

Operator's manual

Programmable focusing optics (PFO) 33 (KF023)

Operator's manual

**Programmable focusing optics
(PFO) 33** (KF023)

Original operator's manual

Edition **2022-03**

Order Information

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Address for orders

TRUMPF Laser GmbH

Vertrieb

Aichhalder Straße 39

78713 Schramberg

Fon: +49 7422 515 - 0

Fax: +49 7422 515 - 436

Internet: <http://www.trumpf-laser.com>

E-Mail: info@de.trumpf-laser.com

Address for service

TRUMPF Laser GmbH

Technischer Kundendienst

Aichhalder Straße 39

D-78713 Schramberg

Fon: +49 7156 303 - 37 444

Fax: +49 7422 515 - 148

Internet: <http://www.trumpf-laser.com>

E-Mail: service.tls@de.trumpf.com

E-Mail: spareparts.tls@de.trumpf.com

Good to know

What do the operating instructions contain?

These operating instructions contain important information on the focusing optics, its functions, the necessary adjustment work and upkeep. This information will help you operate the laser product safely, avoid any risks, reduce service costs and breakdown times and increase its reliability and service life.

Other regulations

In addition to the Operator's manual, observe the regional regulations regarding accident prevention, laser safety, and environmental protection.

Who is the operator's manual for?

The laser product Operator's manual must be read and observed by every person who is commissioned with working on the laser product.

Examples of work on the laser product:

- Operation
- Maintenance
- Transport

Documentation for further reference

- Operator's manual for the laser device
- Interface descriptions
- Dimensional drawings
- Installation directive

Further information on the operation and programming of the focusing optics can be found in the software manual TruControl 1000 for PFO, document no. 12-12-14-A2-CR.



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Chapter 1

Safety

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1. For your safety

Safety is essential This chapter contains important hints for a safe operation of the laser product. Read the hints carefully before putting the laser product into operation.

Note

For "partly completed machinery" in accordance with the EC Machinery Directive, this document corresponds to the assembly instructions.

Chapter safety This chapter summarizes information that the operator must know to ensure a safe operation of the laser device.

Information on the following factors is indicated:

- Hazards that may arise from the laser product.
- Devices and measures which we have already realized as the manufacturer to ensure a safe operation of the laser product.
- Instructions that the user must realize in order to operate the laser product safely in the work environment and to protect the health of persons.

Hazards and warning hints The operator's manual contains descriptions and instructions for the efficient use of the laser product. When hazards may arise, the instructions are preceded by warning hints warning of the consequences.

Note

The operator must permanently keep the operator's manual at the place where the laser product is used.

2. Warning instructions

A warning instruction is information that:

- Names the type and source of a danger.
- Indicates possible consequences in case the danger is not avoided.
- Gives instructions for how to avoid any damage.

One of the **signal words** "Danger", "Warning", "Caution", or "Attention" indicates the severity of the possible consequences in case the instructions are not observed.

"Danger" warns against a great danger. If not avoided, it leads to death or serious injuries.

"Warning" warns against a danger that may cause medium or serious injuries with permanent damage.

"Caution" warns against a danger that may cause light or medium injuries without permanent damage.

"Attention" warns against possible material damage.

Example of a warning instruction:



Eyes and skin may be exposed to laser radiation if the laser light is not placed under a protective cover!

Laser light can burn the skin. Direct or scattered laser light can permanently damage your eyes.

- Take the necessary protective measures as specified below, depending on the laser class.
-

It is absolutely necessary to observe and follow the warning instructions!

3. Terms

Laser product Laser products include devices, systems or components used for generating, transmitting and using laser light.

TRUMPF products summarized under the term "laser product" include:

- Lasers (beam sources)
- Laser machines
- Laser workstations
- Laser devices
- Laser light cables
- Focusing optics

Laser light Laser light is electromagnetic radiation with wavelengths from 100 nm to 1 mm produced as the result of controlled stimulated emission.

Laser is an acronym, short for: **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation.

Laser The term "Laser" summarizes all components directly used for generating laser light:

- Resonator, comprising rear mirror and output coupling mirror
- Laser material
- Pump source

Other components of lasers might include:

- Modulators
- Q-switch
- Converter for generating other wavelengths

With certain forms of lasers, the components mentioned above can be integrated as structures in a basic material.

Examples:

Rear mirror and output coupling mirror:

- in fiber lasers as Bragg gratings
- in diode lasers as surfaces in semiconductor crystals.

Laser machine Laser machines are machines the main purpose of which is to weld or cut material with laser light or to process it in any other way. In laser machines, movements of the workpieces and focusing optics are mainly controlled automatically.

Laser workstation Laser workstations are facilities at which workpieces are mainly processed manually using laser light.

Laser device Laser devices include all components required for generating laser light.

Laser device components include:

- Laser with pump source
- Energy supply for the pump source, e.g. diode power supply, lamp power supply
- Control
- Cooling unit

Depending on the type and maximum power of the laser device, it may have other components, such as:

- Additional components in the mains distribution
- Cabinet cooler
- Air cleaner or recirculating air dryer system
- Gas purging unit

Pump light cable The pump light cable is a flexible connecting element between the supply unit and laser head. The pump light is guided from the pump diode to the laser head in an **optical fiber**. The optical fiber is surrounded by several devices that prevent an uncontrolled escape of laser light and protect the optical fiber.

Laser light cable The laser light cable is a flexible connecting element between laser device and focusing optics. The laser light is guided from the laser to the focusing optics in an **optical fiber**. For ultra-short pulse lasers, so-called hollow-core fibers are suitable due to the high peak power, where the intensive laser pulse is not conducted in glass, but in a vacuum, air or another filling gas. The optical fiber is surrounded by several devices that prevent an uncontrolled escape of laser light and protect the optical fiber.

Focusing optics Focusing optics are optical assemblies. Their main function is to form the laser beam so that it achieves its maximum power density at a defined point, the **focal point**.

In the reflective focusing optics (RFO), the conical laser beam coming out of the laser light cable hits the focusing mirror, which guides the laser beam through the exit port and merges it in the focal point.

The programmable focusing optics (PFO) includes one or two scanner mirrors which allow the laser beam to be guided over a processing field. It is thus possible to produce, for example, welding seams without moving the focusing optics and the workpiece.

The distance of the focal point from a certain edge or surface of the focusing optics is called **working distance**. The working distance of the focusing optics determines the distance in which the workpieces must be positioned so that they can be processed with the laser.



Laser beam guidance The laser beam guidance deflects the output radiation of the laser to the workpiece.

4. Hazards

The laser product has been built in accordance with state-of-the-art standards and the recognized safety rules. However, it might cause hazards for persons or material property during use. If you do not observe the accident prevention regulations, these hazards may result in damage.

The following overview indicates the possible hazards that might be caused by your laser product.

- It indicates how **TRUMPF** has reduced the risk by applying constructive measures.
- You, as the user, can ensure safe operation of the laser product by taking additional measures during its use.

4.1 Laser light

Solid state lasers generate laser light in the near infrared spectral range (900-1250 nm). Using converters, the laser light can also be produced in the visible range (400-700 nm) or in the ultraviolet spectral region (< 400 nm).

Laser light may be hazardous to eyes and skin.

Depending on the severity of the danger, laser products are classified in **laser classes**.

The classification of the laser product in laser classes is defined internationally in the EN 60825-1 and IEC 60825 standards.

The meaning of the laser classes is described briefly below. The precise definition listing limit values can be found in the standards stated above.

- Laser class 1** Class 1 means that the laser light of this laser product is not dangerous in standard operation.
The laser device is classified as class 1M (acc. to EN 60825-1) if there may be a risk when observing laser light through optical instruments.
- Laser class 2** A class 2 laser product only emits in the visible spectral region (400-700 nm). A brief exposure does not involve any risk. Deliberate staring in the beam might be dangerous for your eyes. Active reactions are sufficient to protect your eyes against damage: Avert your eyes, move your head or close your eyes.
The laser device is classified as class 2M (acc. to EN 60825-1) if there may be a risk when observing laser light through optical instruments.

Laser class 3 Class 3 is subdivided into class 3R and class 3B acc. to EN 60825-1. A previously existing restriction of class 3 to certain spectral ranges no longer exists.

Class 3R laser products exceed the limits of class 2. In most cases the risk is low. The risk of injury increases with the time of exposure. A deliberate irradiation of your eyes is dangerous.

Class 3B laser products are normally dangerous when you look directly into the beam. The observation of diffuse reflections is usually not dangerous. Class 3B laser products the power of which almost reaches that of class 4 might produce light skin injuries; they might also ignite inflammable material.

Laser class 4 Exposure of the eye or skin to class 4 laser products is dangerous. Even diffuse radiation (scattered laser light) can be dangerous. Class 4 laser light can ignite inflammable material and make explosive mixtures explode.

4.2 Gases, aerosols, dust

During workpiece processing, substances in form of gases, aerosols or dust can be escape from the workpieces; they are dangerous to health. The biggest risk is caused when the substances enter your body through the respiratory tract. But even contact with your skin or mucous membranes in your mouth, nose or eyes can be dangerous.

Dust:

Solid particles > 1 µm.

Aerosols:

Gases containing finely divided solid or liquid particles < 1 µm.

Some escaping substances may cause **cancer**. The cancer risk depends mainly on the material of the workpieces and the volume of emissions. Therefore it is important to analyze the composition of substances that may be produced during processing.

Carcinogenic substances include, for example:

- Beryllium compounds
- Zinc chromates

The **volume of emissions** depends on:

- the type of material.
- the processing speed.
- the laser power.
- the cutting gas pressure, if applicable.

Exhaust system Only use the laser product together with a suitable compact dust extractor to extract harmful substances directly from the

processing point. The laser may only be switched on if the compact dust extractor is functioning.

Regularly check the functioning and operational safety of the compact dust extractor and ensure sufficient ventilation of the room.

When returning exhaust air to the room, make sure that residual quantities of harmful substances are below the permissible limits.

Inform people who are in the room about the risks and instruct them to be aware of hazardous situations.

4.3 Mechanical movement

WARNING

Heavy focusing optics (> 20 kg)

Lifting and carrying the focusing optics can cause injuries.

Dropping or tipping the focusing optics can cause injury and damage to property.

- Move the focusing optics using a suitable means of transport (e.g. trolley, crane, boom lift).
- Persons with existing physical injuries should not lift the focusing optics.
- Secure the focusing optics to prevent them from falling over in transport.
- Securely fasten the focusing optics to the carrier.
- Always store the focusing optics securely so that they cannot fall.
- Always use two people to lift and carry the focusing optics.
- Keep transport routes free of obstacles
- Wear suitable protective clothing (safety shoes, protective gloves).

WARNING

Focusing optics in unmounted state

If handled improperly, the focusing optics may tip over, slip or otherwise change position when unmounted.

Dropping or tipping the focusing optics can cause injury and damage to property.

- Handle the focusing optics with the necessary care when unmounted.
- Wear suitable protective clothing (safety shoes, protective gloves).

4.4 Thermal energy

Fire, explosion

Class 3B or 4 laser light may cause fire if it ignites inflammable material.

If there is a potentially explosive mixture of gases or aerosols (e.g. oxyhydrogen, wood or carbon dust) in the air, a laser beam might cause an explosion even if it does not hit solid material with a high power density.

Do not lay hot workpieces on flammable material. Keep a hand-held fire extinguisher readily available.

Temperature of the workpiece

Due to the processing by means of the laser beam, the workpiece may be heated up. The degree of heating depends on the material of the workpiece and the energy given off by the laser beam to the workpiece during processing.

WARNING

Risk of burns when touching the hot workpiece

This may result in skin injuries.

- Remove hot workpieces using an appropriate tool.
- Wear protective gloves, if necessary.

Hot surfaces on the focusing optics

Due to reflections of laser light on the workpiece, the underside of the focusing optics may become very hot. Misadjusted or soiled components may also cause the heating. The temperature can reach levels that may burn the skin if touched.

CAUTION

Hot surfaces on the bottom side of the focusing optics may burn your skin.

- Avoid contact with hot surfaces.
- Let the focusing optics cool down before carrying out maintenance or cleaning work.

4.5 Noise

Focusing optics The use of focusing optics in conjunction with lasers and assist gas produces noise.

Sources of noise in the area of the focusing optics include:

- Material that evaporates as a result of the exposure to laser light.
- Cutting gas or shielding gas passed to the processing point.
- Compressed air coming out of the crossjet.

During laser welding, compressed air comes out of a nozzle, called **crossjet**, transversely to the direction of the laser beam. If a crossjet is present, it is often the biggest source of noise. Measurements have given values > 90 dB(A).

 WARNING

High noise level when operating a focusing optics, especially when using a crossjet!

Noise can result in permanent ear damage and other unfavorable consequences to health, especially upon prolonged exposure.

- Surround the processing point with a protective cover that is sufficiently silencing.
 - Wear ear protection if the noise levels are high.
 - Operate the focusing optics only with the silencing protective cover closed, if possible.
-

The room in which a focusing optics is operated should have the following characteristics:

- The processing point should be as far away as possible from places where people stay permanently.
- Walls and devices are particularly good absorbers of noise.
- The areas that are at risk from noise are labeled.
- Ear protection devices are available in sufficient numbers.

5. Safety of the laser product

5.1 Laser beam emission openings

The programmable focusing optics (PFO) is intended for welding using CW lasers and pulsed lasers. Two scanner mirrors in the PFO deflect the laser beam laterally in a certain angular area so that the laser beam can reach a field determined by the focal length with fixed PFO. Lenses with different focal lengths are available for the PFO. At large focal lengths (up to 900 mm), the highest power density of the laser beam is achieved far away from the lens.

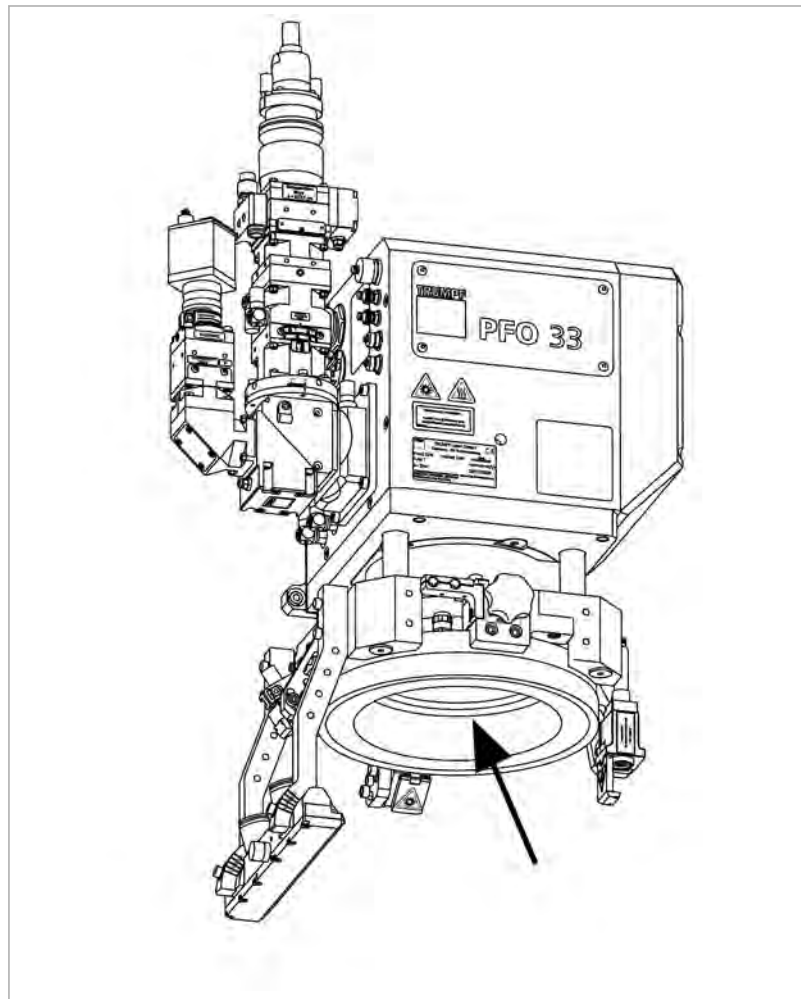


Fig. 112259

More than one processing optics can be connected to a laser device. The laser light is emitted from the focusing lens (arrow). Laser light will not emerge at other places of the laser device.

⚠ WARNING

Eyes and skin may be exposed to laser radiation if the laser light is not placed under a protective cover!

Laser light can burn the skin. Direct or scattered laser light can permanently damage your eyes.

- In general, install the focusing optics and the processing spot in a protective housing or below a protective cover so that no laser light may be emitted during the production operation.
Basically, the protective housing or the protective cover must completely surround the laser beam path, the focusing optics and the processing spot and be designed in such a way that the accessible laser light is below the limit value of laser class 1 (according to EN 60825-1).
If protective housing or protective cover are not possible, the laser product falls into the category of laser class 4. In this case, all required measures have to be taken according to EN 60825 (e.g. labels, signalization, access limitation).
- Monitor the protective housing or protective cover by means of a safety circuit.
- Wear laser safety glasses which are adapted to the wavelength of the laser light (see information labels) and cover the long-wave Raman radiation as well.
- Mark dangerous areas and organize access limitations.
- Instruct potentially endangered persons.

⚠ WARNING

Scattered radiation with a wavelength of up to 1080 nm reflected by the workpiece!

Direct or scattered light can permanently damage your eyes.

- Matched to the wavelength of the scattered light: Select laser safety glasses or filter glasses for observation window.

⚠ WARNING

Incorrect wavelengths will lead to spontaneous leaking of radiation!

If the focusing optics is used with a laser device whose wavelength does not match the focusing optics, this may damage the optics. This may cause uncontrolled emission of radiation.

- Only use laser devices that generate laser light with a wavelength that is suitable for the optics.

Wavelengths

The laser power and wavelengths emitted by the focusing optics depend on the laser device to which they are connected. Relevant information is contained in the Operator's manual for the laser device and the data sheet for your focusing optics.

- Laser light for material processing: 515 nm - 1085 nm.
The wavelength spectrum for which the lenses of the focusing optics are optimized is indicated on the adhesive label attached to the focusing optics.
- Pilot laser and line laser: 630 nm - 680 nm.

Note

A sticker on the focusing optics indicates the wavelength for which it is suitable. For example, a label stating " $\lambda = 1030$ [1030-1085]" means that the focusing optics are calibrated to 1030 nm and can also be operated at 930 nm to 1085 nm, but in that case has a different focus position and XY position.

Reference wavelength

The focusing optics is calibrated to a reference wavelength. The reference wavelength is indicated on a label attached to the collimation of the focusing optics.

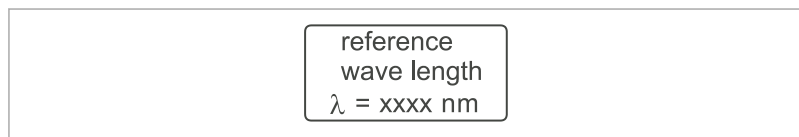


Fig. SE-15120

If the focusing optics is operated with a wavelength other than the reference wavelength:

- the focal position will be shifted.
- the focusing optics must be recalibrated.

Laser classes

Device, component	Laser class
Laser device with closed hood	1
Laser device with open hood	4
Laser light cable	1
Focusing optics under a closed protective cover (person outside the protective cover)	1
Focusing optics under a closed protective cover (person inside the protective cover)	4
Focusing optics without protective cover	4
Laser workstation with closed hood	1
Laser workstation with open hood	4
Pilot laser at the exit of the focusing optics	2
Line laser	2
Teach module	2

Tab. 1-1

Laser warning lamp option

A laser warning lamp can be connected to the laser device. This will signal a "Laser On" if laser light is generated on the laser device.

5.2 EMERGENCY STOP push-button

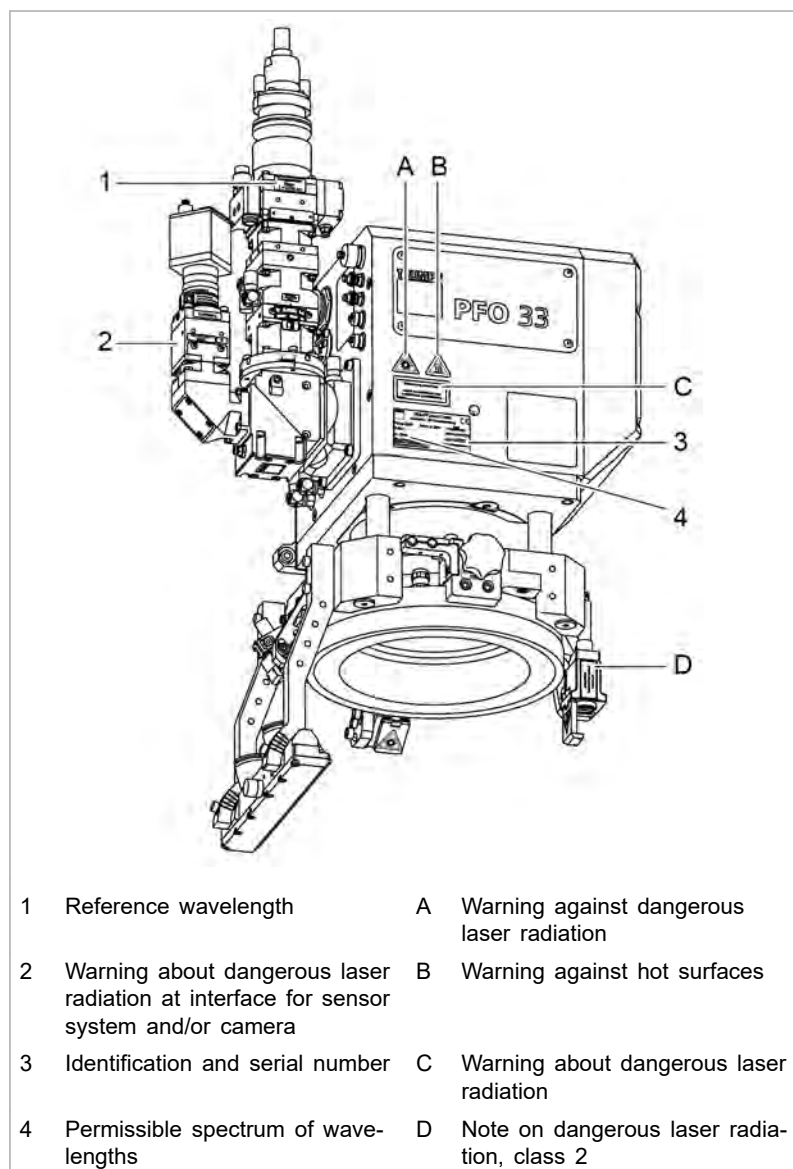
TRUMPF recommends the provision of an additional EMERGENCY STOP push-button at the workplace of the focusing optics. For further information see the interface description of the laser device.

5.3 Labels and warning signs

Note

Observe the instructions on the labels. Keep the labels in a readable condition.

Labels on the focusing optics



Labels and warning signs on the focusing optics

Fig. 112260

A



Warning of dangerous laser radiation

Fig.
WS-02012

B



Warning against hot surfaces

Fig.
WS-02015

C



Warning of dangerous laser radiation

Fig. 0779894

D



Note on dangerous laser radiation, class 2

Fig.
19-01-09-66

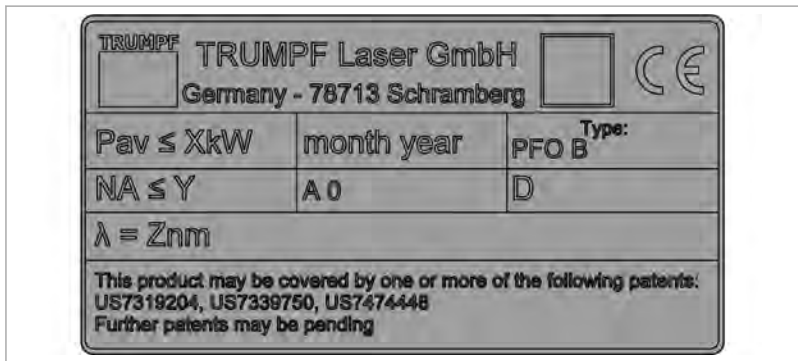
2



Warning about dangerous laser radiation at interface for sensor system and/or camera

Fig. 2327108

Adhesive labels



Adhesive label on the focusing optics PFO 33

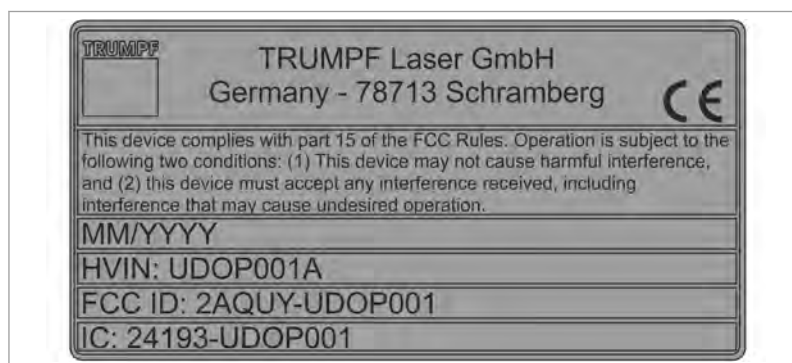
Fig. 112304

Details on the adhesive label:

- S/N: Serial number of the focusing optics
- Pav: maximum permissible average power. The focusing optics may be operated at this specified permissible average laser power at maximum.
- NA: Numerical aperture (half angle) of the focusing optics. The numerical aperture specified here (half angle) in mrad of the focusing optics must not be less than that of the laser device.
- λ : reference wavelength and [wavelength spectrum] of focusing optics.

The focusing optics must be designed for the same wavelength spectrum as the laser device (see "Intended use", pg. 1-21).

There is an extra sticker on the housing of the protective glass monitoring unit of the focusing optics PFO 33. It contains all the required approval references in relation to the radio equipment.



Adhesive label on the focusing optics PFO 33

Fig. 112318

Note

FCC declaration

This device has been tested and found to comply with the limit values for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits values are intended to provide appropriate protection against radio interference when the device is operated in a commercial environment. This device generates, uses and can radiate radio frequency energy. If the device is not installed and used in accordance with the instructions, it can cause interference in radio communications. Operation of this device in residential areas is likely to cause radio interference. In this case, users must eliminate the interference at their own expense.

Pursuant to Part 15 of the FCC Rules, any changes or modifications to this device not expressly approved by TRUMPF can render the user's authority to operate the device null and void.

ISED declaration

This device contains non-proprietary transmitters/receivers that are compatible with the requirements of Innovation, Science and

Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

The device is not allowed to cause any interference.

This device must tolerate interference immissions, including interference that can cause undesired operation of the device.

E

Request to wear ear protection

Fig.
WS-02007

Label D is an adhesive label with removable protective film. The label has not yet been attached on the crossjet of the focusing optics, as the arrangement of the workstation where the focusing optics is to be fitted to, is normally not known at the time of delivery.

Mandatory marking

As the operator of the laser device you are obliged to attach label D on the focusing optics in such a way that it is easily visible in a built-in state.

Labels in the range of the focusing optics

F

Request to wear ear protection

Fig.
WS-02007

Mandatory marking

As the operator of the laser device you are obliged to attach label E near the focusing optics, so that it can be visible to the persons staying within this area.

6. Measures of the user

6.1 Intended use

The programmable focusing optics (PFO) is intended exclusively for processing solid metals or metal alloys.

The wavelength spectrum, for which the optical elements of the focusing optics are optimized, is indicated on the adhesive label attached to the focusing optics.

The wavelength spectrum depends on the laser device to which the focusing optics are connected.

Notes

- When the focusing optics are optimized for a specific wavelength then a label displaying this wavelength is attached to the focusing optics. The focusing optics must not then be operated at any other wavelength.
- Not all combinations of laser device, laser light cable and focusing optics are safe. Personal injury and damage to property can occur if laser device, laser light cable and focusing optics do not match with one another.

Information on permissible combinations can be found in the section "Safe combinations of laser device, laser light cable and focusing optics" in the chapter "Assembly and installation" (see ["Safe combination of laser device, laser light cable and focusing optics"](#), pg. 2-17).

Intended use also includes the following:

- observing the instructions set out in this operating manual.
- wiring and connecting electric lines to the focusing optics in compliance with the regulations regarding electromagnetic compatibility.
- carrying out necessary inspections and maintenance work.

Exception The PFO is **not designed** for:

- use with other wavelengths than those indicated on the adhesive label.
- for processing metals or metal alloys in connection with flammable or explosive materials (examples: containers filled with combustible gas or fuel, ammunition).
- use in atmospheres subject to explosion hazards.

Disclaimer The manufacturer cannot be held liable for any damage resulting from use of the focusing optics contrary to the designated use. Such use is at the sole risk of the user.

6.2 Technical measures

Condition of the laser product	The laser product may only be used if it is in perfect technical condition. Any faults, especially those affecting safety of the unit, must be eliminated immediately!
Modifications	Do not modify the laser product without previous consent of TRUMPF as this may impair the safety of the laser product.
Spare parts	Spare parts must comply with the requirements specified by TRUMPF. This is guaranteed with original spare parts.
Software	Do not modify the software programs in programmable components.
Cables and hoses	Always lay laser light cable, electric cables and hoses in such a way that they are protected at all times or at a sufficient height and the minimum radius is observed. Keep the cables and hoses in particular away from: ▪ traffic routes. ▪ moving or heavily vibrating machine parts.
Separate ground cable	If the ground cable cannot be connected via the mains cable, the ground cable must be connected separately to the grounding of the building. The ground cable must be installed protected so that it cannot be damaged or disconnected. The ground cable may only be connected by trained electricians.
protective covers	Always cover the laser beam path, focusing optics, and processing points with protective covers. Protective covers must be designed in such a way that laser light cannot escape. Protective covers can be: ▪ Housings in which focusing optics and processing point are located. ▪ Walk-in protective cabins. All parts of protective covers that can be opened by the operating personnel during operation must be monitored. Monitoring must be designed such that laser light emission is stopped immediately when a protective cover is opened. Protective covers that are opened only for repair have to be monitored in the same way. If they are not monitored, tools must be required for opening them. TRUMPF laser devices have safety circuits that guarantee the described safety function when they are appropriately wired. More information is given in the interface description of the laser devices.

Walk-in protective cabins should additionally be equipped with motion detectors or similar equipment. This allows to determine whether there are persons in the protective cabin even if the cabin door is closed.

Cordoning off the hazardous area

Cordon off the areas in which laser light can escape to prevent access of unauthorized persons, for example by using code locks or suitable signaling devices.

6.3 Organizational measures

Laser safety officer

If your company operates a class 3B, 3R or class 4 laser product, appoint a laser safety officer. Make sure that this person is qualified and can assess the hazards caused by the laser and take appropriate measures. Put this laser safety officer in charge of supervising the protective measures against hazards caused by the laser.

Selecting and qualifying personnel

As the laser device user, only employ trained or instructed staff. Clearly specify the individual responsibilities of the persons for operation, setup and servicing.

Registering the laser product

As the user, you are obliged to report the operation of class 3B and class 4 laser products to the authorities responsible for laser safety.

If you have any **questions**, contact the local sales office of TRUMPF.

Skilled electrician

According to the rules of electrical engineering, any work on the electrical system of a laser product may only be carried out:

- by an electrician.
- by instructed persons under the supervision and guidance of an electrician.

6.4 Observing standards and regulations

Some important standards and regulations which you have to observe when operating a laser product are listed in the following table.

As the operator, you are responsible for ensuring that the standards and safety regulations in force in your region are observed as far as they are mandatory.

International standards

EN 60825-1	Safety of laser products
IEC 60825-1	Radiation safety of laser products
EN 207	Filter and safety glasses against laser radiation (laser safety glasses)
EN 60204-1	Electrical equipment of machines

Tab. 1-2

6.5 Behavior in certain operating stages

Normal mode Operate the laser product only when all protective and safety relevant devices, - e.g. Emergency Stop equipment, protective covers, safety contacts, exhausters - are in place and fully operative.

Open the safety circuit of the light path in question when an error occurs. Have any defects eliminated immediately.

Maintenance Service work may be carried out by trained personnel only.

For maintenance and repair, open the safety circuits of all affected light paths and make sure that they remain open for the entire duration of the work.

Before working on the electrical system of the laser product, turn the main switch to OFF. Lock the main switch in this position using a padlock.

Carry out the adjustment, maintenance and service work stated in these operating instructions in due time. Observe information regarding the replacement of parts.

Check the correct functioning of the guards of the laser product regularly.

6.6 Behavior in case of emergency

Emergencies are understood here as meaning:

- Laser light exits unexpectedly.
- A part of the machine in which the laser product is operated makes uncontrolled movements.
- A fire or explosion can be triggered.
- Substances which may affect health are leaking.

If it must be expected that these or similar events may injure persons or damage material, appropriate measures must be taken.

If an emergency was caused by the laser product, **press an EMERGENCY STOP push-button** to stop laser light emission and movements of the machine.

Further measures depend on the situation.

As the user of the laser product, TRUMPF recommends you identify the possible hazards in a risk analysis and define suitable measures to diminish these or personal first-aid measures.

Prepare a directive establishing what to do in an emergency. Attach the directive in the danger zone in a way that everyone can read.

6.7 Selecting and qualifying personnel

Only use trained and instructed staff.

Define the responsibilities on the laser product for:

- Setup
- Operation
- Maintenance

Any work on the electrical equipment of a laser product must be carried out by a trained electrician only.

Instructed personnel may work on the electrical equipment if

- the rules for electrical safety are observed.
- the work is carried out under the supervision and guidance of a trained electrician.

6.8 Instructing the personnel

Obligations of the owner	As the operating company, make sure that all persons operating the laser product have the knowledge and qualifications to do so. In particular, the personnel needs the required awareness of possible dangers that might be caused by the laser product.
Read operator's manual	Before starting the work, the personnel entrusted with work on the laser product must have read the operator's manual and the chapter "Safety" in particular. This applies especially to persons working only occasionally on the laser product, e.g. during maintenance.
Training with TRUMPF	If required, TRUMPF offers trainings for operators and personnel responsible for maintenance. Please contact the TRUMPF® Training Center.

Directives Inform any person in the dangerous areas by means of directives. Attach the directives clearly visible and protected in the dangerous areas.

Directives are short informative texts, mostly not longer than a page, which present all essential information to:

- avoid dangers as far as possible.
- act correctly if accidents occur in spite of safety measures.

Signs Please observe the labels attached to the laser product. Ensure that the labels are in a legible state. Any labels that are damaged or not longer legible must be replaced.

For further information on the labels: see section "Labels".

6.9 Wearing personal safety equipment

If your risk assessment for the laser product shows that technical measures are not sufficient, persons can be protected in addition by wearing personal safety equipment.

Examples:

- Laser safety glasses to protect the eyes against escaping laser light.
- Protective gloves to protect the hands against hot workpieces.
- Respiratory equipment to protect the respiratory tract against hazardous substances.

Make sure that the provided personal safety equipment is effective. For laser safety glasses, for example, the filtering glasses have to be suitable for the wavelengths of the laser light emitted by the laser. The optical density of the filtering glasses must be adapted to the beam intensity.

Check the provided personal safety equipment on a regular basis. The safety equipment must be in perfect condition. Laser safety glasses must be free of damage and scratches.

Stipulate wearing of personal safety equipment clearly, for example in a directive.

Make sure that this regulation is observed.

Punish any violation of this regulation.

Chapter 2

Assembly and installation

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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:

- All guards must be installed and ready for operation.
- Suitable laser safety glasses must be at hand.
- If additional media are required, they must be provided:
 - Shielding gas
 - Compressed air
 - Exhaust system
 - Cutting gas
- There must be enough samples for the commissioning procedure. A suitable workpiece holder for the samples must be provided.

In case of a subsequent start-up, the conditions for operating the focusing optics have to be established in the laser device:

- Installation of the Interface Intelligent Optics (IIO).
- Installation of an additional supply unit with the supply voltages required by the focusing optics (depending on the existing laser device).
- Installation of units for cooling water supply to the focusing optics (cooling water distributor, hoses, etc.).

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 directive of the PFO 33, doc. no.: 12-12-30-A108-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.

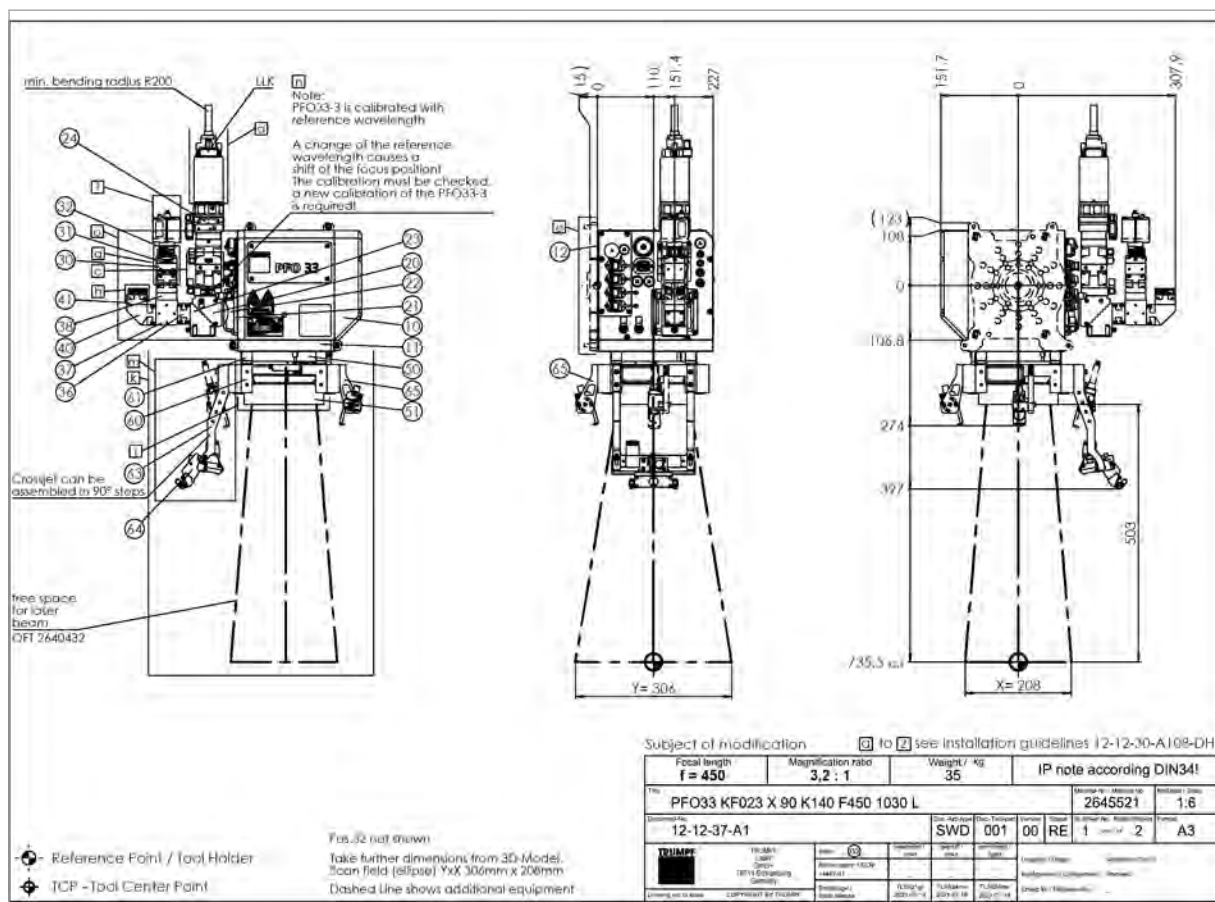
How to deal with dimensional drawings and installations instructions is described by means of an example in the following sections:

Installation directive

The installation directives contain important information on the insulation of the focusing optics against the system environment. The focusing optics must be fastened in accordance with the installation directives using the insulating fastening means (e.g. insulating mounting plate).

1.1 Mounting

The following example shows how to find information on the fastening in the relevant dimensional drawing or in the installation directives.



Dimensional drawing of a PFO 33 (example)

Fig. 112319

In addition to the dimensions, you will also find letters on the drawing.

Under "e" in the installation directives you will find the required drilling pattern of a mounting plate on the carrier side for fastening the focusing optics.

In addition, the installation directives contain information on mounting with robot plate including different diameters of the centering disks.

Installation directives:

- for PFO 33: doc. no.: 12-12-30-A108-DH.

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.
- Setup:
 - for Aligning the focusing optics.
 - for adjusting the focal position.
 - for adjustment of the picture sharpness of eyepiece or camera.
 - for adjusting the cross hairs.
 - for adjustment of the picture sharpness of eyepiece or camera.
- for maintenance and service work:
 - for connecting and disconnecting the LLK.
 - for connecting supply lines, such as compressed air and cooling unit.
 - for removing and fitting the lens protection.
 - for positioning tools.
 - for attaching measuring devices.

Specifications for clearances to be observed

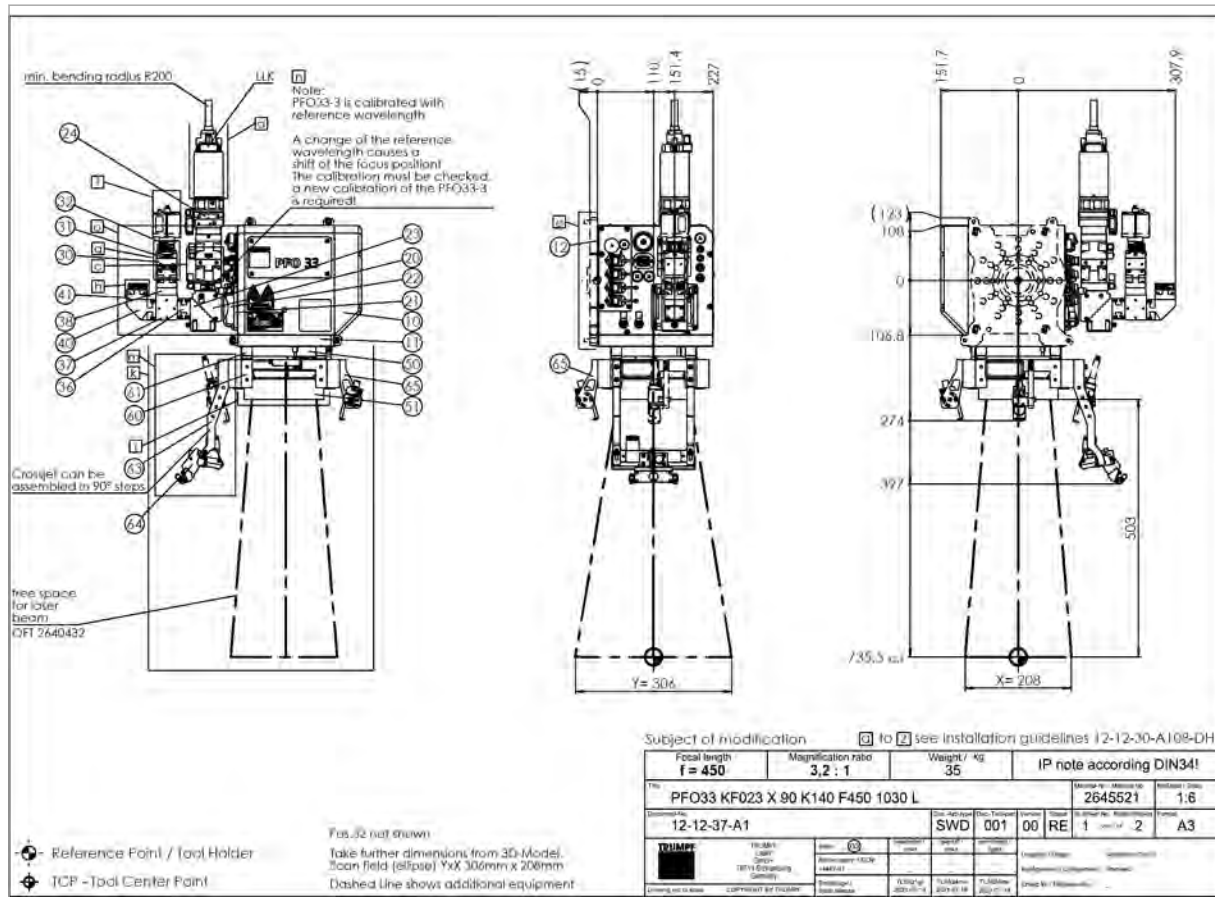
Specifications for clearances which have to be observed are given in the following documents:

- in the dimensional drawings of the PFO 33.
- in the installation directive for programmable focusing optics PFO 33, doc. no.: 12-12-30-A108-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 References to the installation directive

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



Dimensional drawing of a PFO 33 (example)

Fig. 112319

The installation directives supplement the dimensional drawing with important notes and dimensional details which have 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 LLK-DK Smart & LLK-X
- **[b]** XY adjustment
- **[c]** LLK – PFO connection (collimator)
- **[d]** Hose system sequence (LLK optics)
- **[e]** Screw-on drilling pattern for PFO / flange connection on robot, linear axis
- **[f]** Process sensor systems
- **[g]** Observation
- **[h]** Customer interface sensor system
- **[i]** Camera (connecting lines)
- **[j]** Lens protection, replacement of protective glass

-
- **[k]** Clearance for laser beam and periphery (crossjet, teach module, lighting,...)
 - **[l]** Center of gravity (example dimensional drawings)
 - **[m]** Crossjet
 - **[n]** Reference wavelength
 - **[o]** Clearance for electrical interfaces & plugs

The details are described in the installation directive.

Installation directives:

- for PFO 33: doc. no.: 12-12-30-A108-DH.

2. Electrical insulation

The mounting surface of the focusing optics is made of electrically insulating material.

Note

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 electric component or device may only be mounted to the focusing optics PFO 33 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.

2.1 Measuring the insulation resistance

Condition

- Mounting of the focusing optics is completed.

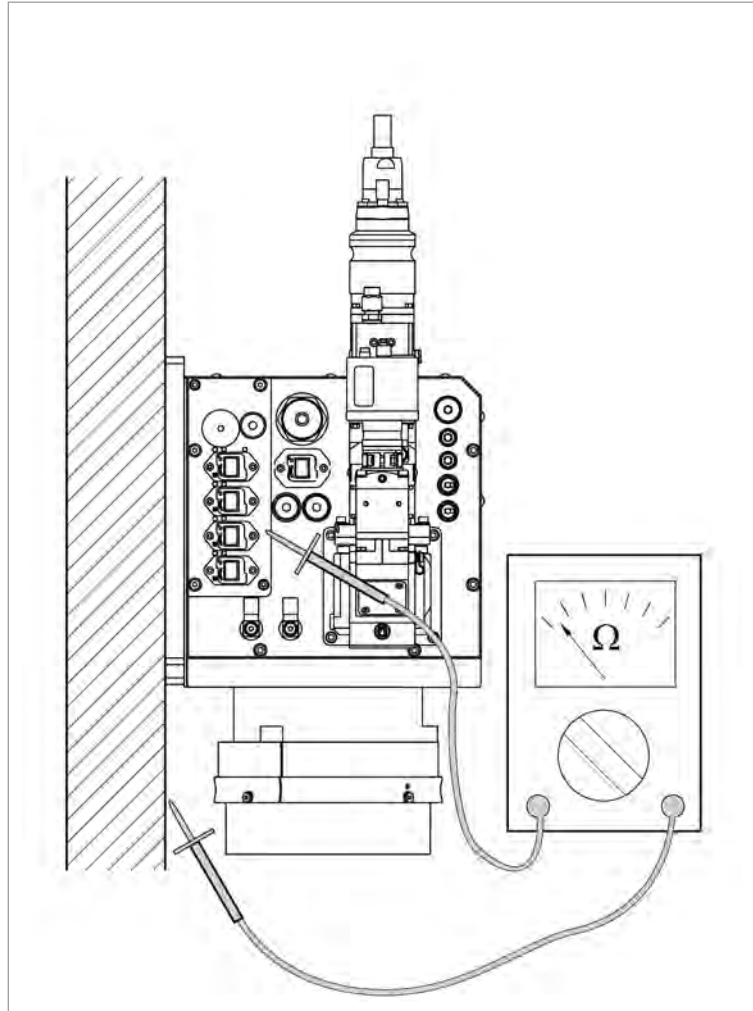


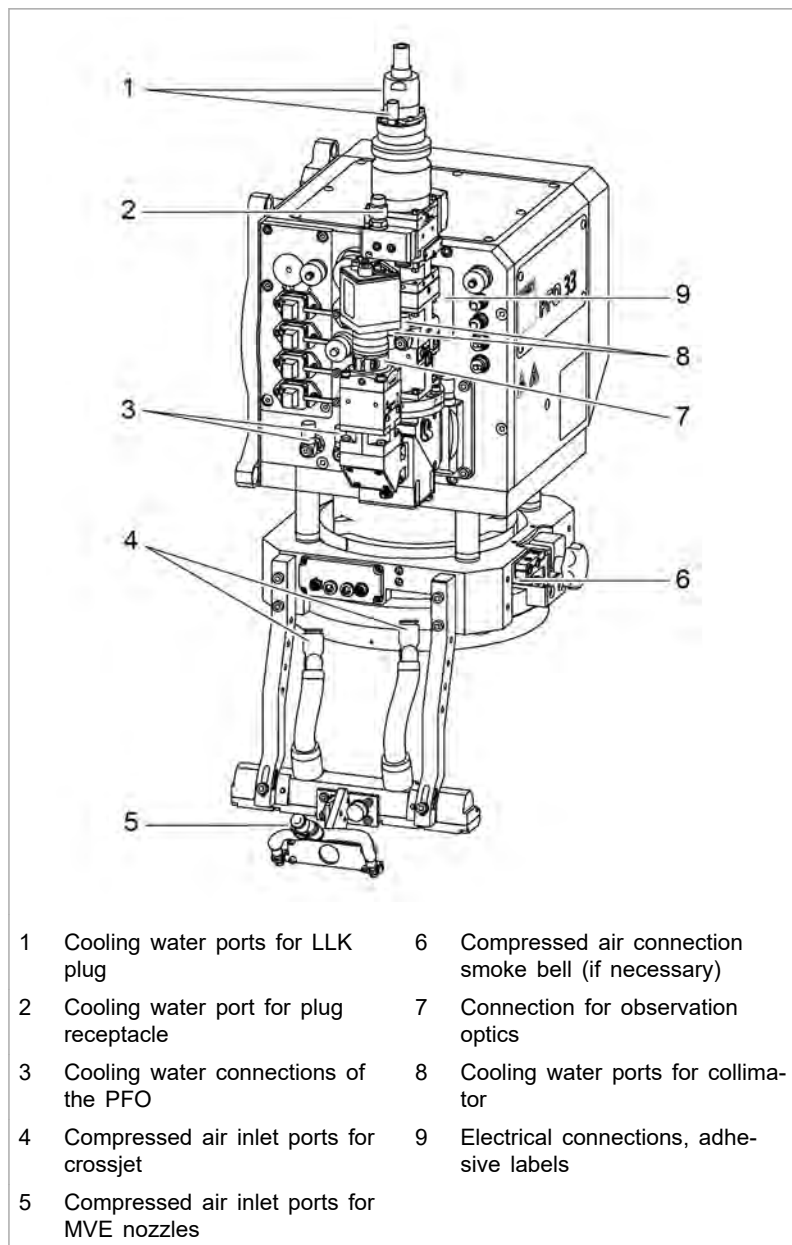
Fig. 112261

1. Unplug the plug-in connectors from the connections.
2. Measure the insulation resistance at a bare spot of the focusing optics, e.g. at the front frame of the Ethernet interface.

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

3. Installation

3.1 Overview of the connections

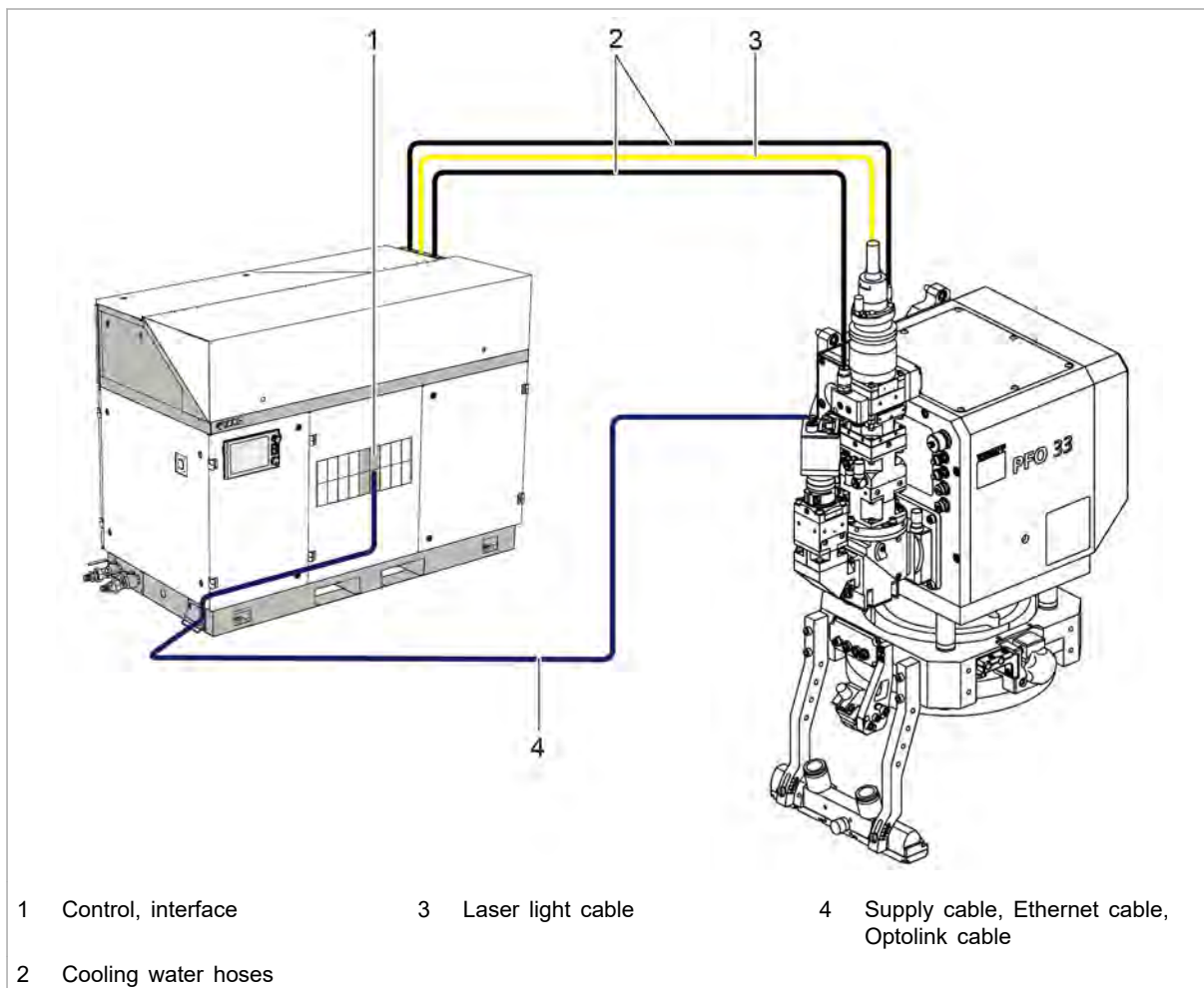


Connections of the PFO (example PFO 33 with smoke bell) Fig. 112262

The connections are 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 Connections with a laser device



PFO connected to a laser device (diagram)

Fig. 112263

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 8 mm.
- Inside diameter 6 mm.

Note

The programmable focusing optics is sufficiently cooled by the laser device cooling unit only if the cooling water hoses are shorter than 50 m. If the cooling water hoses are longer than 50 m, an additional cooling unit must be used for direct cooling of the optical system. Pay attention to the required quality of cooling water (see "Connections for cooling", pg. 2-32).

**Monitoring functions of the
PFO 33**

During operation, the protective glass monitoring module monitors the degree of contamination of the protective glass. If the corresponding option is activated, the protective glass monitoring module communicates wirelessly with the data memory on the protective glass using RFID. Among other things, this can be used to check whether a protective glass has been inserted and correctly coated.

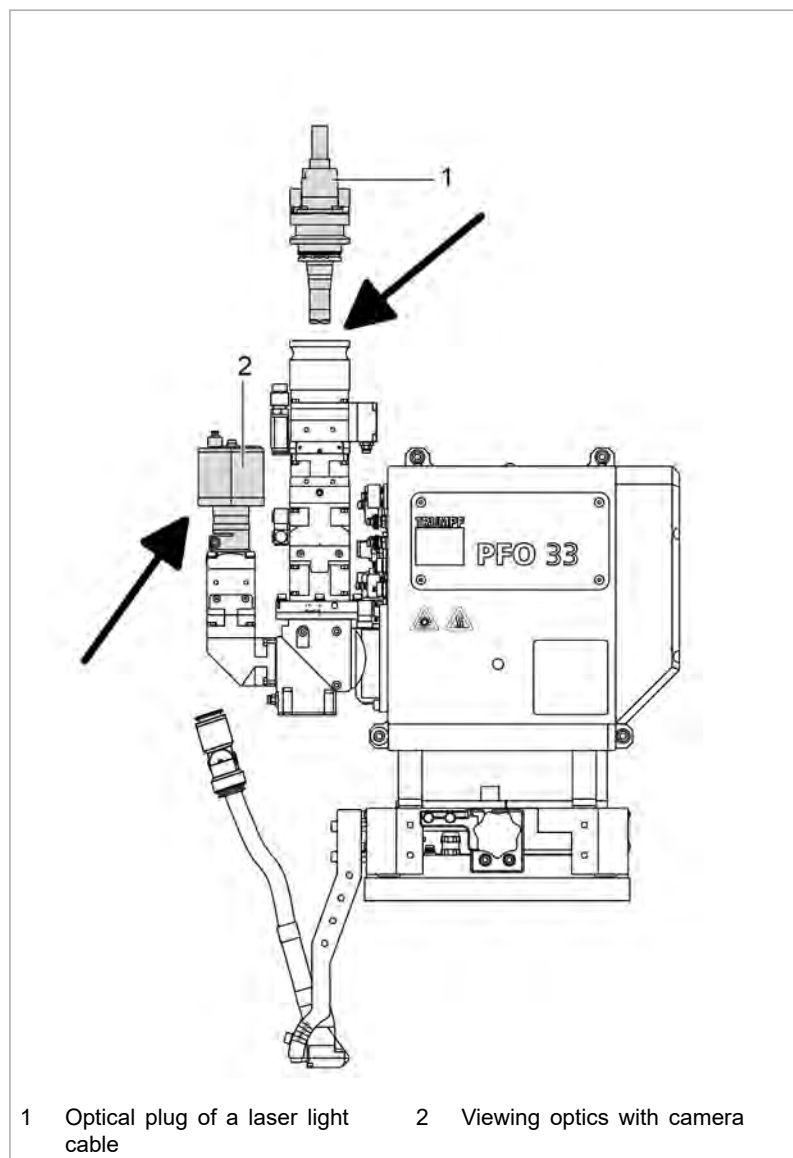
In addition, the scattered light on the LLK protective glass is monitored.

For more information on this topic, please refer to the software manual of the controlled focusing optics.

3.3 Optical connections

The programmable focusing optics (PFO) has two optical connections:

- Connection for a laser light cable.
- Mounting plate for observation optics (option).



Optical connections of the PFO

Fig. 112264

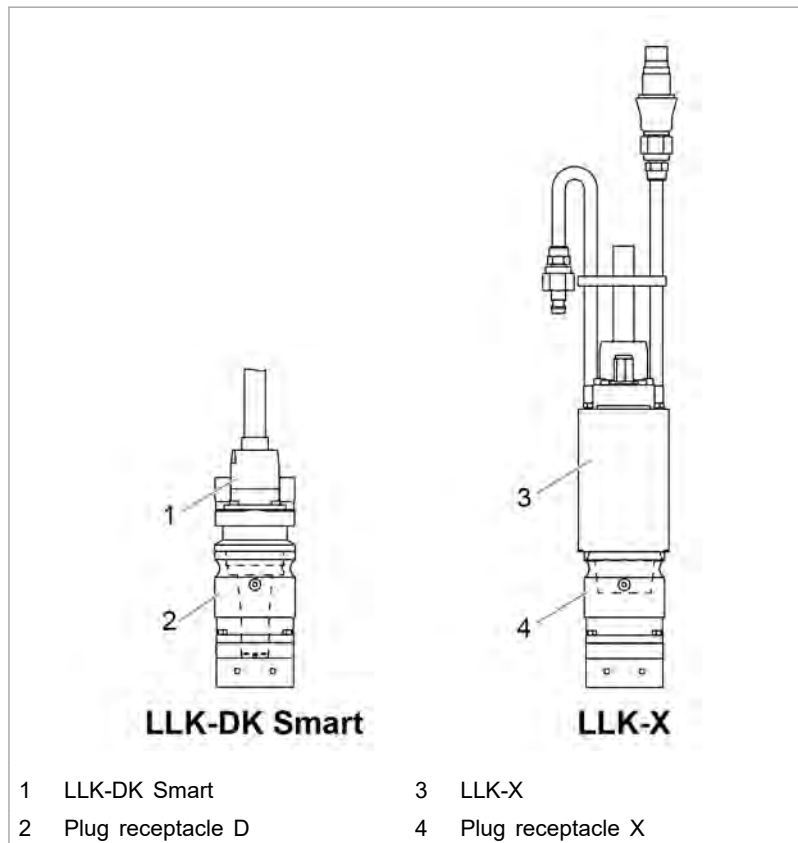


Fig. 112265

Laser light cable One of the following laser light cables LLK-DK Smart or LLK-X can be connected to the plug receptacle, depending on the laser device and focusing optics.

Note

For laser devices > 12 kW, the LLK-X laser light cable must be used.

For this purpose, the appropriate connection between laser light cable - focusing optics has to be established.

Observation optics The mounting flange is closed with a cover if the viewing optics is not used.

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

All volumes penetrated by laser light must be free of absorbing gases or suspended particles.

Otherwise, when the laser light penetrates the volumes, the pressure inside them may increase rapidly and damage or destroy parts of the optical components.

All surfaces of optical components penetrated by laser light or reflecting laser light must be completely free of absorbing deposits or particles.

Otherwise, the deposits or particles may burn in the surface of the optical components. This normally destroys the optical components.

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.

Practice

For the use of focusing optics and laser light cables (LLK) this means:

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.

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.

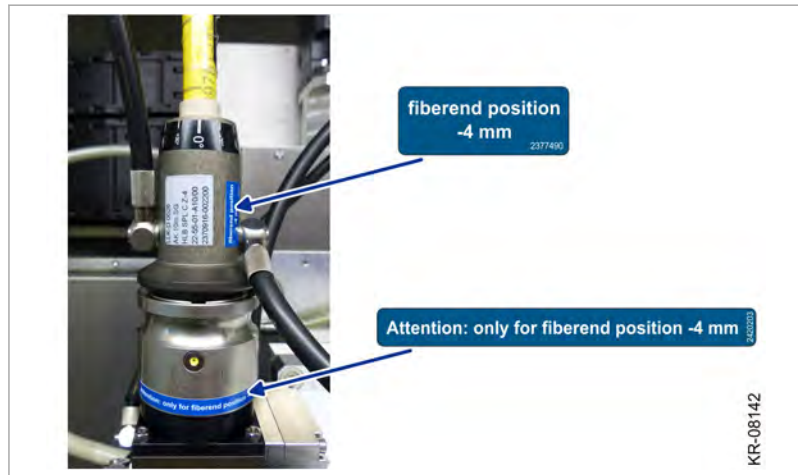
The joints between the LLK plugs and the focusing optics must be sealed by means of **adhesive tape**.

In highly contaminated environment, it is necessary to protect the joints by means of **protective sleeves** to avoid the penetration of dirt.

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.

Make sure that the plug receptacles and the LLK plugs are unprotected only during connection and disconnection. **Under no circumstances** should the surfaces of the optical components be touched **with fingers**.

Numerical aperture (NA) Position of the fiber end



Information plates about the fiber end position

Fig. KR-08142

NOTICE

Position of the fiber end: -4 mm!

If the wrong combination of laser light cable and focusing optics is used, the destruction of the laser light cable or the focusing optics may result.

- If there is an information plate "Attention: only for fiber end position -4" on the plug receptacle of the focusing optics, the focusing optics may only be operated with a TruFiber FD34 laser device.

TruFiber FD34 laser devices are characterized by the following features:

- "FD34" printed on the nameplate
- Blue information plate "fiber end position -4 mm" on the LLK plug
- This does **not** apply to laser devices TruFiber FD34-50.

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.
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 ($> 300\text{ °C}$). 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.

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 ($> 300\text{ }^{\circ}\text{C}$). 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.
- **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 average power than that which is specified. The housing of the focusing optics can heat up strongly ($> 300\text{ }^{\circ}\text{C}$). 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.

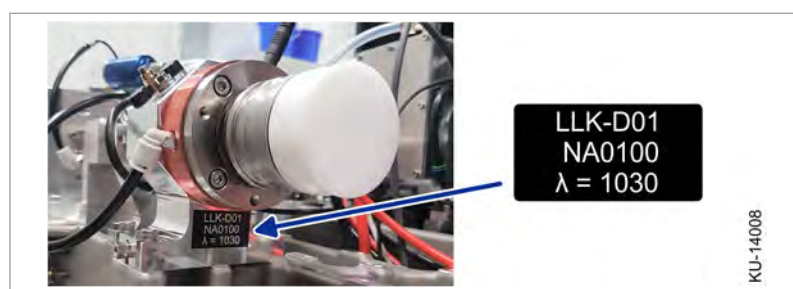
Information required to assess the safety of a combination

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.



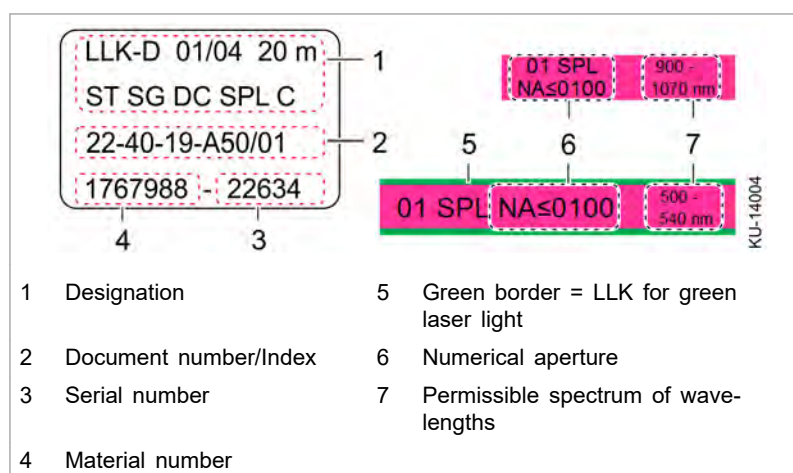
Information in the user's compartment (example TruDisk FD17) Fig. KU-14007



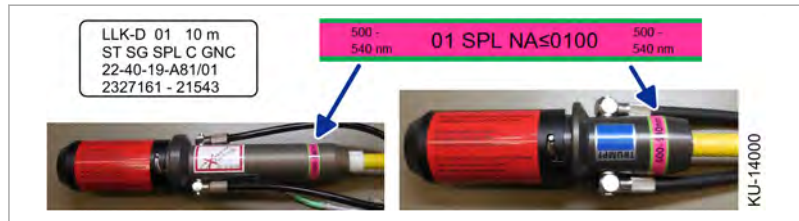
Information on the incoupling optics (example TruDisk FD27) Fig. KU-14008

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. KU-14004



Information on LLK-D NA01 (green)

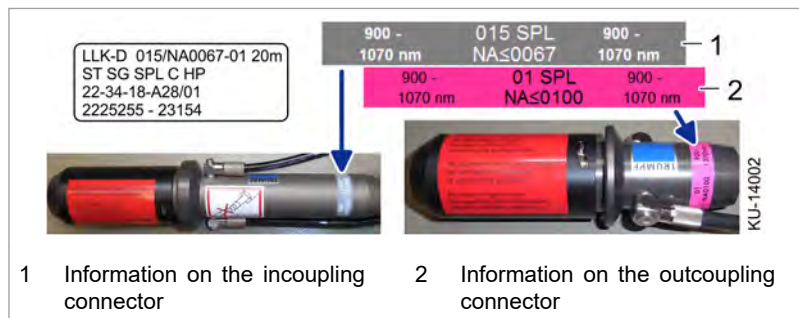
Fig. KU-14000



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

Fig. KU-14001

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



1 Information on the incoupling connector

2 Information on the outcoupling connector

Information on LLK-D NA0067/015-01 HP

Fig. KU-14002

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. KU-14003

The housing of a programmable focusing optics contains information on power, numerical aperture and wavelength.



Specification on programmable focusing optics (example PFO 33)

Fig. 113220

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 4002 (FD17)	LLK-D 02 SPL	Programmable focusing optics (PFO)
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

Connection of the laser light cable (LLK)

LLK protection

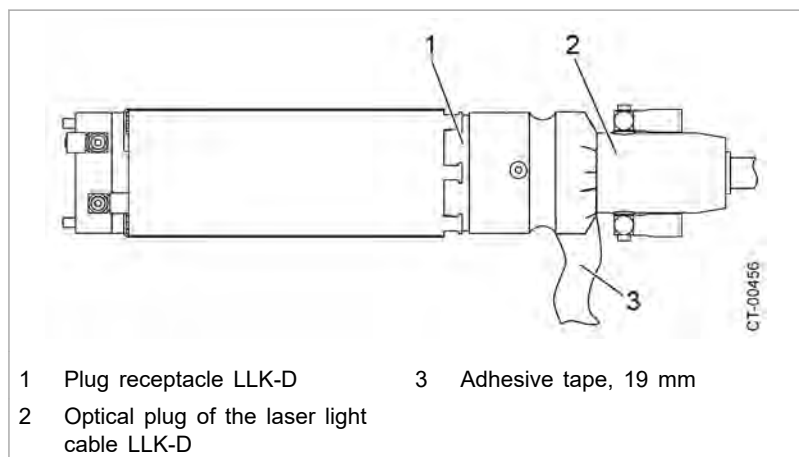


Fig. CT-00456

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 no.
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.

It is assumed 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

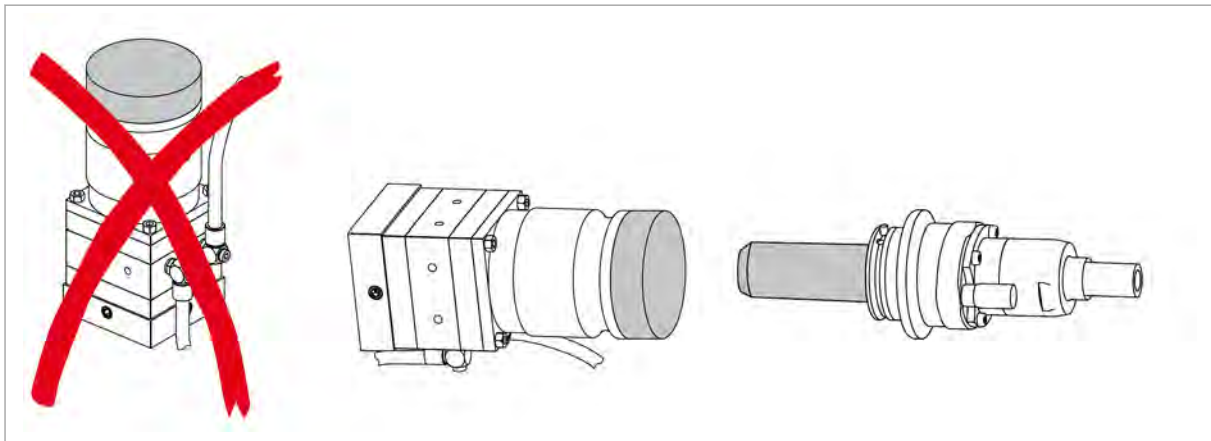
- Adhesive PVC tape, 19 mm, material no.: 1420313
- LLK-D protective collar, material number 1416727

NOTICE

Dirt in beam path!

This may destroy the LLK or focusing optics.

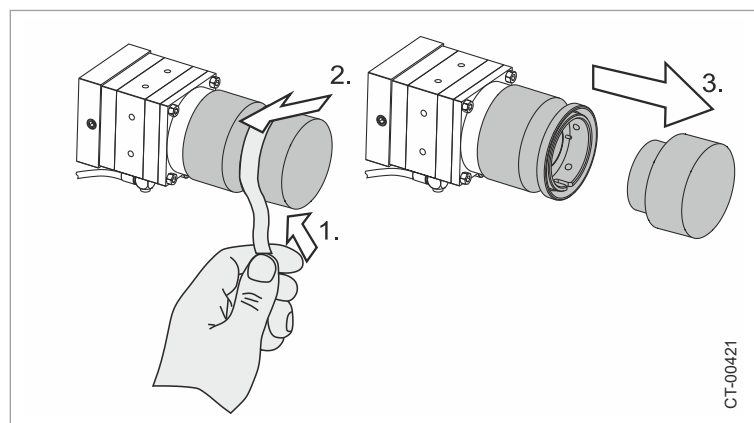
- Leave openings on LLK and focusing optics unprotected as short as possible.
- Put the shaft of the plug receptacle in horizontal position as long as the plug receptacle of the focusing optics is open.
- Do not touch optical surfaces.



Plug receptacle and LLK (sealed with adhesive tape)

Fig. 112314

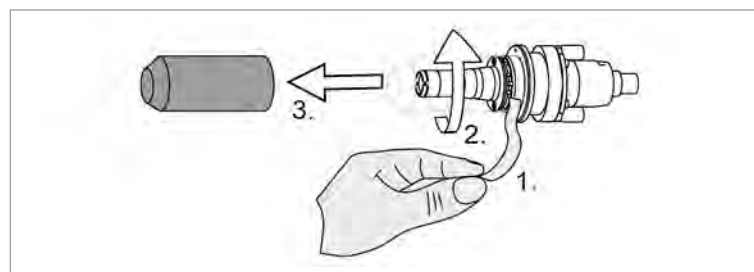
1. Store the focusing optics such that the shaft of the plug receptacle for the LLK is in a horizontal position.



Remove the sealing plug from the plug receptacle

Fig.
CT-00421

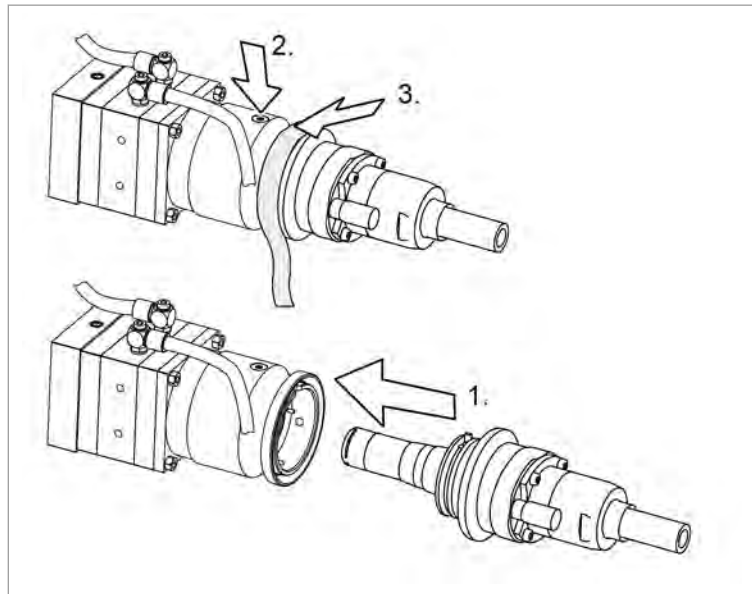
2. Remove the adhesive tape from the plug receptacle (1) of the focusing optics.
3. Push sliding sleeve (2) towards the focusing optics until this engages.
4. Remove the plug (3).



Remove the protective cap from the LLK plug

Fig. 112315

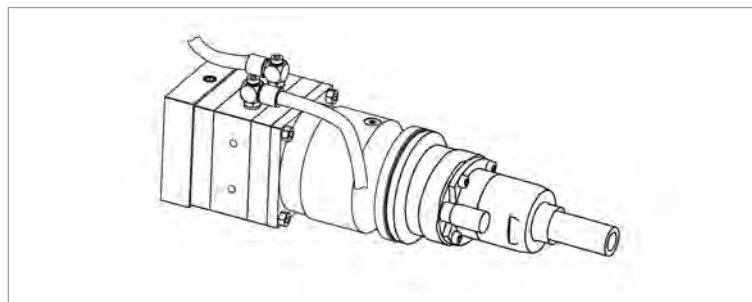
5. Remove the adhesive tape from the LLK plug (1).
6. Remove the protective cap from the LLK plug. by turning protective cap to the left (bayonet locking) (2) and (3).



Steps for mounting

Fig. 112316

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. 112317

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. 0260-47-T

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.

Rotary flange for rectangular fiber

The PFO can also be operated with an LLK with rectangular fiber instead of an LLK with round fiber. In order to be able to align the rectangular focus in the processing plane parallel to the X and Y axes of the PFO, the upper part of the joint can be rotated counter-clockwise by means of the rotating flange.

- Rotary flange 0° position: rectangular focus rotated to the axes.
- Rotary flange 17° position: rectangular focus aligned parallel to the axes.

Rotating the rotary flange to 17° position

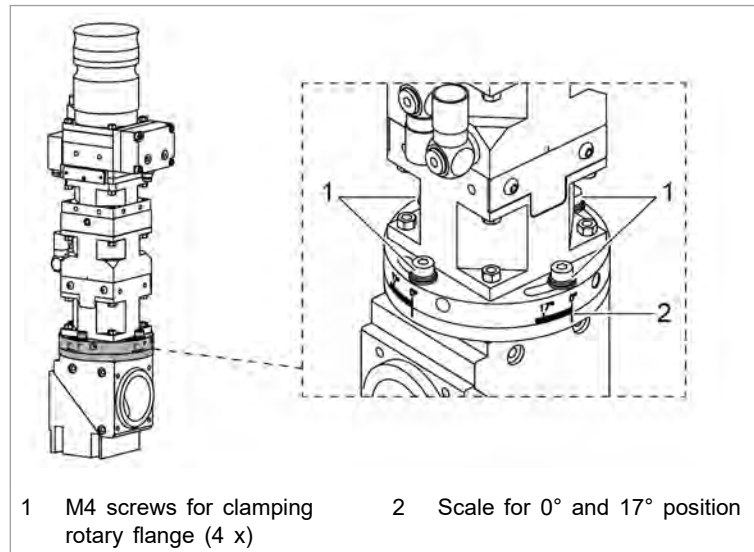
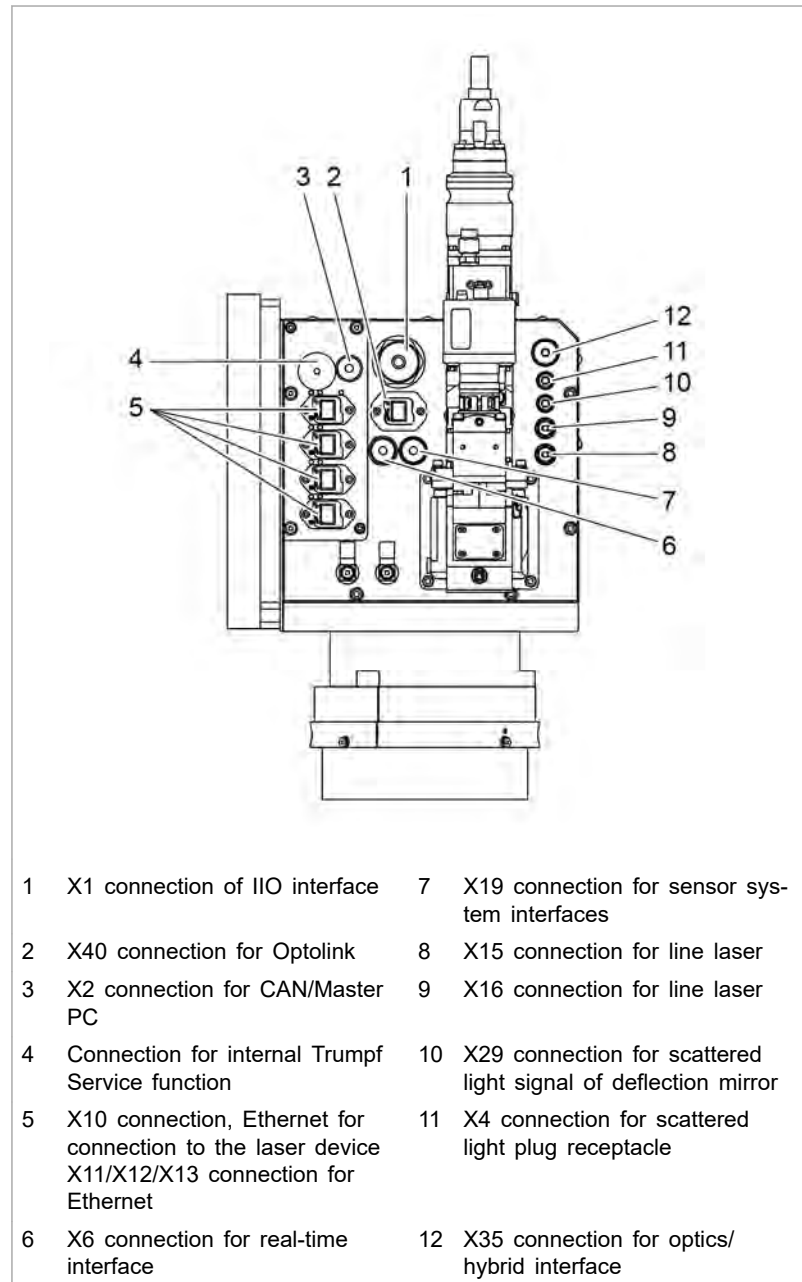


Fig. 112307

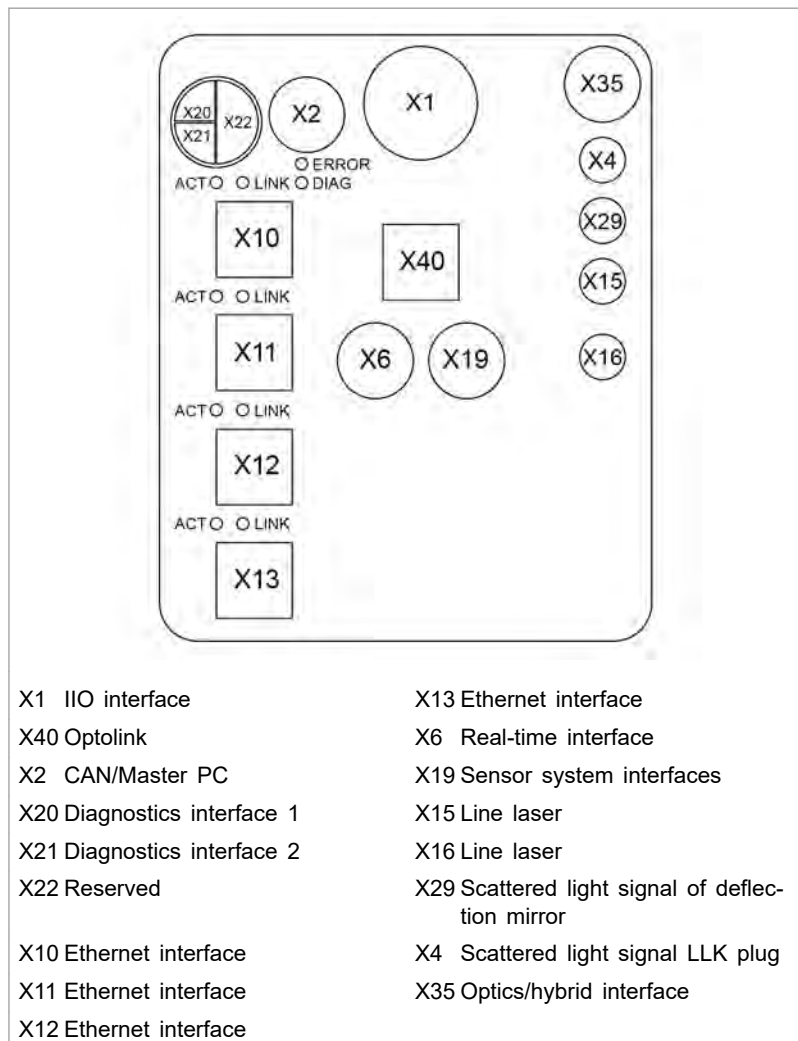
1. Loosen 4 x M4 screws, but do not completely unscrew them. There must be no gap between the two parts of the rotary flange to prevent dirt entering the optical compartment of the PFO.
2. Turn the upper part of the joint counter-clockwise to 17°.
3. Retighten the 4 x M4 screws.

3.4 Electrical connections



Electrical connections

Fig. 112266



Electrical connections, adhesive labels

Fig. 112267

NOTICE**Dirt inside the focusing optics may damage the focusing optics.**

- All electrical connections are closed ex-factory by means of covering caps. Remove these covering caps only if you want to use a connection.
- Store the covering caps of the electrical connections when removing them for connecting the connecting lines in a safe place for a later use.
- Make sure that all electrical connections that are not connected are closed by means of covering caps.

CAN-Interface

The focusing optics is equipped with a CAN interface for an external control unit.

Further information, for example, on pin assignment of connector X2 is given in the interface description of the CAN connection (document no. 12-12-40-A1-BA02).

Real-time interface	The focusing optics is equipped for an external control with real-time interface. Further information, for example on pin assignment of connection X6: (see "Real-time start for PFO program", pg. 2-44)
Ethernet interfaces	The focusing optics is equipped with four Ethernet interfaces, connections X10, X11, X12 and X13. X10 is used to connect to the laser device.
Optolink interface	The Optolink interface is used to transmit the laser power set value and various real-time signals such as camera data.
Interface Intelligent Optics (IIO4)	The Interface Intelligent Optics (IIO4) is a subassembly in the control of the laser device. Connectors for connecting supply and control cables for the focusing optics are located on the front plate of the IIO4.

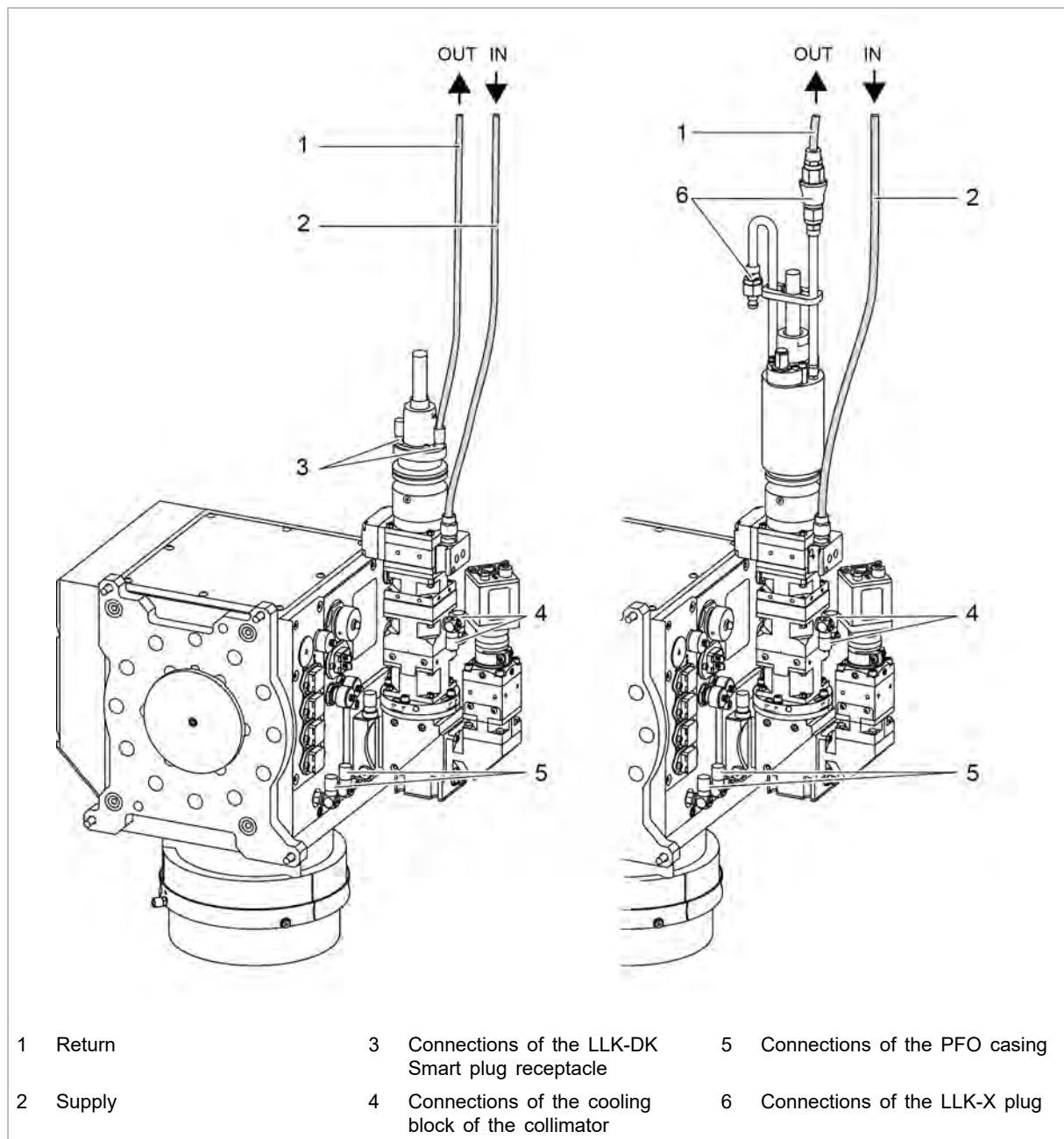
Note

The number of the focusing optics that can be connected to the laser device depends on the design of the laser device.

Contact TRUMPF if you wish to have further information on this.

TLN	If your CW laser is equipped with TRUMPF LaserNetwork (TLN), the supply and control cable is connected to the IFO box of the corresponding light path in the laser device. The LLK coding cable runs parallel to the LLK and is connected to the ILN box of the corresponding light path in the laser device.
Supply and control cable	Three cables are required to connect to the laser device: ▪ Supply cable (at X1) ▪ Ethernet cable (at X10) ▪ Optolink cable (at X40) Total length of all connecting cables of a chain: max. 100 m. Use only cables provided by TRUMPF.
Scattered light monitoring module	Note All PFO 33 have a connection for a scattered light monitoring module.

3.5 Connections for cooling



PFO: Connections for cooling water

Fig. 112268

The cooling lines are already fully installed on the focusing optics. Only the connections to the cooling water supply and the LLK still have to be connected.

Both cooling lines for supply and return on the PFO are marked "IN" and "OUT". The cooling water supply is connected to the line marked "IN" (2). The line marked "OUT" (1) is connected to the LLK or to the return.

Sequence The cooling water flows through the components of the focusing optics in the following order:

LLK-DK Smart: plug receptacle - collimator - focusing optics - flange cooled - LLK plug

LLK-X: plug receptacle - collimator - cooling block - focusing optics - flange cooled - LLK plug

Connections on the case Heat that arises in the interior of the PFO is dissipated through the connections on the casing (5).

Connections on the plug receptacle and on the LLK plug The heat generated at the transition from laser light cable to collimator is dissipated through the connections on the plug receptacle (3) and, if used, on the LLK plug (6).

Cooling water

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.

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

Note

When using the cooling hoses with a length of 50 m and higher, the focusing optics must be connected to an external cooling.

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.
- Particle size < 200 µm.

Note

A focusing optics that was operated in a cooling circuit with the water quality described above, must be thoroughly rinsed using deionized water 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.

Supply	Temperature	25 °C to 33 °C 25 °C when switched on for 100 % of the time 30 °C when switched on for 80 % of the time 33 °C when switched on for 70 % of the time
	Pressure	max. 6 bar
	Flow	> 60 l/h

Tab. 2-4

Note

Connected hoses cause an additional pressure loss, depending on the length and diameter of the hoses.

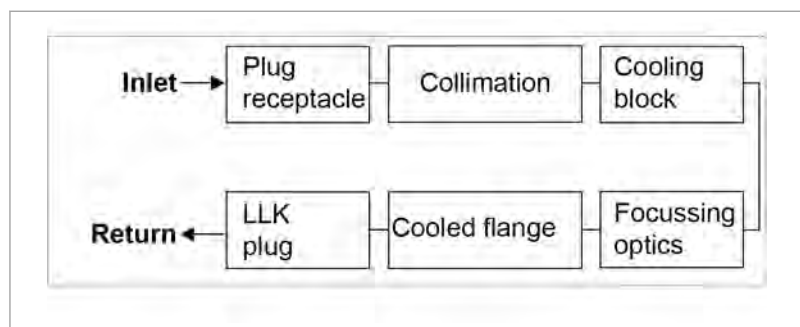
An external cooling unit must continue transporting coolant for 2 minutes before it is switched off to quicker evacuate the heat in the focusing optics and on the optical plug of the laser light cable.

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 agent Nalco 3DT199 (Water Care-Copper). There is no long-term experience for other anticorrosive agents.

Hoses Cooling water hoses are connected and laid (see "Fig. 112268", pg. 2-32).

The cooling water flows through the components of the PFO 33 in the following order: plug receptacle - collimator cooling block - focusing optics - other additional components, e.g. cooling plate OCT (optical coherence tomography), LLK plug.



Hose installation scheme of the PFO with LLK

Fig. 112269

3.6 Connections for crossjet and MDE nozzles

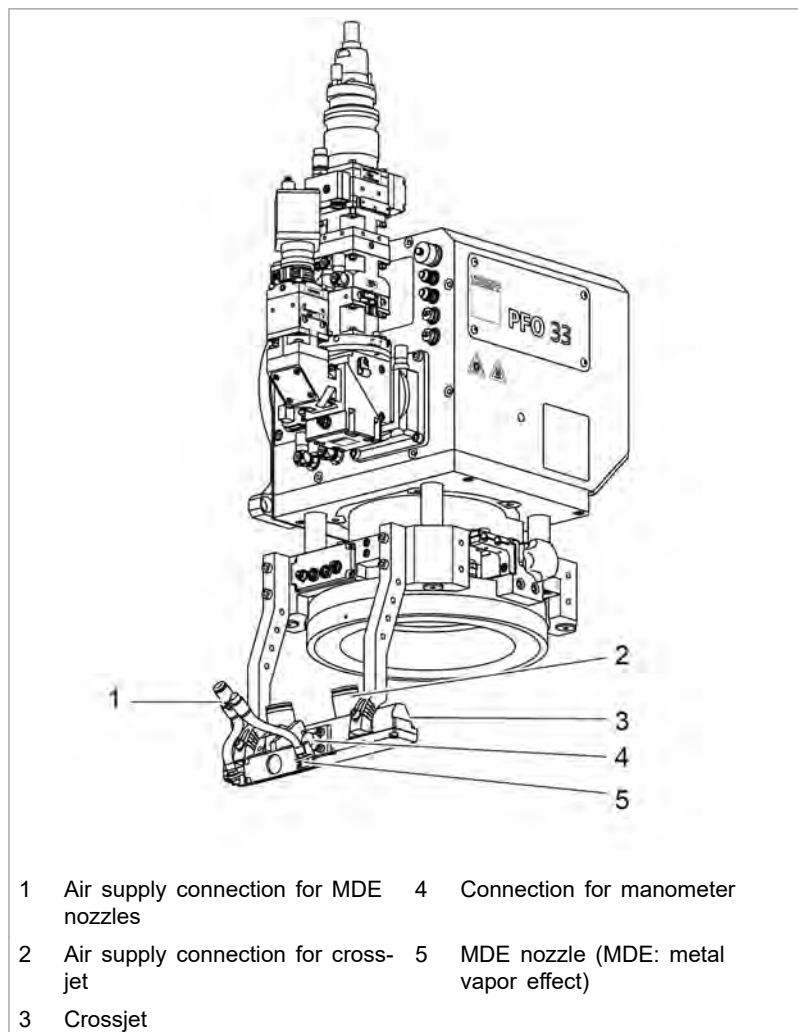


Fig. 112270

Supply air Cleaned and dried compressed air is supplied through the air supply connection.

The compressed air must have the minimum quality according to DIN ISO 8573-1:

- Class 2 for solids, maximum particle size 1 μm .
- Class 5 for water content, maximum dew point 7 $^{\circ}\text{C}$.
- Class 3 for oil content, maximum oil concentration 1 mg/m^3 .

	Crossjet TL 150 S0.25	Crossjet TL 200 S0.25	MDE nozzles
Pressure¹	2.5 to 5.0 bar (recommended 4.5 bar)	2.5 to 5.0 bar (recommended 4.5 bar)	0.4 to 0.8 bar
Hose diameter	1 x 16 mm	2 x 16 mm	6 mm
Air consumption	1500 to 2200 l/min	max. 3300 l/min	60 to 90 l/min
Slot width	0.25 mm	0.25 mm	–
Noise level	> 90 dB(A)	> 90 dB(A)	–

Compressed air

Tab. 2-5

Crossjet Note

The cross-section of the compressed air supply line must be large enough to ensure optimum mode of operation of the crossjet (3).

Use a compressed air hose with an outside diameter of 16 mm and inside diameter of at least 11 mm for the supply!

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

Please note that the indicated pressure must be present in the nozzle body of the crossjet. The connected hose causes a pressure loss, depending on the length and diameter of the hose.

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

Note

The air consumption has to be adjusted directly before the MDE nozzles by means of suspended solid particle flowmeter and reducing valve in the supply line.

¹ inside the nozzle body of the crossjet

3.7 Connection for smoke bell

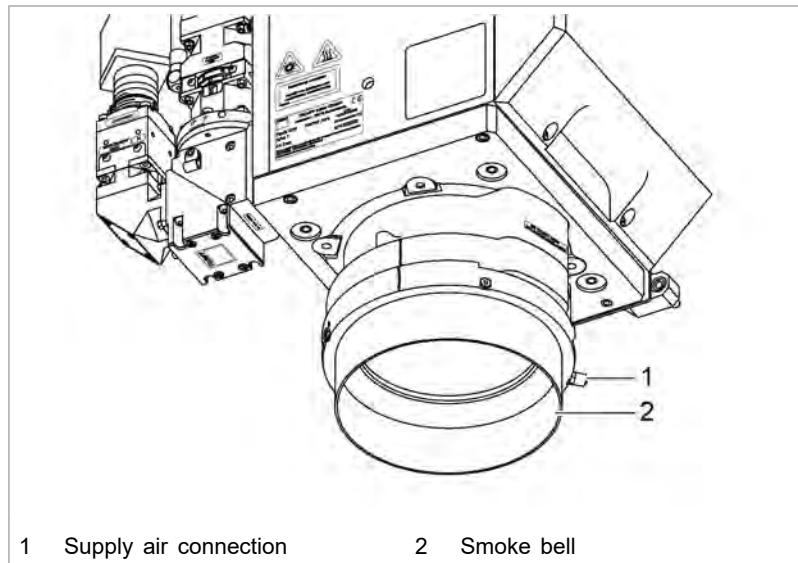


Fig. 112271

Supply air Cleaned and dried compressed air is supplied through the air supply connection.

The compressed air must have the minimum quality according to DIN ISO 8573-1:

- Class 2 for solids, maximum particle size 1 μm
- Class 5 for water content, maximum dew point 7 $^{\circ}\text{C}$
- Class 3 for oil content, maximum oil concentration 1 mg/m^3 .

	smoke barrel
Pressure	0.4 bar to 0.5 bar
Hose diameter	6 mm
Air consumption	40 l/min to 60 l/min

Tab. 2-6

Note

Observe the above mentioned values for pressure and air consumption. Smoke can be taken in if the adjustment of the pressure/air consumption is too high.

The air consumption has to be adjusted directly before the smoke bell by means of suspended solid particle flowmeter and reducing valve in the supply line.

3.8 Connection for LED ring light

See "Assembly instructions LED ring light", doc. no.: 12-12-33-A53-AK.

3.9 Connection for line laser

Note

The line laser can also be controlled via the image processing software VisionLine; see the operator's manual "VisionLine Gen. 2", doc. no.: 22-50-12-A4-CR.

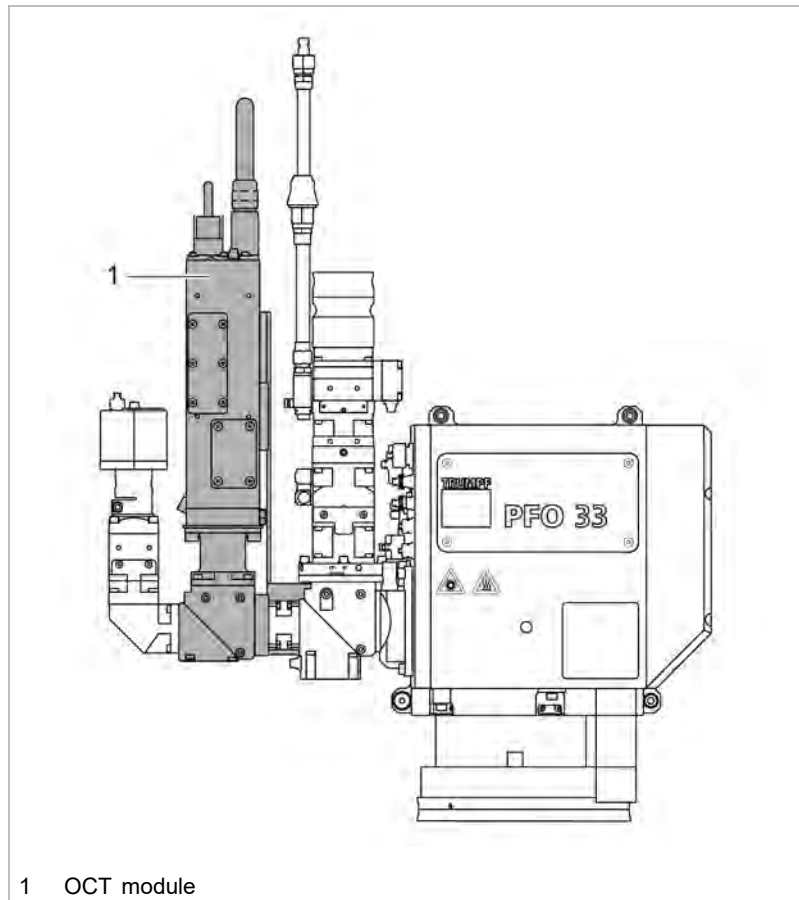
3.10 Camera connection

Note

For further information about the observation optics, see the operator's manual "VisionLine Gen. 2", doc. no.: 22-50-12-A4-CR and the operator's manual "VisionLine Cam", doc. no.: 22-50-12-A0-01-CR.

3.11 Other connections for PFO 33

OCT



OCT module

Fig. 112295

Optionally, an OCT module for seam position control can be connected, see the Operator's manual "VisionLine OCT Detect", doc. no.: 83-01-01-A0-CR.

3.12 Connection for process diagnosis sensors

The process diagnosis sensors can only be purchased directly from the sensor manufacturer.

Contact the sensor manufacturers if you want more information on this.

3.13 Switching on/off the protective glass monitoring unit PFO 33

By selecting a corresponding application data set created in the TruControl 1000, the protective glass monitoring unit can be switched on and off as required.

Conditions

- The PFO 33 is assigned to the light path.
- TruControl version 3.26 or new version is used.

Creating application data sets

1. Select the main activity *Programming*.
2. Select tab *PFO BEO app. data*.
3. Select free storage space.

The selected storage space is highlighted in yellow.

4. Select *New*.

The dialog *Create PFO application data set* is displayed.

5. Create application data set "Protective glass on" and set *Protective glass soiling* as active by pressing "Yes".

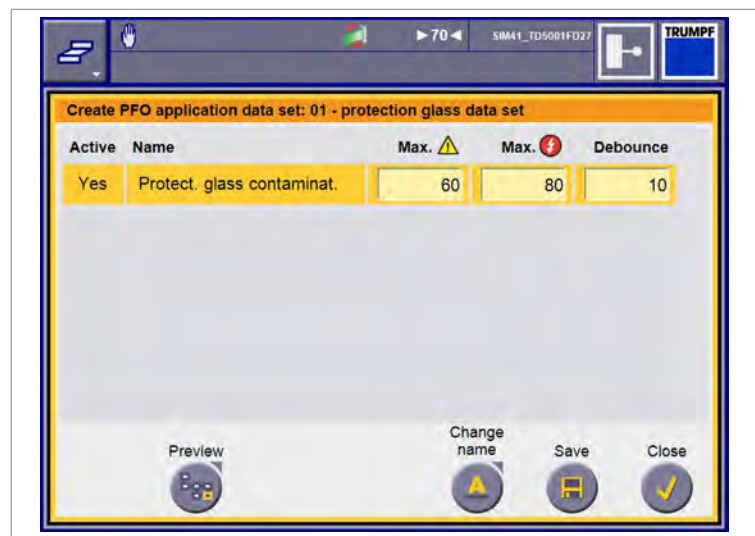
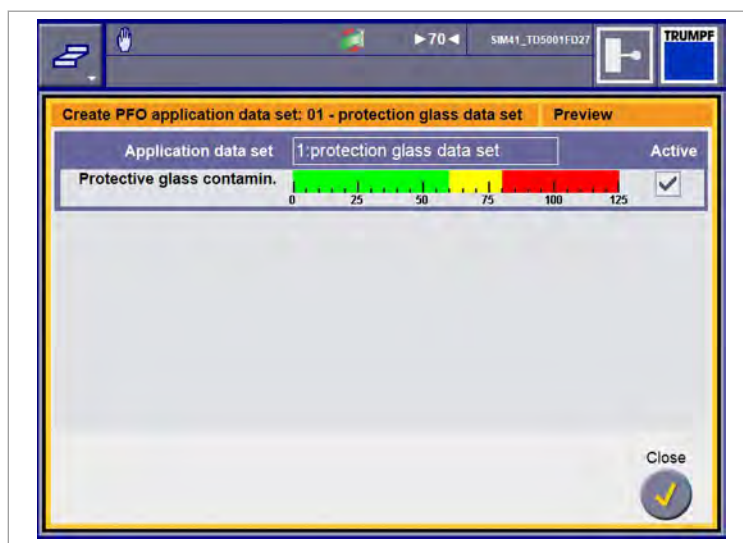


Fig. 112313

6. Set limit values.
7. Create application data set "Protective glass off" and set *Protective glass soiling* as inactive by pressing "No".

Application data set is created.



Protective glass contamination active - preview

Fig. 112300

Selecting application data set

8. Select the main activity *Programming*.



Fig. 112311

9. In the menu >*Change line*, select the line *PFO application data*.

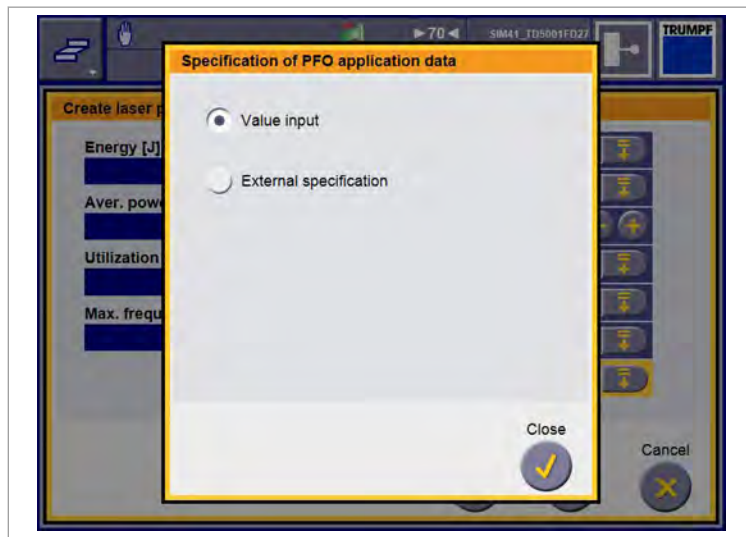


Fig. 112310

10. Select *Value entry*.

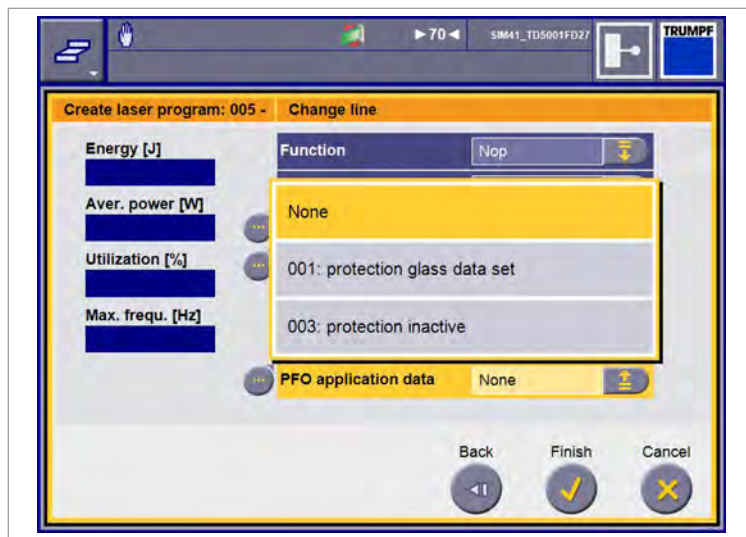
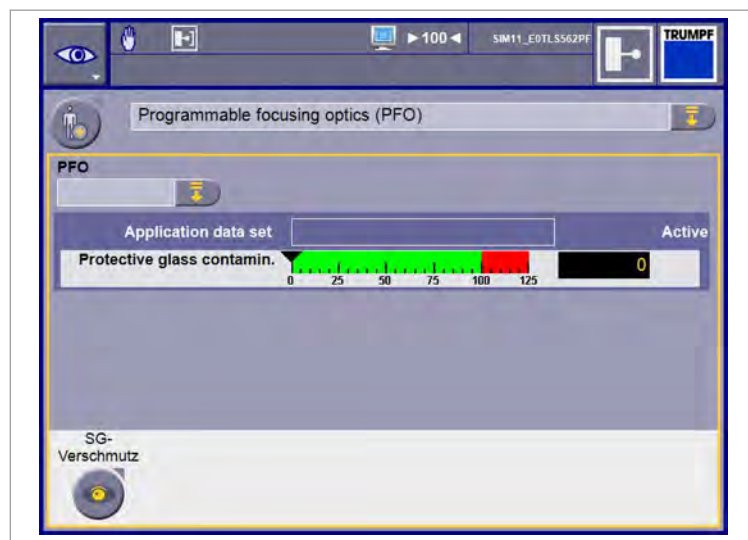


Fig. 112312

11. Select the corresponding application data set ("PFO app. data") in the laser program.

The protective glass monitoring unit is switched on and off.

The currently selected application data set is shown in the diagnostics dialog "Focusing optics (PFO)". In addition to the limits from the data record, the current measured value of contamination is also displayed.



Protective glass monitoring active

Fig. 112272

4. Real-time start for PFO program

4.1 Overview

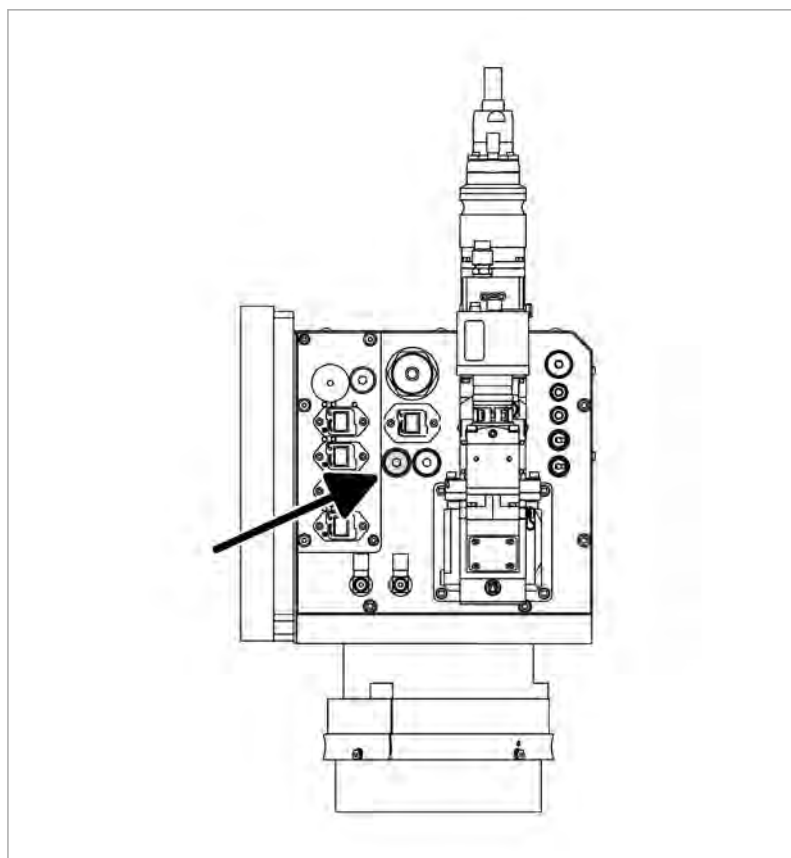
The TruControl 1000 operating program has a "Real-time start" function with which PFO programs can be started by a trigger signal. The "Real-time start" function can be activated in the laser program editor if a PFO program is inserted into a program line of a laser program.

If a PFO program is executed in a laser program with the "Real-time start" function:

- the focusing optics travels to the starting point of the geometric figure.
- the PFO program is only started if an external trigger signal becomes active on the real-time interface of the PFO.
- the control creates a fault message if the trigger signal is activated before the PFO has reached the starting point.

4.2 Real-time interface X6

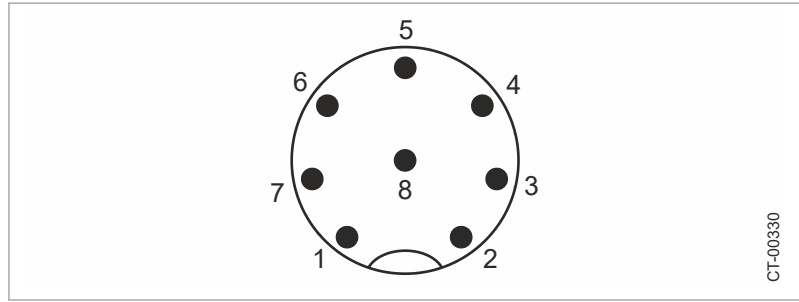
Position of the real-time interface



PFO: real-time interface X6 (arrow)

Fig. 112273

Connection:



M12, 8-pin, pins, A-coded

Fig. CT-00330

4.3 Signals of the real-time interface X6

Pin	Signal	Description
1	PFO_RT_START	Input (flank triggered) starts a PFO program in real time. Prerequisite: - A laser program that contains a PFO program with real-time start is started. - The PFO has reached the starting position of the geometric figure of the PFO program. - An active output signal FIRST_POS_REACHED signalizes that the PFO has reached the starting position. Note: If the input signal PFO_RT_START is activated before the PFO has reached the starting position of the geometric figure of the PFO program, the control reports a light path fault.
2	Reserved	
3	Reserved	
4	PFO_GEO_AKTIV_POWER	The output is active as long as the PFO is running a PFO program. When the signal is active, the laser power is > 0 W. This output can be used as a feedback signal for the input signal PFO_RT_START. Information on the time response of the signal: (see "Time response", pg. 2-47).
5	FIRST_POS_REACHED	Exit is activated as soon as the PFO reaches the starting position of the geometric figure of the PFO program With an active output signal FIRST_POS_REACHED, the execution of a PFO program is started by activating the input signal PFO_RT_START.
6	Reserved	
7	24V_EXT	Extern power supply (24 V) for outputs Note: The power supply must also be connected if only inputs are wired as the protective circuit is also supplied.
8	0V_EXT	Reference voltage for inputs and outputs

Tab. 2-7

Input signal

Parameters	Value
Input voltage	0 V ... 27 V
Switching level high (signal = active)	> 16 V
Switching level low (signal = inactive)	< 6 V
Input current	5 mA at 24 V input voltage
Insulation voltage	500 V

Tab. 2-8

Output signal level

Prerequisite:

- The outputs are supplied with a voltage of $24\text{ V} \pm 10\%$ using the signals 24V_EXT and 0V_EXT.

Parameters	Value
Unloaded output voltage (signal = active)	24 V (max. 27 V)
Loaded output voltage (signal = inactive)	> 22 V at 0.1 A and 24V_EXT = 24 V
Output voltage (signal = inactive)	0 V
Output current	0,3 A (continuous current per output)
Interrupting current	7 A (short-circuit proof)
Insulation voltage	500 V

Tab. 2-9

4.4 Time response

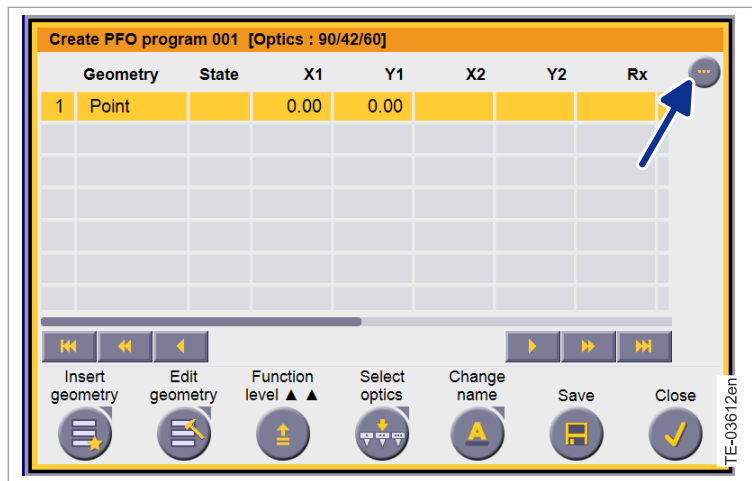
Event	Value
Start time Time between the rising flank of the input signal PFO_RT_START and the beginning of the drive-in vector. At the end of the drive-in vector the output signal PFO_GEO_AKTIV_POWER is activated.	200 μ s $\pm$ 50 μ s
Activation of the laser power The PFO program is executed with the delay specified in "Start time". When starting a PFO program, the PFO needs a drive-in vector to reach the speed specified in the program. The laser power is activated at the end of the drive-in vector. The value of the laser power corresponds to the value specified for the first geometric figure in the PFO program. The PFO delay (duration of the drive-in vector) can be set for each PFO program (see "Setting the prevector" , pg. 2-48). It allows to adjust the mirror movement and the laser movement to each other. Therefore, it is specific for the drives and mirror sizes used. PFO delay , default setting: Time from the rising flank of the signal PFO_RT_START until the activation of the laser power: Prerequisite: The first geometric figure is programmed with laser power.	4 ms. PFO delay + 0.7 ms
Time delay after the start of a laser program After the start of a laser program, a time of max. 60 ms passes until the PFO reaches the starting position of the PFO program. After that the FIRST_POS_REACHED reached signal is active. This time depends on the distance to be covered by the PFO to the starting point.	approx. 60 ms
Time delay between nominal laser power and laser switching off. If the nominal laser power = 0, the signal PFO_GEO_AKTIV_POWER = 0 and the laser switches off after the specified delay.	200 μ s

Tab. 2-10

4.5 Setting the prevector

1. Select in TruControl 1000 the following menu path: >*Programming* > *PFO program*.
2. Mark the PFO program to be processed.
3. Load PFO program into the PFO program editor: Select >*Change*.

The PFO program editor is started, the selected PFO program is displayed.



Button "PFO program, settings" (arrow)

Fig.
TE-03612en

4. Select *PFO program, settings* (arrow).
5. Enter the value for the desired delay in the field "PFO delay". Standard value: 4 ms.
6. Select button *Close*.

The PFO delay for the PFO program is set.

4.6 Real-time start function

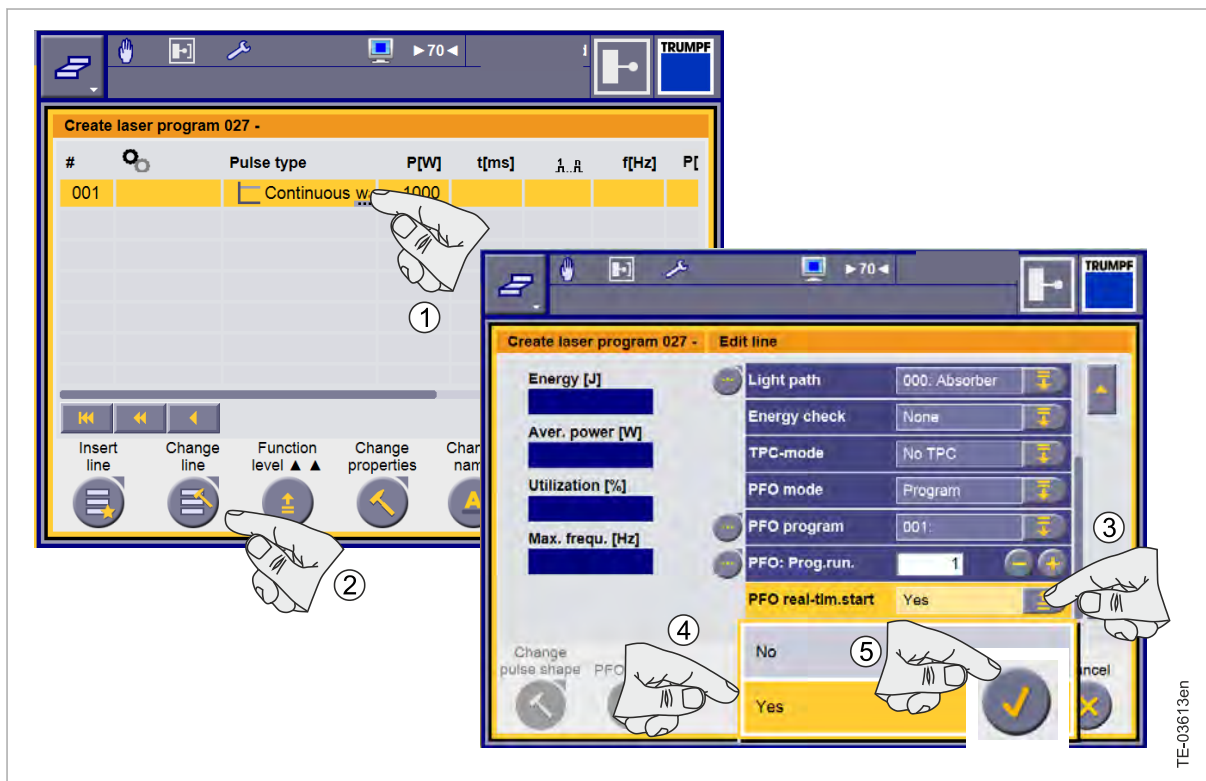


Fig. TE-03613

Activating the real-time start function

Conditions

- The laser program editor in TruControl 1000 is open.
- A laser program with a PFO program call is loaded in the laser program editor.

1. Mark the program line in which the real-time start is to be activated.
2. Select "Change line".
The "Edit line" dialog box is displayed.
3. Open the "PFO real-time start" selection list.
4. Select "Yes".
5. Checkmark the button.

The "Real-time start" function for the selected PFO program is activated.

5. Ambient conditions

Temperature	Operation:	+15 °C to +40 °C
	Storage: Note: Drain the cooling water line for storage.	+5 °C to +40 °C
Relative humidity		Non condensing
Protection type		IP 50
Maximum acceleration		2 g at 5 - 150 Hz

Tab. 2-11

The programmable focusing optics must **not** be operated in environments subject to explosion hazard.

Cooling water temperature

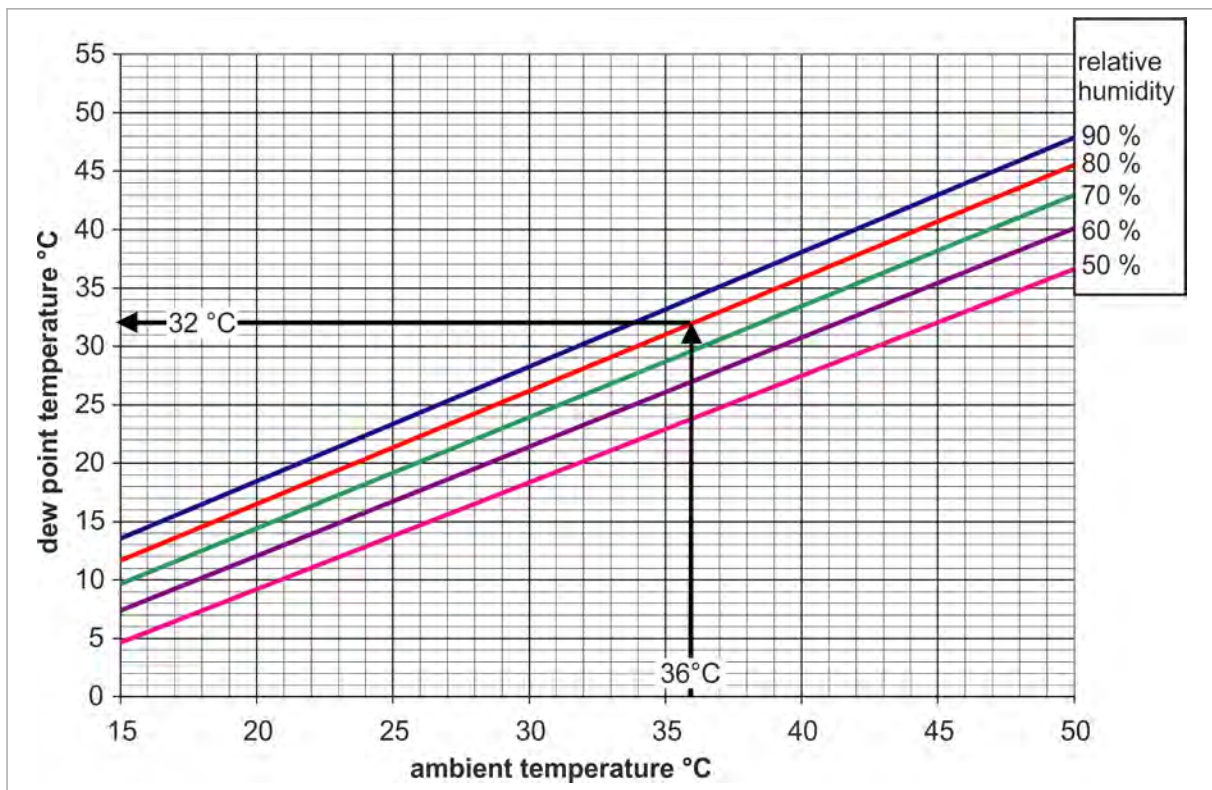
Condensation water forms whenever warm and humid air comes in contact with cold surfaces at certain temperatures.

To prevent condensation water formation on the optics and electronics of the focusing optics, the cooling water temperature must not be set too low.

To determine the required cooling water temperature, the ambient temperature and humidity must be measured in the vicinity of the focusing optics. These measured values can be used to read in the dew point diagram the temperature at which the ambient air is subject to condensation.

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

5.1 Calculating required cooling water temperature



Dew point diagram

Fig. SG-02007

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. Read dew point temperature (in the example: 32 °C).

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

Observe the laser device and welding optics requirements when determining the required cooling water temperature. In tropical countries, the cooling of the focusing optics must be ensured using an external cooling unit.



Chapter 3

Description

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1. Variants and options

The focusing optics has a modular design. Various modular system components can be combined, depending on the application. Special applications may require special models.

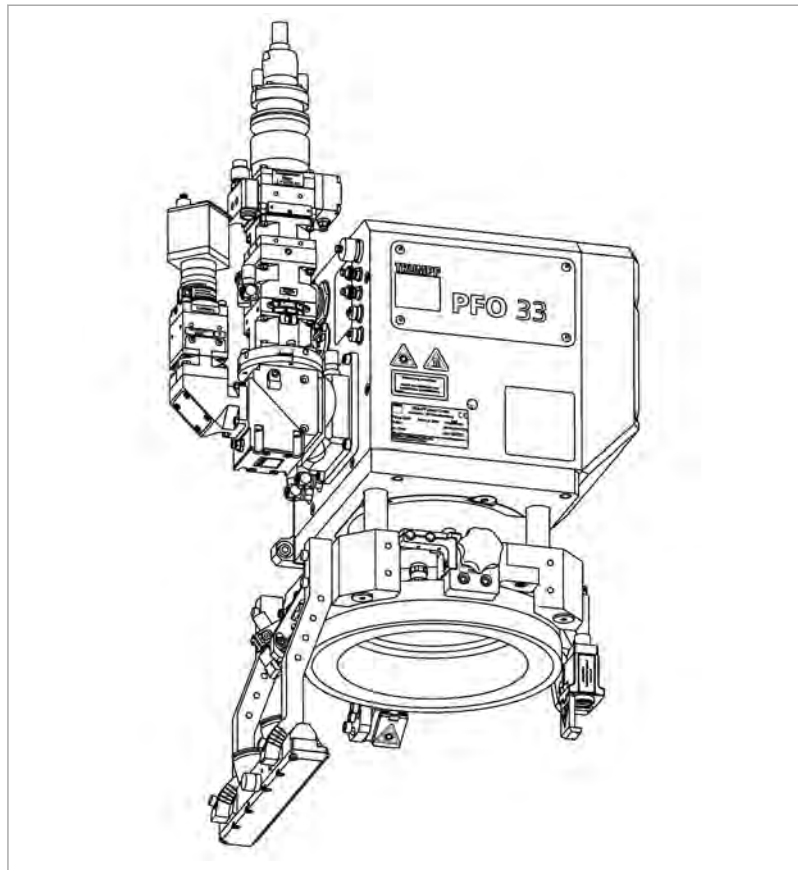


Fig. 112274

Laser device The focusing optics can be connected to different laser devices (TruFiber, TruMicro, TruDisk). For information on permitted laser power, please refer to the data sheet of your focusing optics.

LLK A laser light cable guides the laser light from the laser device to the focusing optics.

Focal lengths For information on focal length of lens and collimation, please refer to the data sheet and dimensional drawing of your focusing optics.

Using accessories

Accessories	Advantage
Crossjet	Vapor and spatter are kept away from the lens
Lens protection - smoke bell	Precipitation of smoke residue on the protective glass is reduced

**Using accessories**

Accessories	Advantage
Teach module	Aids for alignment of the focusing optics to the workpiece surface
Camera with monitor	Monitoring of the welding process is possible
MDE module	The plasma torch is eliminated
OCT module	Additional equipment for seam position control
Teach laser	For altitude determination
LED ring light	Red LED lighting for image processing applications
Process diagnosis supports	The welding process can be evaluated

Tab. 3-1

2. Parts

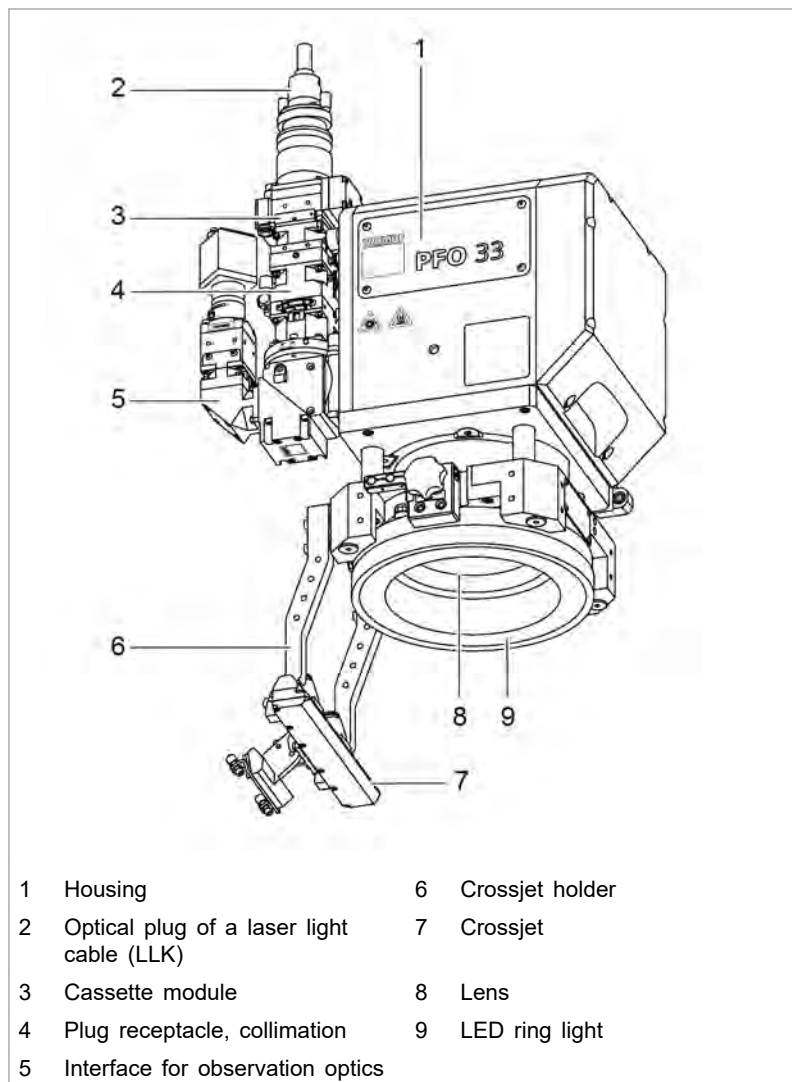


Fig. 112275

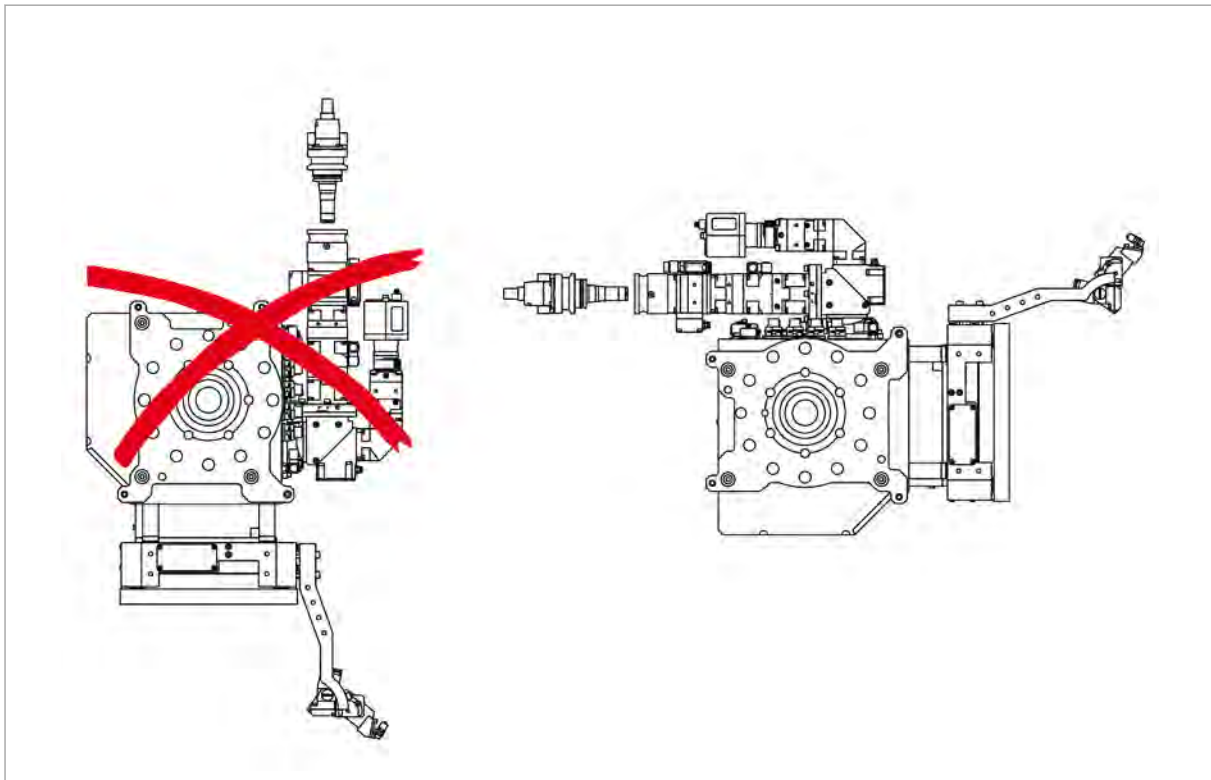
Optical plug (LLK) The optical plug of the laser light cable (LLK) is inserted into the plug receptacle and fixed with a circlip.

Plug receptacle The plug receptacle holds the optical plug of the laser light cable and aligns the fiber end faces with the axis of symmetry of the optical unit.

The plug receptacle is cooled.

Note

Seal the connection hole with the sealing plug intended for this purpose if no laser light cable is plugged in.



Position for opening of the LLK connection

Fig. 112276

Turn the focusing optics always in a horizontal position before the LLK is connected or disconnected if the installation setting allows this.

Collimation

The collimation unit forms the conical laser beam coming out of the LLK to a parallel beam.

Connecting piece

The connecting piece connects the following components with the programmable focusing optics (PFO):

- the collimation (4).
- the optional observation optics (5).

A mirror deflects the collimated laser beam by 90° and guides it into the casing of the focusing optics.

Mounting plate

The focusing optics is fixed to a robot, machine carrier or linear axis using the mounting plate.

More information can be found in the installation directives:

- for PFO 33: doc. no.: 12-12-30-A108-DH.

objective

The lens focuses the collimated laser beam onto the workpiece surface. This generates the high power density in the focal point required for welding.

The plane field lens moves the focal point on one plane when turning the scanner mirrors.

Lens protection, smoke bell

The lens protection and the smoke bell are provided with a protection glass which protects the lens outwards. The protective glass protects the lens against soiling by particles or material vapors formed during the welding process.

Note

Only one side of the protective glass may be used.

After cleaning the protective glass, never fit it into its holder with the cleaned side towards the lens. The cleaned surface contains residual contamination, which will vaporize when the laser operates and which may lead to damage (contaminants being burned in) to the lens.

Protective glass monitor

During operation of the PFO 33, the focusing optics in conjunction with the protective glass monitoring (optional) monitors whether a protective glass is inserted. If no protective glass is present, no laser light emerges from the focusing optics.

Cooling ring for the focusing lens

The objective lens of the PFO 33 is additionally cooled due to the higher laser powers.

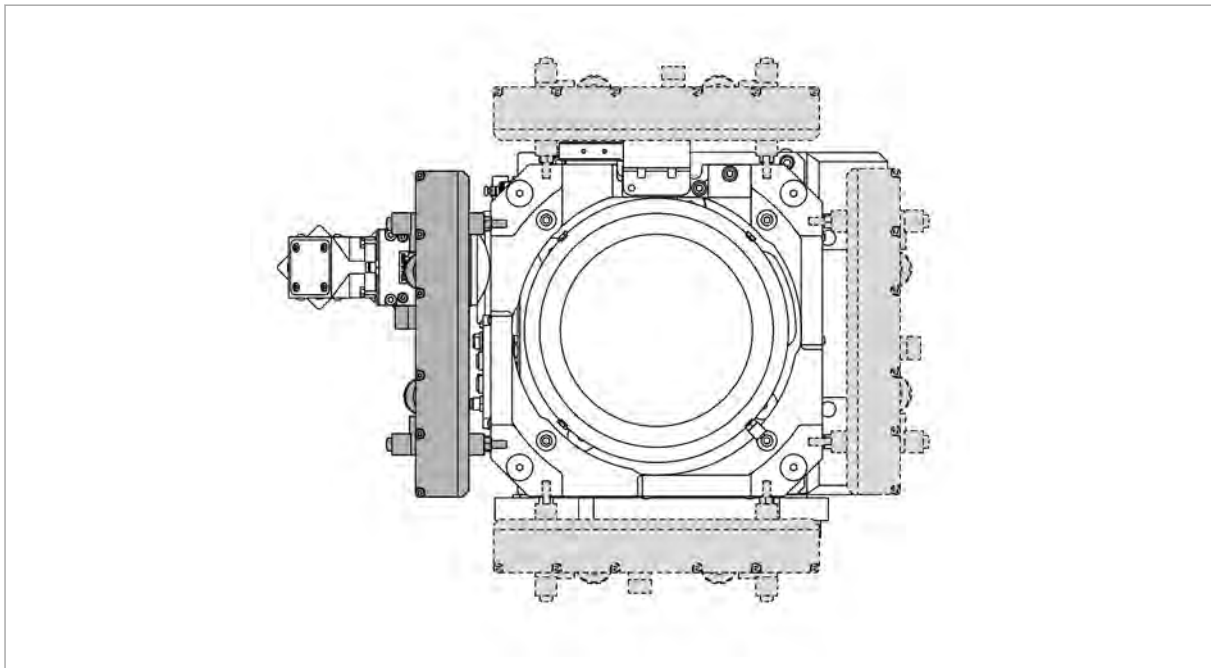
Housing

The casing contains scanner mirrors with drives and the complete electronics of the focusing optics. The heat arising during operation is dissipated by means of the cooling water connections on the housing.

Crossjet

For welding applications with a strong production of splashes and vapor, a crossjet can be used. The flat nozzle of the crossjet generates an air flow at a right angle to the direction of the laser emission. The air flow deflects particles and vapors from the protective glass. Impurities on the protective glass are reduced.

Cleaned and dried compressed air is used as supplied air. For further information, see chapter "Assembly and installation".



Crossjet mounting positions for PFO 33

Fig. 112277

The crossjet can be mounted in one of four positions (4 x 90°) at the PFO 33, as required. Preferably, the crossjet should be mounted so that it does not blow in the direction of the line laser for height measurement.

MDE nozzles

The MDE nozzles are attached to the crossjet (MDE: metal vapor effect).

The two MVE nozzles create an airflow in the direction of the processing plane which reduces the plasma torch.

The plasma torch which is created during the welding process absorbs laser power.

smoke barrel

For welding applications with a heavy smoke production, a smoke bell can be used.

The smoke bell consists of:

- Protective glass
- Concentric nozzle
- Protective funnel

The concentric nozzle creates a draft in direction of the processing plane which directs the smoke away from the protective glass. Impurities on the protective glass are reduced.

The smoke bell can be slid on the lens instead of the lens protection.

Teach module The left and right teach modules each contain a semiconductor laser with power < 5 mW, which emits red laser light (wavelength 650 nm).

The laser light is emitted through a slot of the teach module and hits the processing plane in form of a line. The teach modules are offset by 90°. This is why a red-light cross is visible on the processing plane during operation.

Both teach modules can be used together with a teach function in robot application to set the distance and the position of the focusing optics vertical to the workpiece surface.

If you bought the teach modules later or want to attach them to a different position, these have to be adjusted by a service engineer of TRUMPF during a service mission after installation on the focusing optics.

LED ring light for PFO33 (option)

CAUTION

Blinding due to LED ring light

- Attach a sign warning people about this danger.
- Set up access restrictions.
- Brief any persons potentially at risk.

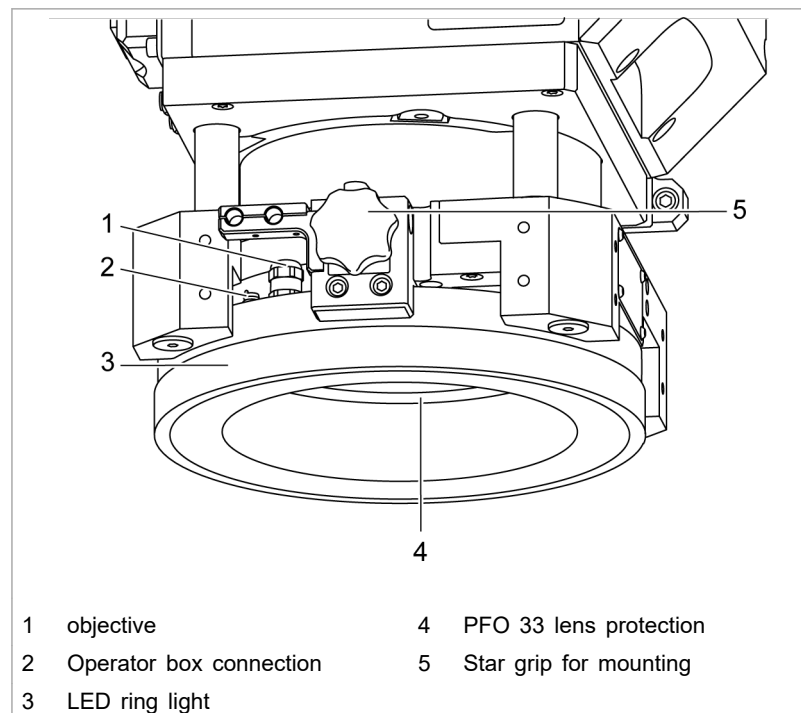


Fig. 112278

The LED ring light (red LEDs) lights the processing point. This allows the user to recognize the processing point on the work-piece more easily.

The LED ring light is operated by means of the operator box.

The operator box and the LED ring light are supplied with voltage via a power connection cable and a power supply unit for connection to 230 V.

An additional cable (2) connects the LED ring light to the operator box.

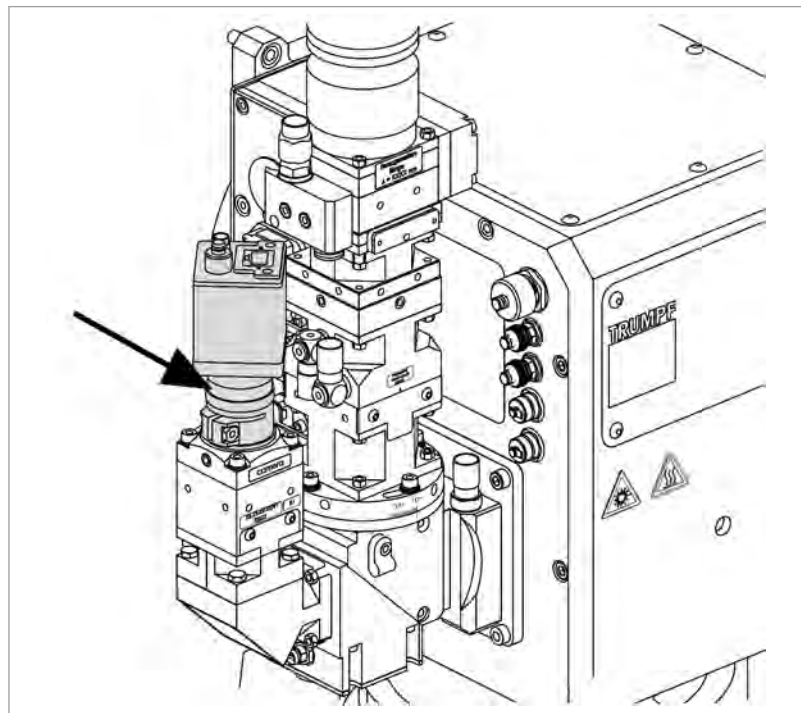
The LED ring light is covered on the outside by a protective glass.

Interface for observation optics

Observation optics including camera and monitor can be connected to the interface for observation.

A filter is built into the observation optics as protection against escaping laser radiation. This reduces laser light by 99.9 %. At constantly intense laser radiation, the 0.1% of residual light can quickly lead to the camera becoming defective. In such cases, an additional filter needs to be installed.

For further information about the observation optics, see the Operator's manual "VisionLine Gen. 2", doc. no.: 22-50-12-A4-CR and the Operator's manual "VisionLine CAM", doc. no.: 22-50-12-A0-01-CR.



PFO with camera

Fig. 112279

Pilot laser

The pilot laser is a small semi-conductor laser that emits red laser light with a wavelength range from 635 nm to 650 nm.

A red light spot or a red light ring is visible in the processing plane when the pilot laser is activated:

- a light spot when the focal point is on the surface of the workpiece.
- a light ring when the focal point is below or above the surface of the workpiece.

The deflection of the light spot or the light ring from the center of the processing field corresponds to the current position of the scanner mirror.

Deviations The pilot laser and the working laser have different wavelengths. The focusing lens of the focusing optics is optimized for the wavelength of the working laser.

As a result, the light spot of the pilot laser can deviate from the position of the weld point.

Process diagnosis module The sensors of the process diagnosis module deliver parameters which can be used for evaluation of the welding process.

2.1 Protective glass

LLK protective glass

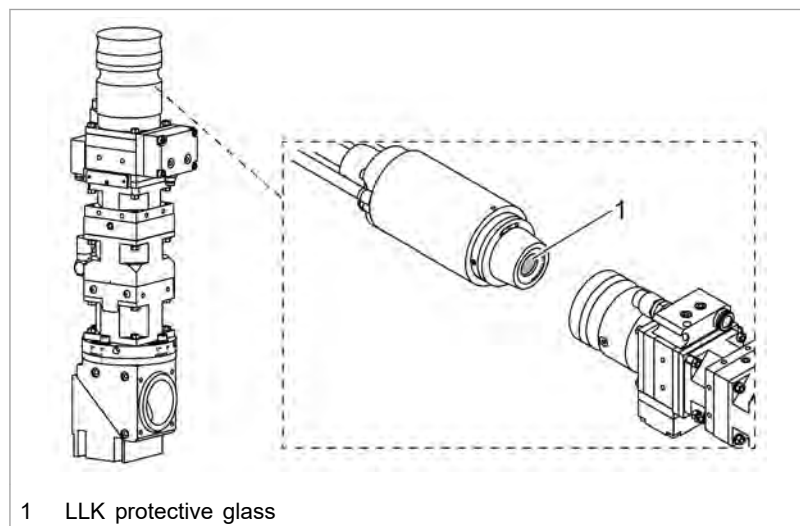


Fig. 112306

LLK Protective glass monitoring

During operation, the LLK protective glass monitoring module monitors the scattered light of the LLK protective glass. In case of impermissibly high values, a warning or error message is sent. In addition, the laser is switched off.

Collimator protective glass

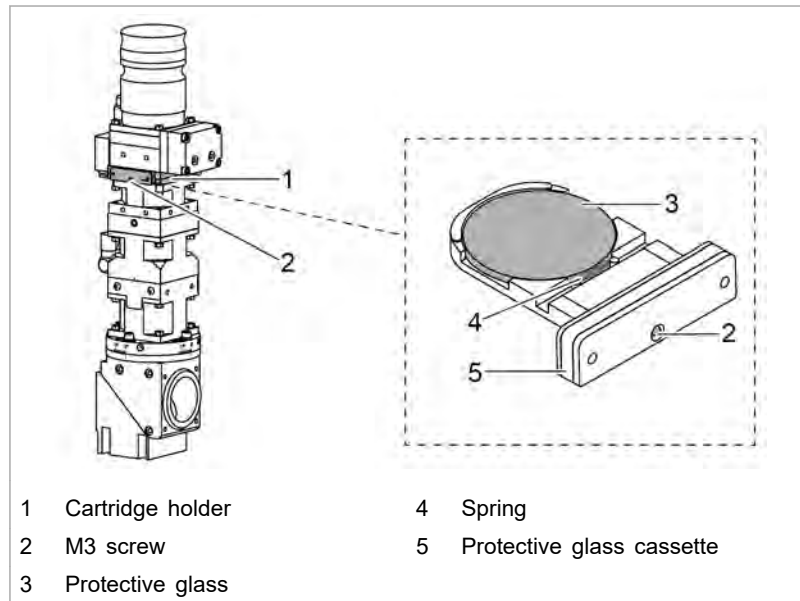


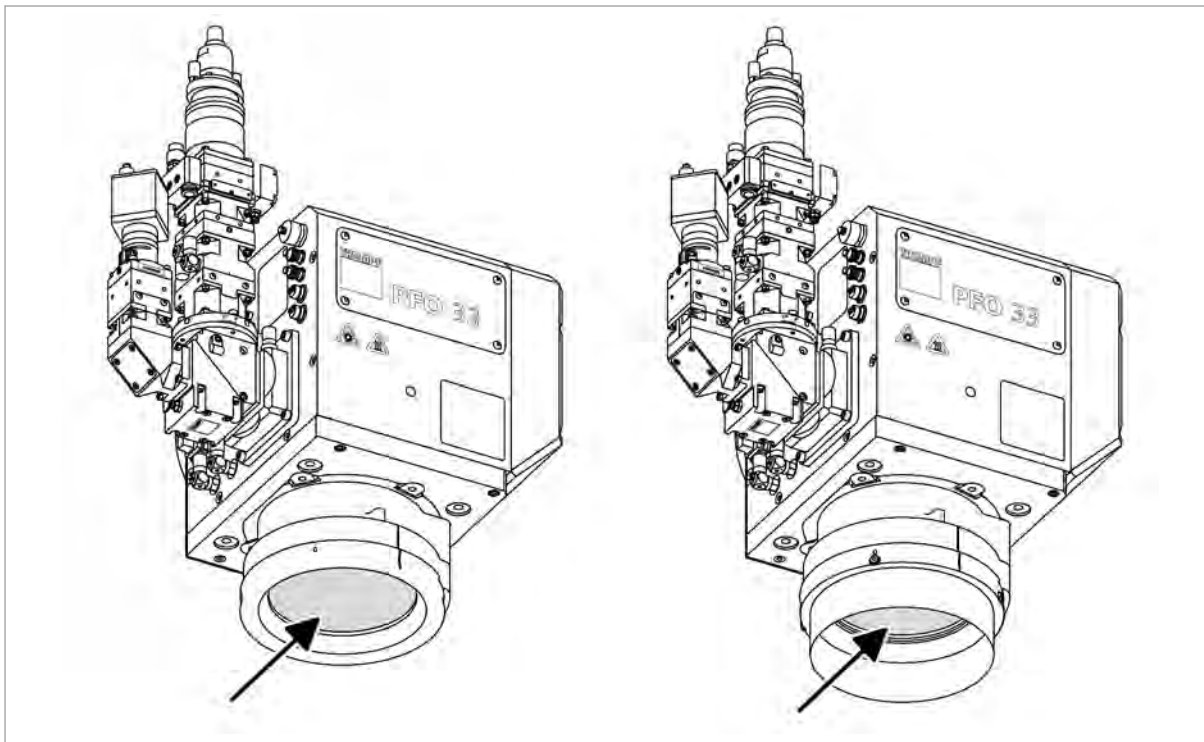
Fig. 112296

The protective glass prevents contamination of the collimator lens when the plug receptacle is open.

The cassette holder is located between the collimator and the plug receptacle.

The protective glass can easily be replaced (see chapter "Maintenance").

Objective protective glass



PFO with protective glass in the lens protection (left), PFO with protective glass in the smoke bell (right)

Fig. 112287

The protective glass prevents contamination of the objective lens when the plug receptacle is open.

The protective glass can easily be replaced without any tools (see chapter "Maintenance").

Objective protective glass monitoring

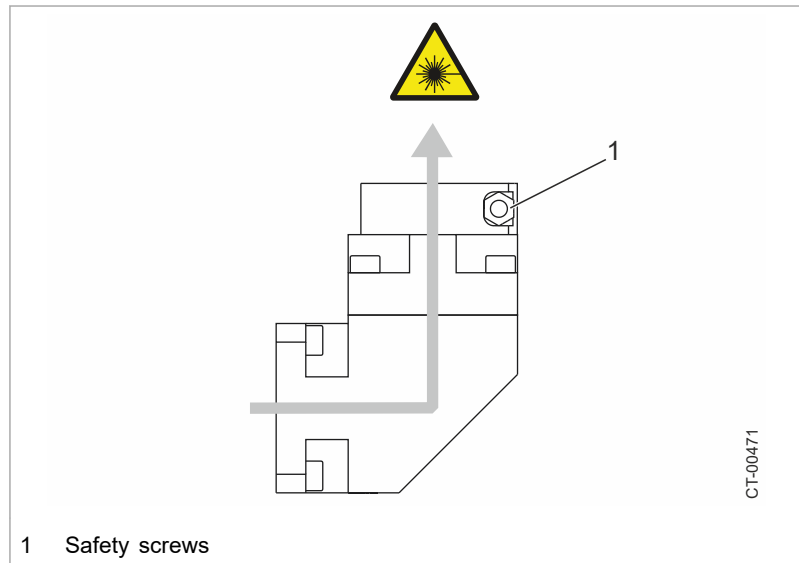
During operation, the protective glass monitoring module monitors the scattered light on the objective protective glass. The signal strength of the scattered light is used to calculate the contamination.

A message is displayed on the screen of the operating PC if the contamination of the protective glass exceeds the permissible range set in TruControl 1000. In this case, the protective glass must be replaced.

Note

To be able to monitor the soiling of the protective glass, the monitoring must be enabled in TruControl 1000. For more information on this topic, please refer to the software manual of the controlled focusing optics.

2.2 Interface for sensor module



Interface for sensor module, Example 90°

Fig. CT-00471

A sensor module for process monitoring is connected via this interface. The sensor module detects the laser radiation reflected by the workpiece and the radiation emitted from the machining point.

There is **no laser protective filter** in the interface for the sensor module. Therefore use of the eyepiece or camera at this interface is **not allowed**. The interface is secured by way of safety screws (hexagon socket screws with pin).

During operation of the focusing optics, the sensor module has to be attached to the interface or the interface has to be protected against laser radiation emission by an aluminum sealing plug.

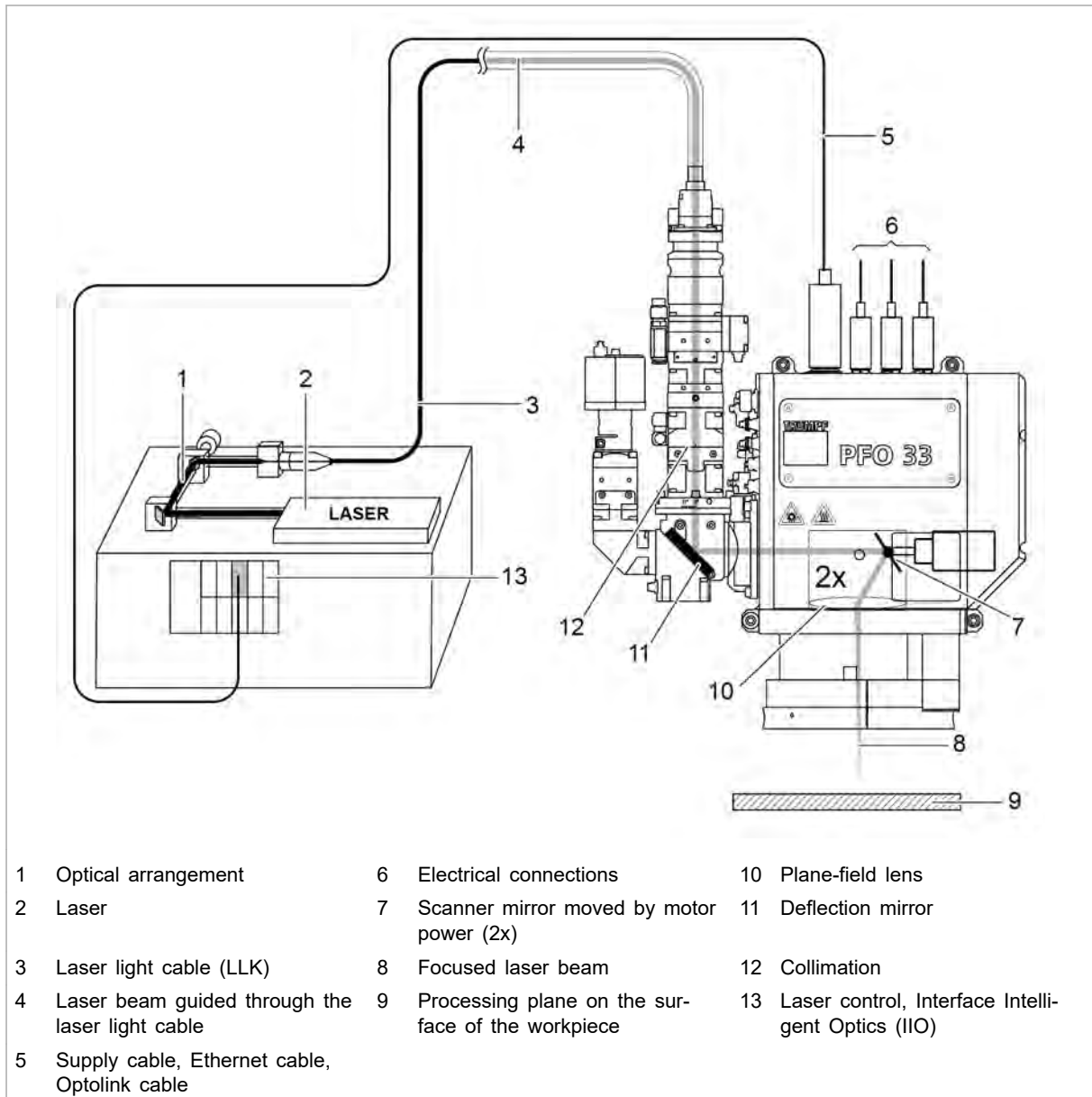
WARNING

There is no laser protective filter in the interface. If you use the interface without sensor module or sealing plug, your eyes and your skin may be exposed to laser light!

Laser light can burn your skin. Direct or scattered laser light can permanently damage your eyes.

- Never look into the interface.
- Use the focusing optics only if the interface is closed by a sensor module or a sealing plug.
- Never attach eyepiece or cameras to the interface.

3. Functional description

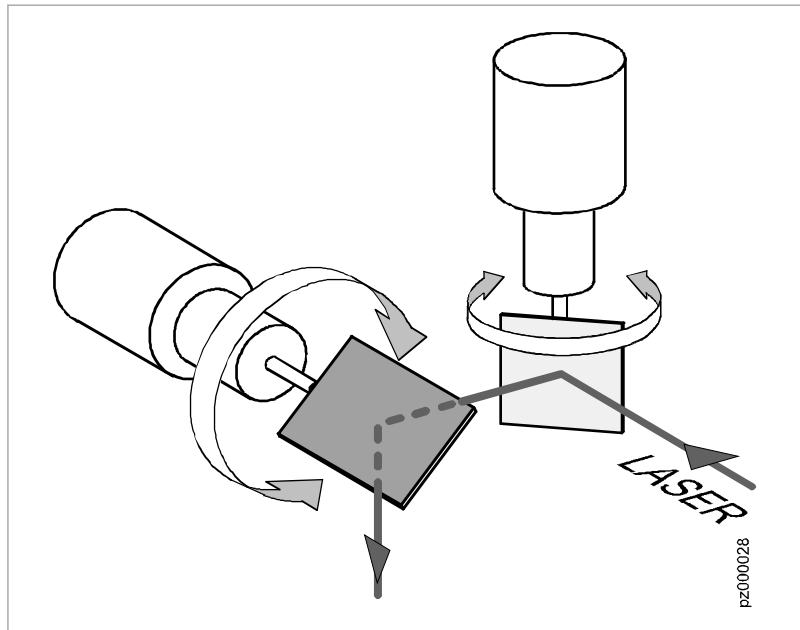


PFO: beam course, signal flow

Fig. 112280

Light path

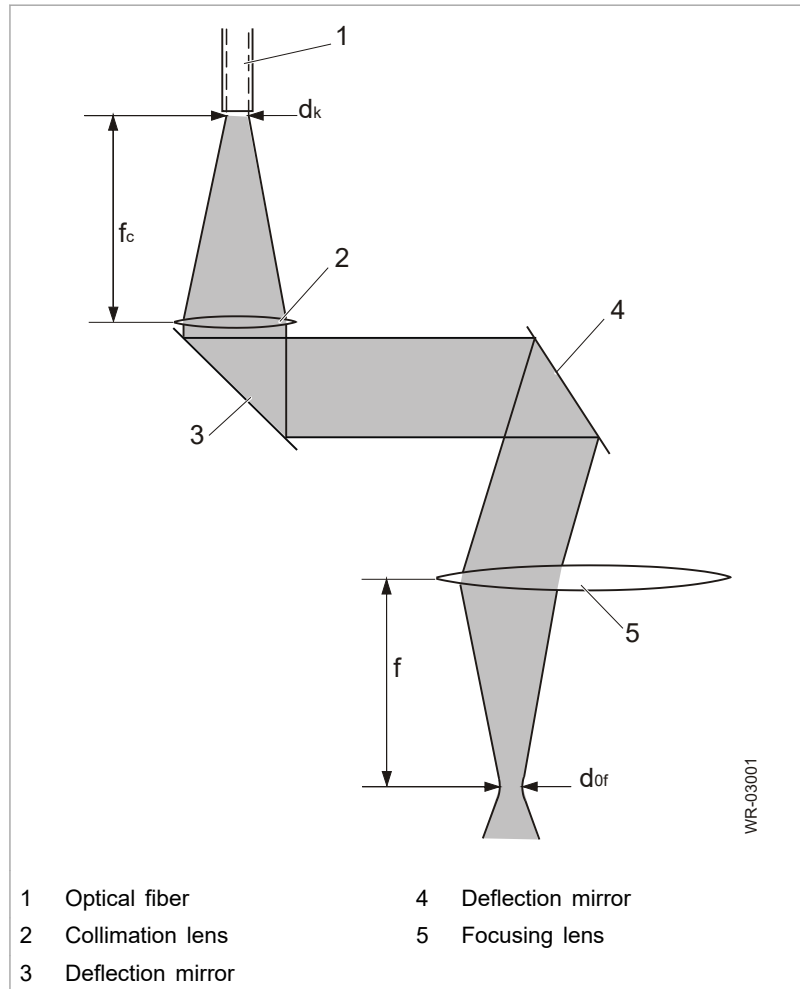
Laser light is generated in the laser device and coupled into the laser light cable (3). In the collimation unit of the programmable focusing optics (PFO), the laser light is emitted conically from the laser light cable. The collimator (12) forms a collimated laser beam which runs nearly parallel.



Deflecting a laser beam with two mirrors

Fig. pz000028

The laser light enters the housing of the focusing optics via the deflection mirror (11). There it impinges in succession on two scanner mirrors (7). The scanner mirrors can be turned by motor power. In accordance to their position, the plane-field lens (10) focuses the laser beam (8) to a point on the processing plane (9).



Beam path in the PFO

Fig.
WR-03001

Focal diameter The diameter of the focused laser beam at the smallest point (waist) is called focal diameter d_{of} .

$$d_{of} = \frac{f}{f_c} \cdot d_k$$

Fig. SG-02002

d_{of} : focal diameter [mm]

f : Focal length of lens [mm]

f_c : Focal length of collimation [mm]

d_k : Fiber core diameter [mm]

Aspect ratio The ratio of lens focal length f to collimation focal length f_c is named aspect ratio β .

$$\beta = \frac{f}{f_c}$$

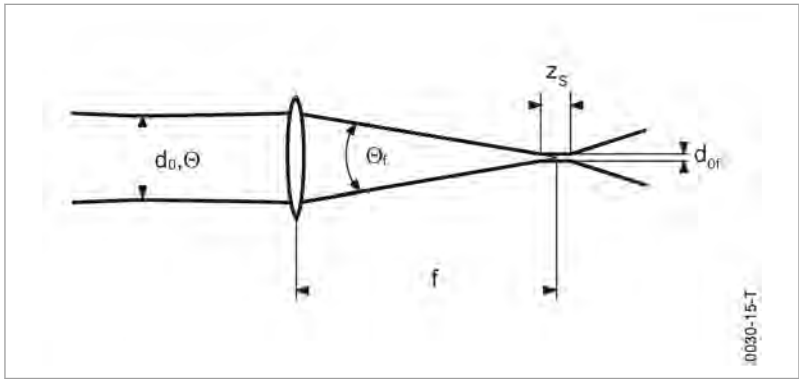
SR-90254

Fig. SR-90254

- β : aspect ratio
- $\beta > 1$ means that $d_{0f} > d_k$
- $\beta = 1$ means that $d_{0f} = d_k$
- $\beta < 1$ means that $d_{0f} < d_k$

Depth of focus The length of the optical axis in the focus where the focal diameter d_{0f} changes only negligibly, is called depth of focus. It is calculated as follows:

$$Z_s = 2 \cdot Z_R$$



Depth of focus of a laser beam

Fig. 0030-15-T

f	Focal length of the lens [mm]
θ	Divergence [rad]
θ_f	Divergence of the focused beam [rad]
d_0	Beam waist diameter [mm]
d_{0f}	Focal diameter [mm]
z_s	Depth of focus [mm]

Tab. 3-2

The Rayleigh length (Z_R) indicates the distance to the focal point in which the cross-section of the beam has been doubled. It is calculated as follows:

$$z_R = \frac{d_{0f}^2}{4 \cdot SPP} = \frac{\left(\frac{f}{f_c} \cdot d_k \right)^2}{4 \cdot SPP}$$

Fig.

d_{0f}	Focal diameter [mm]
f	Focal length of the lens [mm]
f_c	Focal length of collimation [mm]
SPP	Beam parameter product

Tab. 3-3

Effect on the practical use

The highest power density of the laser beam is achieved in the focal point. Position and diameter of the focal point as well as the depth of focus depend on the focal length of the used lens.

Short focal lengths of lens show the following advantages compared with long focal lengths of lens:

- The focal diameter is smaller. This results in a higher power density in the focal point.

Long focal lengths of lens show the following advantages compared with short focal lengths of lens:

- Larger working distance. By this, less soiling of the lens protection as usually. The power density on the processing point will drop with increasing soiling. This diminishes the processing quality.
- The depth of focus is longer. This allows a larger working distance range without changed machining results.

The processing task, the selected components and thus the beam guideway of the laser light determine the working distance between focusing optics and the workpiece.

As a result of the given focal diameter and depth of focus, the working distance must be maintained, if high-quality results are to be achieved.

Best processing results are achieved

- with a focusing optics tuned to the processing task at hand.
- with a correctly adjusted working distance.
- with clean optical components
- with workpieces which are clean at the processing point.

Supply and control The electrical connection of the focusing optics to the "Interface Intelligent Optics" (13) in the control unit of the laser device is realized with the supply and control cable (5) .

In this way, the focusing optics:

- is supplied with the necessary operating voltages.
- is loaded with PFO programs.
- is synchronized with the laser during the program run.

Conditions The program memory of the focusing optics has to contain at least one PFO program (see software manual, chapter "Operation").

The laser light parameters are stored in the laser program (see Software manual).

The program memory can be empty if the focusing optics is activated externally by a CAN interface.

Operation of pulsed laser device The laser device gives the command to start a PFO program. Then the following processes take place:

- The focusing optics reads the position of the next welding point from the PFO program and positions the scanner mirrors such that the laser beam will impinge on it.
- The focusing optics sends a signal to the laser control as soon as the scanner mirrors are positioned correctly.
- The laser control releases a laser pulse.

This procedure is repeated until all welding dots in the PFO program have been approached and processed.

Operation of the CW laser device The laser device gives the command to start a PFO program. Then the following processes take place:

- The laser power entered in the PFO program is transmitted to the laser device at the start of the PFO program.
- The focusing optics travels along the geometrical figure stored in the PFO program and determines the laser power to be used.
- At the end of the PFO program, the focusing optics returns the control of the laser power to the laser device.

4. Technical data

For information on technical data, refer to the data sheet and dimensional drawing of your focusing optics.

5. Software

The software for the programmable focusing optics (PFO) is integrated in the TruControl 1000 program.

Instructions how to operate the PFO software can be found:

- for TruControl 1000:
in the software manual "TruControl 1000 for PFO", doc. no.:
12-12-14-A2-CR



Chapter 4

Setting work

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General notes on adjustment work

The following conditions must be fulfilled:

- The focusing optics must have been installed in the system.
- The focusing optics must have been connected correctly to the laser device by way of the LLK.
- All guards must be installed and ready for operation.
- Suitable laser safety glasses must be at hand.
- There must be enough samples for the commissioning procedure. A suitable workpiece holder for the samples must be provided.

1. Aligning the focusing optics

1.1 Alignment of the focusing optics to the processing plane

In order to get good processing results, the optical axis of the focusing optics has to be aligned exactly vertically to the processing plane.

Aligning the reference surface

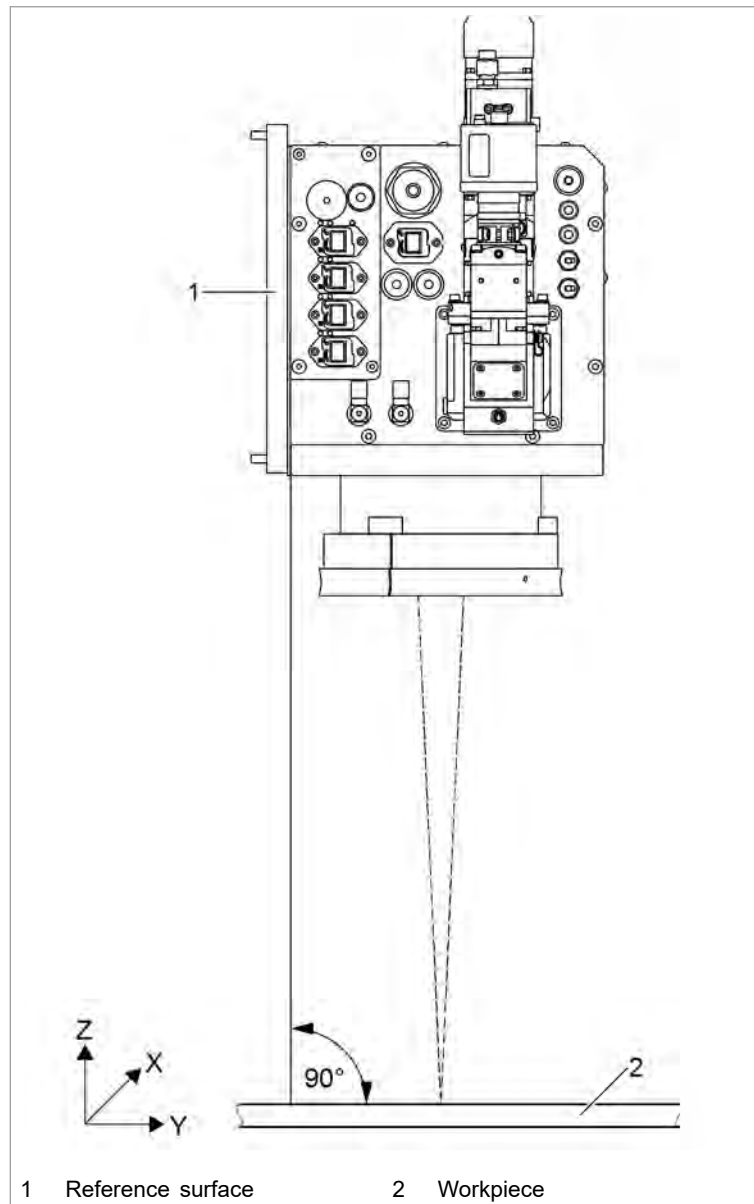


Fig. 112281

1. Align the reference surface vertically to the Y direction of the processing plane.

- Align support with focusing optics vertically to the X direction of the processing plane.

The optical axis of the focusing optics is positioned vertically on the processing plane.

Tip

If welding is performed with strong back reflections, the focusing optics should be set at an angle so that the back reflections pass by the focusing optics. An external absorber plate may also be required.

1.2 Processing of reflective materials

Absorption behavior of metals

Graphic (see "Fig. CT-00571", pg. 4-5) shows the absorption behavior of some metals depending on the wavelength λ . Metals such as iron (Fe), copper (Cu), aluminum (Al), and their alloys are often machined with laser beams. In addition, silver (Ag) and gold (Au) are being increasingly used, for example in watches and jewelry as well as in the electronics industry.

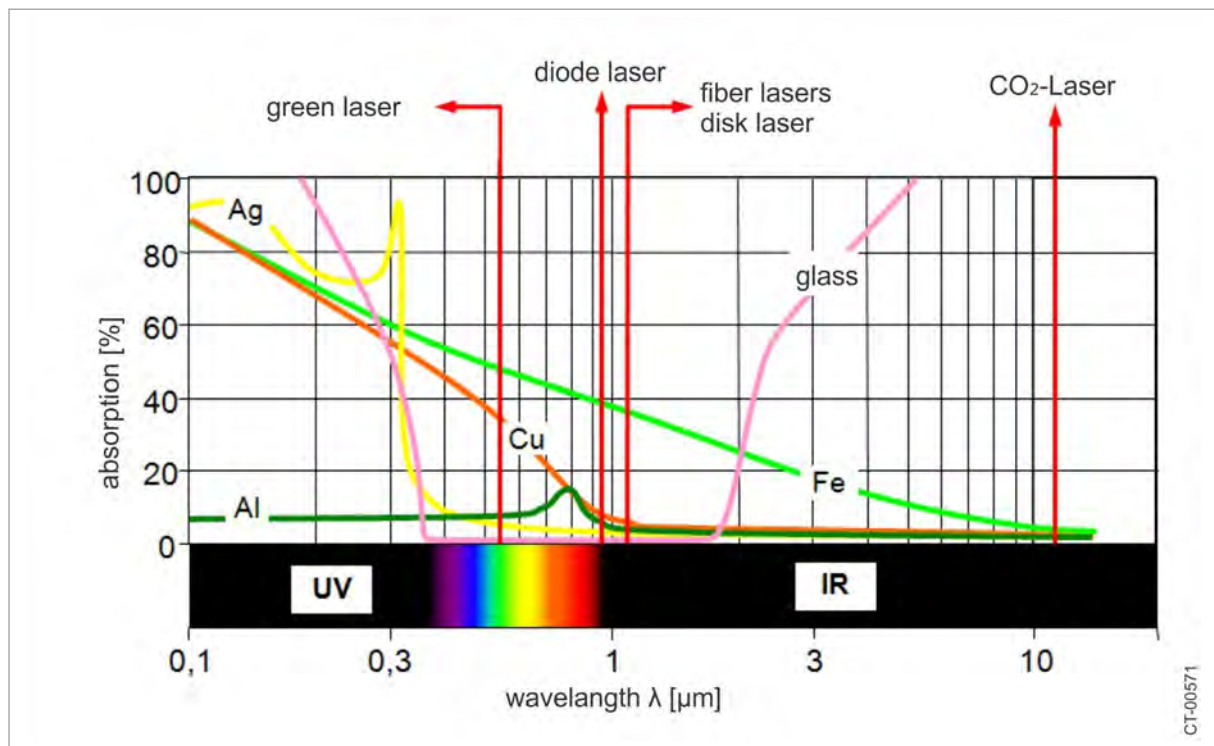


Fig. CT-00571

The absorption of metals at the laser wavelengths in the infra-red range is considered here. While the absorption of iron is relatively high, copper, aluminum and silver absorb only a fraction of the laser radiation.

The lower the absorption, the higher the reflection. A high reflection on a certain surface involves the problem of back reflection.

Back-reflection can cause damage to the focusing optics or the laser light cable.

Sensitive materials for back-reflections

Special caution is required when machining copper and copper alloys, aluminum, galvanized steel, silver and gold.

critical	noncritical
Copper	High-alloy steel
Aluminum	Mild steel
Galvanized steel	Ceramics
Silver	
Gold	

Tab. 4-1

What kind of damage can back-reflections lead to?

The reflected beam travels the same path back through the focusing optics. However, it can easily land next to the fiber of the LLK and cause destruction.

For scanner optics (PFO), the back-reflections can also be absorbed by the inner housing wall. Smoke residue is created. This can cause internal contamination in the optics, which can absorb the laser beam and thus impair the welding result (e.g. welding depth).

Sensitive processes for back-reflections

Reflection is particularly noticeable:

- In heat conduction welding (especially if this is achieved by large defocusing, e.g. outside the rayleigh length).
- In piercing during cutting processes.
- At the beginning of the deep welding process.
- In all unstable cutting and welding processes, which can be caused, for example, by impurities or the inhomogeneous nature of the workpiece surface.

Back-reflections can occur in different processing situations:

Critical processes	Non-critical processes
Heat conduction welding (large defocusing)	Deep welding
Between heat conduction and deep penetration welding	Cutting in focus
Piercing when cutting	Welding in focus
Cutting with large defocusing	
Deep penetration welding with large defocusing	
Incorrect positioning of the laser beam in the fillet seam or corner seam of thick sheets. This can be caused by heat distortion of the sheet during welding or by incorrect positioning in the clamping fixture. 	
Welding with heavily soiled protective glass. The heavily soiled protective glass can reflect the laser radiation back into the focusing optics. 	
Repeated passing over (welding) a seam	

Tab. 4-2

What kind of damage can back-reflections lead to?

If the high power of the back-reflections hits the fiber core of the laser light cable in a slightly defocused or laterally offset manner, the laser light cable can be destroyed in extreme cases (e.g. by burning).

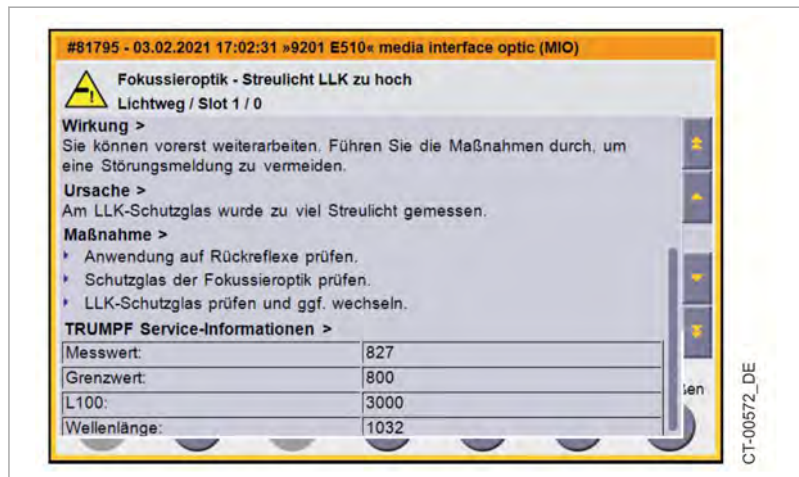
If the high power of the back-reflections hits the optics at an angle so that housing parts are struck, this may lead to a focusing optics defect.

Back-reflection sensors

Certain focusing optics and laser light cables from TRUMPF are equipped with back-reflection sensors (scattered light sensors) to detect beam back-reflections.

If a sensor is installed, a warning message is displayed in TruControl 1000 if back-reflections that could destroy the laser light cable or the focusing optics are detected.

The following warning message appears on the TruControl window. Processing can continue, provided that the measures specified in the message are taken.



Warning message to the back-reflections

Fig. CT-00572

Measures against back-reflections

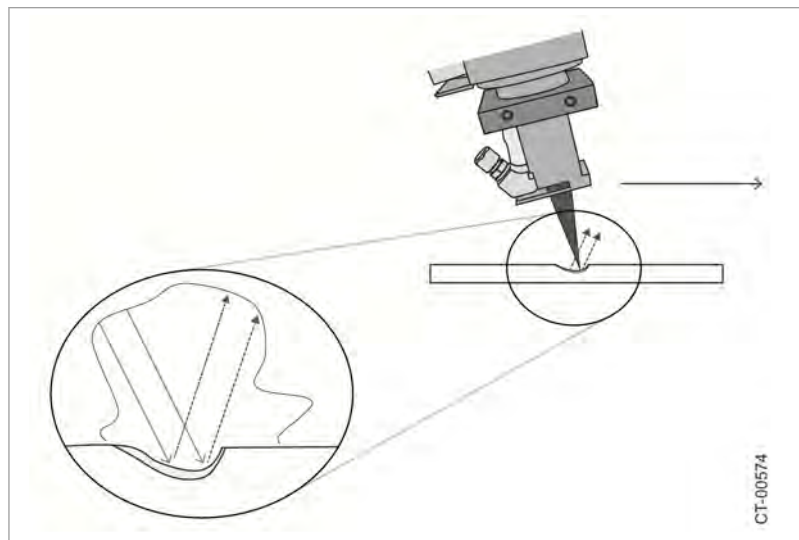
The following measures can reduce the occurrence of back-reflections:

- Inclination of the focusing optics.
- Change the welding process.
- Change the focus position.
- Replace the protective glass.

Inclination of the focusing optics

By slightly inclining the focusing optics, a back-reflection in the focusing optics is avoided.

This prevents the back-reflection from damaging the focusing optics, the laser light cable or the laser.



Avoidance of back-reflections by inclining the focusing optics Fig. CT-00574

If the focusing optics are not inclined during the critical processes, the focusing optics or the laser light cable may be damaged by back-reflections.

NOTICE

By inclining the focusing optics, the reflected laser radiation passes the laser beam emission opening.

Laser light can damage the focusing optics from the outside or objects inside the enclosed protective housing.

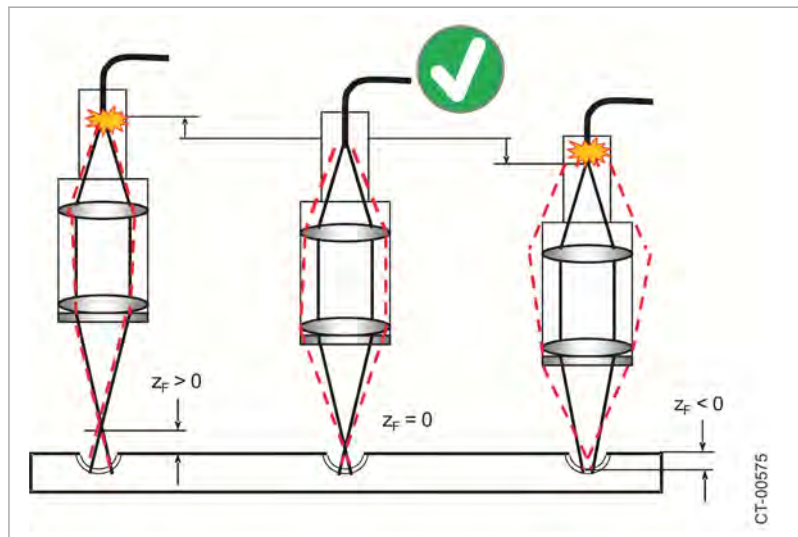
- If necessary, attach additional covers to protect components from damage.

**Recommended procedure
depending on the welding
process**

Process	Process examples	Recommended procedure for critical materials
Heat conduction welding (HCW)	▪ Bending edges ▪ Cosmetic seams	▪ Inclining focusing optics ▪ Defocusing focusing optics only inside the rayleigh length ▪ Careful position control (e.g. fillet welding not next to the fillet)
Deep penetration welding (DPW)		Non-critical process, therefore no particular procedure required In deep penetration welding, the back-reflection depends on the key-hole.
Marginal cases between HCW and DPW	▪ Welding with wire ▪ Welds in which the welding seam depth is the same as the welding seam width	▪ Inclining focusing optics* ▪ Do not defocus the focusing optics too much ▪ Careful position control (e.g. fillet welding not next to the fillet) * Inclining the focusing optics is only partially helpful in marginal cases, because an incipient keyhole forms around the laser beam, to which the reflected laser beam also aligns. The reflected laser radiation can therefore be reflected into the optics even if the optics are inclined.

Tab. 4-3

Focal position The focus position can be changed by positioning the focusing optics. By choosing a focus position that processes the work-piece next to the focus, it is possible to avoid a high intensity of back-reflection and thus damage to the focusing optics, laser light cable or laser.



Incorrect or correct focus positions

Fig. CT-00575

TRUMPF regulations for avoiding back reflections

Generally, special care is required when processing highly reflective materials. The following recommendations can minimize the risks of back-reflection:

- Setting of the focus position near focus.
- Incline the focusing optics so that the reflected laser beam does not go back into the focusing optics.
- Weld without fillet offset.

We recommend consulting with TRUMPF when highly reflective materials are to be processed.

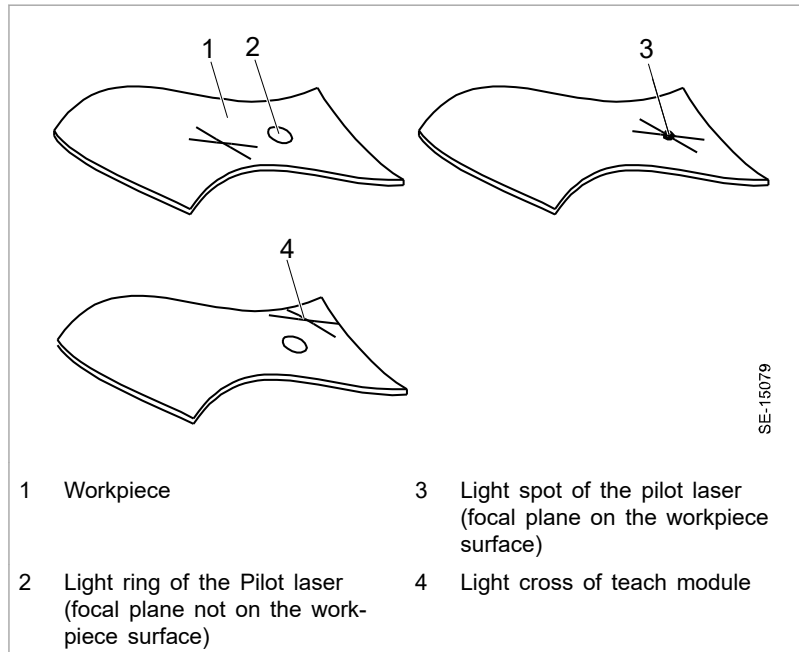
1.3 Teach module and Teach function

If the PFO 33 is used on a robot, the focusing optics can be aligned to the optional component teach module. This method is especially suitable for workpieces with arcs and radii.

The vertical alignment to the processing plane is performed using the teach function (accessories for the focusing optics).

1. Switch on the pilot laser. To do so, activate the teach function (see Software manual).
2. Open the flap of both teach modules and activate the laser of the teach modules by means of the external interface.

Adjusting the Z axis

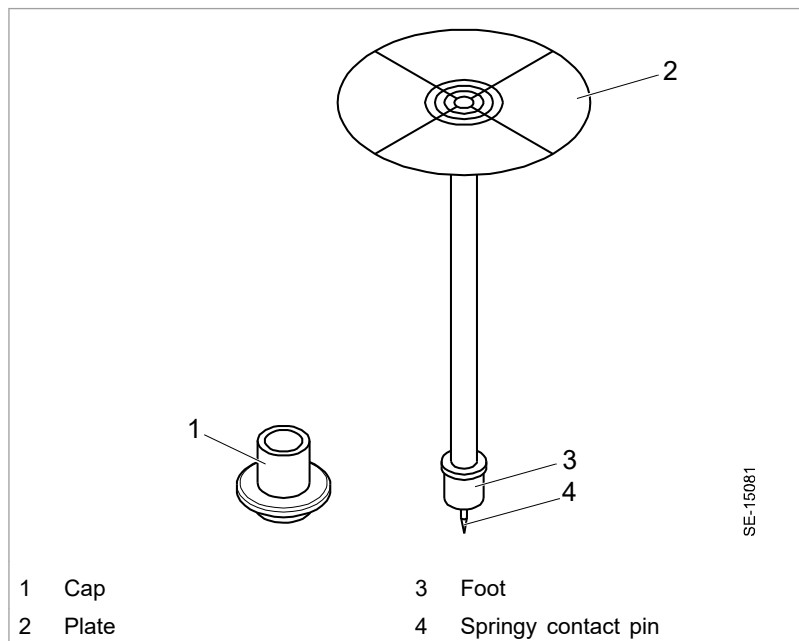


Light of the pilot laser and teach modules on the workpiece Fig. SE-15079 plane (example)

- Set the clearance between the PFO and the workpiece such that the light cross of the teach module is identical to the light spot of the pilot laser (3).

The focal point is now on the surface of the workpiece.

Setting the x and y axes



Teach function

Fig. SE-15081

- Remove the cover from the teach function and put the teach function with the springy contact pin (4) exactly at the focal point.

A magnet in the foot (3) of the teach function maintains the teach function on the workpiece.

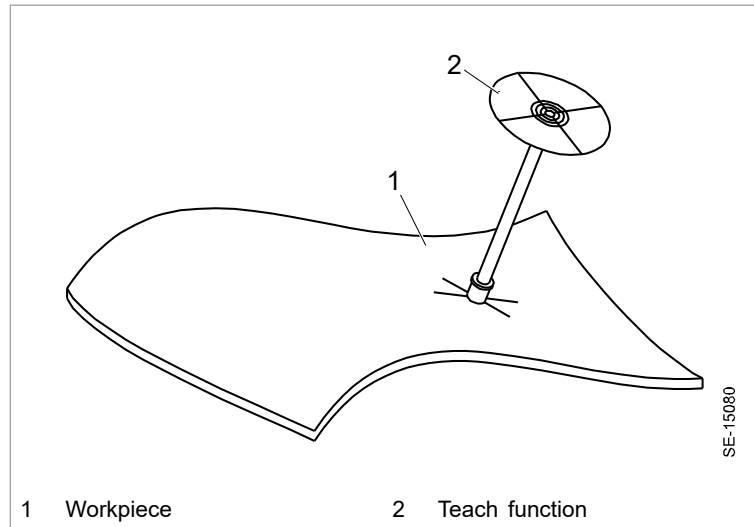


Fig.
SE-15080

5. Rotate the focusing optics around the x and y axes (tool center point coordinate system of the robot) until the light ring of the pilot laser is positioned centrally on the table (2) of the teach function.

The optical axis of the focusing optics is positioned vertically on the processing plane.

The focusing optics is set in the x, y and z directions on the processing plane.

2. Setting the working distance using the teach modules (option)

2.1 Adjusting the working distance

If the focusing optics is equipped with teach modules (option), these can be used for setting the working distance of the focusing optics. This function is particularly useful when the focusing optics is used with a robot.

Conditions

- The light path to the focusing optics is blocked.
- The pilot laser of the light path to the focusing optics is activated.

1. Start the PFO editor and the function wizard.
2. Select "Teach".

The teach function is active.

3. Select *Zero point*.

The scanner mirrors of the focusing optics are positioned such that the laser beam hits the center of the processing field.

4. Open the flaps of the two teach modules.
5. Use the external control unit to activate the line lasers of the two teach modules.

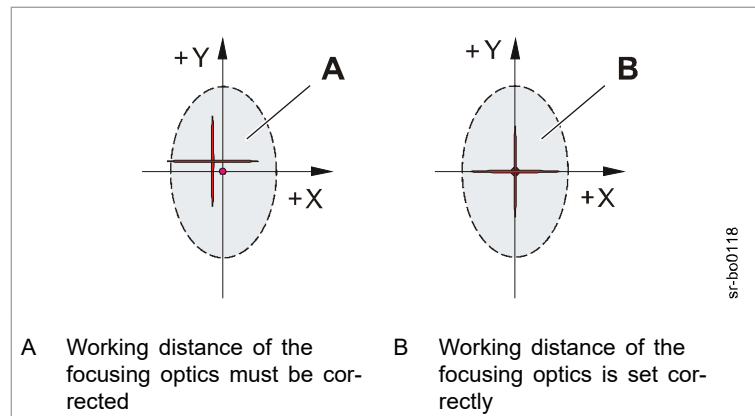
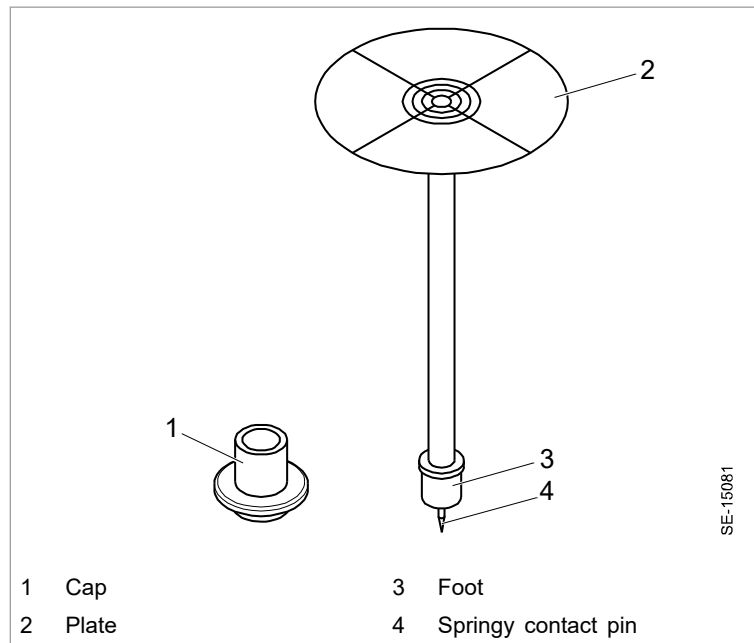


Fig. sr-bo0118

6. Change the distance between focusing optics and workpiece until the intersection point of the line lasers coincides with the light spot of the pilot laser.



Teach function

Fig.
SE-15081

7. If the horizontal alignment of the focusing optics relative to the working surface is not ensured (e.g. when used on a robot):
 - Switch off the line lasers of the two teach modules with the external control unit.
 - Place the teach function in the middle of the light spot of pilot light on the workpiece.
 - Change the focusing optics position until the pilot light hits the center of the plate of the teach function.
8. Repeat steps 4 to 6 until the focusing optics position and working distance are set correctly.

Position and working distance of the focusing optics are set for the teach point on the workpiece.

3. Focal position

3.1 Adjusting the focal position by means of test weldings

Adjustment of the height of the programmable focusing optics (PFO) above the processing plane with the focal point on the workpiece surface is described in this section.

Reference wavelength

The focusing optics is calibrated to a reference wavelength. The reference wavelength has one of the following values, depending on the laser type:

- 515 nm
- 1030 nm
- 1075 nm

The reference wavelength is indicated on a label attached to the collimation of the focusing optics.

If the focusing optics is operated with a wavelength other than the reference wavelength:

- **the focusing optics must be recalibrated.**

Conditions

- The optical axis of the focusing optics has to be positioned vertically to the processing plane (see ["Aligning the focusing optics"](#), pg. 4-4).
- The reproducible change of the clearance between the focusing optics and the processing plane must be possible, for example with an adjustable Z axis.
- The focusing optics together with a laser device has to be ready for operation.
- The light path must be adjusted such that laser light is guided to the focusing optics.

Means, Tools, Materials

- You need a test sheet; we recommend a flat piece of black-anodized aluminum sheet.

Note

The PFO is adjusted at the factory. Readjustment of the collimator adjustment rings is not permitted.

If the processing requires it, a change of the working distance in Z or the focus position in X and Y must be realized via an external adjustment (robot, linear axis, etc.).

Setting the focal position

1. Select the operating mode for the laser and the parameters as follows:

Pulsed laser device:

- Square pulse, number of pulses: 1
- Pulse power: 700 Watt
- Pulse duration: 1 ms

CW laser device:

- Power: 300 W
- Duration: 10 ms

2. Start the PFO editor and the function wizard as described in chapter "Operation".
3. Select "Teach".

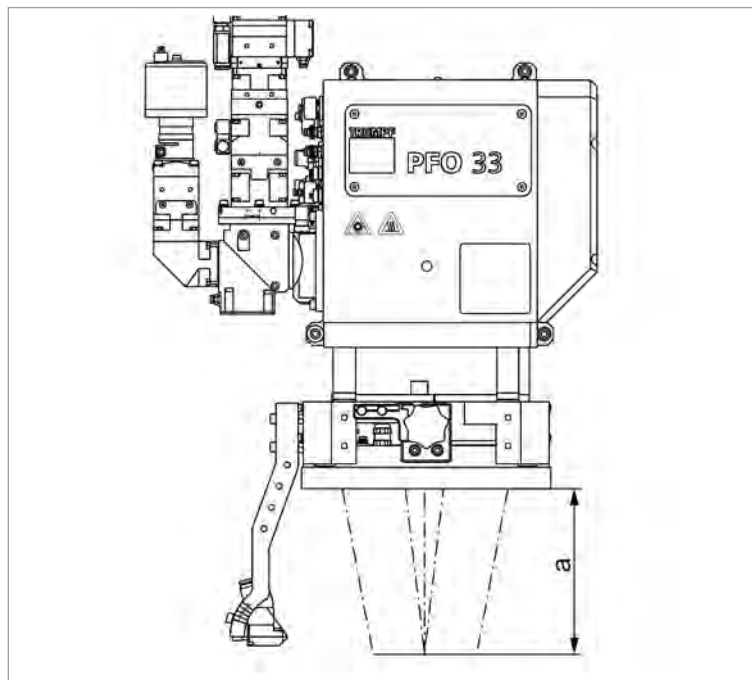
The teach function is active.

4. Select *Zero point*.

The scanner mirrors of the focusing optics are positioned such that the laser beam hits the center of the processing field.

5. Adjust the focusing optics to the working distance a (see dimensional drawing) above the surface of the test sheet.

The working distance depends on the focal length of the lens used (see data sheet of your focusing optics).



Adjusting working distance a to workpiece

Fig. 112282

6. Position the test sheet below the focusing optics such that the laser beam can impinge on it.

⚠ WARNING

In the next working step, laser light will emerge from the focusing lens of the PFO!

Laser light can burn your skin or irreparably damage your eyes.

- Close the protective cover, if provided.
- If no protective cover is provided, then wear laser safety glasses suitable for the wavelength of the laser light.
- Do not look into the focusing lens.
- Do not put your hand between the focusing lens and work-piece.

⚠ WARNING

High noise level when operating a focusing optics, especially when using a crossjet!

Noise can result in permanent ear damage and other unfavorable consequences to health, especially upon prolonged exposure.

- Surround the processing point with a protective cover that is sufficiently silencing.
- Wear ear protection if the noise levels are high.
- Operate the focusing optics only with the silencing protective cover closed, if possible.

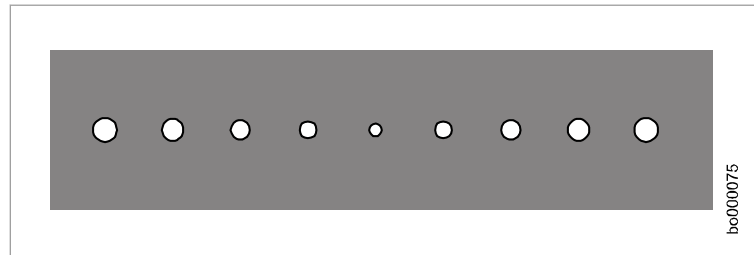
7. Make a weld point on the sheet.
8. Keep a record of the adjusted distance.
9. Increase the distance by approximately the value given in the following table:

objective	Distance interval
F-Theta ≤ f100	0.3 mm
F-Theta > f100 to ≤ f200	0.5 mm
F-Theta > f200 to ≤ f450	1.0 mm
F-Theta > f450 to ≤ f600	1.5 mm
F-Theta > f600 to ≤ f900	2.0 mm

Tab. 4-4

10. Move the test sheet a little bit.
11. Repeat steps 7 to 10 around eight to ten times.

You will get several weld points of different sizes on the test sheet.



Weld points on the test sheet

Fig.
bo000075

12. Adjust the clearance between the focusing optics and the test sheet to the value with which you generated the smallest weld point.

This completes the adjustment of the focal position on the surface of the test sheet. Now you still may have to correct the clearance by the thickness of the test sheet.

4. Adjusting the crossjet

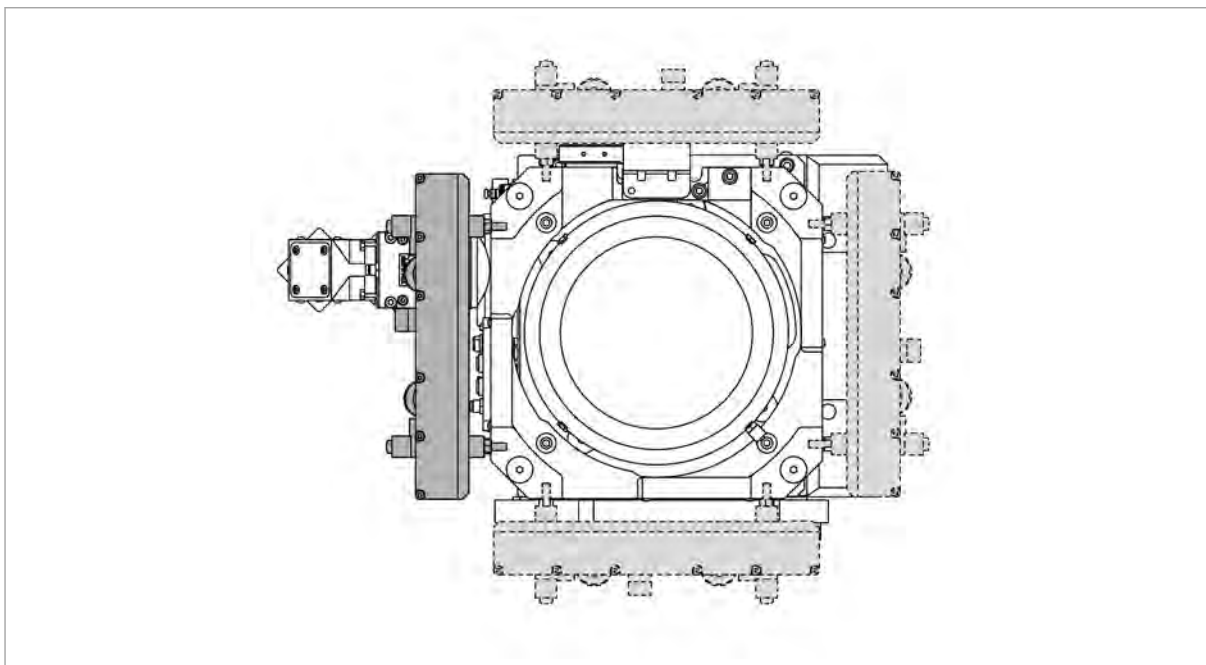
4.1 Adjusting the distance

Angle of inclination The distance and position of the crossjet are fixed; the angle of inclination must be set depending on the application.

4.2 Removing the crossjet

Means, Tools, Materials

- Allen wrench.



Crossjet mounting positions for PFO 33

Fig. 112277

Notes

- The crossjet can be mounted in one of four positions.
The position of the crossjet must be selected such that the crossjet does not blow in the direction of the line laser.
- Only the TL 200 crossjet can be used in combination with the optional LED ring light.

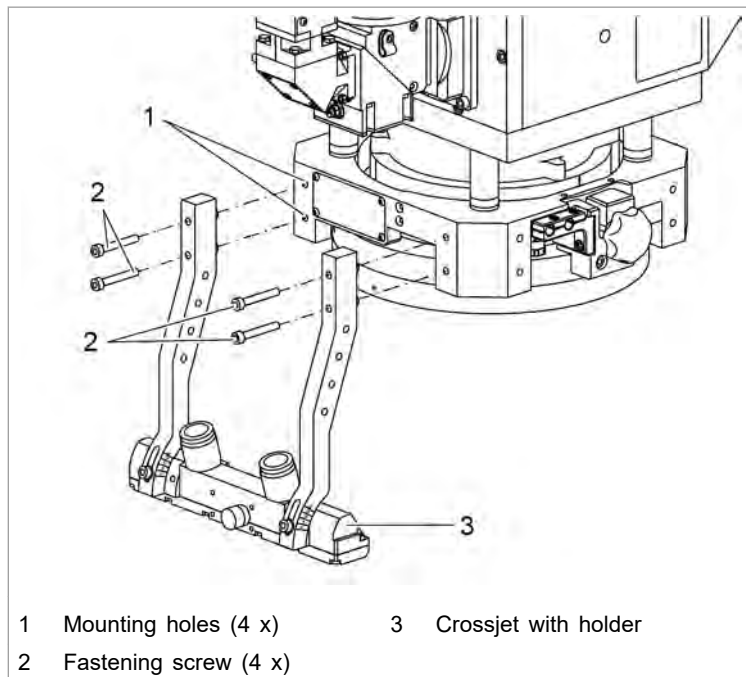


Fig. 112283

1. Unscrew the four fastening screws (2) and remove the crossjet incl. the holder (3).
2. Turn the crossjet (3) by 90° or 180°.
3. Attach the crossjet (3) to the module carrier in such a way that the mounting holes (1) are located above the drilling holes in the module carrier.
4. Screw in the fastening screws (2).

5. Applying the teach function with pilot laser

General Properties	This section describes the teach function of the programmable focusing optics (PFO). Here, the teach functions are explained which apply to all application situations.
Operation, specific features	More information about the operation and the specific features of the teach function is contained in the software manual.
Explanation, manner of speaking	The term "Teach function" logically derives itself from the English word "to teach". Pronounced: "tietsch". The following sections contain information on the following subjects: ▪ Purpose and function of the teach function. ▪ Conditions which have to be fulfilled when using the teach function. ▪ Necessary auxiliary equipment to use the teach function.

5.1 What is the teach function?

The teach function allows you to demonstrate that the programmed geometrical figure is transmitted correctly from the focusing optics onto the workpiece. An online correction of the program is possible in case of deviations.

Example	You have programmed, for example, a straight line. Now you can use the teach function to check: ▪ whether the end points of the straight line are correctly positioned on the workpiece. ▪ whether the points between the end points are correct with regard to number and position.
----------------	--

If you detect any deviations you can use the function wizard to:

- change the position of the end points.
- change the number of the intermediate points.
- observe immediately the result of the changes.

If you are satisfied with the result, the optimized straight line can be stored in the PFO program.

5.2 Prerequisites of using the teach function

The following prerequisites have to be fulfilled to use the teach function:

- It must be possible to activate the teach function in the function wizard. Operating elements and indicators are provided for this in the function wizard (see Software manual).
- The software version of your PFO has to support the teach function.
- The PFO must be equipped with an auxiliary facility (see ["Auxiliary equipment for the teach function"](#), pg. 4-22).

Contact TRUMPF, if you need further information on this.

5.3 Auxiliary equipment for the teach function

The teach function can be used only if the focusing optics is provided with one of the following auxiliary devices:

- Pilot laser
- Observation optics with camera and monitor.

Pilot laser

The pilot laser is a small semi-conductor laser which emits red laser light (635 nm to 650 nm).

A red light spot or a red light ring is visible in the processing plane when the pilot laser is activated:

- a light spot when the focal point is on the surface of the workpiece.
- a light ring when the focal point is below or above the surface of the workpiece.

The deflection of the light spot or the light ring from the center of the processing field corresponds to the current position of the scanner mirror.

Example If you represent, for example, the starting point of a straight line with the teach function, the light spot is on the programmed starting point.

Deviations The pilot laser and the working laser have different wavelengths. The focusing lens of the focusing optics is optimized for the wavelength of the working laser.

As a result, the light spot of the pilot laser can deviate from the position of the weld point.

Result for the pilot laser The pilot laser is a simple aid to use the teach function. It is suitable if the occurring deviations can be accepted with respect to accuracy.

Observation optics with camera and monitor

WARNING

There is no laser protective filter in the interface. If you use the interface without sensor module, camera or sealing plug, your eyes and your skin may be exposed to laser light!

Laser light can burn your skin. Direct or scattered laser light can permanently damage your eyes.

- Never look into the interface.
- Use the focusing optics only if the interface is closed by a sensor module, a camera or a sealing plug.
- Never attach the eyepiece to the interface.
- When using an eyepiece, mount a laser protection filter in front of the eyepiece.

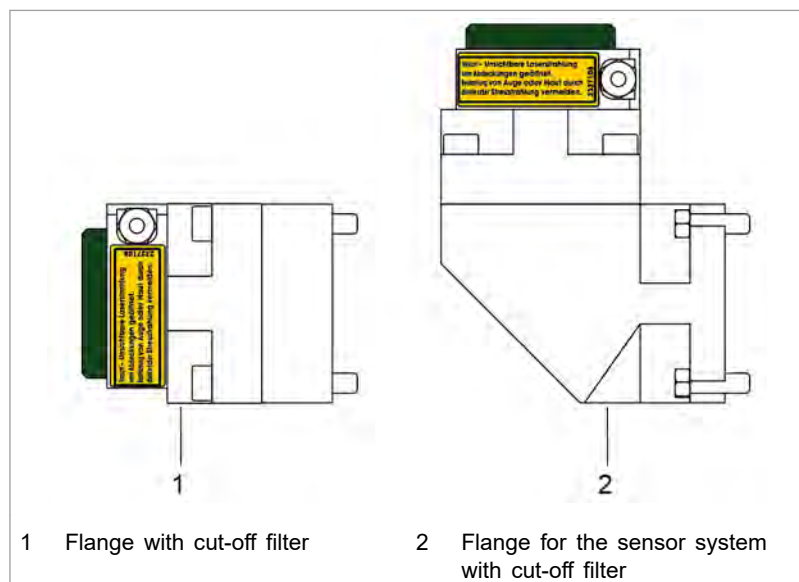
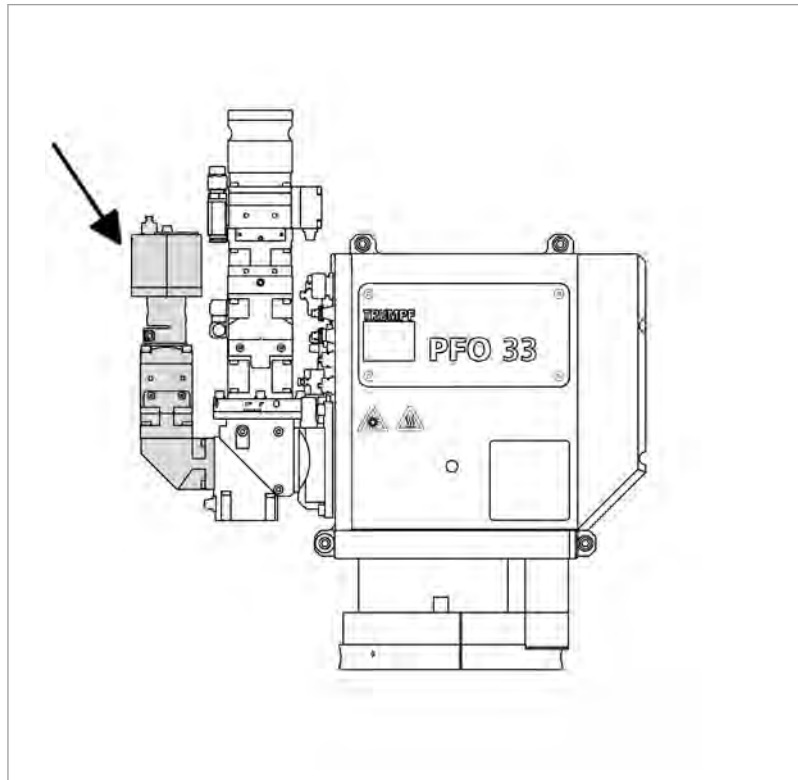


Fig. 112308

You can use the observation optics with a camera attached in place of the eyepiece, which is connected to a monitor.

Cross-hairs generator

If your camera is equipped with a cross hair generator, the cross hairs mark approximately the point where the laser beam will impinge, given the current scanner mirror position.



PFO with camera and monitor

Fig. 112285

Deviations

The same observation accuracy as for the pilot laser (see above) will be achieved if the camera is sensitive in the visible range of the spectrum.

LED ring light for PFO33 (option)



Blinding due to LED ring light

- Attach a sign warning people about this danger.
- Set up access restrictions.
- Brief any persons potentially at risk.

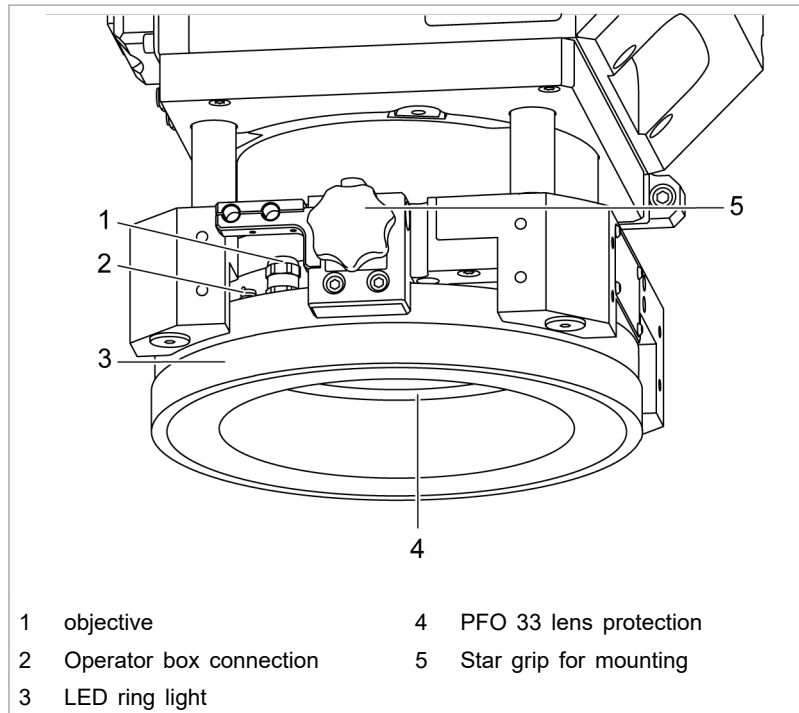


Fig. 112278

The LED ring light (red LEDs) lights the processing point. This allows the user to recognize the processing point on the work-piece more easily.

The LED ring light is operated by means of the operator box.

The operator box and the LED ring light are supplied with voltage via a power connection cable and a power supply unit for connection to 230 V.

An additional cable (2) connects the LED ring light to the operator box.

The LED ring light is covered on the outside by a protective glass.

Mounting LED ring light

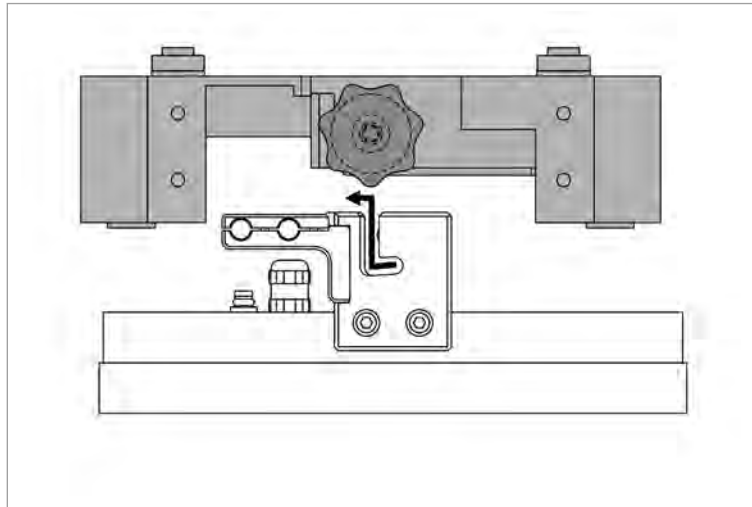


Fig. 112305

1. Loosen star grip.
2. Hook in the LED ring light.
3. Tighten star grip.
4. Establish electrical connections, see "Assembly instructions, LED ring light", doc. no.: 12-12-33-A53-AK.

5.4 Operating elements and indicators of the teach function

The teach function is described in the software manual "TruControl for PFO" (document no.12-12-14-A2-CR).

6. Adjusting the observation optics

The operations which can be carried out at Gen 2 observation optics are described in this section. You will learn how to:

- adjust the picture sharpness or the camera.
- adjust the cross-hairs.

6.1 Adjusting the picture sharpness of the camera

The picture sharpness of the camera has been adjusted ex works. Carry out the following steps to improve the picture sharpness, if necessary.

Condition

- The connected laser device has been switched off and secured against renewed switching on, e.g. by means of a shackle padlock.

or

- The light path to the focusing optics is blocked.

Means, Tools, Materials

- Allen key, 90°, 1.5 mm
- Allen key, 90°, 2.5 mm

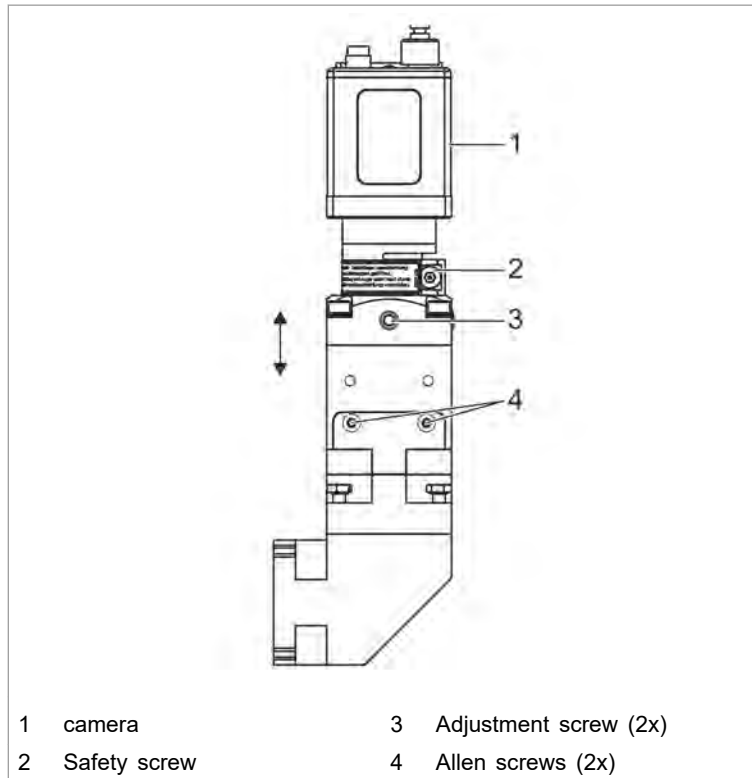
Adjusting the distance to the workpiece

Note

The viewing optics must be set with correctly adjusted distance.

1. Adjusting the distance to the workpiece ([see "Setting the working distance using the teach modules \(option\)", pg. 4-13](#)).

Adjusting the picture sharpness



Fastening the camera

Fig. 118251

2. Undo the two Allen screws (4) and remove the cover plate.
3. Turn the setting ring below by hand or with a hexagonal socket screwdriver $\leq$ AF2.
4. watch the monitor with the camera picture
5. If the image of the processing point is sharp, reinstall the cover and tighten the screws.

6.2 Adjusting the cross-hairs

The cross hairs of the focusing optics have been adjusted to the center ex works. Readjust the cross hairs when maladjusted.

Condition

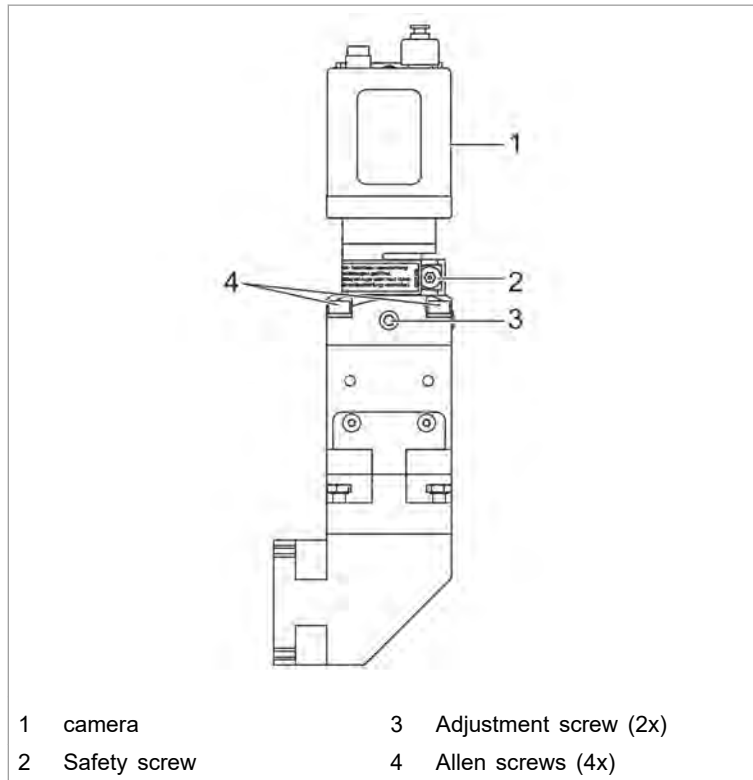
- The connected laser device has been switched off and secured against renewed switching on, e.g. by means of a shackle padlock.

or

- The light path to the focusing optics is blocked.

Means, Tools, Materials

- Allen key, 90°, 2.0 mm
- Allen key, 90°, 2.5 mm



Adjusting the cross-hairs

Fig. 118252

1. Undo the Allen screws (4) slightly.
2. Use the adjusting screws (3) to make adjustments in the X and Y direction.
3. Tighten the Allen screws (4).

The cross hairs are fixed in the center of the picture.

Tip

The crosshairs can also be moved digitally via the panel PC, see "VisionLine Gen. 2" operator's manual, doc. no.: 22-50-12-A4-CR.



Chapter 5

Maintenance

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1. General notes

The correct maintenance is an important precondition for trouble-free operation of the focusing optics and for the quality of the working result.

The focusing optics has been designed to require little maintenance.

Regularly check the condition of your focusing optics. Carry out maintenance work as a precautionary measure when you detect signs of wear or dirt.

Check regularly the laser light cable for damaged sheathing. The laser light cable must be replaced in case of a damaged sheathing.

Pay attention to the monitoring messages the connected laser device indicates on the screen. They may give information on necessary maintenance work.

DANGER

While carrying out maintenance work on the laser device you may have to deal with parts dangerous for persons and material.

Improper or incautious procedures can cause injuries or damages to property.

- Maintenance work may be carried out by trained personnel only.
- Any work at the electrical equipment may only be performed by a skilled electrician.
- Always observe the warning notes in these maintenance instructions.
- Switch off the laser device before starting maintenance work.

Note

The connected laser device must be switched on during maintenance work only if it is necessary for maintenance or control purposes. You will be informed about this in the corresponding sections of this manual.

CAUTION

Deionized water (DI water) is used to fill the tank!

Cooling water can be aggressive against skin and textiles.

- Do not let cooling water come into contact with eyes, nose or mouth.
- Avoid that cooling water comes into contact with your clothing.
- You can wash off cooling water with tap water.
- Wear protective gloves, safety glasses and protective clothing.

Maintenance of the focusing optics

When processing material with a laser, particles or vapors may be emitted from the surfaces of the workpieces, which will result in a fog and a soiling on the protective glass or on other parts of the focusing optics. A soiled protective glass diminishes the laser power on the workpiece.

Regularly check the condition of the protective glass. Clean the protective glass and other parts of the focusing optics if they are visibly soiled.

The protective glass has to be replaced if it shows soil particles burnt-in, which cannot be removed by cleaning it.

The following describes the cleaning and changing of following parts:

- Protective glass of the lens
- Protective glass of the cassette receptacle
- Protective glasses of the teach modules
- Crossjet
- Smoke residue crossjet
- smoke barrel
- MDE module

Checking the hose connections

Pressurized gas or pneumatic hoses may burst or become loose. Gas escapes under high pressure as a result of uncontrolled swinging around.

WARNING

Risk of injury if pneumatic hoses burst or become loose.

Eye, skin injuries and hearing damage.

Startled responses by people in the surrounding area.

- Check the hose connections are secured on a regular basis, correcting this if necessary.
- Check the condition of the hoses on a regular basis and replace any hoses if necessary.

2. Material

2.1 Wearing parts

See the spare parts catalog.

2.2 Optics cleaning set

TRUMPF recommends using the optics cleaning set available for cleaning optical components.

The optics cleaning set can be obtained from TRUMPF. It has the material no. 779603.



Fig. TE-01606

2.3 Consumables

For maintenance work on the focusing optics, you need the following consumables:

- Lens cleaning paper (available from photo shops).
- or
- Swabs to clean optical glasses.
- Methanol as cleaning agent for optical glasses.

 CAUTION

Methanol is inflammable and toxic when you inhale or swallow it.

- Keep methanol away from open fire and other ignition sources.
- Do not smoke.
- Supply sufficient fresh air.
- Do not inhale methanol vapor.

2.4 Disposal

Some maintenance work will produce waste material that must be disposed of. Instructions for an appropriate disposal are given in the corresponding sections.

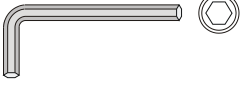
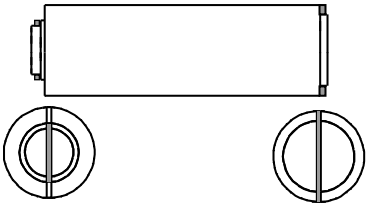
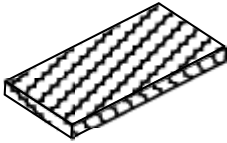
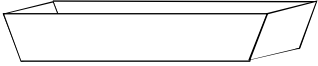
Note

The instructions for disposal of waste material are recommendations, derived from regulations applied at the place and time when these operating instructions were issued. You as the operating company, however, are obliged to inform yourself about the regulations concerning waste disposal and to proceed accordingly.

Unless the regulations applicable do not stipulate otherwise, the waste material is to be disposed of as follows:

- O-rings, sealing rings: Residual waste
- Lens cleaning paper: Residual waste
- Swab: Residual waste
- Cooling water without additives: Sewage system.
- Cooling water with additives: Disposal in accordance with the applicable wastewater disposal regulations for the region.

2.5 Tools and additional equipment

Symbol	Designation	Dimensions, other data
 SR-99005	Hexagon screwdriver, 90°	2.5 mm
	Key for optics (mat. no. 1312392)	to change the protective glasses of teach module and process diagnosis module
	Steel brush	to remove material deposits on the crossjet, the MDE nozzles and the smoke bell
	Polishing fleece	to remove material deposits on the crossjet, the MDE nozzles and the smoke bell
	Optics cleaning kit (see "Optics cleaning set", pg. 5-5)	contains tools and consumables for maintenance work on the focusing optics
	Collecting pan	for cooling water
	Cleaning cloth	to wipe up drained water
	Protective gloves	rubber, to be worn when handling deionized water

Tools and auxiliary tools for maintenance

Tab. 5-1

3. Maintenance work on the optics

3.1 Cleaning the protective glass in the lens protection or smoke bell

The lens is covered on the outside by a protective glass. A protective glass protects the lens against soiling by particles or material vapors formed during the welding process.

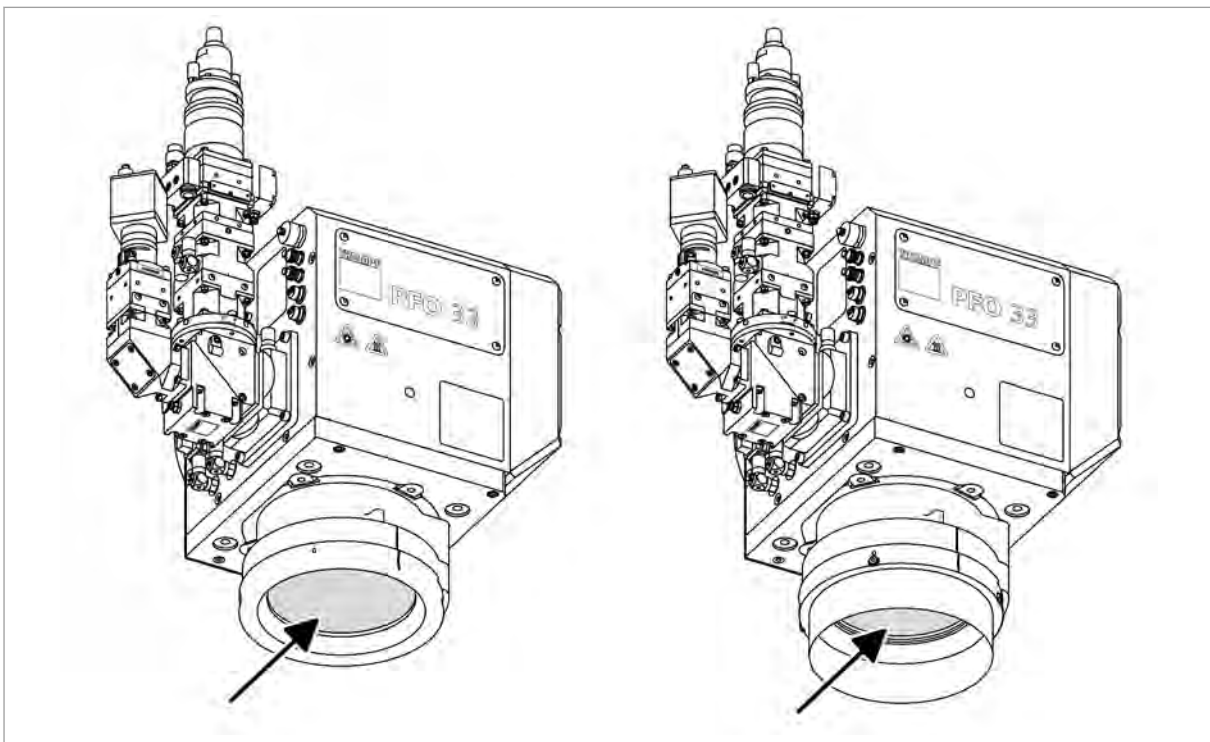
If the protective glass is noticeably soiled, it has to be cleaned.

Condition

- The connected laser device has been switched off and secured against renewed switching on, e.g. by means of a shackle padlock.

or

- The light path to the focusing optics is blocked.



PFO with protective glass in the lens protection (left), PFO with protective glass in the smoke bell (right)

Fig. 112287

! CAUTION

Hot surfaces on the bottom side of the focusing optics may burn your skin.

- Avoid contact with hot surfaces.
- Allow the focusing optics to cool down, before carrying out maintenance or cleaning work.

1. Soak swabs or lens cleaning paper in methanol.

Note

Do not touch the protective glass cassette with the fingers.

2. Slowly wipe across the protective glass until it is clean.

or

- If the protective glass is so dirty that the impurities cannot be removed when installed, the protective glass must be removed for cleaning.

The focusing optics is ready for use.

Note

Only one side of the protective glass may be used.

After cleaning the protective glass, never fit it into its holder with the cleaned side towards the lens. The cleaned surface contains residual contamination, which will vaporize when the laser operates and which may lead to damage (contaminants being burned in) to the lens.

Note

The protective glass has to be replaced if it contains burnt-in dirt particles which cannot be removed by cleaning (see ["Changing the protective glass of the lens protection"](#), pg. 5-9).

3.2 Changing the protective glass of the lens protection

Condition

- The connected laser device has been switched off and secured against renewed switching on, e.g. by means of a shackle padlock.

or

- The light path to the focusing optics is blocked.

Means, Tools, Materials

- Protective glass
- Methanol
- O-rings (if damaged)
- Disposable gloves

Note

TRUMPF recommends an additional lens protection.

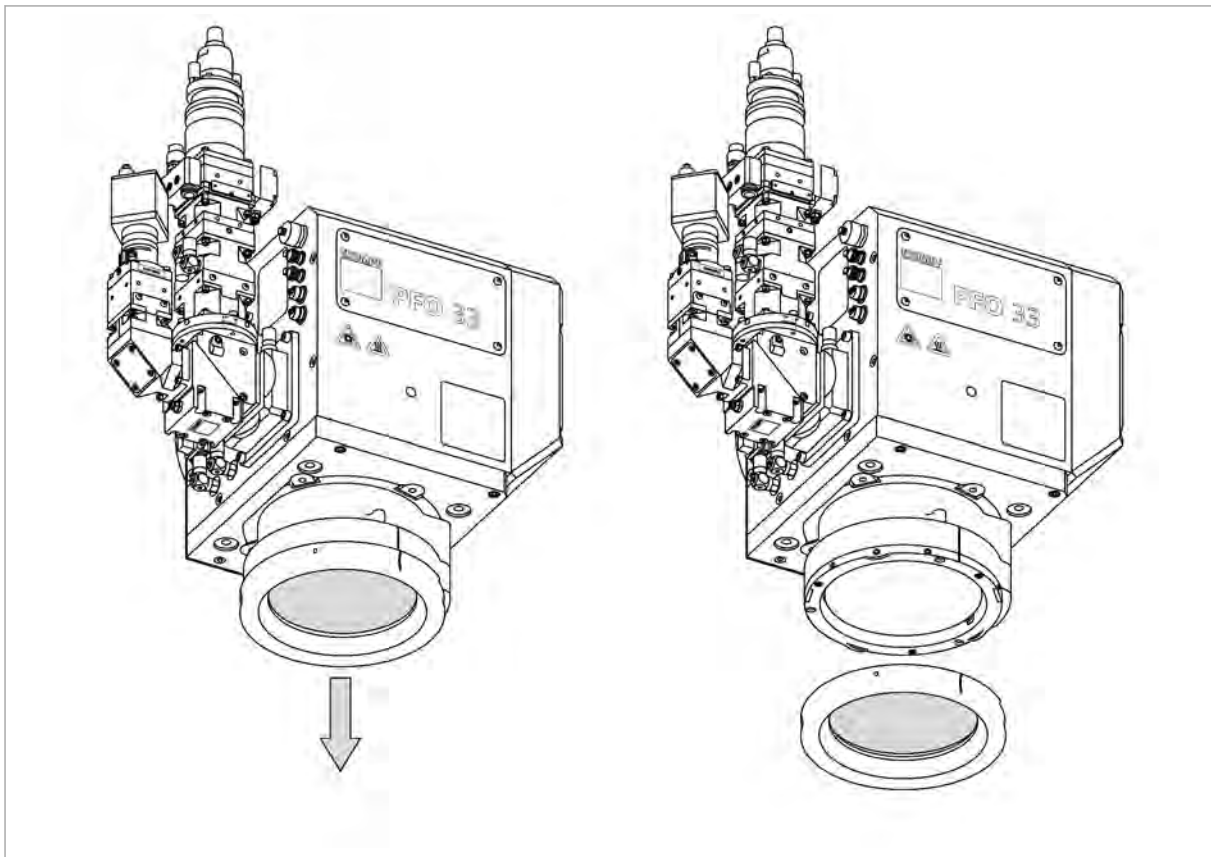
After having removed the lens protection with old protective glass, you can immediately slide the additional lens protection with the new protective glass on the lens and go on working with the focusing optics.

⚠ CAUTION

Hot surfaces on the bottom side of the focusing optics may burn your skin.

- Avoid contact with hot surfaces.
- Allow the focusing optics to cool down, before carrying out maintenance or cleaning work.

Removing the lens protection



Removing the lens protection

Fig. 112288

Preparatory work: if an LED ring light is installed, it must be dismantled.

Note

Touch neither the protective glass nor the focusing lens with the fingers.

1. Loosen and remove the lens protection by turning it.

2. Cover the opening of the focusing optics in loaded environments (e.g. in case of oil mist or intense dust), until you reattach the lens protection.

Removing the protective glass

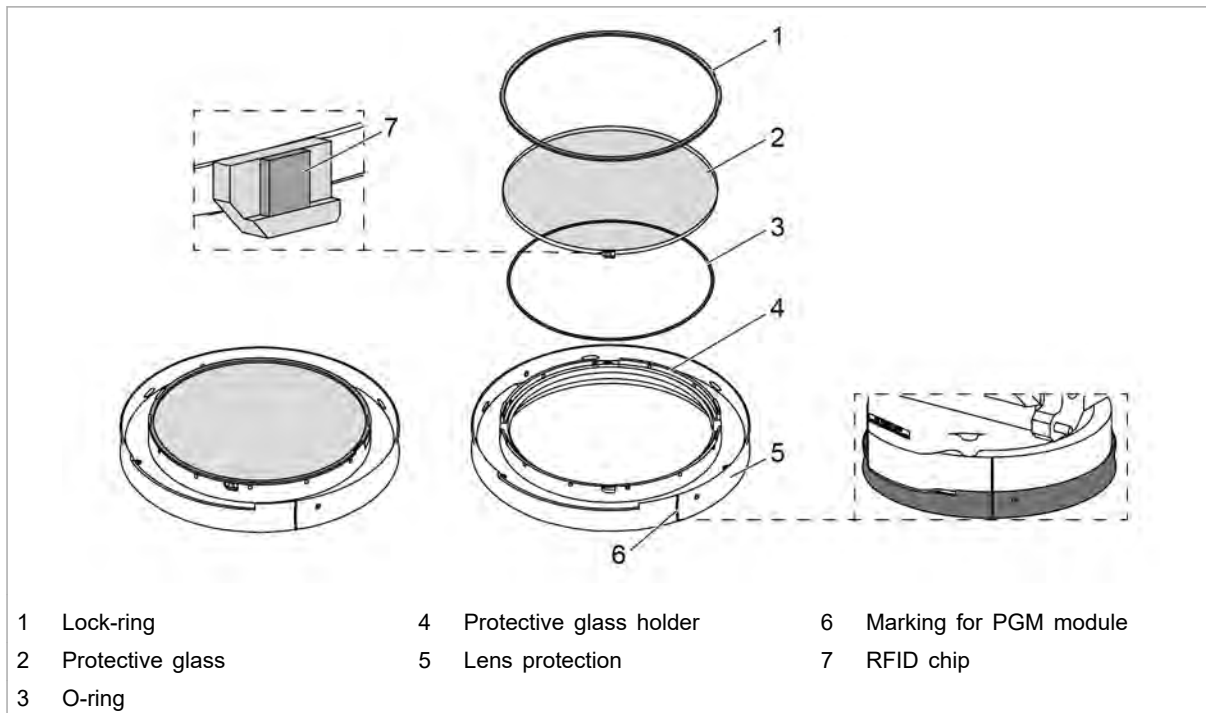


Fig. 112297

3. Bend the clamping ring into an oval by hand and press it in the elastic area so that it can be removed from the detents.
4. Remove the clamping ring (1) and protective glass (2).
5. Clean the O-ring with methanol.

or

- If the O-ring is damaged, replace it (see "Wearing parts", pg. 5-5).

Inserting a new protective glass

6. Place the protective glass holder with the inner side upwards on an even and clean surface.
7. Ensure that the O-ring fits correctly in the groove.

Note

Do not touch the protective glass cassette with the fingers.

8. Put new protective glass in the protective glass holder.
Observe the orientation of the RFID chip (7).

9. Press the clamping ring in the protective glass holder until it engages.
 - In the event of contamination, soak lens cleaning paper or a swab with methanol and slowly wipe over the protective glass.

Putting on the lens protection

10. Check additional protective glass in the objective lens.
 - In the event of contamination, soak lens cleaning paper or a swab with methanol and slowly wipe over the additional protective glass.
 - In case of damage, inform the TRUMPF Service Department.
11. Slide the lens protection as far as possible on the lens of the focusing optics and turn until it engages.

Observe the orientation to the PGM module (6).

The focusing optics is ready for use.

3.3 Cleaning or changing the smoke bell

Molten material spatters are deposited on the smoke bell during the welding process. Clean the smoke bell at regular intervals. The cleaning interval depends on the application and the resultant soiling.

The smoke bell has to be changed if

- dirt particles cannot be removed by cleaning (e.g. burnt-in particles).
- the smoke bell is damaged.

Condition

- The connected laser device has been switched off and secured against renewed switching on, e.g. by means of a shackle padlock.

Means, Tools, Materials

- Wire brushes
- Polishing fleece
- Methanol
- O-rings (if damaged)
- smoke barrel
- Disposable gloves

Note

TRUMPF recommends an additional smoke bell.

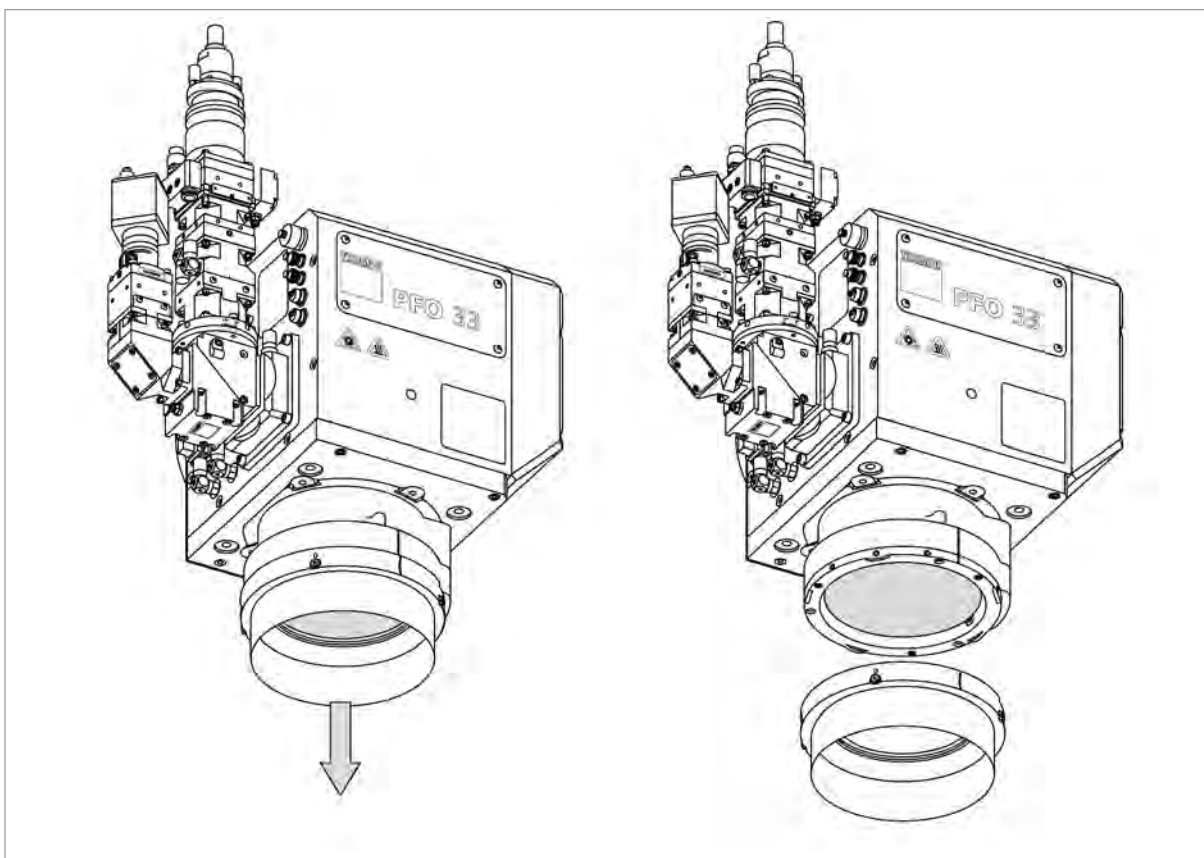
After having removed the soiled smoke bell, you can immediately slide the additional smoke bell on the lens and go on working with the focusing optics.

⚠ CAUTION

Hot surfaces on the bottom side of the focusing optics may burn your skin.

- Avoid contact with hot surfaces.
- Allow the focusing optics to cool down, before carrying out maintenance or cleaning work.

Removing the smoke bell



Removing the smoke bell

Fig. 112289

Note

Touch neither the protective glass nor the focusing lens with the fingers.

1. Loosen and remove the smoke bell by turning it.
2. Cover the opening of the focusing optics in polluted environments (e.g. oil mist or intense dust present) until the smoke bell is reattached.

Removing the protective glass

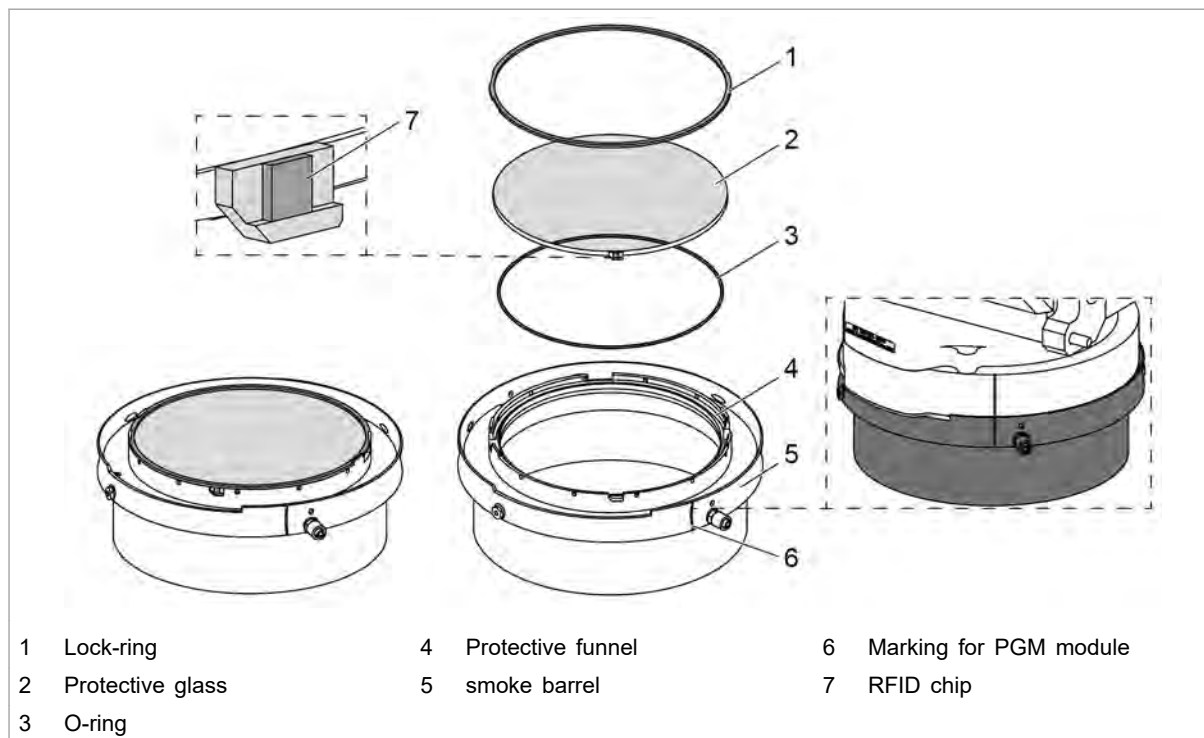


Fig. 112298

3. Bend the clamping ring into an oval by hand and press it in the elastic area so that it can be removed from the detents.
4. Remove the clamping ring (1) and protective glass (2).

Cleaning the smoke bell

5. Clean the O-ring with methanol.
or
➤ If the O-ring is damaged, replace it (see "Wearing parts", pg. 5-5).
6. Remove deposits on the protective funnel by means of a steel brush and polishing fleece.
7. If the protective funnel cannot be cleaned completely or if it is damaged: Use a new smoke bell.

Inserting the protective glass

8. Place the protective funnel with the inner side upwards on an even and clean surface.
9. Ensure that the O-ring fits correctly in the groove.

Note

- Do not touch the protective glass cassette with the fingers.
10. Insert the protective glass into the protective funnel.
Observe the orientation of the RFID chip (7).

Note

Only one side of the protective glass may be used.

After cleaning the protective glass, never fit it into its holder with the cleaned side towards the lens. The cleaned surface contains residual contamination, which will vaporize when the laser operates and which may lead to damage (contaminants being burned in) to the lens.

11. Press the clamping ring in the protective funnel until it engages.

Putting on the smoke bell

12. Check the additional protective glass in the objective lens:
 - In the event of contamination, soak lens cleaning paper or a swab with methanol and slowly wipe over the additional protective glass.
13. Slide the smoke bell as far as possible onto the lens of the focusing optics until it contacts the socket evenly.

Observe the orientation to the PGM module (6).

The focusing optics is ready for use.

3.4 Replacing the protective glass of the smoke bell

Condition

- The connected laser device has been switched off and secured against renewed switching on, e.g. by means of a shackle padlock.

Means, Tools, Materials

- Protective glass
- Methanol
- O-rings (if damaged)
- Disposable gloves

Note

TRUMPF recommends an additional smoke bell.

After having removed the soiled smoke bell, you can immediately slide the additional smoke bell on the lens and go on working with the focusing optics.

Removing the protective glass

1. Loosen and remove the smoke bell by turning it.
2. Removing the protective glass.
3. Clean the smoke bell.

4. Clean O-rings with methanol.

Inserting a new protective glass

5. Place the protective funnel with the inner side upwards on an even and clean surface.
6. Make sure that the O-rings fit in the groove correctly.

Note

Do not touch the protective glass cassette with the fingers.

7. Put new protective glass in the protective funnel (see ["Wearing parts"](#), pg. 5-5).
8. Press the clamping ring in the protective funnel until it engages.
9. Check the protective glass in the objective lens.
 - If the focusing lens is soiled, soak lens cleaning paper or a swab with methyl alcohol and slowly wipe across it.
 - In case of damage, inform the TRUMPF Service Department.

Putting on the smoke bell

10. Put on the smoke bell and turn until it engages.

The focusing optics is ready for use.

3.5 Replacing the protective glass of the collimator protective glass cassette

See the Spare parts catalogue for the material numbers.

Conditions

- The connected laser device has been switched off and secured against renewed switching on, e.g. by means of a shackle padlock.

or

- The light path to the focusing optics is blocked.
- The collimator protective glass cassette is plugged in.
- All gases (crossjet, MDE nozzle and purging gas) are turned off.

Means, Tools, Materials

- New protective glass for collimator protective glass cassette
- Methanol

Removing the protective glass

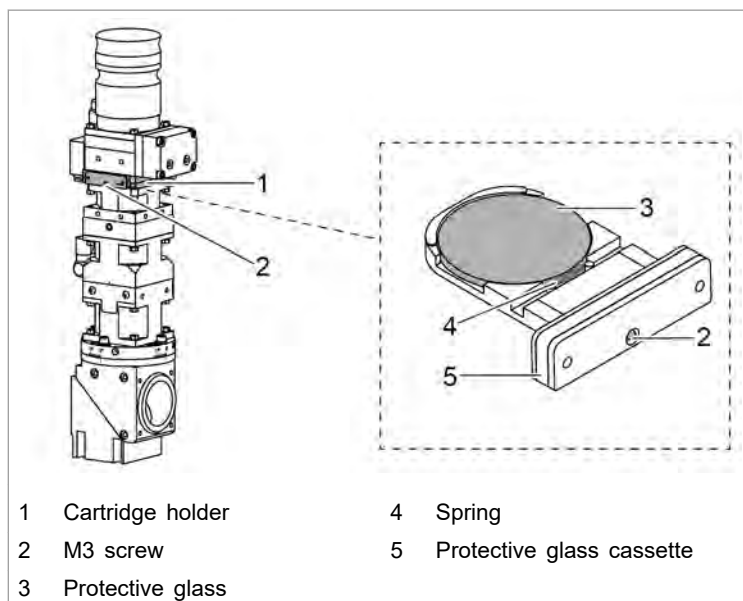


Fig. 112296

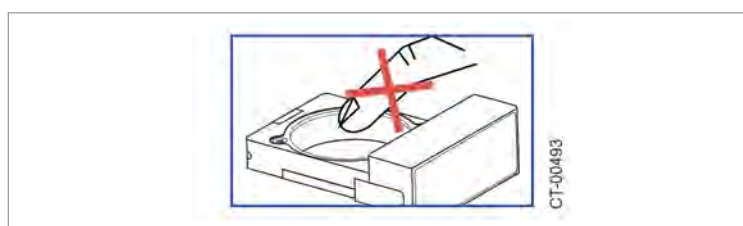
1. Loosen the screw (2) and pull out the protective glass cassette (5).
2. Cover the opening of the protective glass cassette in contaminated environment (e.g. in case of oil mist or a very dusty environment), until you reinsert the protective glass cassette.

Inserting a new protective glass

3. Take the protective glass (3) out of the protective glass cassette.

Note

Do not touch the protective glass cassette with the fingers.

Fig.
CT-00493

4. Grasp the new protective glass at the edge and place it on the spring (4) to insert it into the protective glass cassette.
5. Push the protective glass cassette into the cassette holder and tighten the screw with 1.3 Nm torque.

4. Teach module maintenance

The following figure shows the positions of the teach module.

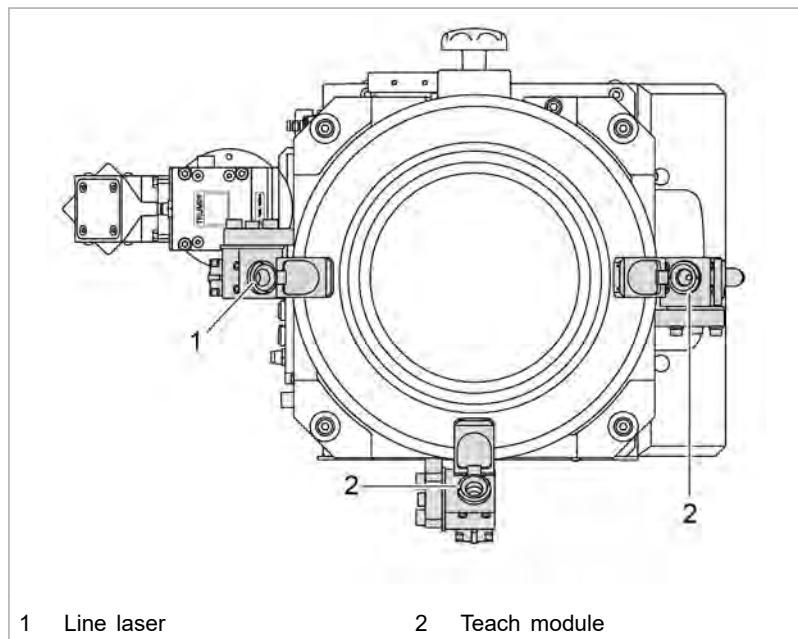


Fig. 112290

4.1 Cleaning the protective glass of the teach module

The teaching module is covered on the outside by a protective glass. A protective glass prevents particles and material vapor which are produced during the welding process from being deposited in the teach module.

If the protective glass is noticeably soiled, it has to be cleaned.

Clean the protective glass

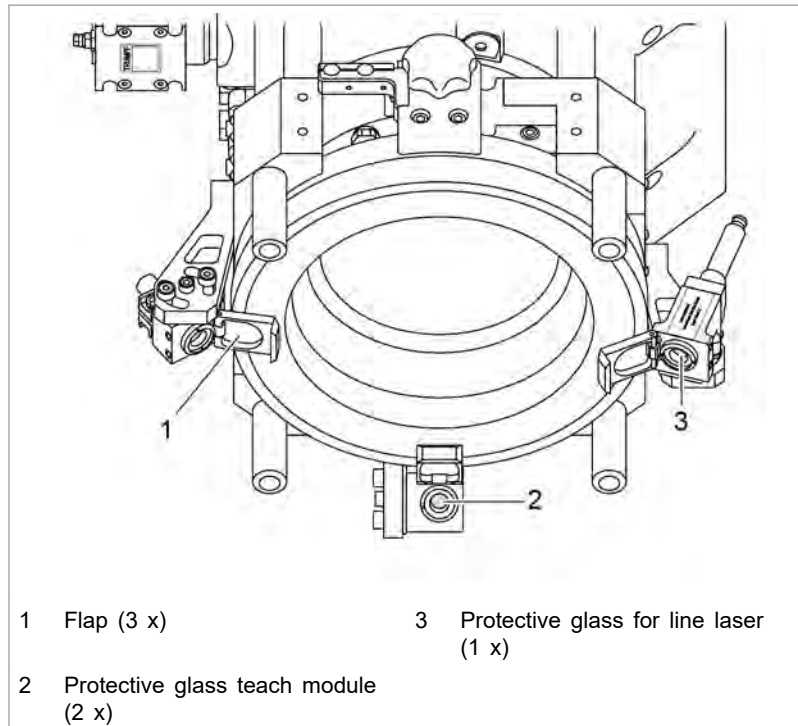


Fig. 112291

⚠ CAUTION

Hot surfaces on the bottom side of the focusing optics may burn your skin.

- Avoid contact with hot surfaces.
- Allow the focusing optics to cool down, before carrying out maintenance or cleaning work.

1. Open the flap (1) of the teach module.
The protective glass is freely accessible.

Note

Do not touch the protective glass cassette with the fingers.

2. Soak swabs or lens cleaning paper in methanol.
3. Slowly wipe across the protective glass (2) or (3) until it is clean.

The focusing optics is ready for use.

Note

The complete protection has to be replaced if the protective glass contains burnt-in dirt particles which cannot be removed by cleaning, (see ["Replacing the protection for teach module", pg. 5-20](#)).

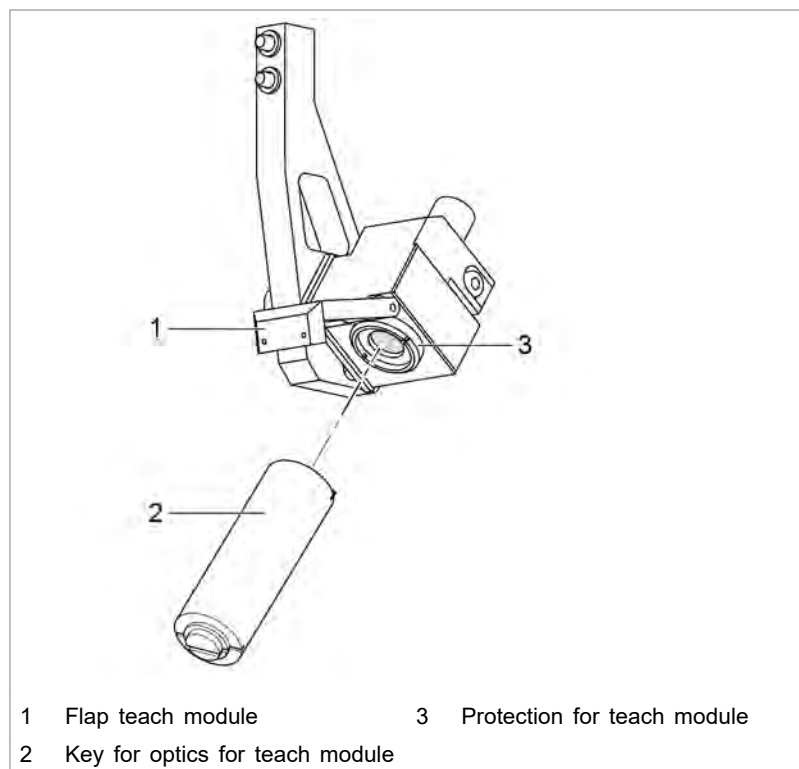
4.2 Replacing the protection for teach module

Condition

- The laser device is switched off and secured against restart.

Means, Tools, Materials

- Protection for teach module (for material no., see wearing parts table (see "Wearing parts", pg. 5-5))
- Keys for optics



Replacing the protection: teach module

Fig. 112299

⚠ CAUTION

Hot surfaces on the bottom side of the focusing optics may burn your skin.

- Avoid contact with hot surfaces.
- Allow the focusing optics to cool down, before carrying out maintenance or cleaning work.

1. Open the flap (1) of the teach module.
The protection of the teach module is easily accessible.
2. Unscrew the protection (3) by using the key for the optics (2).

-
3. Close the cap of the teach module in a polluted environment (e.g. oil mist or heavy dust present).
 4. Use the key for optics to screw the new protection onto the module.
 5. Close the cover of the teach module.

5. Crossjet

5.1 Cleaning or changing the crossjet

Material spatters from the molten material deposit onto the crossjet during the welding process. Clean the crossjet at regular intervals. The cleaning interval depends on the application and the resultant soiling.

The crossjet has to be changed if:

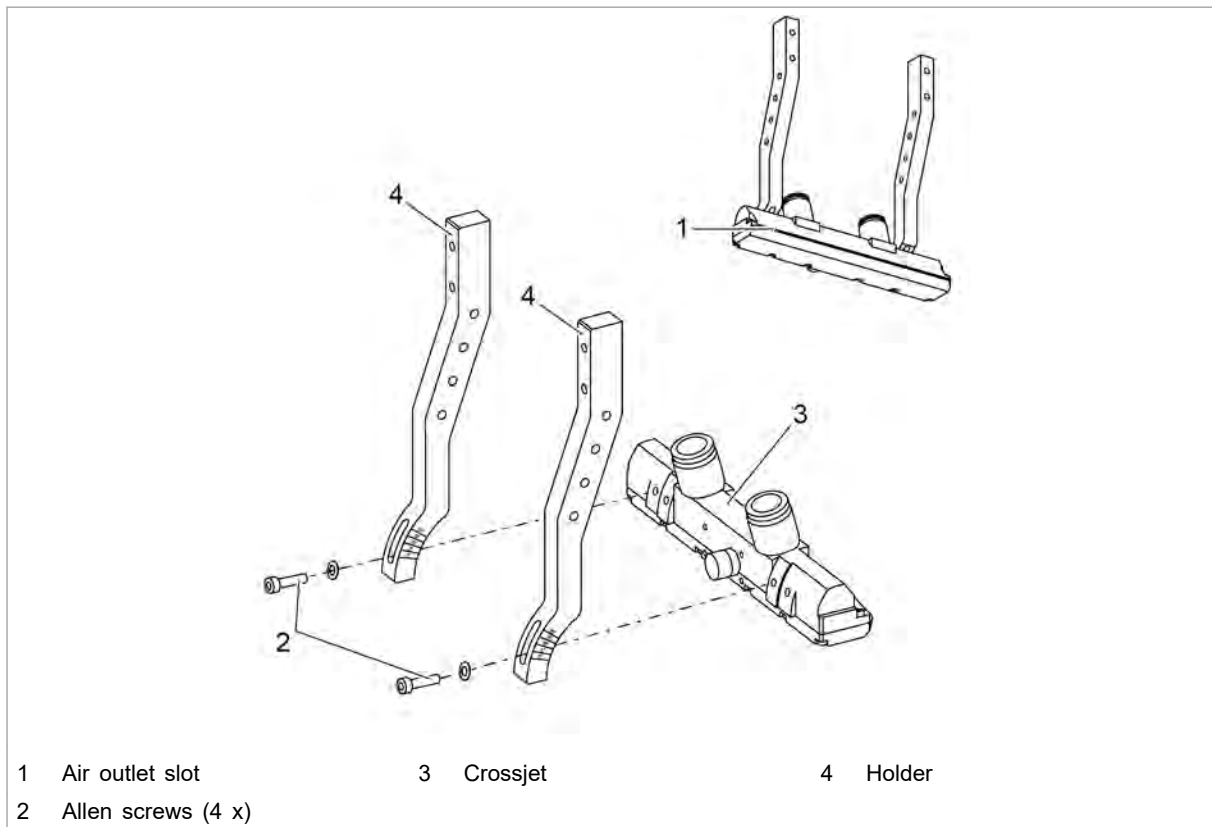
- dirt particles cannot be removed by cleaning (e.g. burnt-in particles).
- the crossjet is damaged.

Condition

- The connected laser device has been switched off and secured against renewed switching on, e.g. by means of a shackle padlock.

Means, Tools, Materials

- Wire brushes
- Polishing fleece
- Crossjet



Crossjet

Fig. 112292

⚠ CAUTION

Hot surfaces on the bottom side of the focusing optics may burn your skin.

- Avoid contact with hot surfaces.
- Allow the focusing optics to cool down, before carrying out maintenance or cleaning work.

1. Unscrew the four Allen screws (2) and remove the crossjet (3).
2. Remove deposits on the crossjet by means of a steel brush and polishing fleece.
Pay special attention to the cleanliness of the air outlet slot (1) to ensure that the air stream can escape freely.
3. If the crossjet cannot be cleaned completely or if it is damaged: use a new crossjet.
4. Place the crossjet on the holder (4) and screw in all the Allen screws.

6. MDE nozzles

6.1 Cleaning or replacing the MDE nozzles

Material spatters from the molten material deposit onto the MDE nozzles during the welding process. Clean the MDE nozzles at regular intervals. The cleaning interval depends on the application and the resultant soiling.

The MDE nozzles have to be changed if

- dirt particles cannot be removed by cleaning (e.g. burnt-in particles).
- the MDE nozzles are damaged.

Condition

- The connected laser device has been switched off and secured against renewed switching on, e.g. by means of a shackle padlock.

Means, Tools, Materials

- Wire brushes
- Polishing fleece
- MDE nozzles

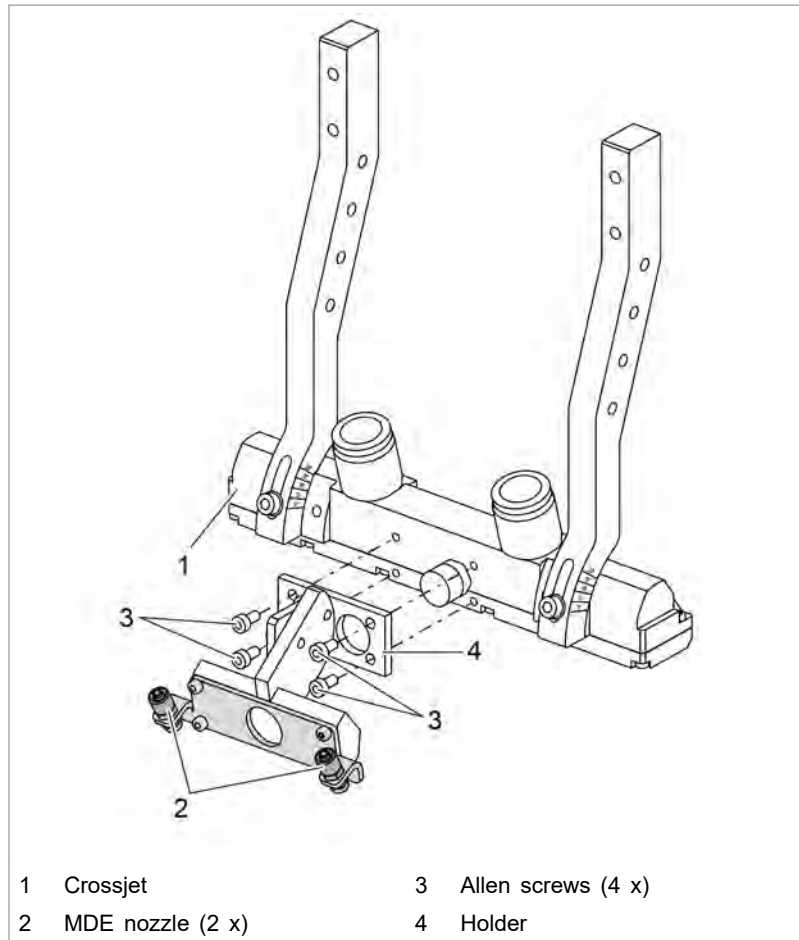
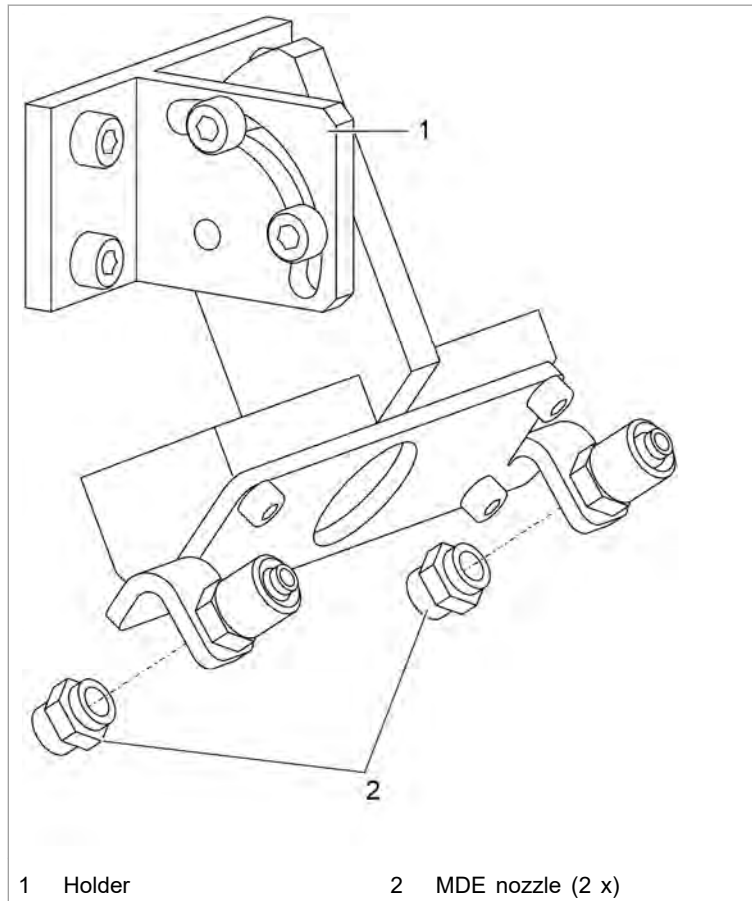


Fig. 112293

1. Unscrew the four Allen screws (3) and remove the MVE module with holder (4).



Replacing the MDE nozzles

Fig. 112294

2. Remove deposits on the MDE nozzles (2) by means of a steel brush and polishing fleece.
3. If the MDE nozzles cannot be cleaned anymore or if they are damaged: unscrew old MDE nozzles and screw on new MDE nozzles.
4. Place the MVE module on the holder (1) and screw in both Allen screws.

7. Cooling water

7.1 Draining cooling water from the focusing optics

The cooling water must be drained from the focusing optics:

- During prolonged storage.
- When storing near the freezing point.
- Before transport when the focusing optics is sent back to the factory for repair and maintenance.

Means, Tools, Materials

- Protective gloves
- Collecting pan

Open safety circuits

1. Open safety circuits of all light paths leading to the protective cabin in which maintenance work is being carried out, for example by opening the door of the protective cabin.

Note

Make sure that the safety circuits of the light path in question or the safety circuits of the light paths in question remain open for the duration of the maintenance work (e.g. by securing the open door against inadvertent closing).

2. Unscrew focusing optics from the holder or the customer-provided mounting plate.
3. Disconnect focusing optics from the electrical system and the supply media.

Emptying the focusing optics

4. Provide a collecting pan.
5. Hold focusing optics in such a way that the optical and electrical components will not get wet.
6. Allow cooling water to drain into a collecting pan.



Chapter 6

Conduct in case of malfunctions

1	EMERGENCY STOP switch	6-2
1.1	Pressing the EMERGENCY STOP button	6-2
2	Observing messages	6-3
3	Activating diagnostics	6-4
4	Informing the service department	6-5

1. EMERGENCY STOP switch

If a malfunction occurs and you are sure that there is no danger to persons or material:

1.1 Pressing the EMERGENCY STOP button

- Press an EMERGENCY STOP button, which is linked to the EMERGENCY STOP circuit of the laser device.

All components which can be dangerous are switched off. In particular, no more laser light is emitted.

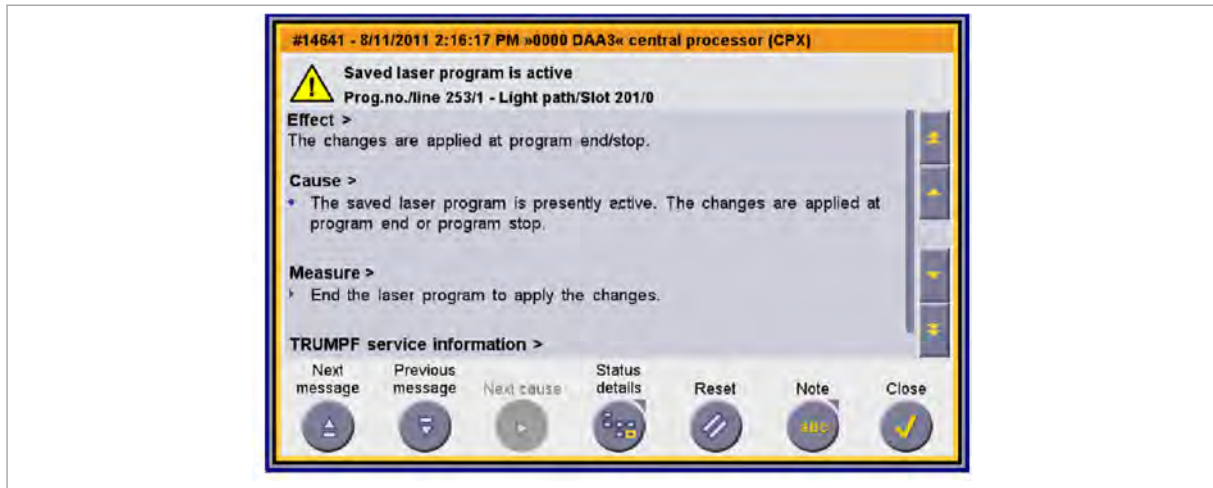
Tip

Further information on the EMERGENCY STOP buttons and other safety equipment can be found in the operator's manual and the interface description of your laser device.

2. Observing messages

Numerous operational values of the programmable focusing optics (PFO) are constantly monitored. In case an operational value is outside the permissible range, a message containing information on the cause of the malfunction and its elimination is displayed on the screen.

The following figure shows an example.



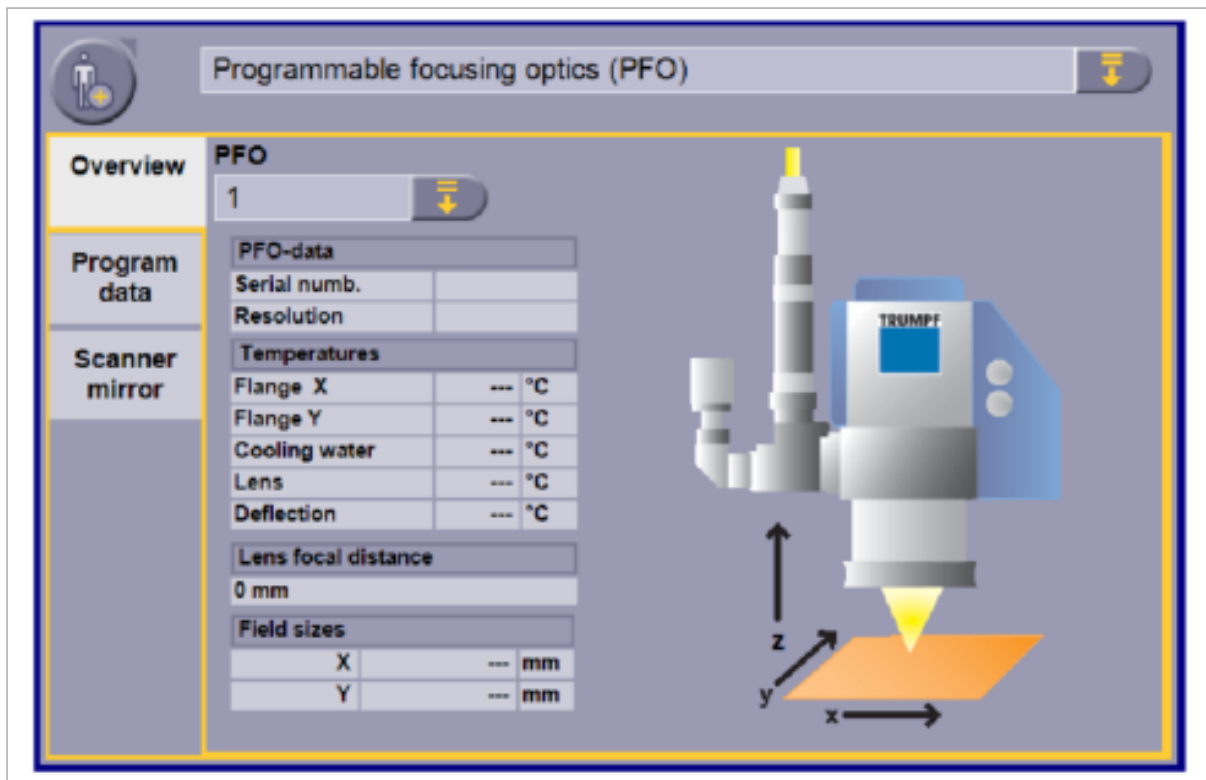
Message (example)

Fig. 0260-35-S

For further information on messages and the necessary actions, please refer to your laser operator's manual.

3. Activating diagnostics

A large number of diagnosis pages with hints to possible causes for the malfunction can be called up in the TruControl 1000 program. The following figure shows an example.



Diagnosis page for the PFO in TruControl 1000

Fig. of000284

Please note:

The diagnosis pages are mainly intended for the service staff. If necessary, the service staff will instruct you by phone to read out certain values on a diagnosis page to the service employee.

If your laser device is provided with the "Remote Support" option, the service department of TRUMPF can dial into your laser device through the Telepresence portal and look at the diagnosis pages.

Contact TRUMPF if you wish to have further information on this.

4. Informing the service department

If a fault occurs and you need assistance in eliminating it, please contact the TRUMPF service department. The service address is given at the beginning of these operating instructions.

Please tell the service staff as precisely as possible:

- Type of the laser device (e.g. TruDisk 1000)
- Number of the laser device (see rating plate)
- What happened?
- What did the screen indicate (e.g. message, number of the message)?
- What did you do?
- Is your laser device provided with the telepresence option?
If yes, indicate the number of the connection.

The service employee will do their best to eliminate the fault as quickly as possible.

