



Chapter 2

Assembly and installation

Assembly and installation	2-3
1 Integration into a system environment	2-4
1.1 Fastening	2-4
1.2 Clearances	2-6
1.3 Example	2-7
2 Electrical insulation	2-10
2.1 Measuring the insulation resistance	2-11
3 Installation	2-12
3.1 Overview of the connections	2-12
3.2 Principles, general rules	2-14
3.3 Safe combination of laser device, laser light cable and focusing optics	2-15
Characteristics of safe combinations	2-15
Dangers due to impermissible combinations	2-15



	Information required to assess the safety of a combination	2-17
	Examples of safe combinations	2-19
3.4	Connection of the laser light cable (LLK)	2-20
	Connecting the laser light cable to the focusing optics	2-22
3.5	Connections for cooling unit	2-26
3.6	Connections for crossjet, purging gas and MVE gas	2-30
3.7	Connection for proximity switch (BEO D50 only, without protective glass monitoring unit)	2-34
3.8	Lighting connection	2-35
3.9	Connection for line laser	2-36
3.10	Camera connection	2-36
3.11	Other BEO D50 Smart connections	2-37
4	Ambient conditions	2-40
4.1	Determining the necessary cooling water temperature	2-41
5	Using shielding gas	2-42
5.1	Gases during laser welding	2-42
5.2	What is shielding gas used for?	2-42
5.3	Shielding gases	2-43
	Nitrogen (N ₂)	2-44
	Argon (Ar)	2-44
	Helium (He)	2-44
	Recommendations	2-44
5.4	Shielding gas supply	2-45
	Linear gas supply	2-46
	Linear gas supply with a lateral MDE nozzle	2-47
	Aerator nozzle gas supply	2-48
	Other methods	2-49
5.5	Arrangement of the shielding gas nozzles	2-50
	Pulsed lasers	2-50
	cw lasers	2-51
	Welding at edges	2-52
5.6	Dosing shielding gas	2-52
5.7	Effect of the shielding gas	2-55



Assembly and installation

Commissioning of the focusing optics:

- is done by a service engineer of TRUMPF during the commissioning of a laser device, if the focusing optics is delivered together with a laser device.
- is done by the user after start-up of an existing laser device, if you purchased the focusing optics afterwards.

The following conditions must be fulfilled:

- The necessary safety equipment must have been installed and must be ready for operation.
- Suitable laser safety glasses must be at hand.
- If additional media are required, they must be provided:
 - Shielding gas
- There must be enough samples for the commissioning procedure. A suitable workpiece holder for the samples must be provided.



1. Integration into a system environment

The focusing optics is composed by modules according to the requirements of your application. This means that each focusing optics has different specifications:

- for the dimensions of the focusing optics
- for the fastening of the focusing optics.
- for the spaces which have to be kept free around the focusing optics.

Documents Dimensional details about the focusing optics and the clearances that have to be maintained are described in the following documents:

- in the dimensional drawing of the focusing optics
- in the installation instructions for focusing optics D50, doc. no.: 22-50-17-A1-DH.

These documents have been delivered together with your laser device or with the separately delivered focusing optics.

Dimensional drawing and installation guideline

The dimensional drawing contains:

- all dimensions in millimeters [mm]
- Clearances to be maintained in millimeters (mm).
- Letters as a reference to the installation guideline.

How to deal with dimensional drawings and installations instructions is described by means of an example in the following sections:

1.1 Fastening

Fastening of the focusing optics is determined by the modules built in.

There are the following fastening methods for the focusing optics:

- on the empty cube.
- At the cube with its different versions:
 - 0° cube.
 - 90° cube.
- At the 2 x 90° double deflection.

The fastening screws (4 x M4) have to be tightened to a torque of 2.5 Nm.

Note

The focusing optics BEO D50 Smart must always be fastened so that they are electrically insulated.

Fastening elements

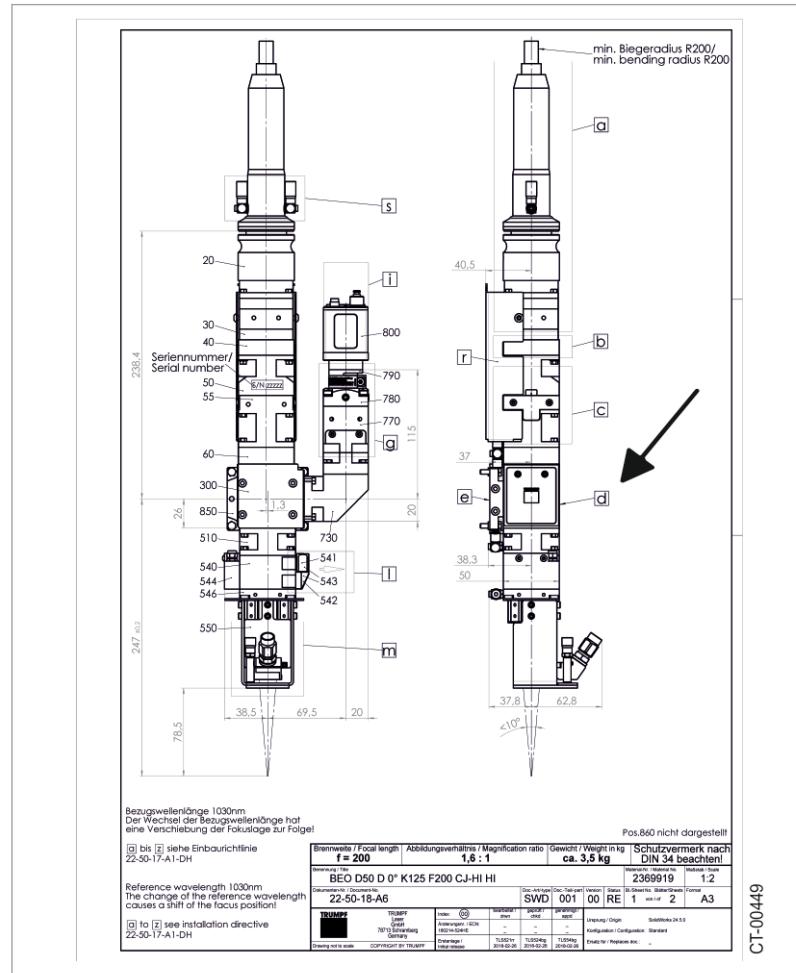
To fasten focusing optics to a robot, a DIN-ISO connection plate is available.

A fastening plate D50 - D70 is also available for fastening focusing optics D50 compatibly with focusing optics D70.

For insulated fastening, there is an insulated fastening plate, D50 - D70.

Fastening specifications

The following picture informs you how to find information on the fastening in the relevant dimensional drawing or in the installation instructions.

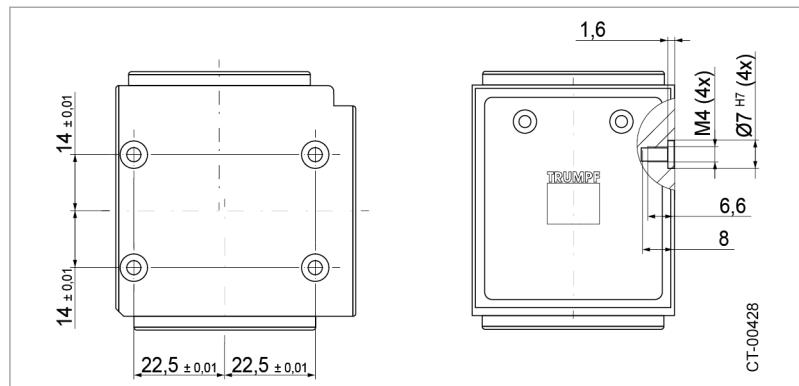


Dimensional drawing of focusing optics (example: BEO D50 Basic)

Fig. 2-1

In addition to the dimensions, you will also find letters on the drawing. The arrow points to the letter "d".

"d" is a reference to the installation instructions, document no.: 22-50-17-A1-DH, the dimensional drawing for the bores "0° cube".



Dimensional drawing for "d" in the installation instructions

Fig. 2-2

1.2 Clearances

Keep free the environment around the focusing optics for the following:

- Unimpeded emission of the laser light.
- Compliance with the working distance at different focal lengths of lens.
- for adjustment work:
 - for aligning the focusing optics.
 - for adjusting the focal position.
 - for adjusting the picture sharpness of the camera.
 - for adjusting the cross hairs.
 - for defocusing the focusing optics.
- for maintenance and service work:
 - for connecting and disconnecting the LLK.
 - for connection of the supply lines, such as for the cooling unit.
 - for removing and fitting the lens protection.
 - for removing and pushing in the protective glass cassettes.
 - for positioning tools.
 - for attaching measuring devices.

Clearances must also be considered for the following operations:

- Design of the carrier system, particularly if the focusing optics is used as a mobile system.
- Attaching a protective cover.

Specifications for clearances to be observed

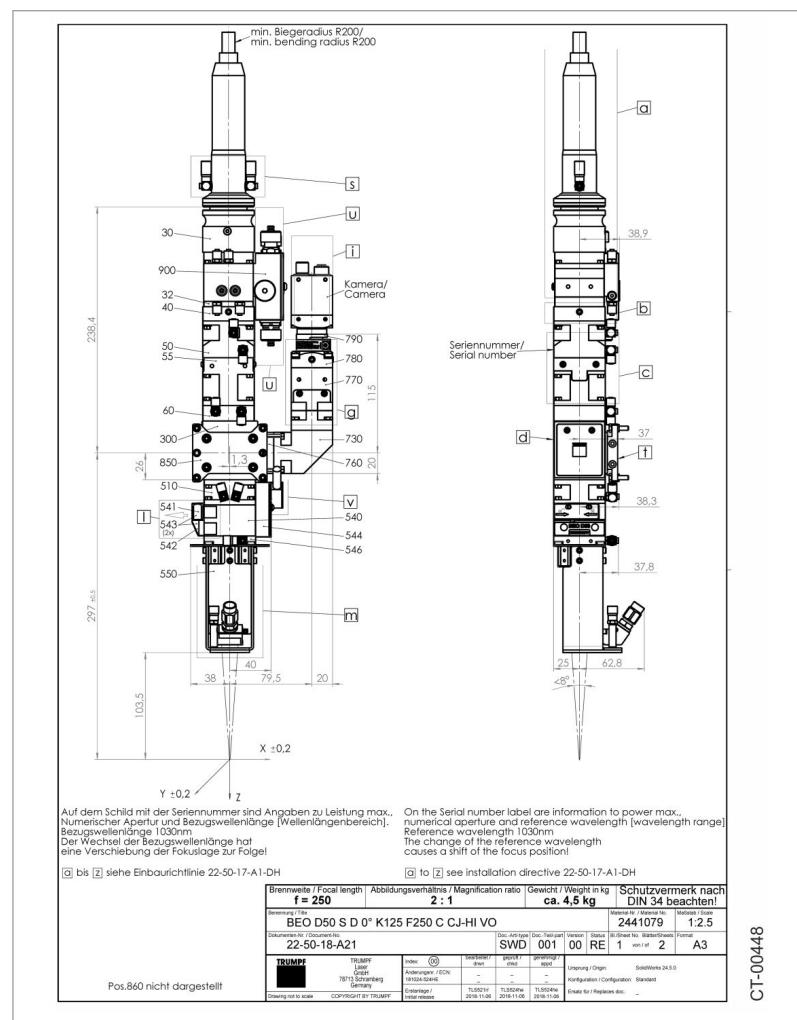
Specifications for clearances which have to be observed are given in the following documents:

- in the dimensional drawing of the focusing optics
- in the installation instructions for focusing optics D50, doc. no.: 22-50-17-A1-DH.

The example in the next section gives information on the meaning of the letters in the dimensional drawing and which specifications are to be found in the installation guideline.

1.3 Example

A dimensional drawing of a focusing optics is shown below as an example of the code letters.



Dimensional drawing of focusing optics (example: BEO D50 Smart)

Fig. 2-3

CT-00448



The installation instruction 22-50-17-A1-DH for focusing optics D50 supplements the dimensional drawing with important notes and dimensional information to be observed when installing the focusing optics in machines and devices. The areas and single components in the dimensional drawing which are marked with a letter are described in detail in the installation directive.

Letters used Below you find a short summary of the letters used in dimensional drawings and information on their meaning.

- **[a]** Plug receptacle D and LLK-type.
Notes on the bending radius LLK-D, insert depth, fuse and space requirements for the adjustment work.
- **[b]** XY adjustment.
Information on space required for adjustment work.
- **[c]** Collimation with defocusing.
Note on how to adjust the focal position.
- **[d]** 0° cube.
Information on the installation of the focusing optics with hole pattern.
- **[e]** Fastening plate D50 - D70.
Information on the installation of the focusing optics with hole pattern.
- **[f]** Beam formation module.
Information on space required for adjustment work.
- **[g]** Observation optics.
Information on the area marked in the dimensional drawing, which has to be kept accessible for adjustment work.
- **[h]** Sensor interface.
Information on saving space when setting a sensor on the sensor module.
- **[i]** Connecting lines.
Information on the area marked in the dimensional drawing, which has to be kept clear for the connecting cable.
- **[j]** Lens protection.
Information on the space required for maintenance work.
- **[k]** Lighting module.
Note on space requirements for the lighting beam path.
- **[l]** Cassette receptacle.
Information on the space required for maintenance work.
- **[m]** Crossjet.
Information on the area marked in the dimensional drawing, which has to be kept accessible for adjustment work.
- **[n]** Fastening plate for accessories.
Information about the attachment of accessories.
- **[o]** Plug receptacle D with defocusing.
Notes on the bending radius LLK-D, insert depth, fuse and space requirements for the adjustment work.



- **[p]** Plug receptacle A with defocusing.
Notes on the bending radius LLK-A, insertion depth, fuse and space requirements for adjustment work.
- **[a]** Plug receptacle A and LLK-type.
Information on space required for adjustment work.
- **[r]** Cover plate.
Information on the space required for maintenance work.
- **[s]** Cooling water lines.
Note on connecting the cooling water lines.
- **[t]** Insulated fastening plate D50 - D70.
Information on the installation of the focusing optics with hole pattern.
- **[u]** Interface module.
Information on the area marked in the dimensional drawing, which has to be kept clear for the connecting cable.
- **[v]** Protective glass monitoring module.
Note regarding the laying of the connecting cable.
- **[w]** Gas monitoring module.
Note regarding space requirement for media feed (supply air).
- **[x]** Fixing sheet.
Note regarding the fastening of the gas lines.
- **[y]** 2 x 90° double deflection.
Information on the installation of the focusing optics with hole pattern.

Details can be found in the installation directive 22-50-17-A1-DH.



2. Electrical insulation

The mounting surface on the insulated fastening plate D50 - D70 of focusing optics BEO D50 Smart is made of electrically insulating material.

Notes

- When mounting the focusing optics, please ensure that there is no electrically conductive connection between the casing of the focusing optics and the mounting frame.
An electrical component or device may only be mounted to the focusing optics BEO D50 Smart in such a way that the potential of the focusing optics is not modified.
- Electrical attachment parts, such as a camera or lighting, are designed so they are electrically insulated from the focusing optics.

The resistance between the focusing optics housing and the carrier plate must be measured, after

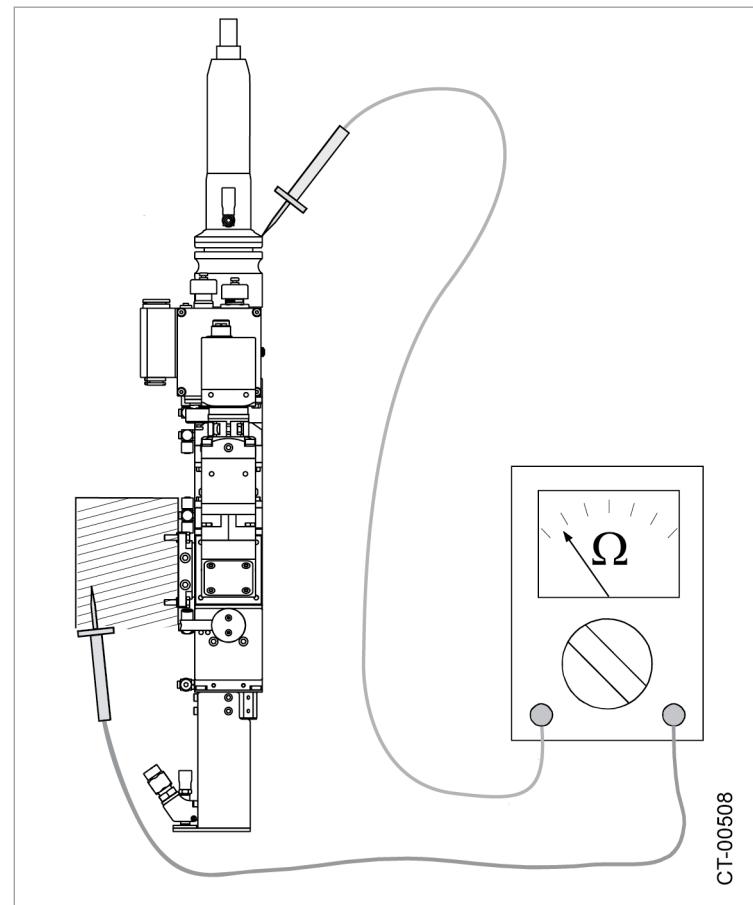
- mounting of the focusing optics is completed.
- an electric component or device has been mounted to the focusing optics.



2.1 Measuring the insulation resistance

Condition

- Mounting of the focusing optics is completed.



Measuring the insulation resistance

Fig. 2-4

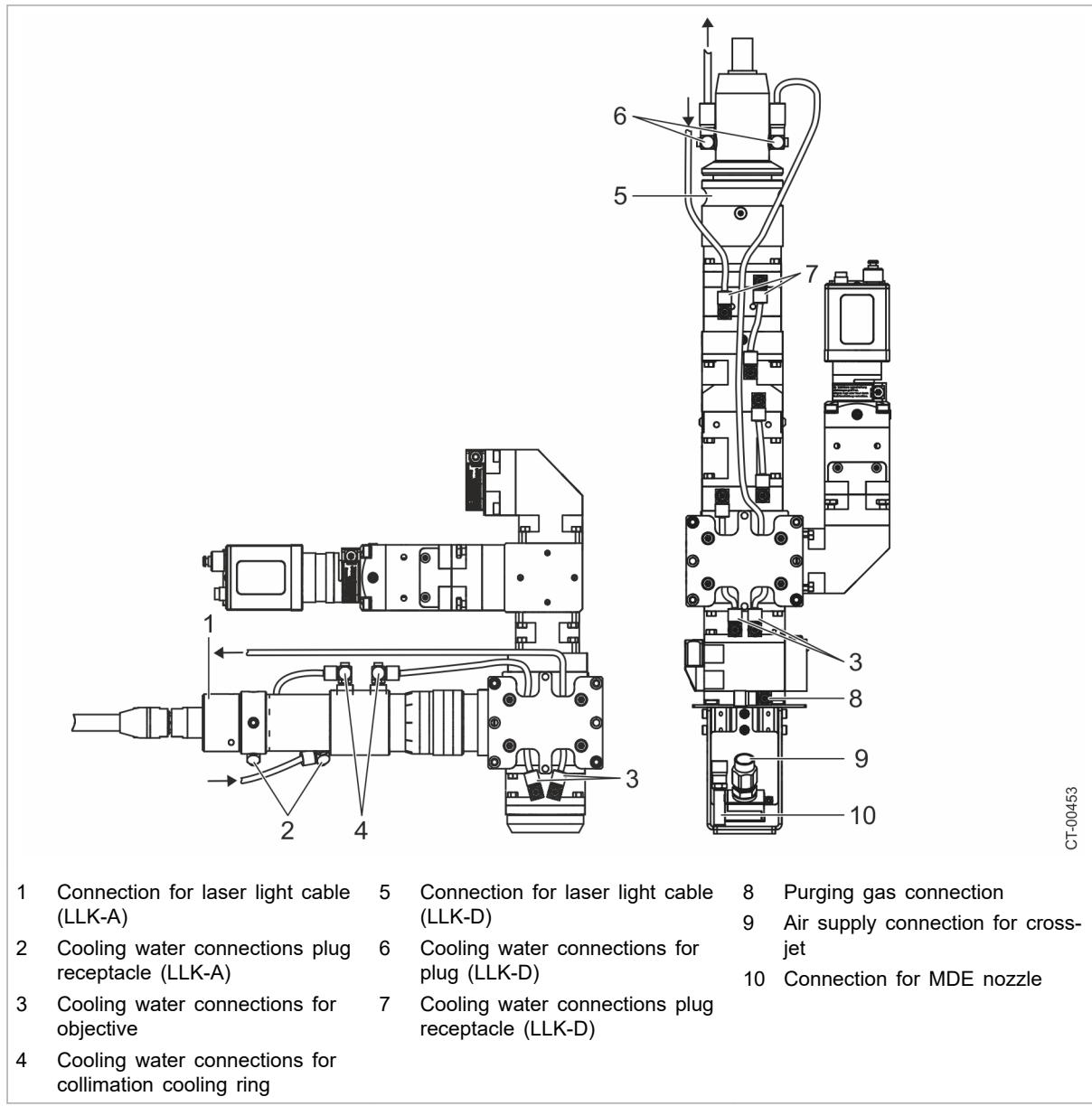
1. Unplug the plug-in connectors from the connections.
2. Measure the insulation resistance between casing of the focusing optics and the mounting frame.

The resistance must be $> 1 \text{ M}\Omega$.



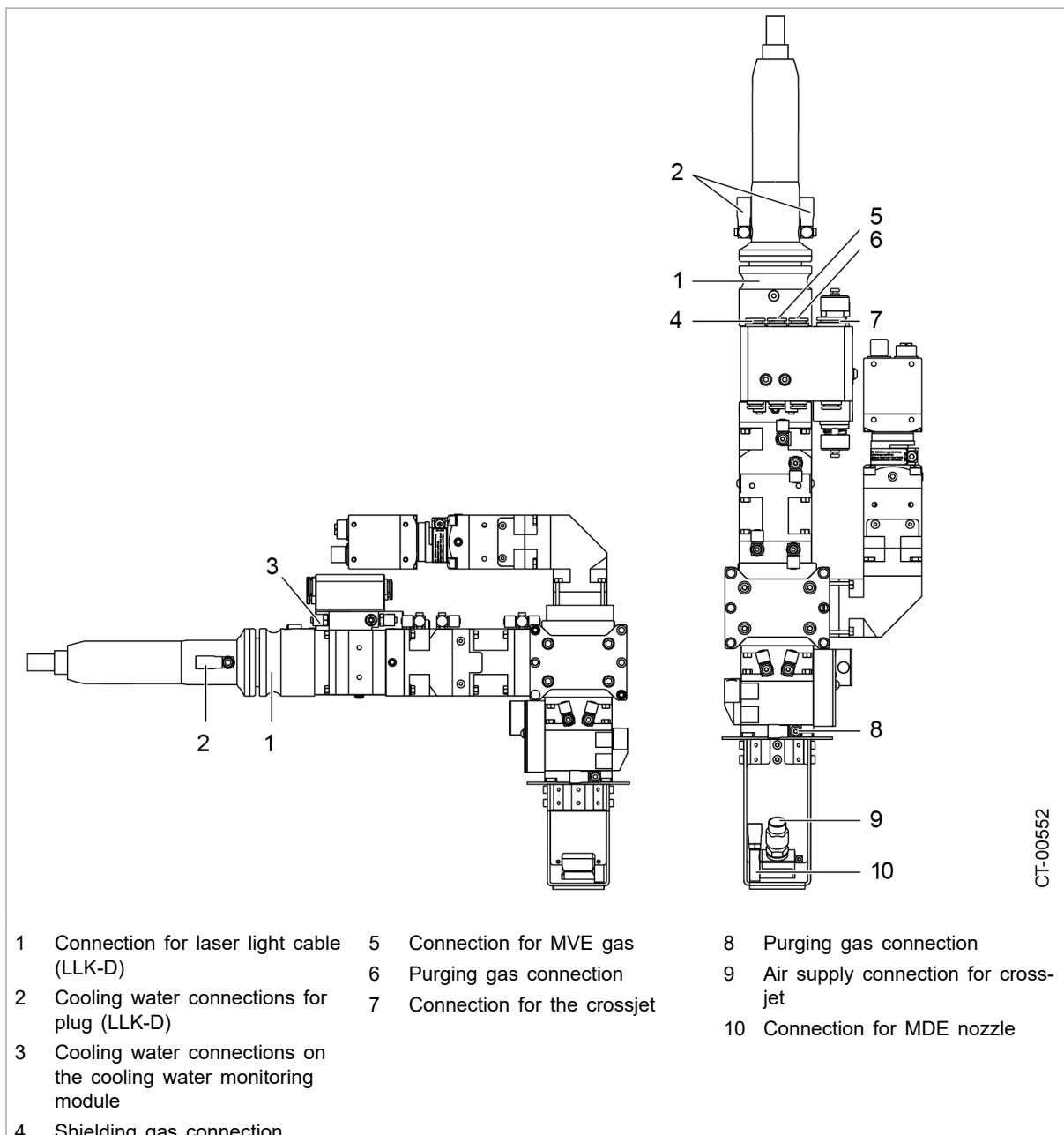
3. Installation

3.1 Overview of the connections



Connections on focusing optics BEO D50 Basic

Fig. 2-5



Connections on focusing optics BEO D50 Smart

Fig. 2-6

The potential connections to the focusing optics BEO D50 Basic and Smart will be described in the following sections.

camera The use of a camera requires additional electrical connections. More information is to be found in the camera manual.



3.2 Principles, general rules

Laser light is a versatile tool of industrial material processing.

The technology of solid-state lasers combines two advantages:

- Solid-state lasers can reach kilowatts in the double-digit range, also as continuous wave.
- The light of the solid-state lasers can be guided and formed by means of glass optics (lenses, mirrors, prisms and fiber glass).

But the advantages have their price: The higher the laser power used, the higher are the demands on cleanliness.

Requirements	<p>All volumes penetrated by laser light must be free of absorbing gases or suspended particles.</p> <p>Otherwise, when the laser light penetrates the volumes, the pressure inside them may increase rapidly and damage or destroy parts of the optical components.</p> <p>All surfaces of optical components penetrated by laser light or reflecting laser light must be completely free of absorbing deposits or particles.</p> <p>Otherwise, the deposits or particles may burn in the surface of the optical components. This normally destroys the optical components.</p> <p>Even if the components are not destroyed, a soiled focusing optics may heat excessively. This may shift the focal position. As a result the process quality may be reduced.</p>
Practice	<p>For the use of focusing optics and laser light cables (LLK) this means:</p> <p>As long as the focusing optics are not connected to LLK plugs, plugs must be inserted into the plug receptacles to avoid penetration of dirt.</p> <p>As long as the optical plugs of the LLK are not connected to the incoupling optics or focusing optics, protective caps must be on the LLK plugs preventing the dirt from penetrating into the protective glasses of the LLK plug.</p> <p>The joints between the LLK plugs and the focusing optics must be sealed by means of adhesive tape.</p> <p>In highly contaminated environment, it is necessary to protect the joints by means of protective sleeves to avoid the penetration of dirt.</p> <p>The plug receptacles must be in horizontal position when connecting or disconnecting the optical plug from the focusing optics. This prevents the particles from entering the plug receptacles from above.</p>



Make sure that the plug receptacles and the LLK plugs are unprotected only during connection and disconnection. **Never** touch the surfaces of the optical components **with your fingers**.

3.3 Safe combination of laser device, laser light cable and focusing optics

Characteristics of safe combinations

A combination of laser device, laser light cable and focusing optics is safe when the following criteria are fulfilled:

Wavelength Laser device, laser light cable and focusing optics must be designed for the same wavelength spectrum.

Rated output Laser light cable and focusing optics must be suitable for the rated power of the laser device.

Numerical aperture The numerical aperture of the laser light cable and the focusing optics must not be smaller than that of the laser device.

	Laser device	Optical laser cable	Focusing optics
Wavelength	= LLK, =focusing optics	=laser device, =focusing optics	=laser device, = LLK
Rated output	\leq LLK, \leq focusing optics	\geq Laser device	\geq Laser device
Numerical aperture	\leq Laser light cable	\geq Laser device, \leq focusing optics	\geq Laser light cable

Tab. 2-1

Dangers due to impermissible combinations

⚠ DANGER

Laser radiation escaping!

Laser radiation can damage skin and eyes. Damage to eyesight or even complete blindness can result.

- Only use safe combinations of laser device, laser light cable and focusing optics.

 **DANGER**
Housing of focusing optics gets hot!
Touching the focusing optics can lead to serious burns.

- Only use safe combinations of laser device, laser light cable and focusing optics.

Numerical apertures cannot be combined
Numerical aperture of the focusing optics is too small

If the numerical aperture of the focusing optics is smaller than the numerical aperture on the decoupling connector, a part of the laser light hits the aperture of the focusing optics. The housing of the focusing optics can heat up strongly as a result (> 300 °C). The following dangers result from this:

- **Fire hazard:** Materials in the environment of the focusing optics can catch fire.
- **Risk of burns:** People who work with the focusing optics may suffer burns.
- **Risks from escape of laser radiation:** People in the environment of the focusing optics may be injured by escaping laser radiation. Skin burns and loss of eyesight are possible.

Numerical aperture of the laser light cable is too small

If the numerical aperture of the incoupling connector of the laser light cable is smaller than the numerical aperture of the laser device, a part of the laser light is coupled into the connector of the laser light cable. This results in increased scattered light. The laser devices switches off automatically.

Wavelength spectrums do not match
Focusing optics is not designed for laser device

Focusing optics are designed for defined wavelength spectrums. If a focusing optics is operated with a different wavelength than specified, unforeseen reflections and transmissions to optical components may occur. The housing of the focusing optics can heat up strongly as a result (> 300 °C). The following dangers result from this:

- **Fire hazard:** Materials in the environment of the focusing optics can catch fire.
- **Risk of burns:** People who work with the focusing optics may suffer burns.
- **Risks from escape of laser radiation:** People in the environment of the focusing optics may be injured by escaping laser radiation. Skin burns and loss of eyesight are possible.
- **Risks of laser radiation in eyepiece and stereo microscope:** People who look into the eyepiece or the stereomicroscope during the processing operation can lose their eyesight.



Focusing optics is not designed for the rated power of the laser device

Rated power of the laser device is too high

A focusing optics will be damaged if it is operated with a higher power than that which is specified. The housing of the focusing optics can heat up strongly ($> 300^{\circ}\text{C}$). The following dangers result from this:

- **Fire hazard:** Materials in the environment of the focusing optics can catch fire.
- **Risk of burns:** People who work with the focusing optics may suffer burns.
- **Risks from escape of laser radiation:** People in the environment of the focusing optics may be injured by escaping laser radiation. Skin burns and loss of eyesight are possible.

Laser light cable or focusing optics are not from TRUMPF

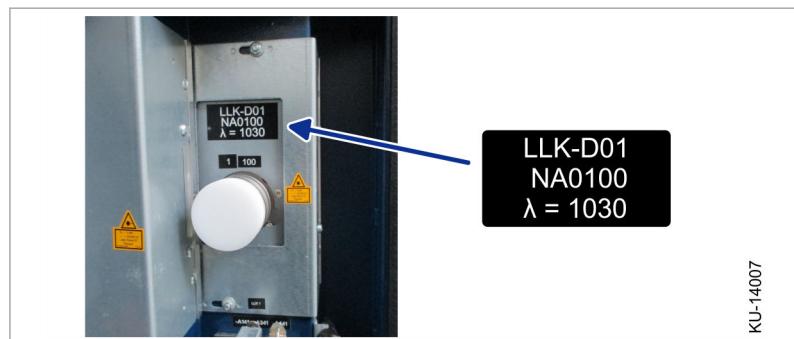
Unknown risks

When the laser device is combined with components that are not from TRUMPF, the integrator or the operator must draw up a risk assessment for the combined machine. This risk assessment must include risks that could occur through the combination of the individual components.

Information required to assess the safety of a combination

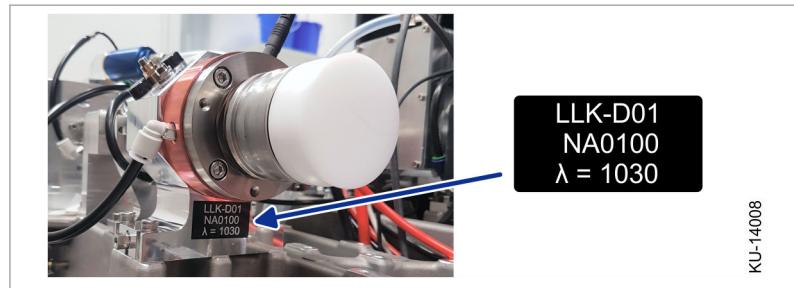
Information on the laser device

Information on the numerical aperture and on the wavelength spectrum is available either in the user's compartment or on the incoupling optics.



Information in the user's compartment (example TruDisk FD17)

Fig. 2-7

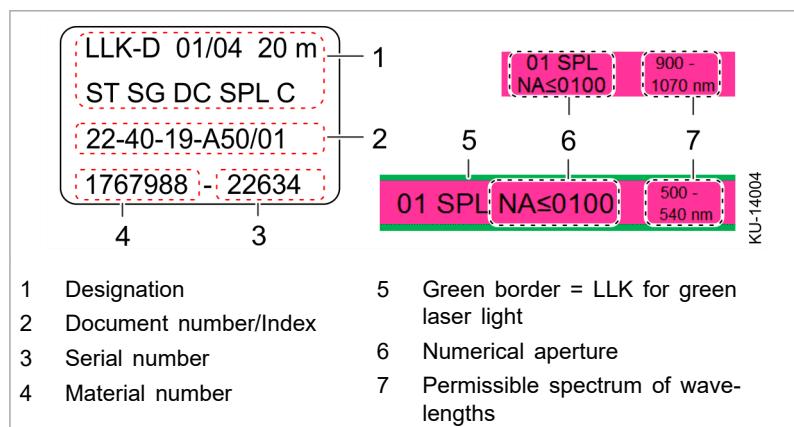


Information on the incoupling optics (example TruDisk FD27)

Fig. 2-8

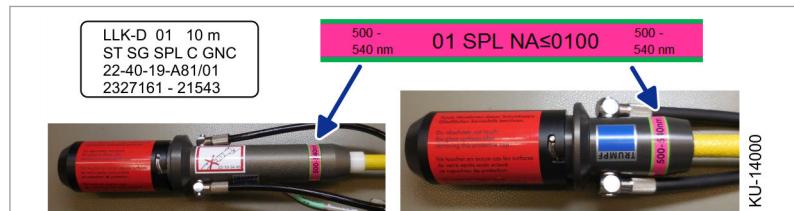
Information on the laser light cable (examples)

Information on the permissible wavelength spectrum and the permissible numerical aperture are to be indicated on the incoupling connector and on the outcoupling connector. The nameplate contains additional information about the laser light cable.



Information on laser light cables (examples)

Fig. 2-9



Information on LLK-D NA01 (green)

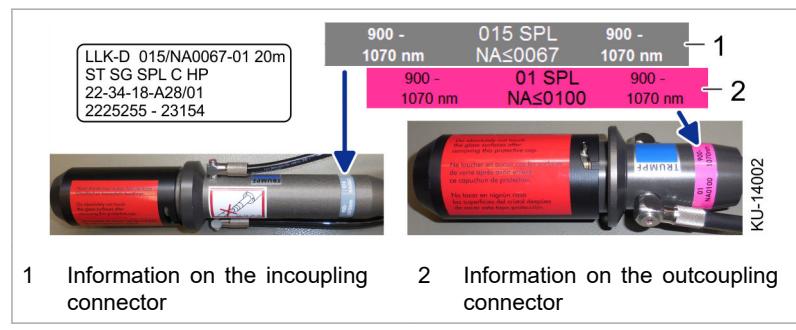
Fig. 2-10



Information on LLK-D 100/400 µm NA01 double-core

Fig. 2-11

Depending on the light laser cable, the information on the incoupling connector can deviate from that on the outcoupling connector.



Information on LLK-D NA0067/015-01 HP

Fig. 2-12

Information on the focusing optics

The processing optics contains information on power, numerical aperture and wavelength spectrum on the plug receptacle.



Information on processing optics (example)

Fig. 2-13

Examples of safe combinations

The following laser devices, laser light cables and focusing optics may be combined with one another (examples):

Laser device	Optical laser cable	Focusing optics
TruDisk 4001 (FD27)	LLK-D 01/04 SPL DC	Processing optics (BEO)
TruDisk Pulse (FP04) (green)	LLK-D 01 SPL GNC	Processing optics (BEO)
TruDisk 10001 (FD25)	LLK-D NA0067/015-01 SPL HP	Processing optics (BEO HP)

Examples of safe combinations of laser device, laser light cable and focusing optics

Tab. 2-2

3.4 Connection of the laser light cable (LLK)

Laser light cable

In the case of focusing optics BEO D50 Basic, the laser light cable LLK-A, laser light cable LLK-B (using an adapter) or laser light cable LLK-D is used.

In the case of focusing optics BEO D50 Smart, only laser light cable LLK-D is used.

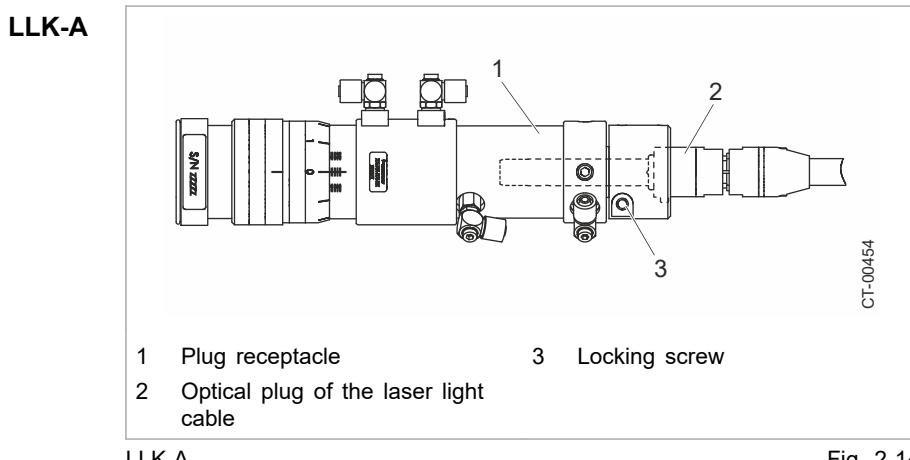


Fig. 2-14

The laser light cable is available in the standard lengths 4 m, 6 m, 8 m, 10 m, 15 m and 20 m. An extension in steps of 10 m is possible.

The optical plug of the laser light cable is inserted into the plug receptacle and fixed with the locking screw.

LLK-D and LLK-B (via adapter)

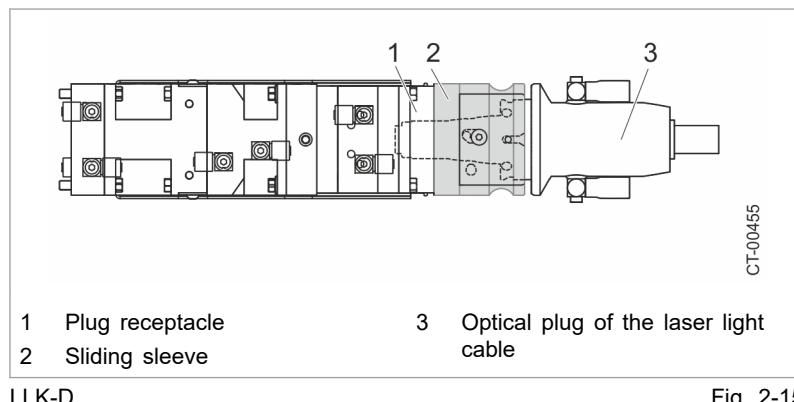


Fig. 2-15

The LLK-D is available with the standard lengths 10 m, 15 m, 20 m, 30 m, 40 m, 50 m, 60 m, 80 m and 100 m. Other lengths are available on request.

The optical plug of the laser light cable LLK-D is inserted into the plug receptacle D and fixed with the locking screw.

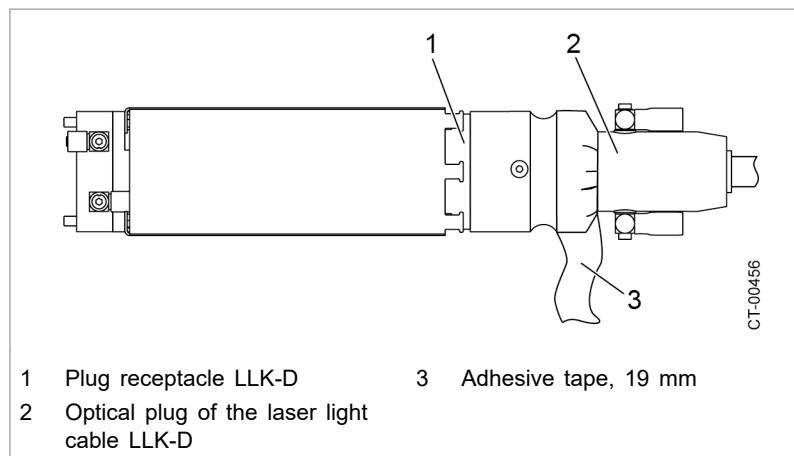
LLK protection

Fig. 2-16

Note

To protect the LLK from dirt, TRUMPF recommends sealing the disconnection point between the LLK plug and the plug receptacle of the focusing optics with adhesive tape.

In a contaminated environment (e. g. dust, oil vapor), TRUMPF recommends the additional use of a protective sleeve.

Parts	Designation	Material Number
	Adhesive tape PVC, 19 mm	1420313
	Protective collar	1416727

Tab. 2-3

Note

For sealing the separation point, **exclusively use the adhesive tape specified here**.

Fiber core diameter Depending on the laser device used, the laser light cables are available with various fiber core diameters: from 50 µm to 600 µm.

Note

Contact the service department of TRUMPF if the LLK is damaged. Change a damaged LLK only if the service department of TRUMPF explicitly agreed to it.

Further information can be found in the Operator's manual of your laser device.

Safety A contact ring inside the plug receptacle and contact pins on the optical plug guarantee that the laser device will only guide laser light through the laser light cable when the optical plug is correctly plugged in the plug receptacle of the focusing optics.

Installing the laser light cables Ensure that the laser light cables are installed without tensile stress, buckles and torsion-free.

bend radius The bend radius of the laser light cable must **not be smaller than 200 mm**.

Connecting the laser light cable to the focusing optics

The following instructions describe how to proceed step-by-step when connecting an LLK to a focusing optics.

In the following instructions, we assume that the optics cannot be rotated on the carrier. If the optics can be rotated, you can vary the described procedure as mentioned above:

- Mount the focusing optics.
- Rotate the focusing optics into a horizontal position.
- Connect the LLK as described below.

Conditions

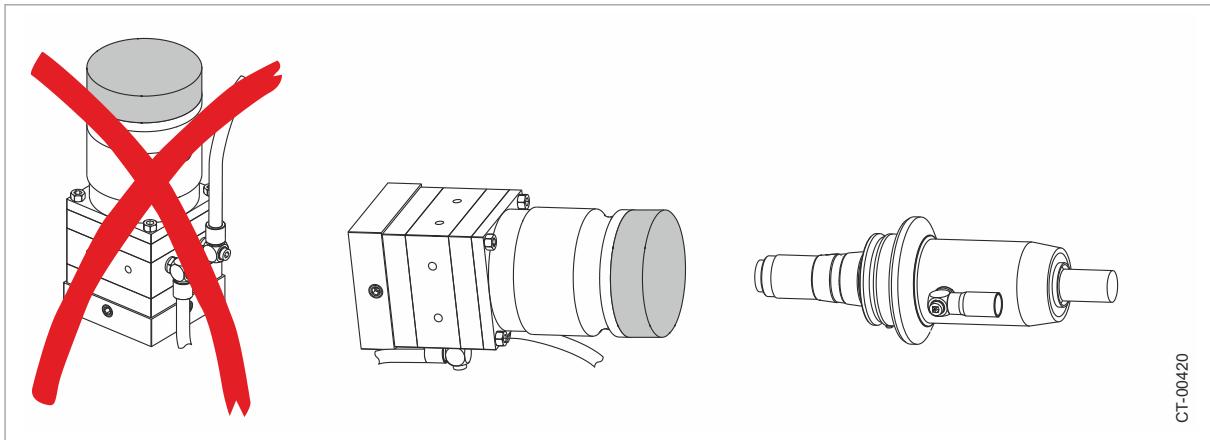
- This concludes the complete assembly of the focusing optics.
- You have removed the transport packaging of the focusing optics and put it on a clean surface.
- The plug receptacle of the focusing optics is closed with a sealing plug.
- The LLK plug you want to connect to the focusing optics is flexible so that it can be plugged in the plug receptacle without applying tensile force to the LLK.
- A protective cap is attached to the LLK plug.
- The carrier on which you want to mount the focusing optics is mechanically and electrically, if required, prepared for mounting.

Means, Tools, Materials

- Adhesive PVC tape, 19 mm, material no.: 1420313
- LLK-D protective collar, material number 1416727

NOTICE**Dirt in beam path!****This may destroy the LLK or focusing optics.**

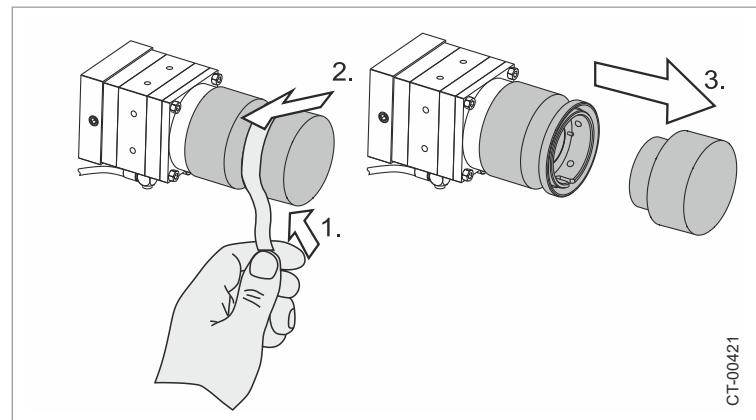
- Leave openings on LLK and focusing optics unprotected as short as possible.
- Put the shaft of the plug receptacle in horizontal position as long as the plug receptacle of the focusing optics is open.
- Do not touch optical surfaces.



Plug receptacle and LLK (sealed with adhesive tape)

Fig. 2-17

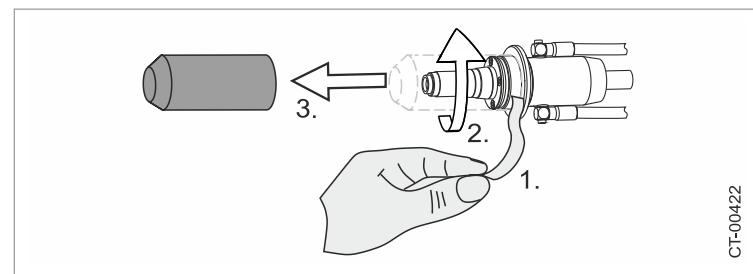
1. Store the focusing optics such that the shaft of the plug receptacle for the LLK is in a horizontal position.



Remove the sealing plug from the plug receptacle

Fig. 2-18

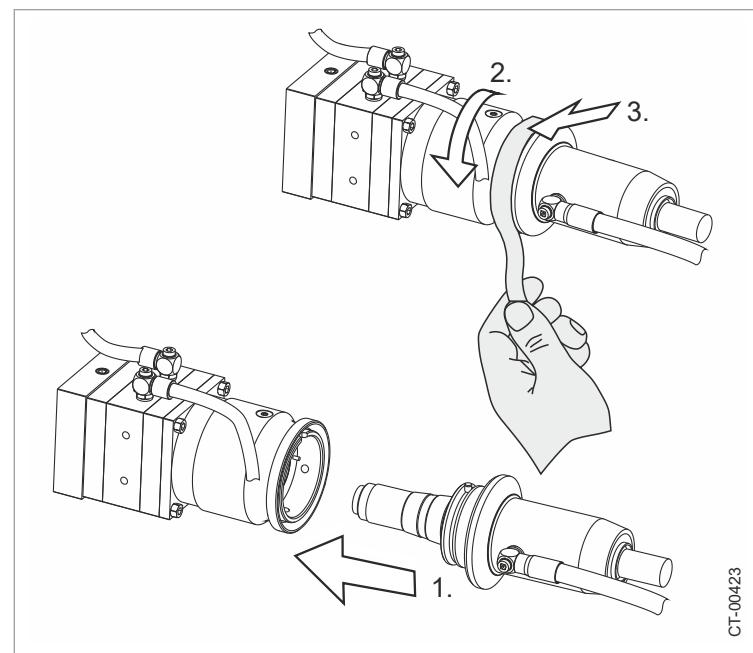
2. Remove the adhesive tape from the plug receptacle (1) of the focusing optics.
3. Push sliding sleeve (2) towards the focusing optics until this engages.
4. Remove the plug (3).



Remove the protective cap from the LLK plug

Fig. 2-19

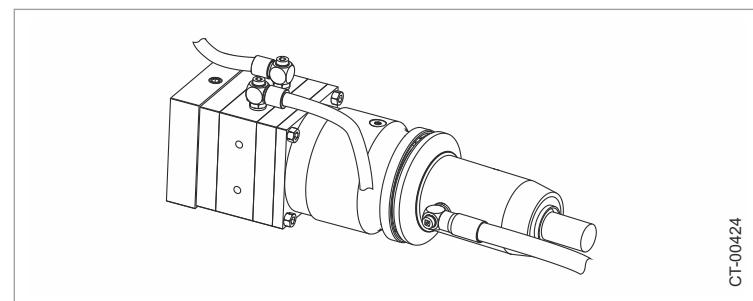
5. Remove the adhesive tape from the LLK plug (1).
6. Remove the protective cap from the LLK plug. by turning protective cap to the left (bayonet locking) (2) and (3).



Steps for mounting

Fig. 2-20

7. **Immediately** plug in the plug of the LLK in the plug receptacle of the focusing optics (1).
8. Turn the sliding sleeve (2) as shown on the applied engraving 5° to the right until this locks.
9. **Immediately** put an adhesive tape around the joint and press it on tightly (3).

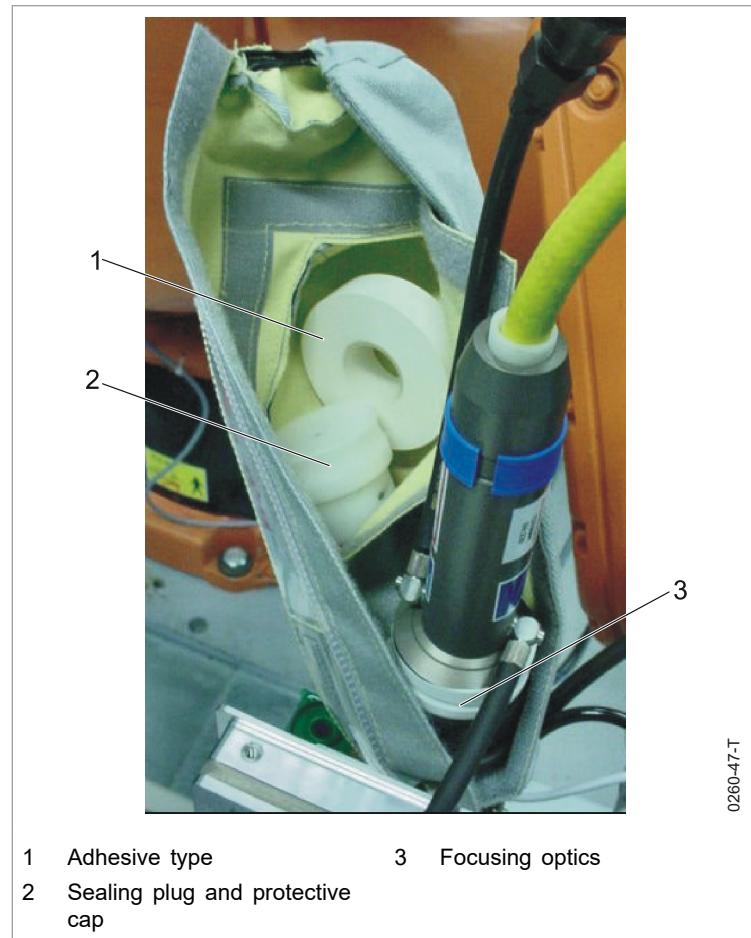


Mounted and taped plug receptacle and LLK

Fig. 2-21



10. Join sealing plug and protective cap and store them carefully.
Both parts will be needed when you separate the focusing optics and the LLK again.
11. Mount the focusing optics to the support.
12. If any, establish all other connections to the focusing optics (electrical plugs, cooling water hoses).
13. Lay LLK and other connected lines such that they have sufficient room for movement.

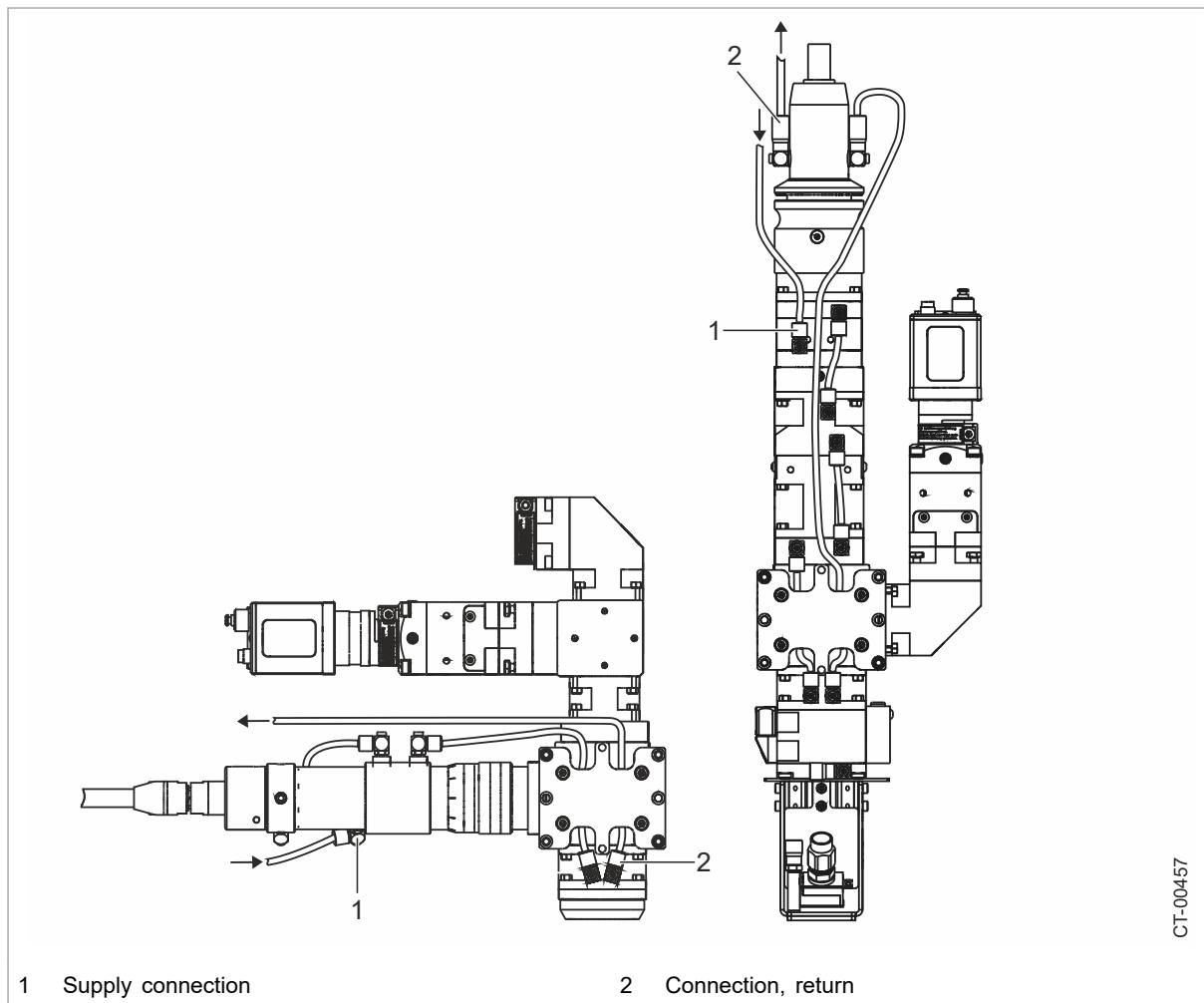


Mounted protective sleeve Fig. 2-22

14. If there is considerable pollution in the environment, for example due to dusts or oil, put the protective sleeve around the plug receptacle and the LLK plug and close it.

You may now use the focusing optics.

3.5 Connections for cooling unit



Connections on the BEO D50 Basic plug receptacle

Fig. 2-23

One pair of hoses, supply and return (black/red hose set), supply the focusing optics with cooling water. When using an LLK-D, the optical plug is also cooled with water.

The cooling lines are already fully installed on the focusing optics. Only the connection for the cooling water supply and for the LLK are still missing.

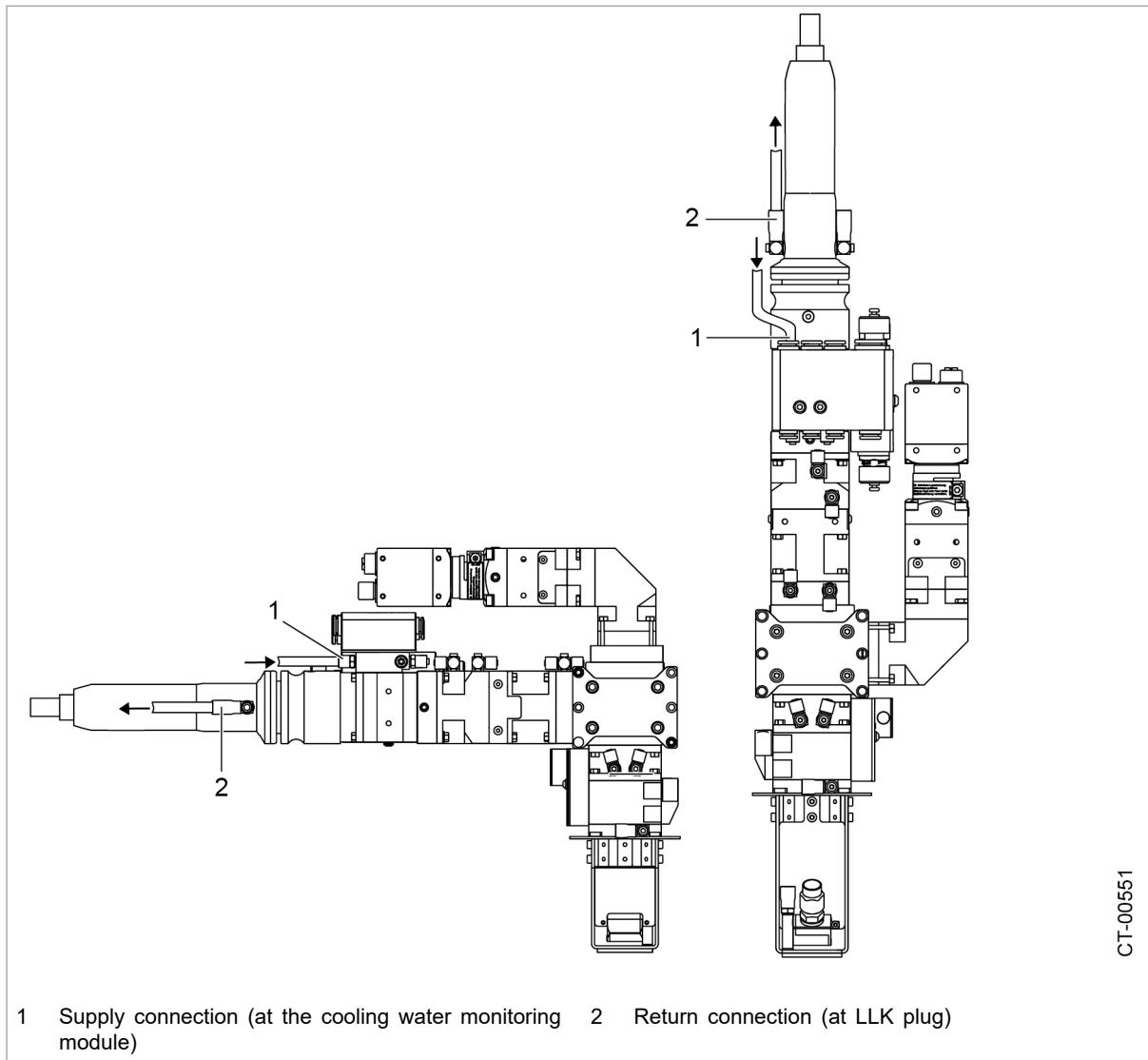
The order for this is as follows: cooling water supply – focusing optics – LLK-D – cooling water return. Both cooling lines on the BEO are marked "IN" and "OUT".

The cooling water supply is connected to the cable marked "IN" (1). The cable marked "OUT" (2) is connected to the LLK-D or to the return.

Connections on the plug receptacle LLK-A

Heat arising at the transition point of the laser light cable and collimation unit is dissipated through the connections on the plug receptacle for LLK-A.

BEO D50 Smart In the case of focusing optics BEO D50 Smart, the cooling water temperature can be monitored within preset limits via the cooling water monitoring module. For more information on this topic, please refer to the software manual of the controlled focusing optics.



Connections at the BEO D50 Smart plug receptacle

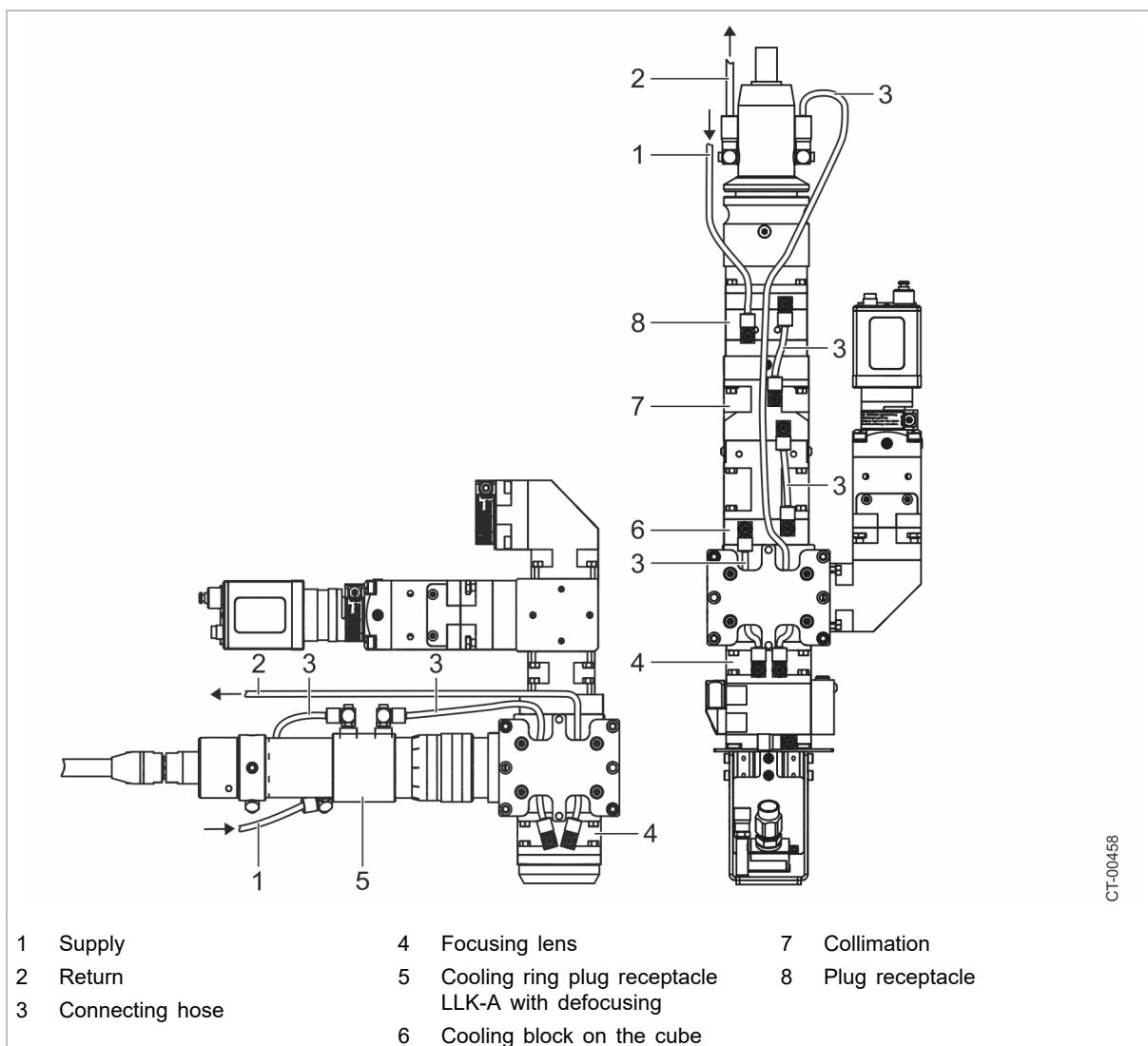
Fig. 2-24

Additional cooling From 600 W average power, the focusing optics is cooled at various cooling points:

- Plug receptacle
- Collimator
- Lens
- Cooling block on the cube

When using these cooling blocks, the hose system is designed as shown in the examples (see "Fig. 2-25", pg. 2-28).

The supply always reaches the plug receptacle first.



Hose system (examples)

Fig. 2-25

Cooling water hoses

The length of the cooling water hoses is adapted to the selected laser light cable. The connections at the focusing optics are automatically acting couplings.

The following cooling water hose is used:

- Outside diameter 6 mm.
- Inside diameter 4 mm.

Note

The focusing optics is cooled by the laser device cooling unit sufficiently only if the cooling water hoses are shorter than 50 m. If the laser light cable is longer than 50 m, an additional cooling unit must be used for the direct cooling of the optics. The quality of the cooling water of the cooling unit must be the same as the quality of the cooling water in the laser device.

Cooling water

Normally the cooling water of the laser device is also used to cool the focusing optics.

⚠ CAUTION**Cooling water contains DI water enriched with anticorrosives!**

- Wear safety glasses and disposable gloves.
- Protect clothing from contact with cooling water.
- Keep cooling water away from eyes and mouth.
- Flush eyes and mouth immediately with drinking water to remove any cooling water.
- Wash hand and parts of the skin that have come into contact with cooling water.

Cooling water for external cooling

In case of external cooling, the cooling water must have the following quality:

- The cooling water has to comply with the VDI Directive 3803 (Appendix A: Recommended values for the water quality in RLT systems).
The pH value of the cooling water must always be < 8.5 because it flows through aluminum components inside the focusing optics.
- Particle size < 100 µm.

Note

The focusing optics that has been operated in a cooling circuit with the water quality described above, must be rinsed thoroughly before it is operated in the cooling circuit of the laser device to avoid contamination of the laser device. The external cooling circuit must remain completely separate from the cooling circuit of the laser device.

The cooling water inflow must meet the following conditions:

- Temperature: 15 °C to 35 °C
- Pressure: max. 6 bar
- Flow: ≥ 60 l/h

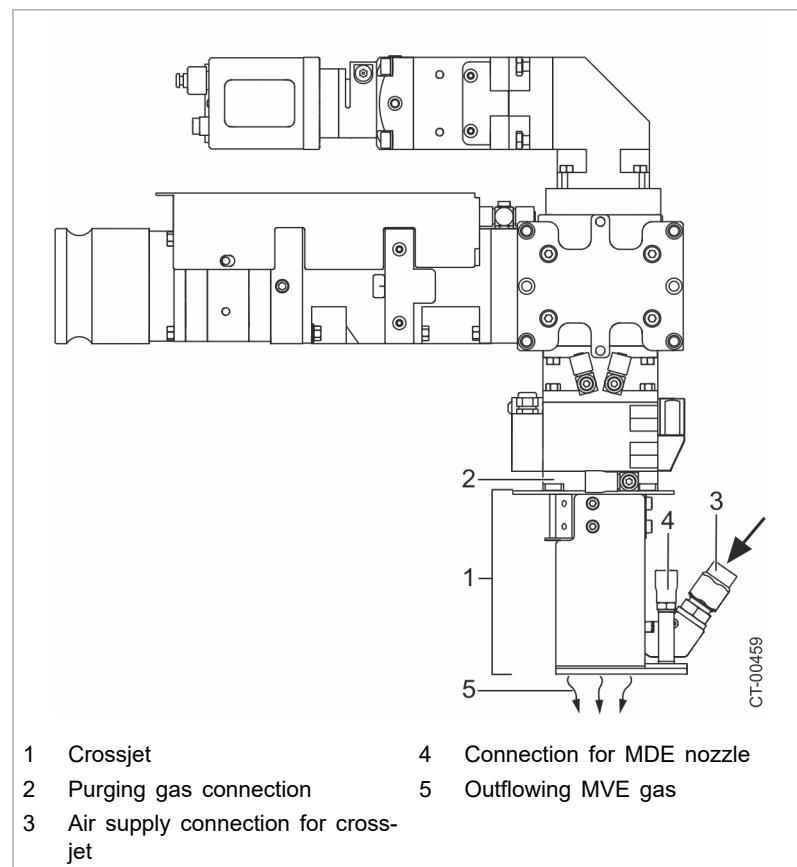
Notes

- The temperature of the cooling water may not be below the dew point of the ambient air to prevent formation of dew.
- If corrosion protection is stipulated for the external cooling device, it is essential that it is used. In case of non-compliance, corrosion residues may cause contamination of the focusing optics and may reduce the flow rate of the cooling water.

TRUMPF recommends the anticorrosive KI 640 HD. There are no long-term experiences for other anticorrosives.

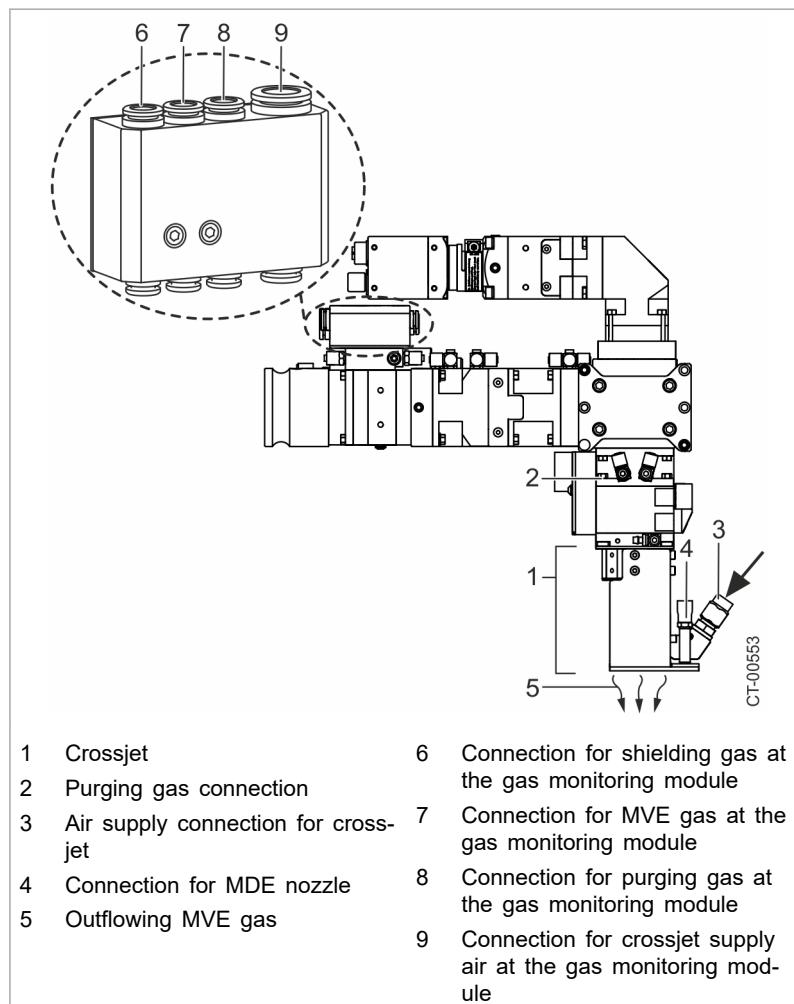


3.6 Connections for crossjet, purging gas and MVE gas



Connections on BEO D50 Basic crossjet

Fig. 2-26



Connections on BEO D50 Smart crossjet

Fig. 2-27

⚠ CAUTION

Hot surfaces on the crossjet can burn your skin!

If the crossjet is bent (e.g. due to improper transport or a crash), the laser beam will hit the crossjet and can heat this up until it glows.

- Avoid contact with hot surfaces.
- Check the crossjet for damage during assembly.

⚠ WARNING

Risk of injury when handling compressed air!

Injuries to eyes, skin and hearing.

- Wear a pair of tight-fitting safety glasses.
- Never clean body parts or clothes that are worn with compressed air.
- Use hearing protection.
- Wear suitable gloves.

Note

In the case of focusing optics BEO D50 Smart, the flow of the process media (purging gas, MVE gas, shielding gas and the crossjet pressure) can be monitored within adjustable limits via the gas monitoring module. For more information on this topic, please refer to the software manual of the controlled focusing optics.

Crossjet Cleaned and dried compressed air is used as supplied air.

	Focal length of lens f150	Focal length of lens ≥ f200
Gap width	0.5 mm	0.3 mm
Pressure	approx. 5 bar	approx. 3.5 bar
Air consumption	approx. 500 l/min	approx. 210 l/min

Compressed air

Tab. 2-4

The compressed air used must comply with the specification according to DIN ISO 8573-1:

- Max. particle size 1 µm
- Max. pressure dew point 7 °C
- Max. oil concentration 1 mg/m³

The required pressure depends on the formation of splatter from the respective welding application. In some cases, the value may exceed the indicated upper limit.

Note

Note that the indicated pressure must be available at the compressed air connection. The connected hose causes a pressure loss, depending on the length and diameter of the hose.

Shielding gas Detailed information about the use of shielding gas and the available shielding gas nozzles can be found in the chapter "Assembly and installation" in the section "Using shielding gas" ([see "Using shielding gas", pg. 2-42](#)).

Scavenging gas When required, purging gas is passed into the interior of the crossjet below the protective glass. The purging gas reduces fouling on the protective glass.

Usually, oil- and water-free compressed air in acc. with DIN ISO 8573-1 or nitrogen is used as purging gas.

The purging gas consumption is approx. 6 l/min.

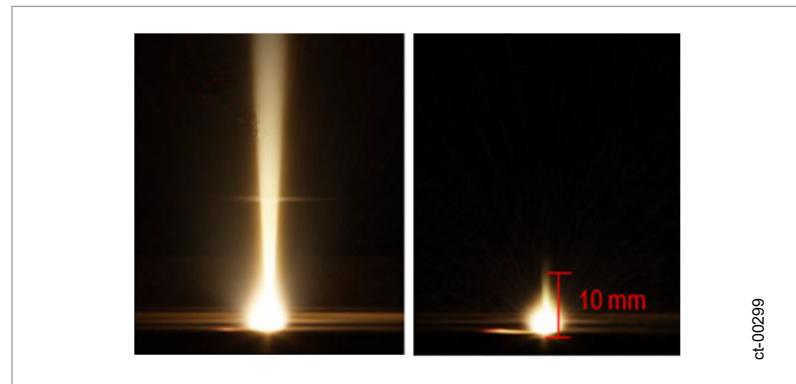
MDE nozzle The MDE nozzle is attached to the crossjet (MDE means metal vapor effect).

During the laser welding process, the laser light may be reduced or deviated due to the particles in the metal vapor



(plasma torch). This may lead to welding depth fluctuations and to irregular weld surfaces.

Cleaned and dried compressed air according to DIN ISO 8573-1 is supplied toward the processing plane via the connection for the MDE nozzle. The air flow of the MDE nozzle eliminates the plasma torch.



Plasma torch with and without use of coaxial MDE nozzle

Fig. 2-28

Hose outer diameter	6 mm
Air consumption (focal length of lens f150)	approx. 35 l/min
Air consumption (focal length of lens \geq f200)	approx. 50 l/min

Compressed air

Tab. 2-5

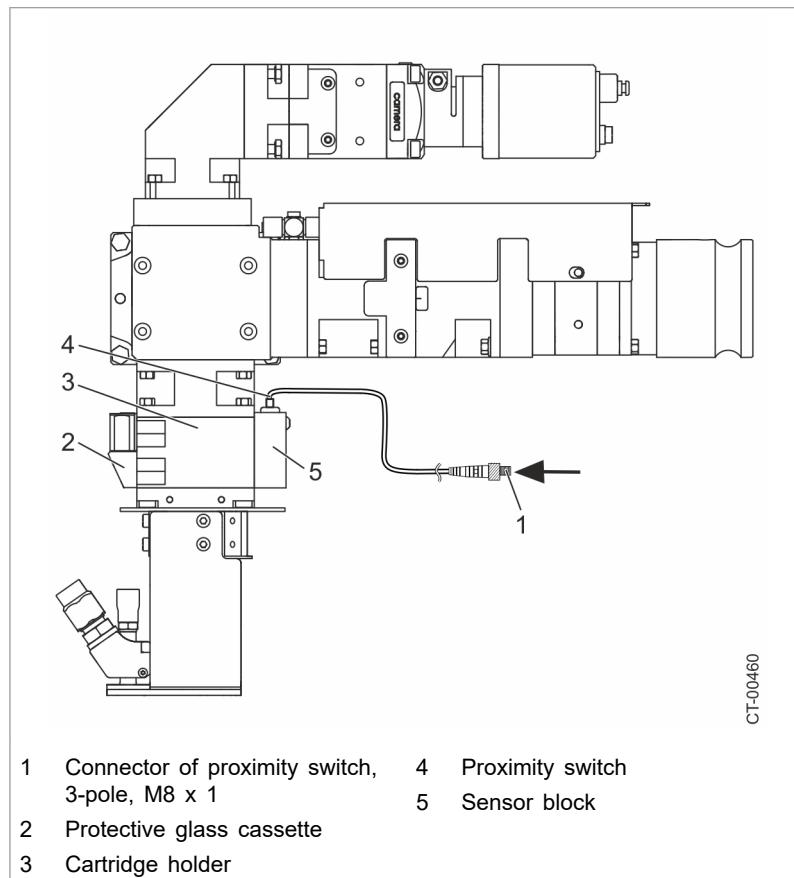
The required pressure depends on the plasma torch of the respective welding application.

Note

Adjust the air consumption (flow rate) directly in front of the MDE nozzle in the air supply hose e.g. by means of a suspended solid particle flow meter and a reducing valve.

Adjust the flow for the MVE nozzle such that the plasma torch is $< 10\text{mm}$ high.

3.7 Connection for proximity switch (BEO D50 only, without protective glass monitoring unit)



Connection proximity switch protective glass cassette

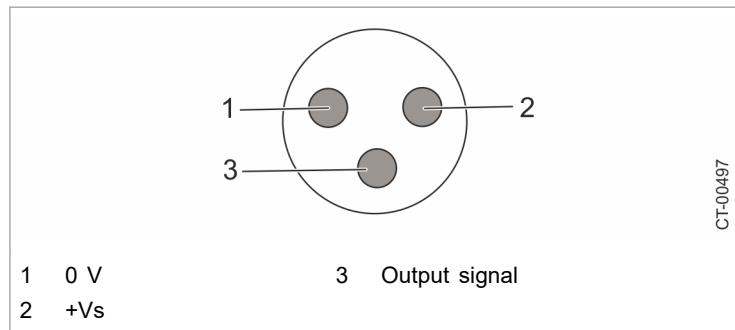
Fig. 2-29

The proximity switch must in all cases be connected for safe operation of the focusing optics and indicates whether a cassette is present or not.

Note

Whether protective glass is placed in the cassette is not monitored!

The proximity switch can be connected to a PLC or a monitoring device by means of a 3-pole connector (M8 x 1).



Proximity switch plug terminal assignment

Fig. 2-30

Proximity switch connection data

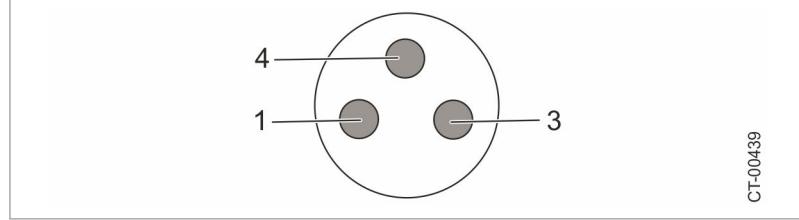
- Operating voltage range +Vs: 10 - 30 V DC
- Max. current consumption (without load): 12 mA
- Operating voltage: 24 V DC.

Signal level at output A

- Protective glass cassette available: 24 V
- Protective glass cassette not available: 0 V

3.8 Lighting connection

The processing point lighting is supplied with 24 V.



Connection for lighting, M8 connector

Fig. 2-31

Pin	Supply line	Designation	Note
1	Brown	+24 V	Max. supply voltage 30 mA
3	Blue	GND	Central earth
4	Black	TRIGGER	On: 8 - 24 V Off: open or < 0.5 V

X1 – connection for lighting, M8 connector, 3-pole

Tab. 2-6

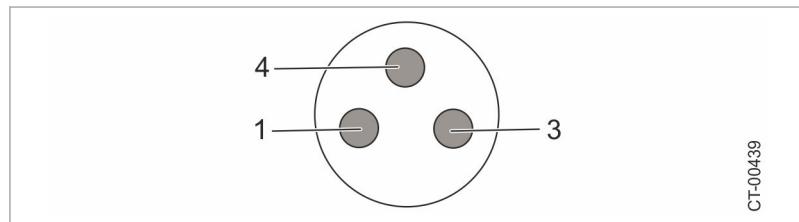
Note

The lighting can also be controlled via the image processing software VisionLine; see the operator's manual "VisionLine", doc. no.: 22-50-12-A0-CR.



3.9 Connection for line laser

The line laser is supplied with 24 V.



Connection for line laser, M8 connector

Fig. 2-32

Pin	Supply line	Designation	Note
1	Brown	+24 V	Power supply:
3	Blue	GND	Central earth
4	Black	TRIGGER	On: high level +24 V

X1 – Connection for line laser, M8 connector, 3-pin

Tab. 2-7

Note

The line laser can also be controlled via the image processing software VisionLine; see the operator's manual "VisionLine", doc. no.: 22-50-12-A0-CR.

3.10 Camera connection

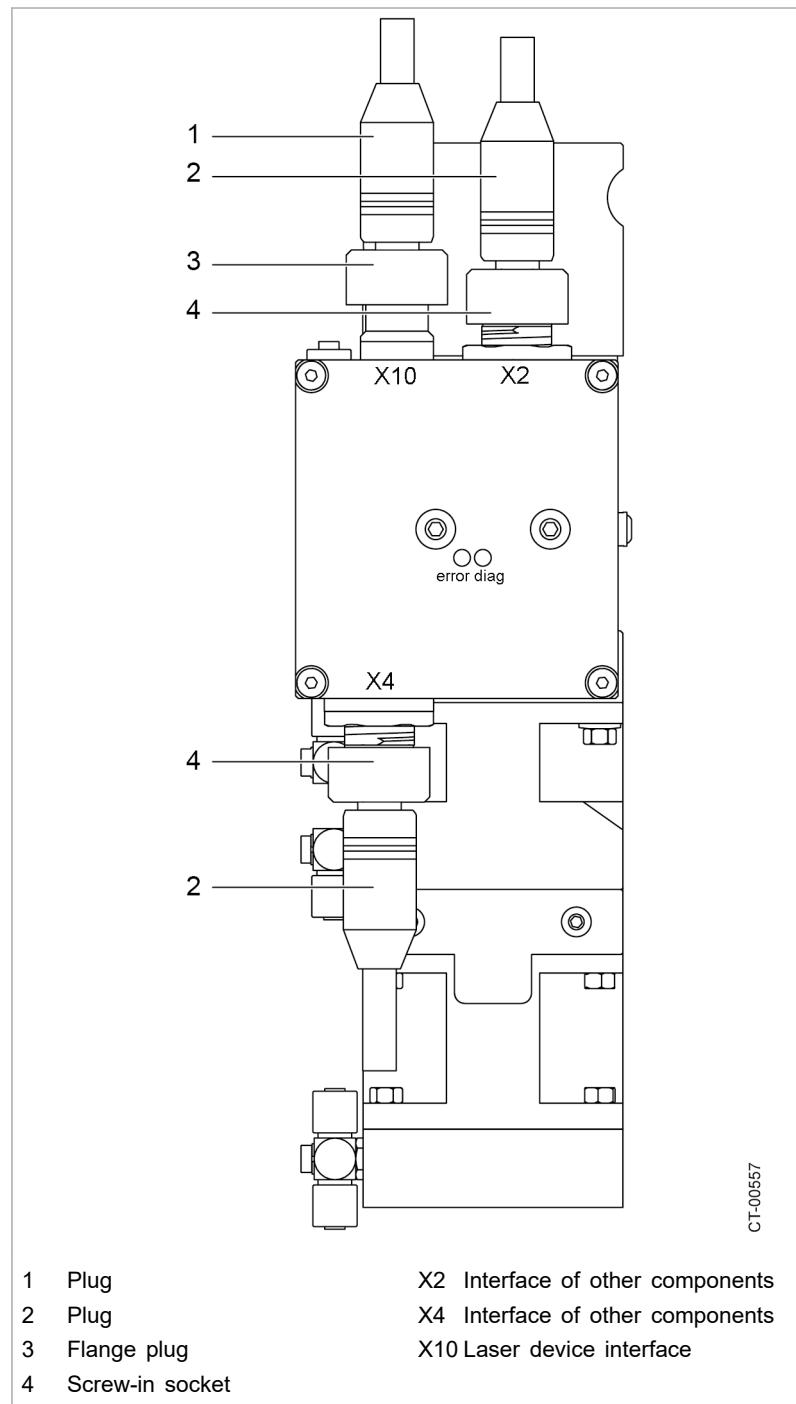
Note

For further information about the observation optics, see the operator's manual "VisionLine", doc. no.: 22-50-12-A0-CR and the operator's manual "VisionLine Cam", doc. no.: 22-50-12-A0-01-CR.



3.11 Other BEO D50 Smart connections

Interface module



Connections on the BEO D50 Smart interface module

Fig. 2-33

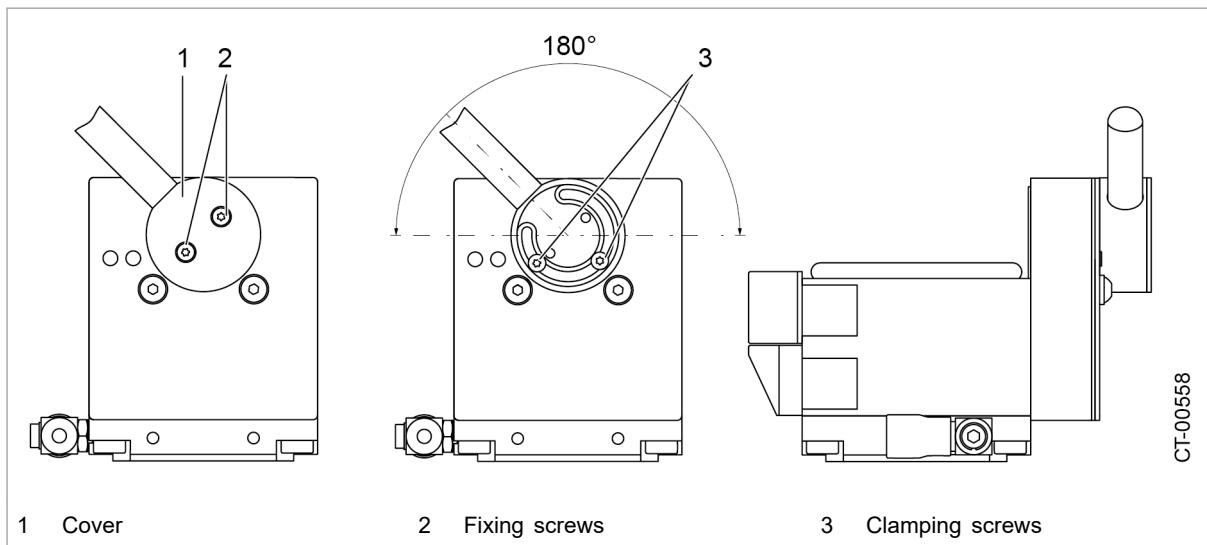
The area marked in the dimensional drawing must be kept free for the connectors.

Connector (1) comes from the IIO board of the laser device and must be able to be manually inserted into/removed from the flange plug (3) of the interface module. Here, the permissible

bend radius of the cable ($R_{min} = 80$ mm) may not be fallen short of if the focusing optics is subjected to dynamic movements. The plug-in length is 9 mm.

Connector (2) comes from the protective glass monitoring unit or another electrical component on the focusing optics and must be able to be manually inserted/removed from the built-in socket (4) of the interface module. Here, the permissible bend radius of the cable ($R_{min} = 80$ mm) may not be fallen short of. The plug-in length is 6 mm.

Connecting cable of the protective glass monitoring unit

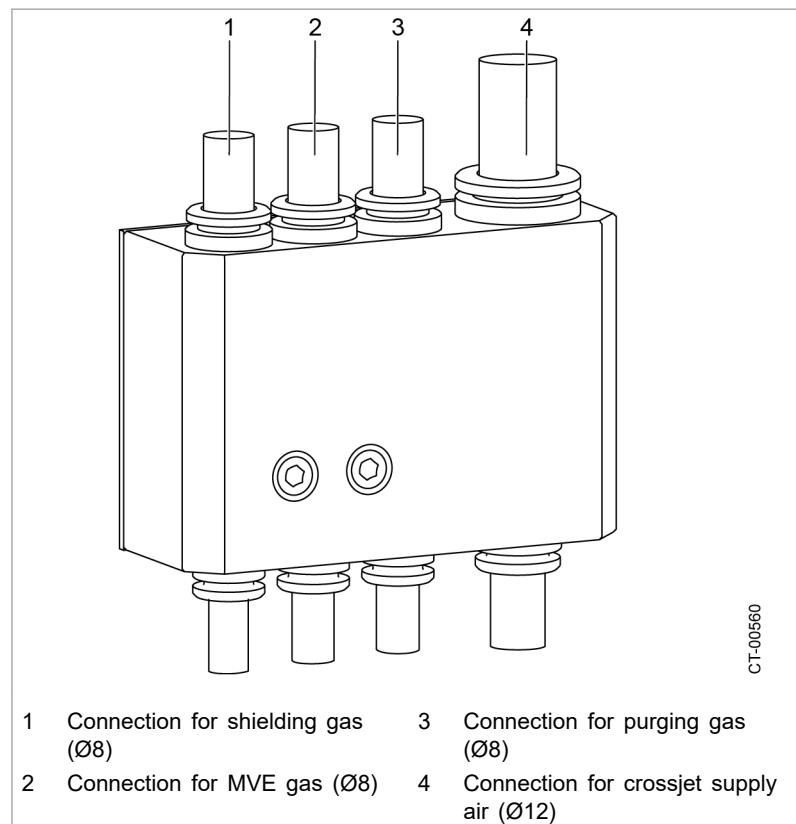


Connecting cable on protective glass monitoring module

Fig. 2-34

When laying the connecting cable of the protective glass monitoring unit, the cover (1) and the fastening screws (2) can be removed. Afterwards, the clamping screws (3) can be slightly loosened and the angular position of the cable can be adjusted.

Once the cable is in the desired position, the clamping screws (3) are tightened again. Afterwards, the cover (1) is remounted with the fastening screws (2).

Gas monitoring module

BEO D50 Smart gas monitoring module

Fig. 2-35

The area marked in the dimensional drawing must be kept free for the media feed (supply air).

The supply interface is equipped with quick-acting couplings, which are marked (1) - (4).



4. Ambient conditions

Temperature	Operation:	+15 °C – +40 °C
	Storage:	+5 °C – +40 °C
Relative humidity	at 40 °C:	max. 40 %
	at 20 °C:	max. 90 %
Protection type:		IP 50
Maximum acceleration:		3 g with 5 – 150 Hz

Tab. 2-8

The focusing optics must **not** be operated in an explosion endangered environment.

Cooling water temperature

If hot and humid air contacts the cold surfaces, condensate is formed at certain temperatures.

To avoid the formation of water of condensation on the focusing optics, the cooling water temperature must not be set to too cold a value.

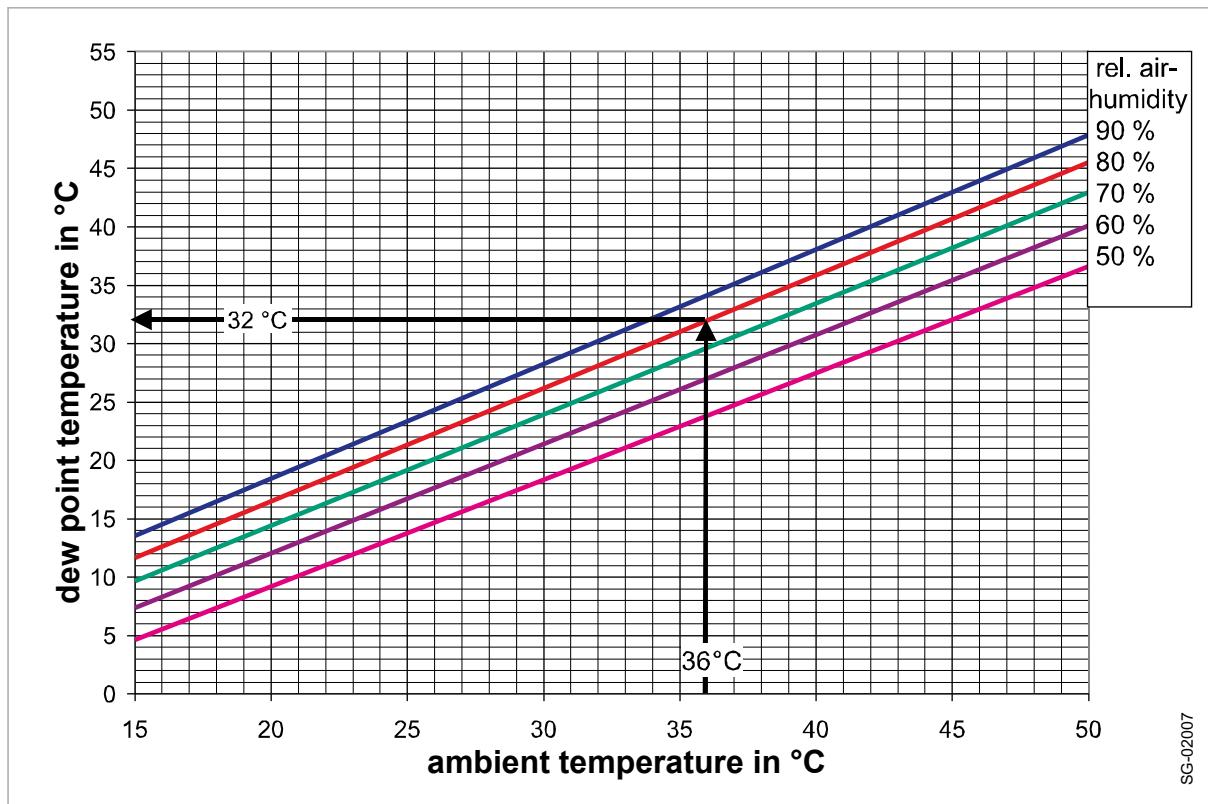
The required cooling water temperature is determined by measuring the ambient temperature and humidity in the surroundings of the focusing optics (see "[Determining the necessary cooling water temperature](#)", pg. 2-41). These measured values can be used to read the temperature in the dew point diagram starting from which the surrounding air will condense.

Note

The cooling water temperature must be at least 2 °C above the indicated dew point temperature.



4.1 Determining the necessary cooling water temperature



Dew point diagram

SG-02007

Fig. 2-36

1. Measure ambient temperature (in the example: 36 °C).
2. Measure the relative humidity (80 % in the example).
3. Draw a vertical line in the diagram from the measured ambient temperature upwards until it intersects with the straight line representing the measured humidity.
4. Draw a horizontal line from the point of intersection to the dew point temperature.
5. View the dew point temperature (32 °C in the example).

The temperature of the cooling water flowing through the focusing optics must be at least 2° C above the dew point temperature: In the example, the cooling water temperature should be at least 34 °C.

Note

When determining the required cooling water temperature, also observe the laser device requirements. In tropical countries, the cooling of the focusing optics must be ensured using an external cooling unit. TRUMPF also offers solutions for an external chiller.



5. Using shielding gas

5.1 Gases during laser welding

During laser welding, gases are used in order to improve the results and avoid deposits on the laser tools.

According to the type of use, a distinction is made between

- Assist gas (MDE gas)
- Inert gas
- Crossjet gas

Assist gases are helpful when welding with Nd:YAG lasers. They suppress the absorption of laser light in the plasma of the metal vapor.

The shielding gas displaces the air at the weld point and thus prevents a reaction with the components of the air.

Crossjet gases are used for welding applications with a strong production of splashes and vapor. The crossjet carries a crossjet gas via a nozzle at a 90° angle to the optics, which protects this from spatter and smoke deposits during the welding process.

The crossjet does not influence the melt and the shielding gas.

5.2 What is shielding gas used for?

Principle of laser welding

The laser generates the laser light and thus the energy necessary for the welding process. This energy is led to the joint of the workpieces via the deflection mirror, laser light cable and focusing device.

The workpieces themselves are arranged and fixed in such a way that the focused laser beam can be guided exactly to the joint. The focusing optics moves over the workpiece along the joints. The high power density of the laser beam in the focal point causes the material to melt and, to a small extent, to vaporize.

The pressure of the escaping metal vapor can increase to such a level that a vapor channel in the material is generated – the so-called "keyhole". This keyhole penetrates the material a few millimeters deep.

When the focusing optics moves over the workpiece the keyhole also moves under the focusing optics. Behind it the melts flow together. The molten and mixed material cools down and the molten mass solidifies to a narrow welding seam.

Many molten metals react with the components of air. This reduces the welding quality. The shielding gas displaces the



components of air and has a positive effect on the quality of the welding seam.

5.3 Shielding gases

For laser welding metals, mainly inert (inactive) gases are used. Inert gases do not react with the base material or only to a very limited extent.

Recommended shielding gases are:

- Nitrogen (N₂)
- Argon (Ar)
- Helium (He)

Purity of the gas

Industrially produced gases always contain a small amount of impurities. The purity of the gases is indicated by a system of digits.

1st digit = number of nines of the percentage

2nd digit = last digit of the percentage

Example: He 4.6 = Helium with purity 99.996 % (by volume)

Service life of a gas cylinder

The service life of a gas cylinder can be easily calculated. Welding gases are supplied in gas cylinders. A gas cylinder contains in most cases 50 liters of a gas which is under a pressure of 200 bar.

$$T = \frac{V \cdot p}{Q}$$

SG-02006

Fig. 2-37

with	T: Service life
	V: Volume of the gas cylinder
	p: Filling pressure
	Q: Specific gas consumption

Tab. 2-9

Example:

V = 50 l, p = 200 bar, Q = 40 l/h

→ T = 50 l • 200 bar / 40 l/h = **250 h**



Nitrogen (N₂)

Nitrogen is a colorless, odorless and inert gas.

Nitrogen is suitable for the welding of chromium nickel steel.

It is **not** suitable for use with zircaloy and titan materials because it can combine with these materials despite its inertness.

When welding steel with nitrogen it should be considered that the nitrogen lowers the stainless protection by removing the chrome-nickel components from the steel.

Argon (Ar)

Argon is a colorless, odorless and inert noble gas contained in air in a concentration of 0.93 % by volume. Argon is non-flammable and non-poisonous. It is suitable as shielding gas for chrome-nickel steel, zircaloy and titanium.

Helium (He)

Helium is a colorless, odorless and inert gas. Because of its reduced density it is very light and quickly escapes upwards when flowing out. For this reason, the consumption of helium as shielding gas is considerably higher than for other gases.

It can be used as shielding gas for aluminum and Al alloys and as addition when welding with nitrogen.

Recommendations

The following table ([see "Tab. 2-10", pg. 2-45](#)) shows an overview of the recommended shielding gases.

	Ar	He	N ₂	Remarks
Aluminum and aluminum alloys	-	+	-	<p>Smooth and polished weld seams are produced with helium or a helium mix.</p> <p>The use of argon causes blowholes in the material.</p> <p>Hydrogen gases cause blowholes in the material.</p> <p>High-quality weld seams can be produced with carbon dioxide (CO₂) or a helium-carbon dioxide mix. However, the weld seams are less smooth and polished.</p>
Chrome-nickel steel	+	-	+	<p>On devices where gas can escape easily, the use of argon is recommended since it is heavier than nitrogen.</p> <p>If corrosion is to be avoided under all circumstances, argon must be used since nitrogen extracts chrome and nickel from the material.</p>
Titanium and titanium alloys	+	-	-	Titanium reacts strongly with the components of air. As long as the weld cooling down still has a temperature of 200 °C, it is necessary to cover the melting bath completely with argon (e. g. use of a glove box).
Zircaloy	+	-	-	-
Copper	-	-	-	Copper must generally be welded without shielding gas. Shielding gas substantially reduces the incoupling of laser light.

Shielding gas recommended for the material: + = yes, - = no

Tab. 2-10

Note

The welding in narrow devices can result in self protection because the metal vapor displaces the oxygen in the surroundings. In such cases, no shielding gas has to be used.

5.4 Shielding gas supply

Shielding gas can be guided to the processing point:

- via a nozzle
- via a clamping fixture on the work station.

The following parameters must be optimally adjusted for utilization:

- gas, pure or mix
- Impact angle
- Impact range
- Gas flow
- Nozzle geometry.

The shielding gas supply must be adapted to the laser device type (cw or pulsed), welding speed and welding seam.

TRUMPF offers some nozzles as standard supply, which are described below in more detail.



Linear gas supply

The linear nozzle is a further development of the multiple tube, where the individual tubes are consolidated. The linear nozzle has the following advantages:

- Better welding seam quality.
- Smaller interference contour thanks to compact structure.
- Can also be used if there is a greater distance between the nozzle and workpiece.

Prerequisites:

- cw laser device.
- Focal length of lens $f = 150$ mm, $f = 200$ mm, $f = 250$ mm and $f = 300$ mm.

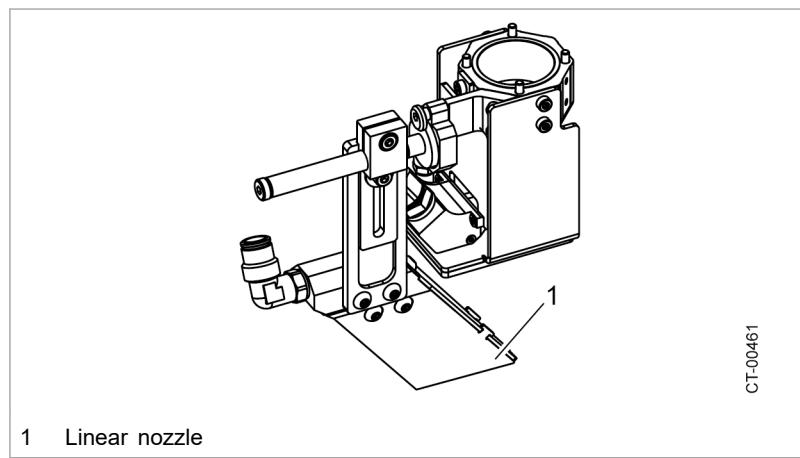


Fig. 2-38

Welding application The linear nozzle is suitable for welding linear welds:

- Butt joint.
- Fillet seam.

Fastening and setting options The linear nozzle can be fastened to the crossjet receptacle. For more detailed information, see dimensional drawing doc. no. 22-51-01-A34-BX.

The distance between focusing optics and the workpiece can be adjusted as required.

It must be made sure that the linear nozzle is not in the beam path.

Note

The crossjet effect might be impaired, depending on the positioning of the linear nozzle.

Shielding gas hose The following shielding gas hose must be connected to the fitting:

- Outside diameter: 8 mm
- Inside diameter: 6 mm

Linear gas supply with a lateral MDE nozzle

Using this nozzle, linear supply of the protective gas is possible while, at the same time, metal vapor effect can be eliminated with a lateral MDE nozzle.

Prerequisites:

- cw laser device.
- Focal length of lens $f = 150$ mm, $f = 200$ mm, $f = 250$ mm and $f = 300$ mm.

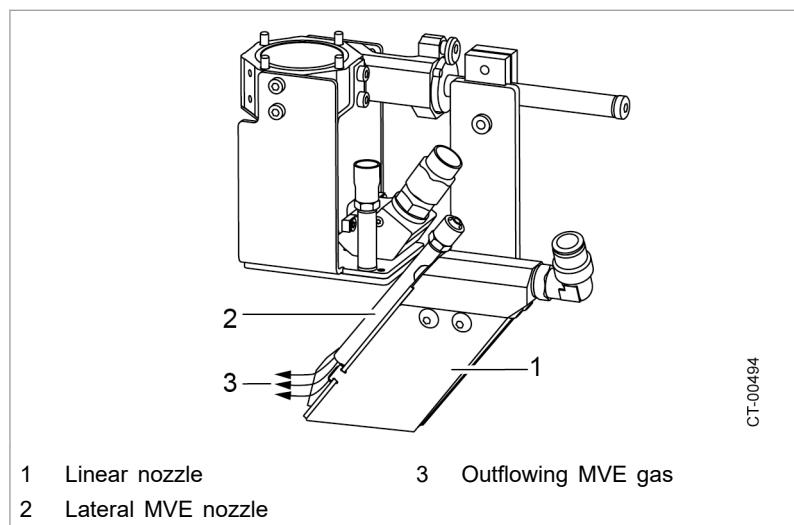


Fig. 2-39

Welding application The linear nozzle is suitable for welding linear welds:

- Butt joint.
- Fillet seam.

Fastening and setting options The linear nozzle can be fastened to the crossjet receptacle. For more detailed information, see dimensional drawing doc. no. 22-51-01-A34-BX.

The distance between focusing optics and the workpiece can be adjusted as required.

It must be made sure that the linear nozzle is not in the beam path.

Note

The crossjet effect might be impaired, depending on the positioning of the linear nozzle.

Shielding gas hose

The following shielding gas hose must be connected to the fitting:

- Outside diameter: 6 mm
- Inside diameter: 4 mm

If a lateral MVE nozzle is installed, the hose of the MVE nozzle must be terminated and connected to the lateral MVE nozzle:

- Outside diameter: 6 mm
- Inside diameter: 4 mm

Aerator nozzle gas supply

The conical nozzle contains an aerator. The aerator provides a steady current and a uniform distribution of the inert gas.

The aerator nozzle can be used if the following conditions are met:

- cw laser device.
- Pulsed laser device.
- Focal length of lens $f = 150$ mm, $f = 200$ mm, $f = 250$ mm and $f = 300$ mm.

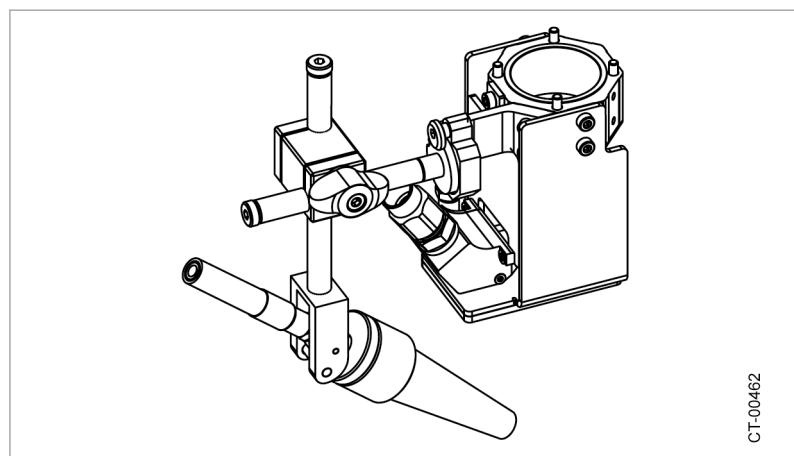


Fig. 2-40

Welding application

The aerator nozzle allows a laminar gas supply for large surfaces at low radiation power and welding speed. The conical nozzle ensures uniform distribution of the shield gas, particularly at positions that are difficult of access.



Depending on the application, a distance of 8 to 12 mm is recommended at a 30° to 50° angle to the workpiece.

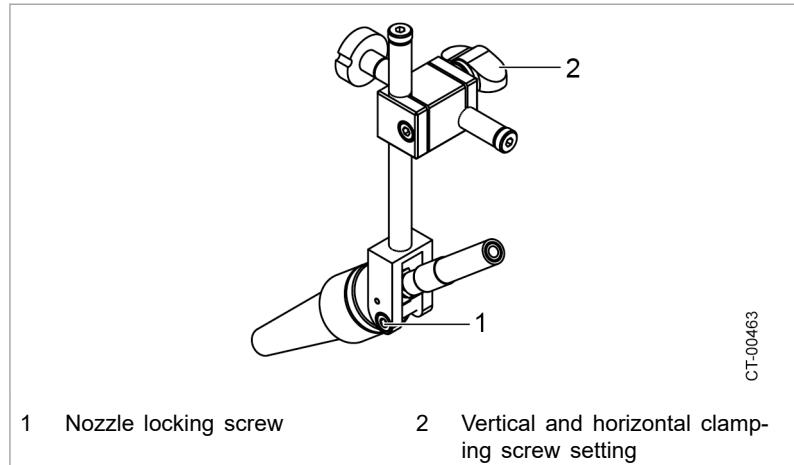


Fig. 2-41

Aerator nozzle The laminar-flow nozzle can be fastened to the crossjet receptacle. For more detailed information, see the dimensional drawing, doc. no. 22-51-01-A34-BX.

The distance to the focusing optics and the angle to the workpiece can be adjusted as required (1 and 2).

It must be made sure that the linear nozzle is not in the beam path.

Shielding gas hose The following shielding gas hose must be connected to the fitting:

- Outside diameter: 6 mm
- Inside diameter: 4 mm

Other methods

If a very good and even covering of the material with shielding gas is required, the use of a glove box is recommended. The glove box encloses the working area completely and the shielding gas cannot escape.

No shielding gas nozzles are required since the glove box is completely filled with shielding gas.

5.5 Arrangement of the shielding gas nozzles

For laser welding, a distinction is made between two welding processes:

- Thermal conduction welding
- Deep welding

With thermal conduction welding, the material is melted at the surface only. Welding seams of some tenth of millimeters depth are produced. This method is especially common with pulsed Nd:YAG laser

With penetration welding, however, very deep and very narrow welds are produced. Penetration welding is done with Nd:YAG-lasers in cw mode.

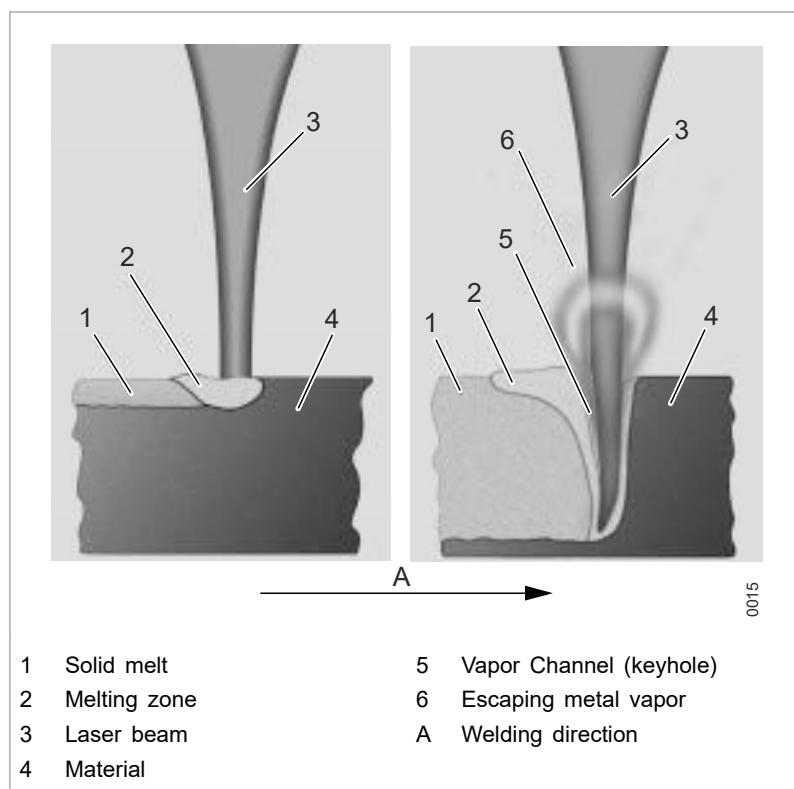


Fig. 2-42

Pulsed lasers

In order to obtain optimal results with a pulsed laser device, the welding wire (if used) is usually fed so that it is dragging (running ahead). The direction where the shielding gas is supplied from can be freely selected.

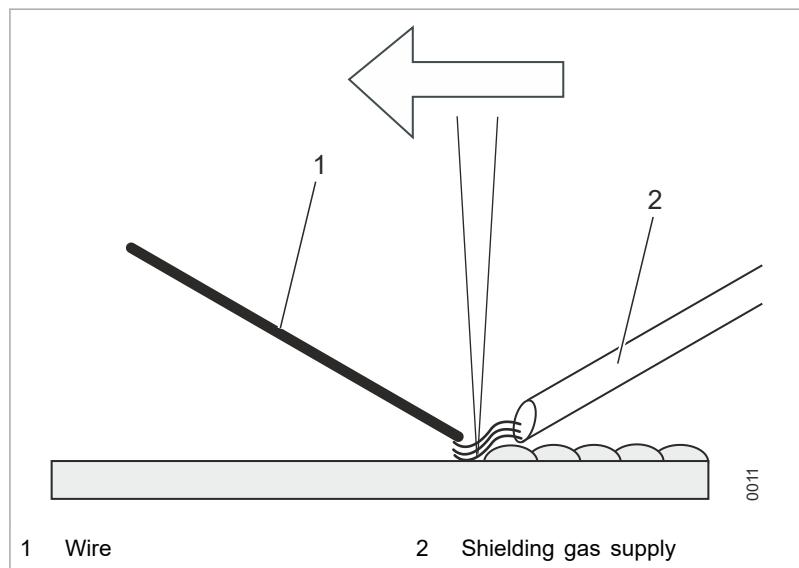


Fig. 2-43

cw lasers

In order to achieve optimum results with cw laser devices, the shielding gas is always supplied trailing and the wire supply (if used) leading.

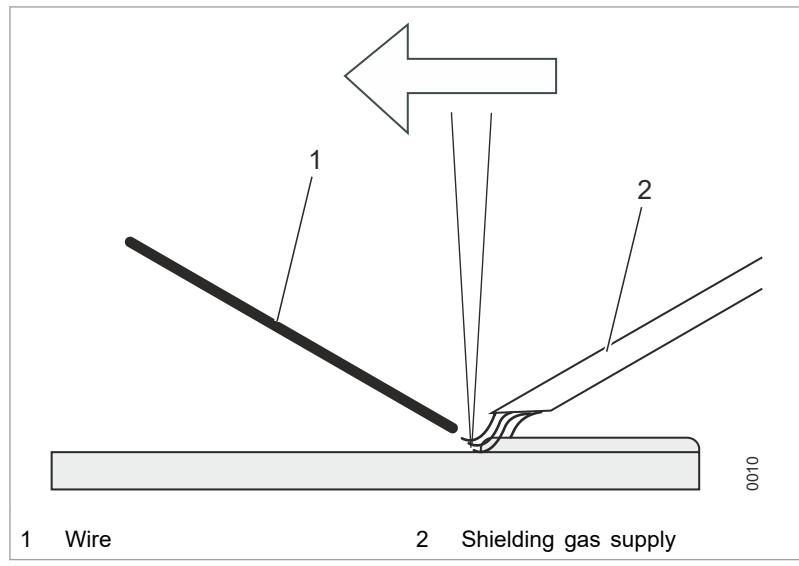


Fig. 2-44

Welding at edges

The nozzles of the shielding gas supply line must be arranged in a way that a laminar, constant gas flow is produced. Especially welding at edges can cause swirls that move the oxygen of the surroundings to the weld point. The material can already react with the oxygen if the oxygen portion > 0.5 %.

If welding is performed on edges, a swirl of the gas flow can be prevented by attaching a deflector.

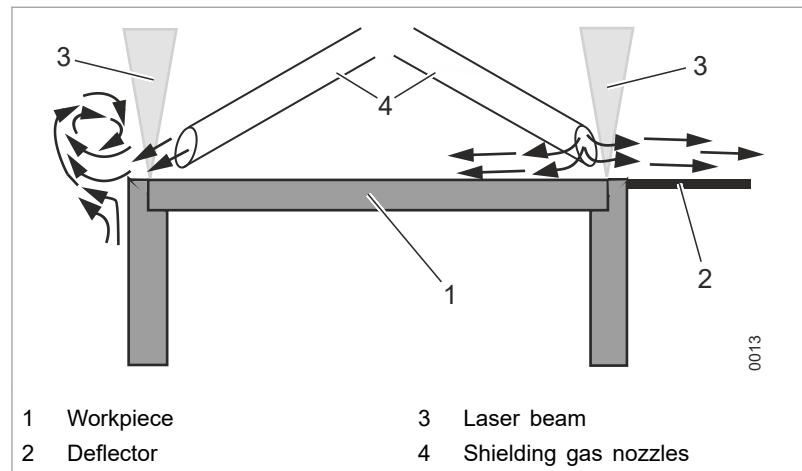
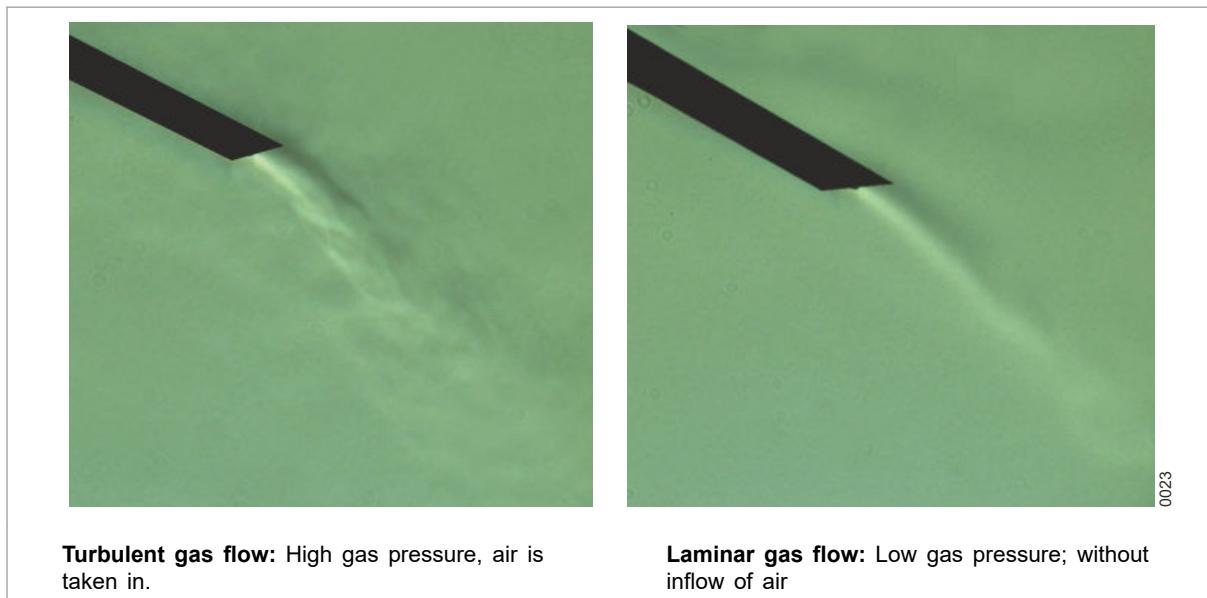


Fig. 2-45

5.6 Dosing shielding gas

Correct dosing of the shielding gas is important for getting an optimal welding result. In the ideal case, the gas flows in a laminar flow evenly over the processing point. If not enough shielding gas is supplied, the protective effect is not sufficient and gas or humidity from the air can reach the welding seam. Too much shielding gas causes swirls that lead air to the weld point.



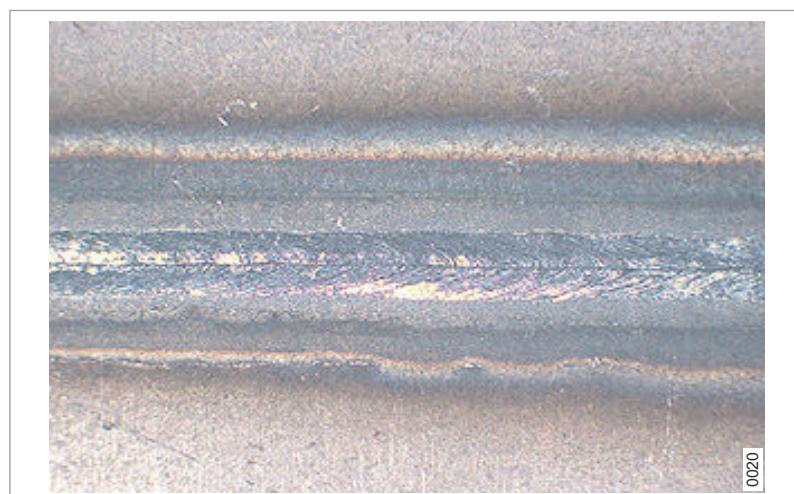
Turbulent gas flow: High gas pressure, air is taken in.

Laminar gas flow: Low gas pressure; without inflow of air

Fig. 2-46

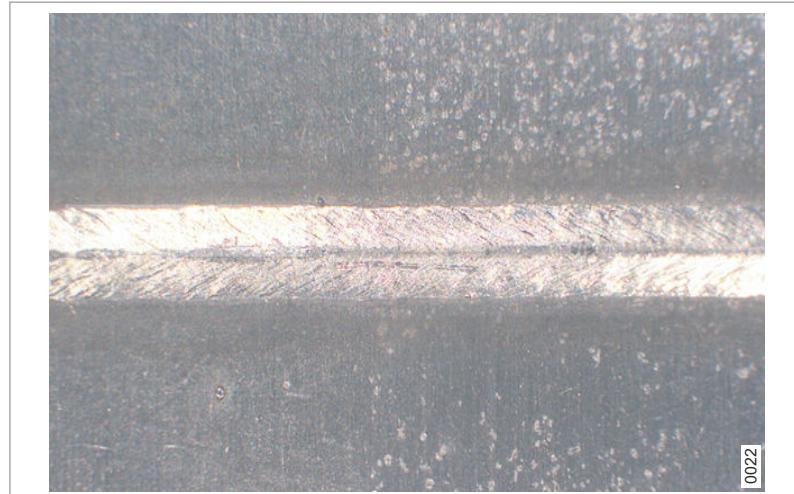
The color of the welding seam allows a statement about the amount of the used shielding gas.

From a gray discoloration of the welding seam can be concluded that no shielding gas was used. If the welding seam yellows, the dose must be optimized further. A high gloss seam is produced when the shielding gas is dosed optimally.



Weld seam: without shielding gas, gray discoloration of the seam.

Fig. 2-47



Weld seam: yellow color zones in the seam (bright areas in the picture); dosing must be optimized further.

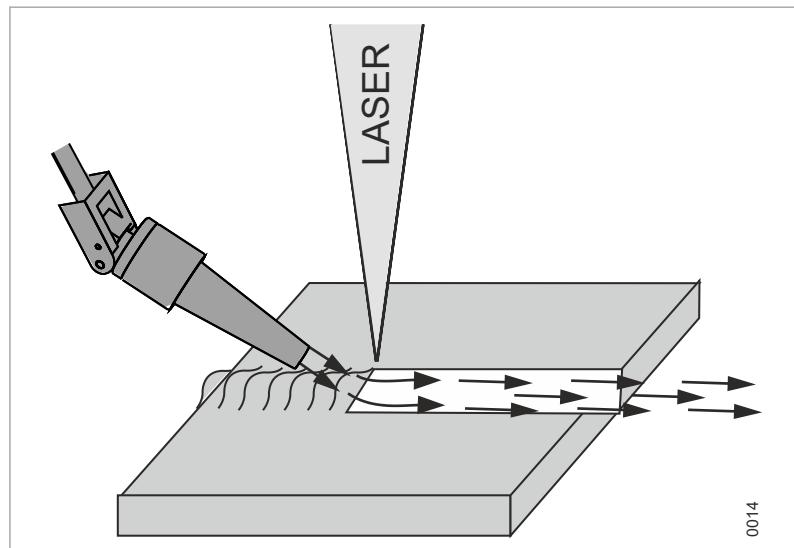
Fig. 2-48



Weld seam: shielding gas optimally dosed, even, high-gloss seam.

Fig. 2-49

A shielding gas nozzle with perlator ensures an even outflow of shielding gas. The same effect can be created with steel wool in the nozzle.



Laminar flow

0014

Fig. 2-50

Crossjet For welding applications with a strong production of splashes and vapor, a crossjet can be used. The crossjet must be adjusted to allow the shielding gas to flow unaffected by the crossjet gas.

Tip

With a simple test, it can be checked if the crossjet was adjusted optimally:

Keep a paper strip over the workpiece and adjust the gas pressure to such a level that the paper strip is not pushed down or drawn in by the crossjet.

5.7 Effect of the shielding gas

The different shielding gases have different effects. They influence the form of the weld seam and can generate seam surfaces which are smoother and glossier. The formation of pores in the weld seam and spatter formation can be influenced by the selection of the shielding gas.

The incoupling of laser light is deteriorated by a shielding gas!

	Argon (Ar)	Helium (He)	Nitrogen (N ₂)	without shielding gas
Seam shape b = width t = depth				
Seam surface	++	+	+	-

	Argon (Ar)	Helium (He)	Nitrogen (N ₂)	without shielding gas
Spatter	+	+	0	-
Pores	++	+	+	-
Incoupling laser light	-	-	-	+
Costs	-	-	0	+

Effect of the shielding gases: + = favorable, 0 = neutral, - = unfavorable

Tab. 2-11

Note

To optimize the effect of the shielding gas, the shielding gas must have been switched on briefly before starting and remain switched on after finishing welding.

After being switched on, the shielding gas takes some time to reach the workpiece.

After finishing welding, the melt must be briefly covered with shielding gas during cooling.