e. the smallest contours, which are usually those cut in pulsed mode

### **12.7.4.4 *Adjusting the pulse parameters in cutting mode***

1. Reduce feed rate
2. Reduce pulse frequency
3. Vary pulse width

### **12.7.4.5 *Adjusting the pulse parameters in piercing mode***

1. Increase piercing time
2. Reduce the initial/end pulse frequency = reduction in applied heat.
3. Increase the laser power
4. Vary pulse width

### **12.7.4.6 *Further influencing factors in pulsed mode***

- Sheet quality and surface finish
- Parts geometry  
The hotter the sheet becomes, the harder it is to achieve a good quality. If a set of pulse parameters is working reliably in a hot sheet, then these parameters are good and have a lot in reserve.

### **12.7.4.7 *Alternatives to pulsed cutting***

Up to sheet thicknesses of 6 mm, cutting using nitrogen can often be employed instead of pulsed cutting.

This has the following advantages:

- The nitrogen cools the material, avoiding burn marks
- machining is much quicker and hence more economic
- no oxide formation

## 12.7.5 Engraving

### 12.7.5.1 General information

Engraving is available as standard on every machine and is a support function for e.g. the following tasks:

- Labeling parts
- Marking positions (guide cross for drill holes)
- Marking bending edges
- Applying optical marks and IDs
- Pre-positioning of sheets or parts
- Vaporizing off films, dyes, paints or other coatings

Engraving is mainly used on stainless steel and steel. It is possible to engrave using nitrogen or oxygen. The same gas should be used for engraving as for cutting, to avoid the need for purging.

Highly reflective materials such as aluminum, copper, brass or polished surfaces are not suitable for engraving.

The cutting parameters supplied by Bystronic include engraving data.

Engraving is easy to program in Bysoft.

### 12.7.5.2 Vaporization of films

For films with poor adhesion, machining can be performed in two steps:

1. Vaporization of film
2. Cutting of sheet

- Start vaporization using the "REPEAT" button (immediately after "START WORK") on the MMC. This vaporizes the film using the "Engraving mode Parameters" at all those points where the sheet will subsequently be cut. For this application, the "Feed, engraving" parameter can be increased to 20000 mm/min. The "Laser power, engraving" also needs to be increased for thicker films. The sheet should be visible after vaporization.
- Working with the nozzle-cleaning option is recommended for vaporization because the nozzle can be soiled with particles of plastic. Where soiling is heavy, the "Nozzle distance, engraving" parameter can also be increased up to 6 mm.

### 12.7.5.3 Assessment of engraving quality

The depth and quality of the engraving is partly determined by the set parameters, partly by the sheet surface finish. In addition, everyone assesses the quality of an



engraving in different ways. Thus the saved parameters should be considered simply as guidelines that can be used as a basis for creating one's own optimum engraving results.

### 12.7.6 Support grids

The strips can be made from various metals. Copper strips have the longest service life in terms of heat resistance. Slag is easy to remove. The high reflectivity of copper can impact negatively on thin sheets when cutting small holes (holes are imprecise) or in oxide-free cutting (plasma formation, beam break). Steel and V<sub>2</sub>A strips have least impact on the cutting process.

You can cut steel and V<sub>2</sub>A strips yourself. The appropriate cutting plans are on the PPC's hard disk. The service life of these strips depends on laser power used for cutting.

<b>Steel:</b>	Economic, low reflection, short creep stability
<b>V2A:</b>	Splashes from this grid cannot oxidize on stainless materials
<b>Copper:</b>	High reflection, long creep stability



**TIP**

*Cutting the grid strips with O<sub>2</sub> saves costs.*

## 12.8 Cut evaluation

### 12.8.1 Waiting time before cutting in continuous wave

Enter a value for the «Waiting time before cutting» parameter if you are piercing in continuous wave. During this waiting time, some of the heat flows away around the piercing hole which ensures good cut quality already when the laser moves away. Select the higher value for «Waiting time for cutting» in the “material-specific details” section in the tables if you want to cut holes with a diameter smaller than the sheet thickness.

### 12.8.2 Machining holes

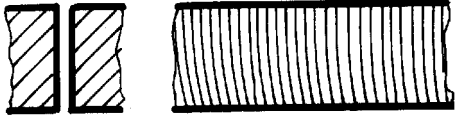
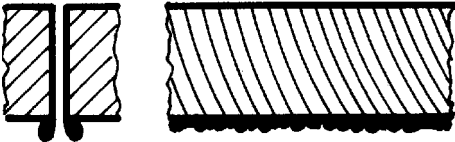
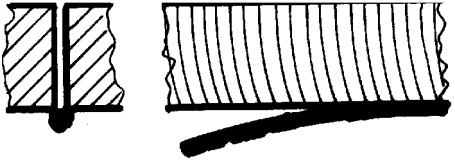

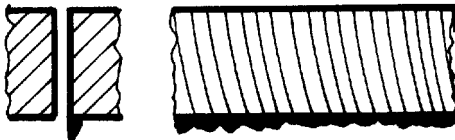
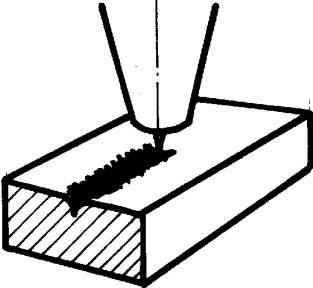
#### 12.8.2.1 *Burring with holes*

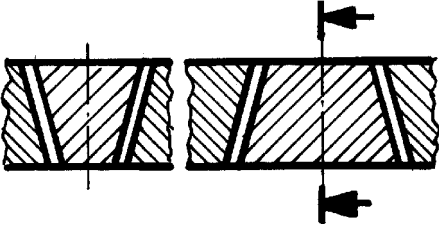
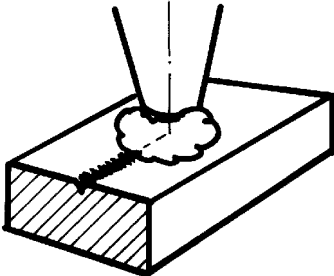

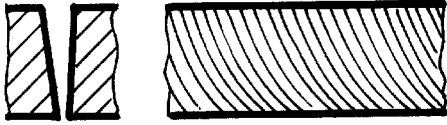


Burring is a sign that the hole was cut too fast. Correction: choose a smaller dynamic factor.

If you reduce the dynamic factor too much, there will be burring on the contour. Correction: cut the hole in pulsed mode.

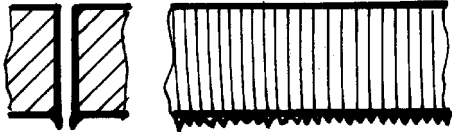
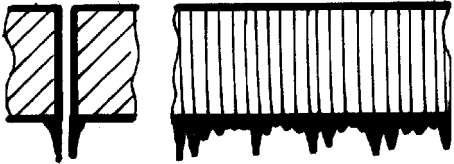

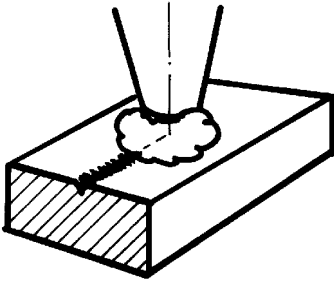
You can influence cutting speed in holes with the aid of the dynamic factor, proportional to feed cutting. If the dynamic factor in thin sheet is too high, holes will be out of round. If the factor is too small, the contours of the holes will burn. If the dynamic factor in thick sheet is too high the result will be burring and the cut will not go right through. If the factor is too small, the cut may resolidify and close and form burrs. Reason: The material gets too hot, absorption increases.

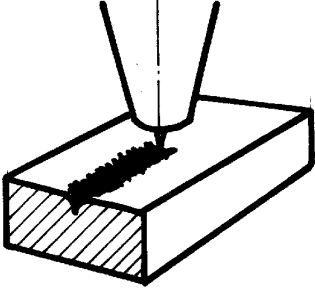
### 12.8.3 Structural steel: Cutting with O<sub>2</sub>

Fault	Possible causes	Remedy
No burring, striation marks regular	Good performance Good speed	
Severe deflection of striation marks at the bottom, kerf wider at the bottom 	Speed too high Laser power too low Gas pressure too low Focal position too high	Reduce speed Increase laser power Increase gas pressure Set focus lower
Burring on the side at the bottom, slag-like, even drop-shaped, easy to remove 	Speed too high Gas pressure too low Focal position too high Laser power too low	Reduce speed Increase gas pressure Set focus lower
Metallic burring, contiguous, easy to remove in one piece 	Focal position too high	Set focus lower
Burring on the side at the bottom, metallic, hard to remove 	Speed too high Gas pressure too low Gas soiling Focal position too high	Reduce speed Increase gas pressure Use purer gas Set focus lower
Burring on one side only 	Nozzle inadequately centered Nozzle aperture defective	Center nozzle replace nozzle
Cleared material on top 	Power too low Speed too high	Increase power Reduce speed

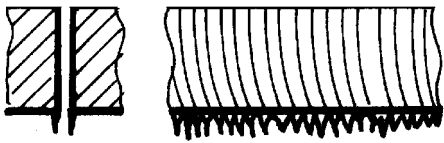
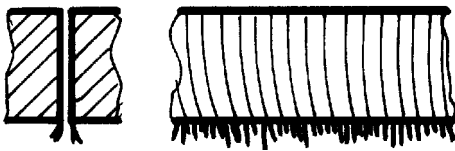
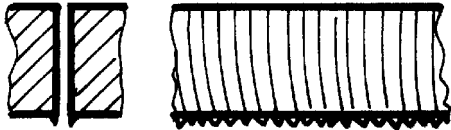
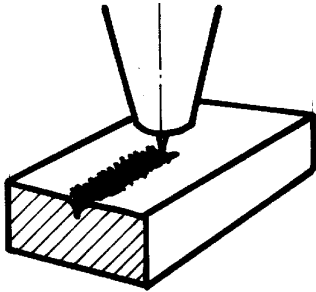
Fault	Possible causes	Remedy
<p>Angled cuts 2 sides OK, 2 sides poor</p> 	<p>Wrong polarization mirror, incorrectly mounted or defective</p> <p>Mount polarization mirror instead of deflection mirror</p>	<p>Check polarization mirror Check deflection mirror</p>
<p>Blue plasma light, work piece not cut through completely</p> 	<p>wrong gas (N<sub>2</sub>)</p> <p>Speed too high</p> <p>Power too low</p>	<p>Use oxygen as assist gas</p> <p>Reduce speed</p> <p>Increase power</p>
<p>Rough cut surface</p> 	<p>Gas pressure too high</p> <p>Nozzle damaged</p> <p>Nozzle diameter too large</p> <p>Inferior material</p>	<p>Set gas pressure lower</p> <p>Replace nozzle</p> <p>Install correct nozzle</p> <p>Material with fine and regular surface</p>
<p>No burring, striation marks curved back Cut narrower towards the bottom</p> 	<p>Speed too high</p>	<p>Reduce speed</p>
<p>Craters</p> 	<p>Gas pressure too high</p> <p>Speed too slow</p> <p>Focus too high</p> <p>Scale on sheet surface</p> <p>Work piece overheating</p> <p>Inclusions in material</p>	<p>Reduce gas pressure</p> <p>Increase speed</p> <p>Set focus lower</p> <p>Use better material</p>
<p>Very rough wrinkling</p> 	<p>Focal position too high</p> <p>Gas pressure too high</p> <p>Speed too slow</p> <p>Material too hot</p>	<p>Set focus lower</p> <p>Reduce gas pressure</p> <p>Increase speed</p> <p>Cool material</p>

### 12.8.4 Stainless steel: High-pressure cutting with N<sub>2</sub>

Fault	Possible causes	Remedy
<p>Fine, regular whiskery burring</p> 	<p>Focus too low Speed too high</p>	<p>Set focus higher Reduce speed</p>
<p>Long coarse whiskers on both sides, whiskers oxidized, on large contours</p> 	<p>Focal position too high Speed too low Gas pressure too low Material too hot</p>	<p>Set focus lower Increase speed Increase gas pressure Cool material</p>
<p>Long, coarse whiskers on one cut edge side only</p> 	<p>Nozzle not centered Focal position too high Gas pressure too low Speed too low</p>	<p>Center nozzle Set focus lower Increase gas pressure Increase speed</p>
<p>Yellowish cut edge</p>	<p>Nitrogen with oxygen soiling</p>	<p>Use better quality of nitrogen</p>
<p>Plasma on straight lines</p> 	<p>Speed too high Power too low Focus too low</p>	<p>Reduce speed Increase power Set focus higher</p>
<p>Beam cuts off</p>	<p>Speed too high Power too low Focus too low</p>	<p>Reduce speed Increase power Set focus higher</p>
<p>Plasma in corners</p>	<p>Corner tolerance too high Modulation too high Acceleration too high</p>	<p>Reduce corner tolerance Reduce modulation or acceleration</p>
<p>Beam cuts off when movement starts</p>	<p>Start-up acceleration too high Focus too low Molten material cannot be blown out</p>	<p>Reduce start-up acceleration Set focus higher Make a start hole Use a gas ramp</p>

Fault	Possible causes	Remedy
Rough cut	Nozzle damaged Lens soiled Gas pressure too high	Changing the nozzle Clean lens (replace if necessary)
Cleared material on top 	Inadequate power Feed too large Gas pressure much too high	Increase power Reduce feed Reduce gas pressure

### 12.8.5 Aluminum alloys: High-pressure cutting with N<sub>2</sub>

Fault	Possible causes	Remedy
<p>Long coarse whiskers on both sides, whiskery, hard to remove</p> 	<p>Focal position too high Gas pressure too low Speed too low</p>	<p>Set focus lower Increase gas pressure Increase speed</p>
<p>Long coarse whiskers on both sides, can be removed by hand</p> 	<p>Speed too low valid up to 4.0 mm 5.0 mm upwards normal</p>	<p>Increase speed</p>
<p>Rough cut</p>	<p>Nozzle diameter too large Nozzle damaged Gas pressure too high Nozzle damaged</p>	<p>Install correct nozzle Replace nozzle Reduce gas pressure Changing the nozzle</p>
<p>Regular burring, hard to remove</p> 	<p>Focus too low Speed too high</p>	<p>Set focus higher Reduce speed</p>
<p>strong plasma formation on straight lines</p>	<p>Speed too high</p>	<p>Reduce speed</p>
<p>Beam cuts off</p>	<p>Speed too high</p>	<p>Reduce speed</p>
<p>Plasma in corners</p>	<p>Corner tolerance too high Modulation too high Acceleration too high</p>	<p>Reduce corner tolerance Reduce modulation or acceleration program radius</p>
<p>Beam cuts off when movement starts</p>	<p>Start-up acceleration too high Focus too low</p>	<p>Reduce start-up acceleration Set focus higher</p>
<p>Cleared material on top</p> 	<p>Inadequate power Feed too large</p>	<p>Increase power Reduce feed</p>

## 12.9 Troubleshooting

Optimum cut quality can only be achieved if the following conditions are met:

- precise adjustment of the machine
- maintenance as per maintenance plan
- operating resources corresponding to demands
- work piece surface free of rust and scale (pickled or polished)
- suitable parameters for given material and sheet thickness
- parameters harmonized to each other

Check the following if cut quality deteriorates compared to previous results:

1. Parameter
2. Cutting head
3. Beam guidance
4. Resonator

### 12.9.1 Parameters

Never overwrite the default parameters supplied with the machine.

Create a new directory for your optimized parameters.

If cut quality deteriorates, check whether the parameters stored in the machine have been changed significantly compared to your optimized parameters.

### 12.9.2 Cutting head

- Nozzle distance according to parameters
- Nozzle shape according to parameters
- Focal length according to parameters
- Scanner free of slag
- Focal point (with Bypos); Focal position (without Bypos)
- Nozzle centered accurately
- Lens clean



- Lens mounted correctly and fixed in place
- Check water cooling on the cutting head
- Check cutting head guides

### 12.9.3 Beam guidance

- Solvent in ambient air
- Excess pressure in beam channel and lens hood followers
- Adequate air quality for beam channel ventilation
- Deflection mirror (cleanliness, fit, cooling)
- Laser mode on test plates
- 4 alignment points on cutting table
- Vertical incidence of laser beam on lens

### 12.9.4 Resonator

- Visual impression of gas discharge
- Power check
- Tube current
- Excess pressure at output coupler
- Deflecting mirror
- Polarizing mirror
- Beam divergence system
- Laser seal
- Output coupler (Service)
- End mirror (Service)

