ProtoLaser R4

User manual

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LPKF
Laser & Electronics

Publisher

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General information

This document contains all information for the intended use of the system/product delivered. This document is intended for persons with basic knowledge of installation and operation of software-controlled systems. General knowledge of operational safety as well as basic knowledge of using PCs running Microsoft Windows® are required.

- Read this document and possibly associated safety data sheets carefully before first start-up and usage of the components.
- Observe the safety regulations as well as the regulations on operational health and safety and protection of the environment.
- Use the system/product only in a technically perfect condition.
- Observe all labels and safety signs on the system/product.
- Never remove the safety signs and replace or clean them if not readable anymore.
- Persons who install, operate, uninstall, or maintain our systems/products must not be under the influence of alcohol, other drugs, or medication that impairs the ability to react.
- Use only approved spare parts and accessories in order to prevent injuries due to unsuitable spare parts and accessories.
- Observe the technical data and ambient conditions specified in this document.

Validity

This document is part of the system/product and corresponds to the technical state at the time of publication. This document has always to be present at the system/product and has to be available to the operating personnel without restrictions, in a complete and legible form and at all times. If the operator changes, this document has to be handed over together with the system/product. The operator has to ensure that all safety measures specified in this document are observed.

The operating personnel must have read and understood this document before performing any task. A basic requirement for safe work is observance of all safety notes and steps. This document contains important information about the system/product that has to be observed when installing, first starting up, or maintaining the system/product. Its structure allows trained personnel to perform all tasks.

LPKF Laser & Electronics AG (abbreviated to **LPKF** in the following) reserves the right to make changes in respect to the content of this document. The figures in this document serve as basic understanding and can differ from the actual state of the system.

Structure of warning messages and safety notes

The safety notes and warning messages in this document identify hazards and risks and they are created in accordance with ANSI Z535.6-2011 and the standards series ISO 3864.

The warning messages are structured as follows:

- Warning sign (only for injuries)
- Signal word indicating the hazard class
- Type and source of the hazard
- Consequences of non-observance
- Measures to avoid the hazard

⚠ + SIGNAL WORD
Type and source of the hazard! Consequences of non-observance. ▶ Measures to avoid the hazard. ▶ Further measure(s) to avoid the hazard.

Warning messages can also be embedded in the format of the surrounding text in order to avoid a *visual disruption* in a sequence. In this case, they are distinguished as follows:

Type and source of the hazard!
Consequences of non-observance.
▶ Measure(s) to avoid the hazard.

Warning messages are classified in hazard classes represented by the signal word. In the following, the warning messages are described in accordance to their hazard classes:

⚠ DANGER

Type and source of the hazard!

This warning message indicates a hazard of high risk that causes death or serious injury if not avoided.

▶ Measures to avoid the hazard.

⚠ WARNING

Type and source of the hazard!

This warning message indicates a hazard of medium risk that can cause death or serious injury if not avoided.

▶ Measures to avoid the hazard.

⚠ CAUTION

Type and source of the hazard!

This warning message indicates a hazard of low risk that can cause minor or moderate injury if not avoided.

▶ Measures to avoid the hazard.

NOTICE

Type and source of the hazard!

This warning message indicates a hazard that can lead to possible property damage.

▶ Measures to avoid the hazard.

Text styles

Various text attributes, notations, and text structures facilitate reading the document. The text attributes (highlightings) inside this document are defined as follows:

Attribute	Function
italic	highlights elements of the user interface and of control elements of the system
bold	highlights important information and keyboard input
`Courier New`	highlights file paths
`[ ]`	highlights elements of buttons on software user interfaces
key	highlights keys of the keyboard

Tasks or procedures that are described in steps are compiled to sequences in this document. A sequence consists of at least three components: objective, step, and result.

Component	Description
■	Indication of an objective. The sequence starts here.
1. 2. 3.	Indication of a sorted list of steps. The specified order must be observed.
□	Indication of an intermediate result that is followed by further steps or the result.
☑	Indication of the result. The sequence is finished.
▶	Indication of a single step.

Additional information

The following symbols are used to indicate additional information:

This note indicates especially useful information.

Advanced information

This advanced information indicates special knowledge.

Registered Trademarks

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Issued patents, if applicable, are listed in the appendix.

Limited liability

All data, notes and instructions in this document have been prepared with consideration to the statutory standards and regulations, the present state of technology, as well as our many years of knowledge and experience.

LPKF accepts no liability for damage due to:

- non-observance of this document
- improper use of the system/product
- employment of personnel that is not sufficiently qualified
- unauthorized modification
- technical changes
- unauthorized manipulation of the safety devices
- use of spare parts that are not approved by LPKF

The actual scope of delivery can deviate from the explanations and presentations given here, due to custom designs, the utilization of additional order options, or due to the most recent technical changes.

We reserve the right for technical modifications of the product for reasons of improved usability and future development.

The responsibilities agreed in the delivery contract, the General Terms and Conditions as well as the delivery conditions of the manufacturer and the statutory regulations valid at the time of the conclusion of the contract are effective.

Warranty

Please note that the warranty is subject to the current regulations in combination with the current General Terms and Conditions.

All information and instructions in this document have been compiled in observance of current regulations and the current state of the art. Before working with the system/product, this document has to be read carefully. The manufacturer assumes no liability for damage and faults due to non-observance of this document.

LPKF Laser & Electronics AG provides a 12-months warranty if the following conditions are met:

- The warranty starts on delivery.
- The warranty covers defects in material or manufacture. During the warranty period, such defects are remedied without cost by replacement or rework of the defective parts. This service is provided by the LPKF Service.
- The operating conditions described in this document have been complied with.
- The maintenance work described in this document has been executed and documented at the specified maintenance intervals.

For further information on wear parts refer to the chapter scope of delivery.

Customer service

For technical information contact our LPKF Service:

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In our continuous effort to improve our documentation we are asking you to give us your feedback if you notice any discrepancy when working with the system/product, or if you have any comments or suggestions for improvement.

At the moment of packaging, the system/product has been equipped with the latest software version and with the software and hardware documentation currently valid. By now, new versions of the documentation as well as new software versions might be available.

For all the latest news and updates visit the support area of our homepage: www.lpkf.com/en/support-services.

Contents

1 Safety

This chapter provides an overview of all important safety aspects for protecting persons as well as for a safe and fault-free operation of the system/product. There are further warning messages in the sections of the individual lifecycle stages.

1.1 Intended use

ProtoLaser R4is a laser system designed for micro material processing and may only be controlled using the system software that is included in the scope of delivery.

The following processing procedures and materials are approved:

Processing procedures

- Structuring laminated substrates
- Separating rigid, flex-rigid, and flexible materials
- Drilling and separating ceramics
- Structuring TCO/ITO
- Cutting LTCC

Materials

- Laminated substrates with a conductive layer of up to 35 µm:
  - FR4
  - RO® type (manufactured by Rogers)
  - RT® type (manufactured by Rogers)
  - TMM® type (manufactured by Rogers)
  - Pyralux® TK (manufactured by DuPont)
  - Pyralux® AP (manufactured by DuPont)
  - TacLamPLUS® (manufactured by Taconic)
  - RF-10® (manufactured by Taconic)
  - CuFLON® (manufactured by Polyflon)
- Polyimide (PI)
- Polyamide (PA)
- Polycarbonate (PC)
- Polycarbonate/Acrylonitrile butadiene styrene (PC/ABS)
- Acrylonitrile butadiene styrene (ABS)
- Polybutylene terephthalate (PBT)
- Glass, borosilicate glass, fused quartz
- Aluminum oxide, LTCC
- Photomasks/Chrome masks, TCO, ITO
- Foils, e.g. brass, copper, aluminum, solder-paste stencil sheets
- Fine polyamide PA2200 (SLS)
- ABS M-30 (FDM smoothed)

In case of doubt contact the LPKF sales department or your local representative to receive more information on alternative materials or processing procedures.

Furthermore, the intended use of the system is ensured by complying with the following points:

Place of installation

- The ambient conditions have to be observed (see page 32).
- The minimum required space of the system has to be observed (see page 76).
- The system may only be used in laboratory environments.

Caution:
The system is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.

Service life

- The system is designed for a service life of 10 years used in one-shift operation (8 hours a day, 5 days a week).
- The system has to be maintained within the specified intervals (see page 135) to ensure the service life of the system.

Personnel

- The system has to be operated by personnel who are sufficiently qualified and trained (see page 22).

Processing conditions

- The materials used must not exceed the maximum processing size of the system (see page 32).
- The system has to be operated with an extraction system (see page 32).

Intended use also includes compliance with all information in these instructions.

Improper use

- Using the system with another or modified system software.
- Bridging or bypassing the safety devices.
- Do not use the system for processing easily flammable materials (e.g. paper, wood, etc.), reflective, or highly reflective materials.
- Using the system without the standard cover and covering parts is not allowed.

Do not leave the system unattended during production (e.g. over night)!

1.2 Residual risks

No residual risks have currently been identified, if the intended use as well as all safety regulations are observed. Any identified residual risks and their avoidance are listed in the form of safety instructions starting in chapter 1.3. Non-observance can cause personal injuries and property damage.

1.3 Basic hazards

Always comply with the warning messages listed here and in the individual sections of this documentation to reduce the risks of injuries and property damage and to avoid dangerous situations.

Mechanical hazards

⚠ WARNING

Risk of injury by moving components!

Moving components can cause serious injuries e.g. crushing injuries or cuts.

- ▶ Never grasp moving components when the system is operating.
- ▶ Never open any covers when the system is operating.
- ▶ Observe the follow-up time. Before opening the cover, ensure that no component is still moving.

⚠ WARNING

Risk of injury by loss of stability!

Loss of stability due to an improper floor or missing locks can cause uncontrollable movement or tilting of the system. This can cause serious injuries.

- ▶ Ensure that the floor is even and has a sufficient load-bearing capacity.
- ▶ Secure the system properly so that it cannot roll away unintentionally.

⚠ WARNING

Risk of injuries by pressurized components!

Pressurized components (e.g. compressed-air supply) can move uncontrollably in case of improper handling or in case of a defect and can cause serious injuries.

- ▶ Depressurize the components before working on them. De-energize the residual energies.
- ▶ Always ensure that there is no unintended escape of compressed air.
- ▶ Defective components that are under pressure when operating the system have to be replaced immediately by sufficiently qualified personnel.

Electrical hazards

⚠ DANGER

Danger to life by electrical shock!

Touching energized parts causes a direct danger to life by electrical shock. Damage to the insulation or damaged individual parts can be dangerous to life.

- ▶ Use only the mains cable included in the delivery or a mains cable approved by LPKF.
- ▶ All work on energized components of the system must be performed by a qualified electrician.
- ▶ If the insulation is damaged, switch off the power supply immediately and initiate the repair.
- ▶ De-energize all energized components of the system or equipment, before working with them. Ensure that the system or equipment is de-energized for the whole time of the task.
- ▶ Never bridge or deactivate fuses.
- ▶ Always keep moisture away from energized parts because it can cause a short circuit.

Hazards by materials or substances

⚠ WARNING

Health hazard by faulty extraction!

When processing materials, gases or dusts hazardous to health can be produced.

- ▶ Ensure that the extraction system is switched on and is working properly.
- ▶ Observe the maintenance intervals of the extraction system.
- ▶ Check the connection to the system regularly.

Other hazards

⚠ CAUTION

Tripping hazard by hoses and cables!

Hoses and cables are routed to the system. If the hoses and cables are laid inappropriately they pose a tripping hazard for the operating personnel.

- ▶ Always ensure that the hoses and cables do not pose a tripping hazard.

1.4 Laser safety instructions

This chapter contains basic information on protection against the hazards of laser radiation. Every user of this laser system must read and understand this chapter before he/she is authorized to work with the system. An annual laser safety instruction delivered by the laser protection officer of the company is required.

1.4.1 Laser radiation hazards

The laser light is very orderly and regular in terms of propagation direction and wavelength. Laser light has a high energy and can travel over wide distances with an almost parallel propagation. The laser power is not dependent on the distance to the target.

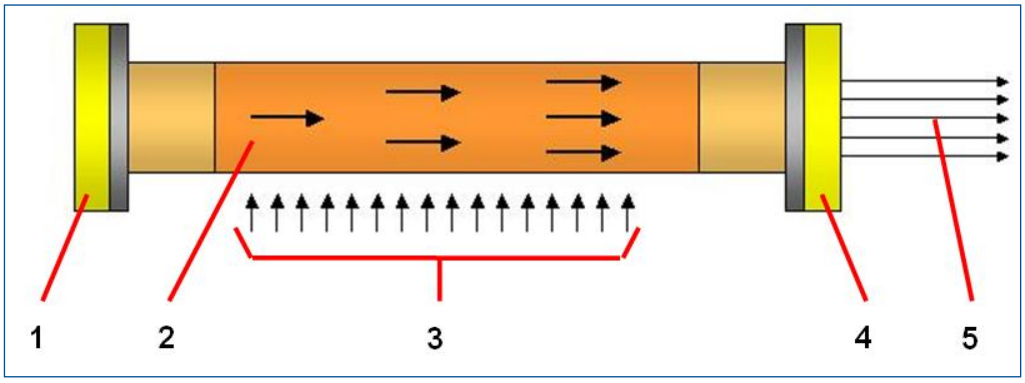


Fig. 1: Functional principle of a laser

1 Mirror (fully reflective)
2 Laser medium
3 Pump energy
4 Mirror (semitransparent)
5 Laser beam

Effects on the human eye

In addition to the high energy and the power density, the high focusability of the coherent laser beam is another danger to the human eye. A laser pulse hitting the visual nerve of the eye can cause blindness.

Effects on the human skin

The extent of damage to the human skin is highly related to the wavelength of the laser beam so that the damage can vary between light sunburn, heavy blistering and carbonization of the skin. The impact also depends on the laser power and the duration of irradiation.

Thermal damage

Thermal tissue damage can be classified into reversible and irreversible physical injuries. Reversible tissue injuries are caused by temperatures below 45 °C (113 °F). Tissue dies off (protein coagulation) due to thermal damage at temperatures between 45 °C (113 °F) and 80 °C (176 °F). The water inside the tissue is vaporized at temperatures above 100 °C (212 °F). At temperatures above 150 °C (302 °F) the tissue is carbonized. At temperatures above 300 °C (572 °F) the tissue is evaporated.

Damage depending on laser beam wavelength

Wavelength (nm)		Spectral range	Eye	Skin
From	To			
180	280	UV-C	Keratitis	Sunburn
280	315	UV-B	Keratitis	Increased pigmentary abnormality
315	400	UV-A	Cataract	Tanning
400	780	Daylight	Retina damage	Burns
780	1400	IR-A	Retina damage, blindness	Burns
1400	3000	IR-B	Cataract or burns of the cornea	Burns
3000	10^6	IR-C	Burns of the cornea or corneal abrasion	Burns

Table 1: Effects of laser radiation

Other laser radiation hazards

A laser system poses primary and secondary hazards. The primary hazards are due to the laser beam itself. The secondary hazards arise from the laser system or the processing procedure.

Source of danger	Description
Pilot laser (if applicable)	The pilot laser is a compact laser diode or a class 2 HeNe laser. Do not expose your eyes to radiation unnecessarily. The laser radiation is harmless for the skin.

Table 2: Sources of danger

1.4.2 Laser classes

The hazard levels of laser systems are based on the accessible emission limits (AEL) and listed in European Standard EN 60825-1 and the American National Standards ANSI Z136.1 for the Safe Use of Lasers.

Class	Concept	Safety measures
1	The radiation emitted by this laser system is not dangerous.	No specific protective equipment is required.
1M	The radiation emitted by the laser system is eye safe when used without optical instruments. The emitted radiation is not safe when optical instruments are used.	No specific protective equipment is required if the laser system is used without optical instruments.
1C	These laser systems are used for medical purposes only. The radiation emitted by the laser system is not subject to any limitations.	The protection is ensured by technical measures so that the laser can only emit a beam while having contact to skin or tissue. For this, the radiation is reduced to class 1.
2	The laser system is eye safe as a result of normal human aversion responses including the blink reflex.	No specific protective equipment is required.
2M	The light that can penetrate the eye pupil has the value of a class 2 laser. Depending on a divergent or widened beam, it may not be safe when optical instruments are used.	No specific protective equipment is required if the laser system is used without optical instruments.
3R	Exceeds the maximum permissible exposure values. The radiation is max. 5 times higher than the AELs of class 1 or of class 2. The risk is slightly lower than the risk of class 3B.	Dangerous to the human eye, laser safety glasses are recommended.
3B	Looking into the laser beam is dangerous to the eyes. Diffuse reflections are not considered as dangerous. (former class 3 B without class 3 R)	Dangerous to the human eye, laser safety glasses are obligatory.
4	Even diffuse reflections are dangerous to the human eye. There is also a danger of fire and danger to the human skin.	Personal protective equipment is absolutely necessary (laser safety glasses and protective screens)!

Table 3: Laser classes

1.4.3 Protective measures

The operator of a laser system is obliged to take structural and organizational protective measures.

Personal protective measures

The operating personnel must comply with certain protective measures when working on a laser system.

Protective measures	1	1M	1C	2	2M	3R	3B	4
Never look directly into the laser beam neither with nor without laser safety glasses.	x	x	x	x	x	x	x	x
Wear laser safety glasses						x	x	x
Attend a laser safety instruction course once a year							x	x

Table 4: Personal protective measures

Structural protective measures

Depending on the laser class, special protective measures must be taken or be existent.

Protective measures	1	1M	1C	2	2M	3R	3B	4
Walls, ceilings and floors must be built solid and fire proofed. The wall areas must be matte, bright and diffusely reflecting.							x	x
Non-metallic (non-reflecting) installations							x	x
Ambient light must be amply dimensioned and adjustable							x	x
Adequate number of emergency stop buttons, room and door contact switches							x	x
Shielding: high absorption, hardly inflammable							x	x
Specular reflection: avoid any unintended reflections						x	x	x
The laser beam must be limited at the end of its useful path		x	x	x	x	x	x	x
Label the laser area (Warning laser beam) inside the working and traffic area				x	x			
Restrict access to the laser area and label the borders (Warning laser beam)						x	x	x
Operation mode displays and warning lights on all entrance doors of the laser area								x

Table 5: Structural protective measures

Organizational protective measures

Depending on the laser class, special protective measures must be taken.

Protective measures	1	1M	2	2M	3R	3B	4
Inform the Employer's Liability Insurance Association and the industry control office.					x	x	x
A laser safety officer must be appointed in written form.					x	x	x
The borders of the laser area must be defined if the laser area is inside working or traffic areas.			x	x			
The borders of the laser area must be defined.					x	x	x
A remote-controllable locking device must be connected to the room or door electric system.						x	x
The laser system must be equipped with a key switch to securely switch-off the system (key removed).						x	x
The operating personnel must wear laser safety glasses acc. to EN 207.					x	x	x
The operating personnel must wear laser adjustment glasses compliant to EN 208 during adjustment tasks.					x	x	x
The operating personnel must wear protective clothes if necessary (for example protective gloves).					x	x	x
The operating personnel of the laser system must attend a laser safety instruction course.		x	x	x	x	x	x
All insured persons inside the laser area must attend a laser safety instruction course.					x	x	x
Adolescents under 16 years of age are not allowed to enter the laser area. Adolescents between 16 and 18 years of age are only admitted to the laser area if it is instrumental to achieving the educational objective.					x	x	x
Immediate medical care in case of any suspected eye injury.	x	x	x	x	x	x	x

Table 6: Organizational protective measures

1.4.4 Actions in case of an injury

In case of injury or only suspected injury, proceed as follows:

- The injured person has to consult a dermatologist or eye specialist immediately. Always have the eye fundus examined.
- Switch off the laser system and secure it against restart.
- Describe the accident details in a report.
- Inform the laser protection officer.
- Inform the supervisor.

1.4.5 Laser Safety Instructions

Observe strictly the following safety instructions for working with laser systems:

- Only the persons whose presence is required should be present in the laser area.
- The laser radiation of systems of laser classes 1C, 2, 2M, 3A, 3B and 4 should reach only as far as required for the specific application.
- Avoid any random reflections when using lasers of class 3 or 4. Keep away, remove or cover any reflecting/glossy objects or surfaces near the laser beam.
- Any person present in the laser area must be informed immediately when a laser system of class 3 or 4 will be switched on.
- A laser system is only safe, when no uncontrolled reflected radiation is emitted and access to the laser beam is prevented during operation.
- Looking directly into the laser beam is forbidden. Even proper laser safety glasses provide only limited protection against direct, specularly reflected or diffusely scattered laser radiation.
- Use only laser safety glasses that are approved for the specific laser system and are able to absorb the wavelength used.
- Check the laser safety glasses before every usage. Only undamaged and approved protective glasses (for wavelength and laser class) must be used.
- Inform the laser protection officer immediately about any damage of the laser system like changes on the protection filter, for example glass cracks, change in color, change in transparency and defects of the carrier.
- Do not wear any jewelry or other glossy or reflecting objects when operating a laser system.
- A laser system that is completely shielded with a protective housing is equivalent to laser class 1. If the protective housing is removed, the laser class is increased.

1.5 Responsibility of the operator

Operator

The operator is the person/company who operates the system/product themselves for industrial or commercial purposes, or makes it available to a third party for use and has the product responsibility for the safety of the system operator/user, the personnel in general, and other persons present.

Operator's obligations

The system/product is used in the industrial sector. The operator of the system/product is thus subject to the statutory obligations for occupational health and safety.

In addition to the safety instructions in this document, the safety, accident prevention, and environmental protection regulations must also be observed at the system's/product's place of operation.

The following applies in particular:

- The operator must inform himself about the effective industrial safety regulations and determine additional hazards in a risk assessment that result from the special working conditions at the system's/product's place of operation. The operator has to implement these in the form of operating procedures for the operation of the system/product.
- During the total operating life of the system/product, the operator has to check and ensure that the established operating procedures comply with the current state of the rules and standards and adapt them, if necessary.
- The operator has to define clear-cut responsibilities for installation, operation, trouble-shooting, maintenance, and cleaning.
- The operator has to make sure that all persons who are working with the system/product have read and understood this document. Furthermore, the personnel has to be trained and informed about the dangers on a regular basis.
- The operator has to provide the required personal protective equipment and instruct the personnel to wear it.
- The operator has to instruct the personnel to maintain a clean and tidy workplace. Eating and drinking at the workplace and especially while operating the system/product must not be permitted.

The operator is also responsible to keep the system/product in good working order. Thus, the following applies:

- The operator has to ensure that the maintenance intervals stated in this document are observed.
- The operator has to check all safety devices for proper function and completeness on a regular basis.

1.6 Personnel requirements

⚠ WARNING

Accident hazard due to insufficiently qualified personnel!

Insufficiently qualified personnel cannot assess the risks of using the system/product and put themselves and others in danger.

- ▶ Allow only qualified personnel to use the system/product.
- ▶ Keep insufficiently qualified personnel out of the working area.

The different tasks described in this document require different qualifications of the persons who are to perform these tasks.

If no personnel qualifications are listed in the individual chapters of this document, the operating personnel is intended to perform the tasks.

Only persons who can be expected to perform the tasks reliably are authorized to perform the tasks. Persons whose ability to react is impaired e.g. by drugs, alcohol, or medicine, are not authorized.

This document uses the following qualifications for persons for the different tasks.

Qualified electrician

A qualified electrician is able to perform work on electrical systems and to detect and avoid possible dangers on his/her own based on his/her professional training, know-how and experience as well as knowledge of the applicable standards and regulations.

The qualified electrician has been trained for the special field where he/she works and knows the relevant standards and regulations.

Maintenance personnel of the operator

Maintenance personnel are those persons who are designated by the operator to perform simple maintenance tasks (e.g. cleaning the system/product, removing parts from the system/product). The operator has to ensure that the personnel is suited for performing the work.

The maintenance personnel is able to perform his/her work and to detect and avoid possible dangers on his/her own based on his/her professional training, know-how and experience as well as knowledge of the applicable standards and regulations.

The maintenance personnel has been trained for the special field where he/she works and knows the relevant standards and regulations.

Service personnel

Service personnel are persons who are authorized by the manufacturer LPKF for servicing the system/product. These tasks may only be performed by the LPKF Service.

Operating personnel

Operating personnel trained by the operator is able to perform his/her work and to detect and avoid possible dangers on his/her own based on the training performed by the operator, his/her professional training, and his/her know-how and experience.

The operating personnel has been trained by the operator for the special field where he/she works and knows the relevant standards and regulations.

1.7 Personal protective equipment

Personal protective equipment protects against health or safety risks when working with the system.

The individual sections of this manual each point out the personal protective equipment (PPE) that has to be worn during the different tasks of working on the system.

This system is classified as laser class 1 if the cover is closed and it is not necessary to wear laser safety specific PPE during normal operation. If the cover is open (service mode), the system is classified as laser class 4.

Protective equipment for startup and maintenance tasks

- Laser safety glasses with a rating of DI LB5 + RM LB6 for 515 nm, protection class 6
- Respirator half mask according to EN 141/143, protection class P3
- Safety shoes, protection class 1
- Protective gloves, protection class 2
- Safety glasses, protection class 2
- Safety goggles, protection class 2
- Latex lab gloves, protection class 1

Personal protective equipment for working with hazardous substances and chemicals

- Respirator mask with gas filter for organic gases/vapors
  (boiling point > 65 °C, e.g. EN 14387 type A), protection class P3
- Safety glasses with side shields (e.g. EN166), protection class 2
- Chemical-resistant gloves, protection index 6
  nitrile rubber (NBR) - 0.4 mm thickness (e.g. EN 374), protection class 3
- Closed work clothing

▶ Always read the safety data sheets before working with hazardous substances and chemicals and always observe the instructions given therein.

Description of the personal protective equipment

Laser safety glasses

Laser safety glasses protect the eyes against laser radiation for the specified wavelength(s) in the ultraviolet, visible, and infrared spectral range for at least 10 seconds or, in case of pulsed lasers, for at least 100 pulses.

Safety goggles

Safety goggles protect the wearer's eyes against chemicals, dust, and splinters. Safety goggles have a seal ring for additional protection.

Safety glasses with side shields

Safety glasses with side shields serve for eye protection in case of flying debris and liquid splashes.

Respirator mask

Respirator masks protect against hazards from harmful substances in gases, vapors, and particles.

Safety shoes

Safety shoes protect the feet against crushing injuries, falling objects and from slipping on slippery surfaces.

Protective gloves

Protective gloves protect the hands against friction, abrasions, puncture hazards and deep cuts as well as when touching hot surfaces.

Chemical-resistant gloves

Chemical-resistant gloves protect the hands against immediate skin contact with hazardous substances. Refer to the safety data sheet for the required glove material and thickness.

Protective clothing

Protective clothing protects the body (except head, hands, and feet) against hazards caused by e.g. heat, cold, and chemicals.

1.8 Safety signs

This chapter lists the safety signs/pictograms that are applied to the system and describes their meaning.

⚠ WARNING

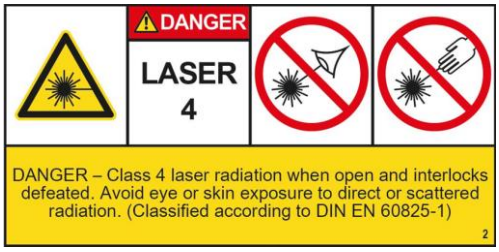
Risk of injury by nonobservance of safety signs!

The safety signs on the system instruct you on safe usage of the system. Nonobservance of the safety signs can cause severe injuries.

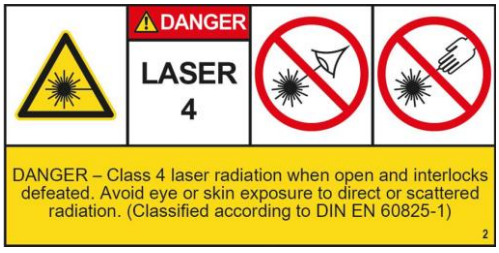
- ▶ Always observe the safety signs.
- ▶ Never remove the safety signs.
- ▶ Stick the safety signs in the language of your country on top of the corresponding safety signs applied on the system.
- ▶ Apply additional laser safety signs in the language used in your factory.
- ▶ If a safety sign is no longer legible, clean or replace the safety sign.

Classification of the laser system acc. to EN 60825-1
This laser system is classified as class 1. The accessible laser radiation is not dangerous.

The label is applied at the following position(s):
- at the cover



Warning against visible and invisible radiation in case of bypassed safety devices in service mode!
Use your personal protective equipment to avoid damage to health. The laser safety sign is marked with a **2** in the **lower right** corner for better identification.



The label is applied at the following position(s):
- at the cover

Warning against laser radiation from the laser output aperture!
In order to avoid serious injuries to your skin or your eyes always comply with the safety instructions while operating the lasers.

The label is applied at the following position(s):

- on the front of the processing head

1.9 Safety devices

This chapter describes the safety devices of the system and how they work.

All system components are connected to the main earthing busbar in the system. The system is connected to the ground potential via the earth wire of the power supply cable.

⚠ DANGER

Danger to life by missing safety devices!

Missing or deactivated safety devices when working with the system cause serious or even fatal injuries.

- ▶ Always ensure that all safety devices are functioning properly and are switched on.
- ▶ Ensure that the safety devices are not bridged or manipulated in any other way.

⚠ DANGER

Danger to life by uncontrolled restart!

An uncontrolled restart of the system can cause serious injuries or even death.

- ▶ Before restarting the system, ensure that the reason for the emergency stop is eliminated and all safety devices are working properly.
- ▶ Only turn the main switch back to **I** or **ON** if there is no danger anymore.

⚠ CAUTION

Risk of injuries by external components!

If you use the main switch (**0** or **OFF**) to switch off the system, only the electrical power supply of the system is disconnected. The supply of the external components (e.g. compressed air, extraction system) is still connected and can cause injuries.

- ▶ Disconnect the supply of all external components immediately.
- ▶ Before working with pressurized components, ensure that these are completely depressurized and de-energized.

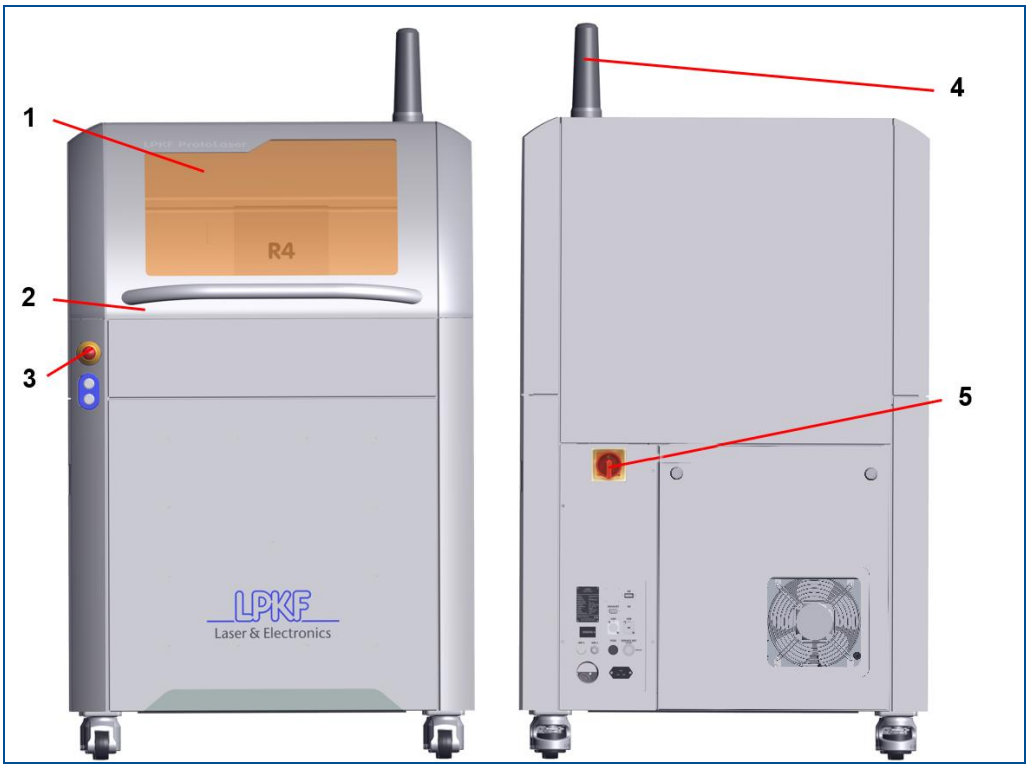


Fig. 2: System with safety devices

1 Cover with laser protection pane
2 Magnet switch of the cover
3 Emergency stop button
4 Stack light
5 Main switch

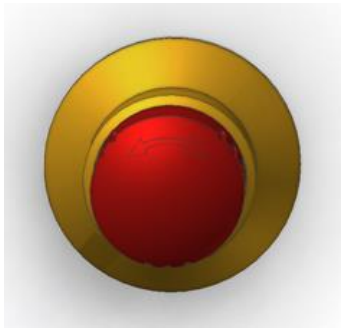
Figure	Description
	The laser protection pane (**1**) protects against laser radiation.
	The magnet switch (**2**) protects against opening the cover while the system is in operation. If the cover is opened while the system is operating, the safety circuit is interrupted and the laser is disconnected from the power supply.
	The emergency stop button (**3**) is located at the front of the system. Pushing this button immediately switches off the laser and stops the motorized axis. This stop is only intended for an emergency.

Figure	Description
	The stack light (**4**) indicates the system's operating state. The following operating states are displayed with the stack light: **Green: Ready for operation** The system is ready for operation or already in operation. No fault is present. **Orange: Service mode activated** Laser class 4 is possible because safety devices have been shut off. **Red: Fault** Work cannot be continued until the fault is successfully reset in the fault monitor. **Blinking red** The emergency stop button has been pushed.
	The main switch (**5**) at the rear of the system switches off or on the mains power supply. But it does not start the system yet. The main switch can be secured against restart with a padlock.

Table 7: Safety devices

Maximum service life of safety-relevant components

Component	Service life in years
Safety relay cover monitoring	8
Laser safety shutter	5
Safety control unit (emergency stop button)	20
Magnet switch of cover	20

Table 8: Service life

1.10 Securing against restart

The system can be secured with a padlock at the main switch. The padlock is not included in the delivery.

⚠ DANGER

Danger to life by uncontrolled restart!

An uncontrolled restart of the system can cause serious injuries or even death.

- ▶ Before restarting the system, ensure that the reason for the emergency stop is eliminated and all safety devices are working properly.
- ▶ Only turn the main switch back to **I** or **ON** if there is no danger anymore.

Securing against restart

1. Turn the main switch to **0 or OFF** to disconnect the system from the power supply.
2. Disconnect the supply of all external components.
3. Secure the main switch with a padlock.

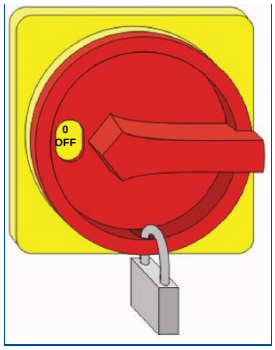


Fig. 3: Securing against restart

4. Keep the key safe.

☑ The system has been secured against restart.

1.11 Actions in case of an emergency

Preventive measures

- Always be prepared for fire and accidents!
- Keep first aid equipment (first aid kit, blankets etc.) and fire extinguishers in good working order and accessible at all times.
- Familiarize the personnel with accident reporting, first aid and rescue equipment.
- Keep access routes clear for rescue vehicles.

Actions in case of fire and accidents

- Use the emergency stop immediately to stop the system.
- Turn the main switch to **0** (**OFF**).
- Disconnect the supply of external components as soon as possible.
- If there is no risk for your own health rescue people from the danger zone.

Actions in case of a laser accident

- The injured person has to consult a dermatologist or eye specialist immediately. Always have the eye fundus examined.
- Switch off the laser system and secure the laser system against restart.
- Describe the accident details in a report.
- Inform the laser protection officer.
- Inform the supervisor.

1.12 Environmental protection

NOTICE

Environmental hazard by improper handling of substances!

Improper handling of environmentally hazardous substances, especially improper disposal, can cause considerable damage to the environment.

▶ Take appropriate measures immediately if environmentally hazardous substances are accidentally discharged into the environment. If you are in doubt, inform the appropriate local authorities about the damage and ask for appropriate measures that have to be taken.

The following environmentally hazardous substances are used:

Lubricants

Lubricants, such as greases and oils, contain toxic substances. They must not be released into the environment. They have to be disposed of by a waste management company.

Cleaning agents

Solvent-containing cleaning agents contain toxic substances. They must not be released into the environment. They have to be disposed of by a waste management company.

Coolant additive EUROLUB Kühlerschutz D-30

Has to be disposed of according to local regulations, e.g. at a suitable disposal site or a suitable incineration plant.

2 Technical data

General

Data	Value	Unit
IP Code (IEC 60529)	IP20	–
Service life	10	Years
Laser class (EN 60825-1:2014)	1 (production mode)	Class
	4 (service mode)	Class

Climatic conditions

Data	Value	Unit
Temperature range (operation)	22 ± 2 (~71.6 ± 3.6)	°C (°F)
Temperature range (storage, transport)	10 to 40, -20 to 50 (~50 to 104, -4 to 122)	°C (°F)
Max. humidity, non-condensing	< 60	%

Electrical data

Data	Value	Unit
Power supply:		
Voltage	110/230 AC	V
Stability	+10/-15	%
Frequency	50/60	Hz
Input fuse	T16	A
	5 × 20 (~0.2 × 0.8)	mm (in)
	250 AC	V
Nominal power	< 2.0	kVA
Leakage current	< 3.5	mA

Mechanical data

Data	Value	Unit
Dimensions (width × height × depth)	910 × 1650 × 795 (~35.8 × 65 × 31.3) (height with opened cover 1765 (69.5))	mm (in)
Weight (w/o packaging)	390 (~860)	kg (lbs)
Weight (with packaging)	482 (~1063)	kg (lbs)

Load capacity

Data	Value	Unit
Min. distributed load	6.8	kN/m²
Minimum point load on an area of 0.00196 m²	0.975	kN

Pneumatic data

Data	Value	Unit
Pressure	6	bar
Standard volume flow	128	l/min

Compressed-air purity acc. to ISO 8573-1:2010-04

Data	Value	Unit
Solid particles	1	Class
Water	4	Class
Oil	1	Class

Laser data

Data	Value	Unit
Laser type	picosecond	–
Laser power	8 (150 kHz or 200 kHz)	W
Laser wavelength	515	nm
Laser pulse frequency	50 to 500	kHz
Laser pulse lenght	1.5	ps
Focused laser beam (diameter)	15 ± 2	µm

Process data

Data	Value	Unit
Max. structuring area (x/y/z)	229 × 305 × 7 (~9 × 12 × 0.3)	mm (in)
Max. material size (x/y/z)	239 × 315 × 7 (~9.4 × 12.4 × 0.3)	mm (in)
Mark speed	5.5 (~0.9)	cm^2/min (sq in/min)
Minimum line/space	50/20 (on FR4 18 µm Cu)	µm
Base plate of the processing table (x/y)	268 × 344 (~13.1 × ~9.9)	mm (in)
z travel range processing table	11 (~0.4)	mm (in)
Accuracy of laser scan area (calibrated)	±8	µm
Positioning accuracy	±5	µm
Repeatability	±0.23	µm
Resolution	0.08	µm
Accuracy of camera scan area (calibrated)	±3.5	µm

Emissions

Data	Value	Unit
Sound pressure level LpA (EN ISO 3744)	< 70	dB (A)
Sound power level LwA (EN ISO 3744)	< 70	dB (A)
EMC limit class	A	–

3 Structure and function

This chapter describes the technical structure and the functions of the system.

3.1 Brief description

The system structures and depanels various circuit board materials with the integrated laser source. The laser source produces green radiation with a wavelength of 515 nm.

The system consists of five essential functional units:

- Laser source
- Chiller
- Beam deflection system with lens
- Processing table
- Camera system

3.2 Scope of delivery

This chapter provides an overview of the system's scope of delivery. For information on optional modules, accessories and extras refer to chapter Optional modules, accessories, extras on page 44.

ProtoLaser R4

- 2 × Control cabinet keys
- 1 × Screen with mains cable
- 1 × Keyboard
- 1 × Mouse
- 1 × Mains cable 230 V
- 1 × Mains cable 115 V
- 1 × Connection cable for extraction system
- 1 × DisplayPort cable
- 1 × USB cable
- 1 × Stack light
- 1 × Compressed-air tube
- 1 × Plastic container
- 1 × Coolant additive EUROLUB Kühlerschutz D-30
- 1 x Filter kit zero air filter
- 1 × Data medium Documentation
- 1 × Data medium CircuitPro PL
- 1 × Starter kit ProtoLaser
- 1 × Logbook

Data medium Documentation

The data medium contains the following:

- Brochure ProtoLaser R4
- User manual ProtoLaser R4
- Basic reference ProtoLaser R4
- Product catalog Rapid Prototyping
- How-to guides ProtoLaser U4/S4/R4

Data medium CircuitPro PL

The data medium contains the following:

- System software CircuitPro PL
- Product catalog Rapid Prototyping

Starter kit ProtoLaser (order code: SET-10-1128)

The starter kit contains the following:

Description	Quantity
Lens-cleaning tissue for lasers, 250 sheets stapled	1 pc
Sinter plate (315 mm x 239 mm x 1.5 mm; 12.4" x 9.4" x 0.06")	1 pc
Thin laminate 104 ML, 5/0 µm 305 (k) x 229 x 0.2 mm (9" x 12" x 0.008") with protective film	2 pcs
Cleaner, for removing oxide layers on copper surfaces	1 pc
Lubricant ISOFLEX TOPAS 5051	1 pc
Special ball-bearing grease Dynalub 510, 30 g (1.05 oz.)	1 pc
Protective gloves, light Nylon knit, lint-free, uncoated, size 9	1 pc
Base material FR4, pre-drilled with 2 register holes (229 mm x 305 mm x 1.5 mm (9" x 12" x 0.06"), copper 0/18 µm (0.7 mil))	2 pcs

Table 9: Starter kit ProtoLaser

Wear parts

The following wear parts are excluded from the warranty:

- Sinter plate
- Gas spring of the cover
- Teflon contact face of the extraction hood

3.3 Type label

The type label is located at the housing of the system. For information on identifying the system and the relevant equipment, specify the system model and the serial number on the type label when you contact the LPKF Service.

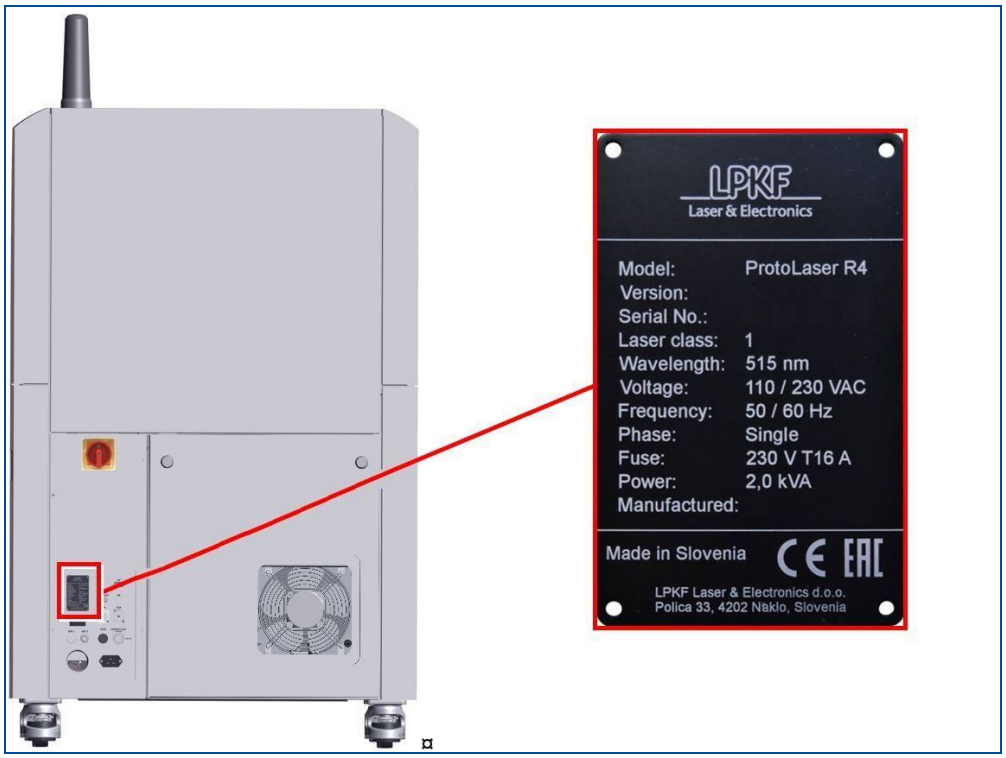


Fig. 4: Type label

Name	Description
Model	System type
Version	Version number
Serial No.	Serial number
Laser class	Laser class
Wavelength	Laser wavelength
Voltage	Operating voltage
Frequency	Line frequency
Phase	Number of phases
Fuse	Fuse protection
Power	Power consumption
Manufactured	Year of manufacture
Made in Slovenia	Country of Origin

Table 10: Type label

3.4 System components

This chapter describes the components of the system. First of all, make yourself familiar with the individual components of the system before starting the operation. Before operating the system, also inform yourself about the important software elements and the different operation modes.

3.4.1 Total view

The following figures show an overview of the system and its components.

Front of the system

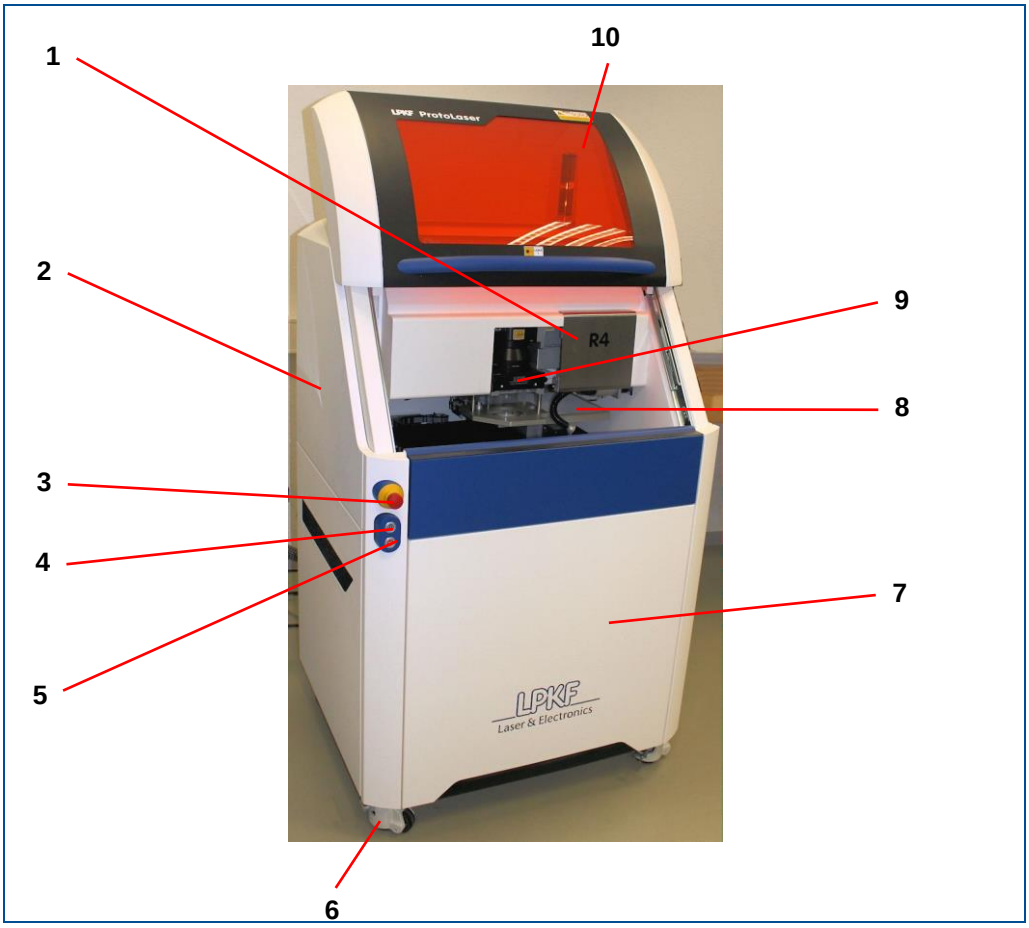


Fig. 5: Front of the system with opened cover

1	Maintenance cover in processing area	**6**	Leveling foot
2	Housing	**7**	Maintenance door
3	Emergency stop button	**8**	Processing table
4	On/Off switch	**9**	Processing unit
5	Button *ACK*	**10**	Cover

Rear of the system

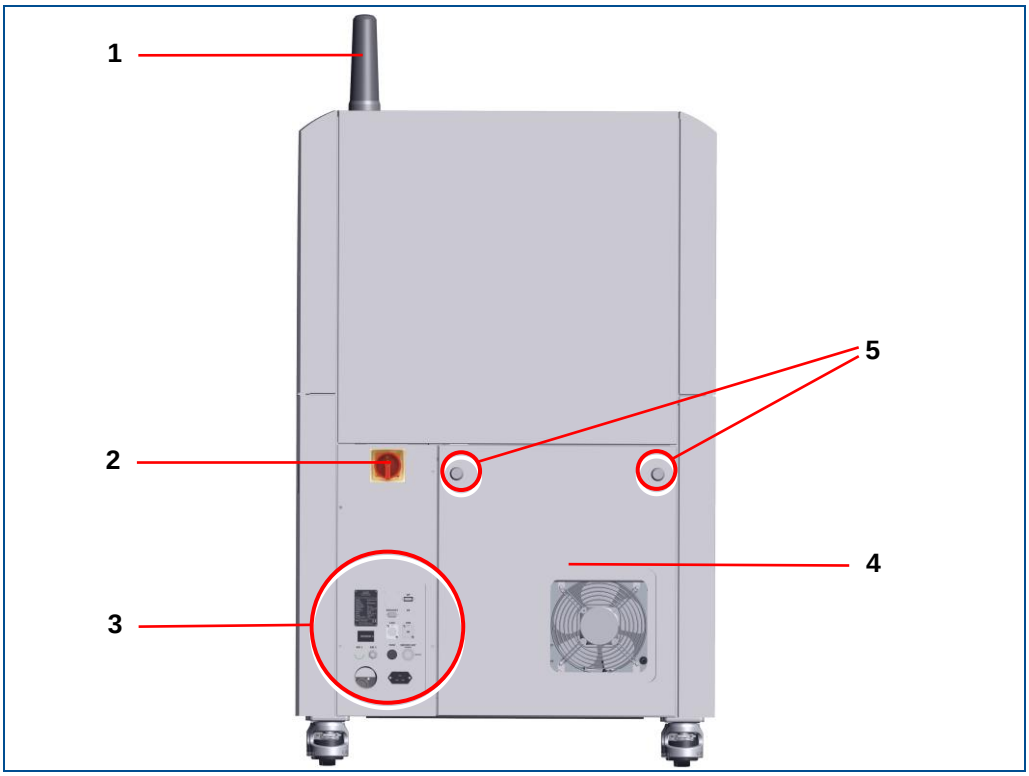


Fig. 6: Rear of the system

1 Stack light
2 Main switch
3 Connectors, displays and control elements
4 Rear cover
5 Keyholes of the rear cover

Right side of the system

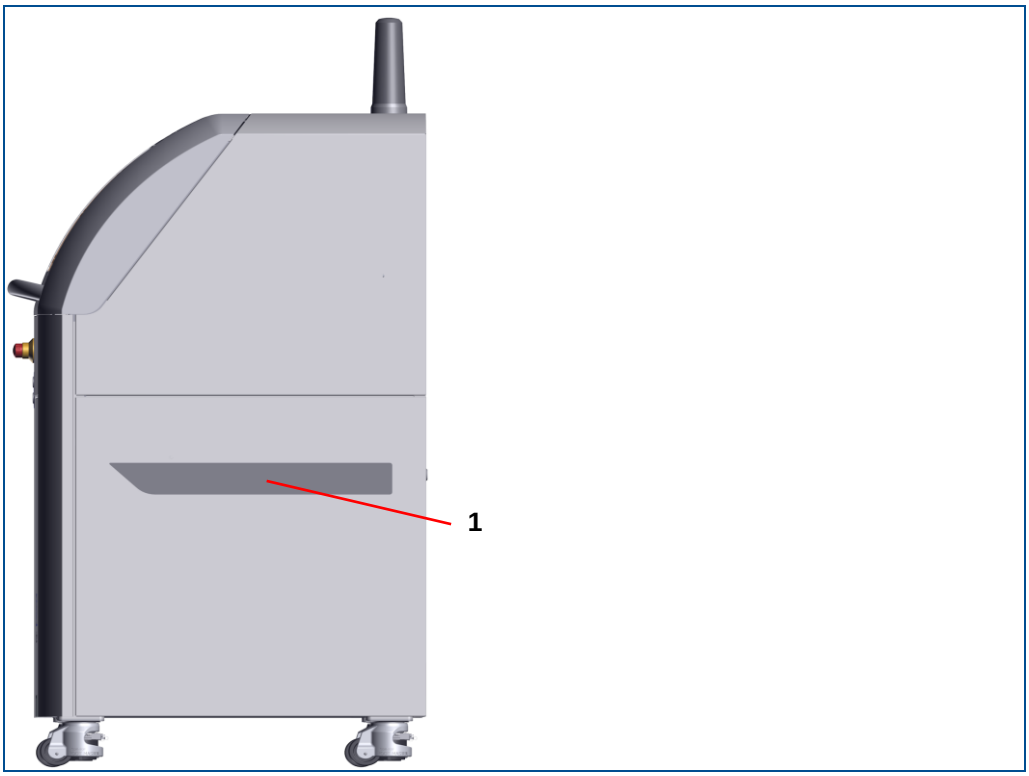


Fig. 7: Right side of the system

1 Ventilation slot

Left side of the system

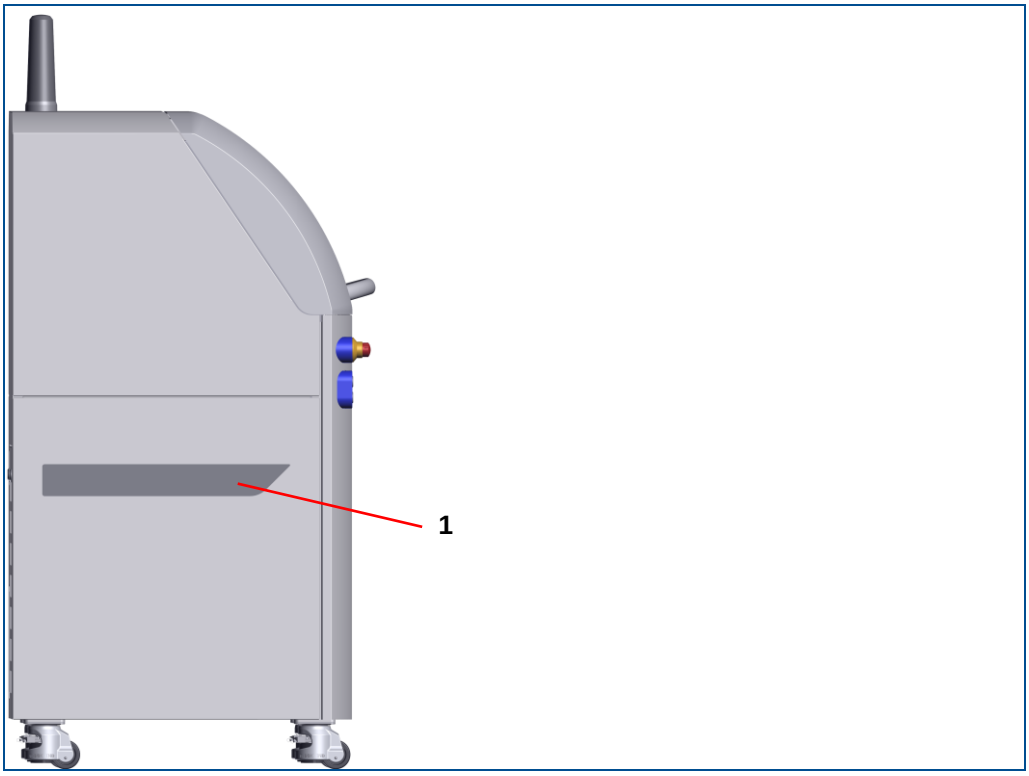


Fig. 8: Left side of the system

1 Ventilation slot

3.4.2 Laser source

The laser source produces pulsed laser radiation with a wavelength of 515 nm with a power of < 8 W. The laser source was designed to produce a laser beam of exceptionally high quality with high pulse-to-pulse stability, excellent long-term reliability and robustness in industrial quality. It contains all the necessary components such as the laser safety shutter. The laser source is suitable for industrial use and requires little maintenance.

3.4.3 Processing head

Processing head

The processing head expands, deflects and focuses the laser beam.

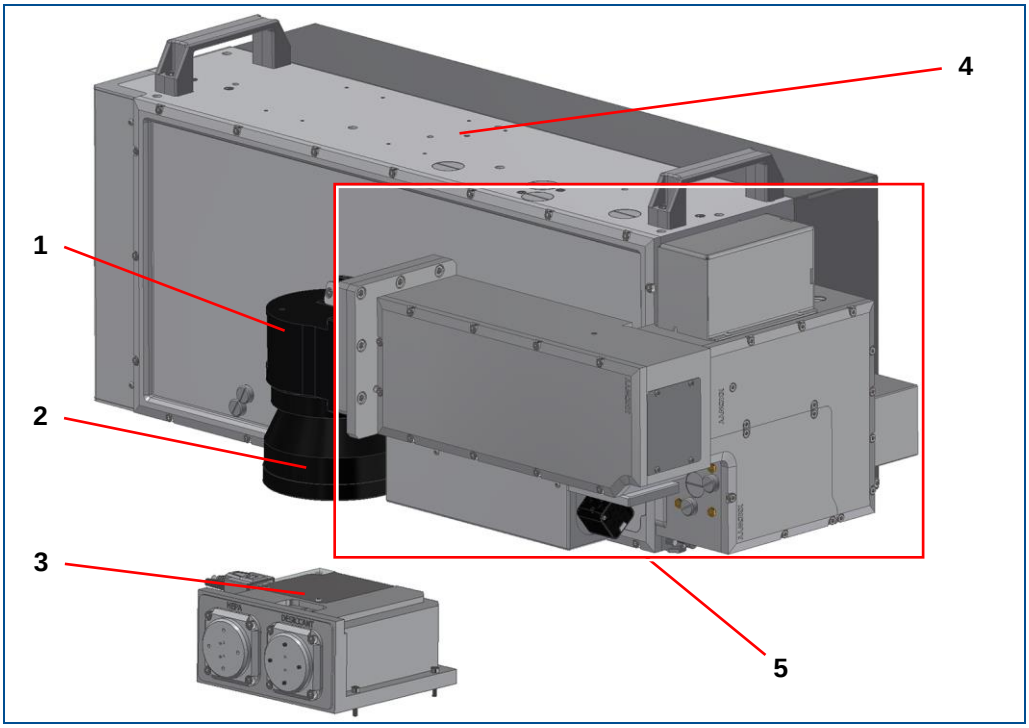


Fig. 9: Processing head

1 Scanner unit

2 Telecentric F-theta lens

3 Zero air generator (located behind the maintenance door)

4 Laser source

5 Beam guidance module

Beam deflection with telecentric f-theta lens

The laser beam (**5**) reaches the lens (**3**) via two 45° deflection mirrors (**2**). In the scanner unit, the laser beam (**5**) is deflected in x and y direction by two individually driven galvanometer scanners (**1** + **6**) (dynamic deflection). This setup in conjunction with the telecentric f-theta lens (**3**) makes it possible to deflect the beam that is otherwise immobile. This produces a square image field that is called the scan field (**4**).

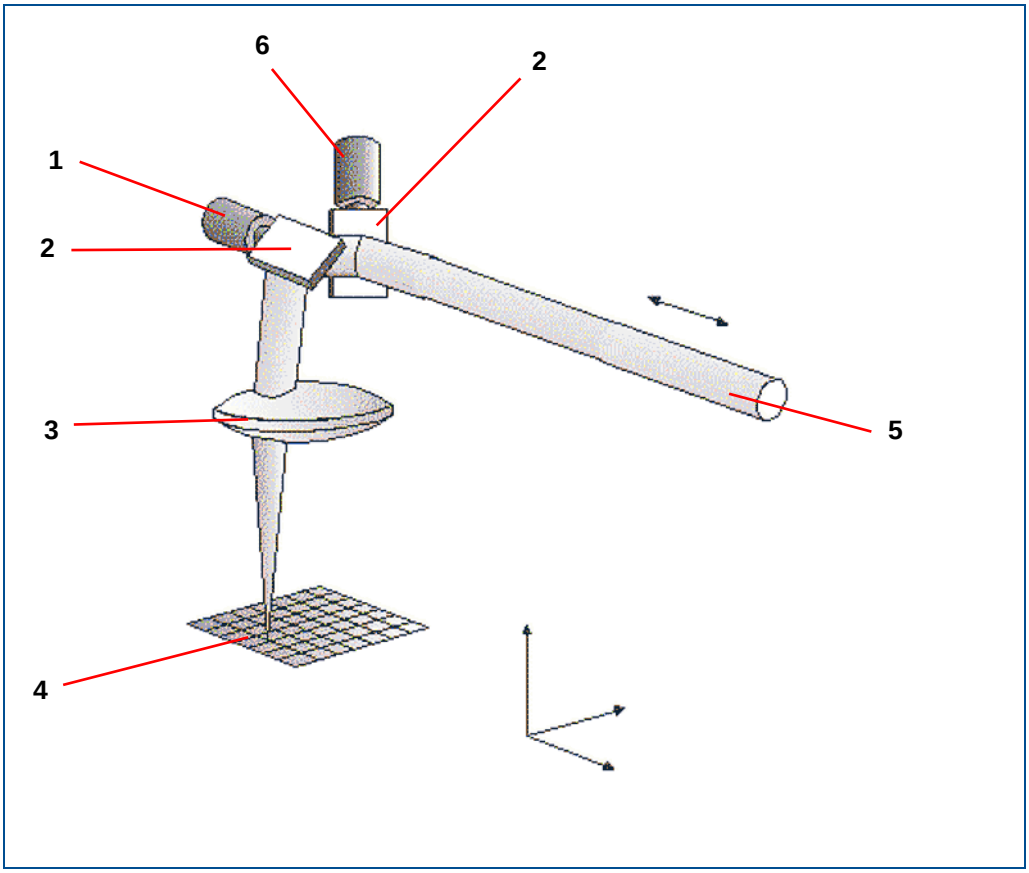


Fig. 10: Scan field creation

1	x galvanometer scanner	**4**	Scan field
2	Deflection mirror	**5**	Laser beam
3	Lens	**6**	y galvanometer scanner

As a result of the rotation of the mirrors attached to the galvanometer scanners, the incident laser beam moves on the mirror surfaces. This causes a cushion or barrel distortion of the scan field (see following figure).

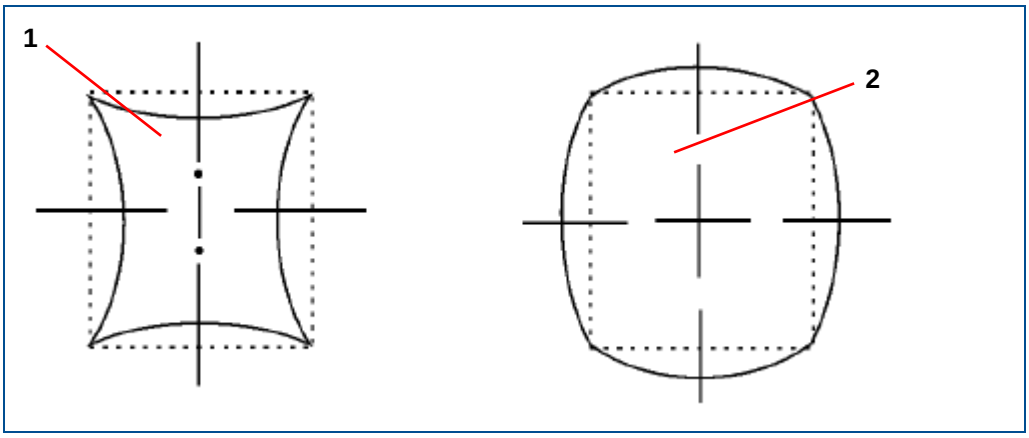


Fig. 11: Cushion and barrel distortion

1 Cushion distortion **2** Barrel distortion

Due to the spatial distance between the two mirrors and additional effects of the lens, the real scan field is a combination of cushion distortion and barrel distortion (see following figure).

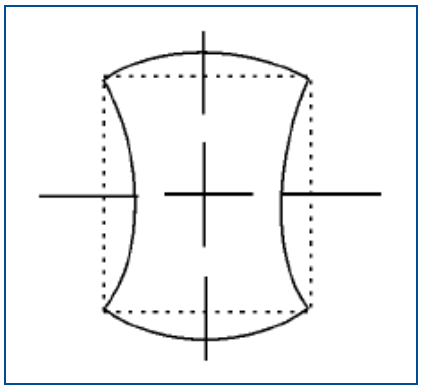


Fig. 12: Cushion-barrel distortion

To allow micro structuring without offsets, the scanner unit is calibrated so that a square scan field is achieved (see following figure).

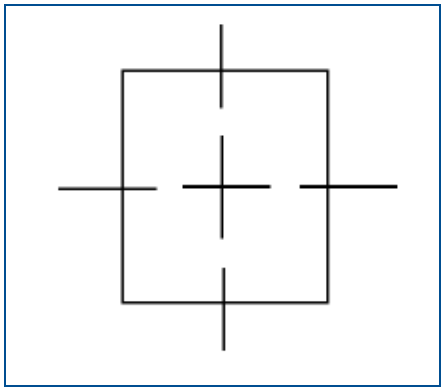


Fig. 13: Calibrated scan field

Any change of the laser focus height, e.g. by changes of the laser to camera offset, repairs or maintenance on the processing table, or replacement of the sinter plate requires that the scan field is checked and calibrated anew, if necessary.

The system has been calibrated ex works. However, if calibration errors should occur, contact the LPKF Service. The contact details are in the first pages of this manual in the information on customer service.

3.4.4 Processing table

The processing table moves the part precisely under the processing head. An integrated vacuum table fastens the material evenly onto the processing surface without the need for pins or clamps.

The mechanical z axis of the processing table allows to process materials of various thicknesses. The mechanical z axis is driven by a combination of a stepper motor and a table-lifting mechanism.

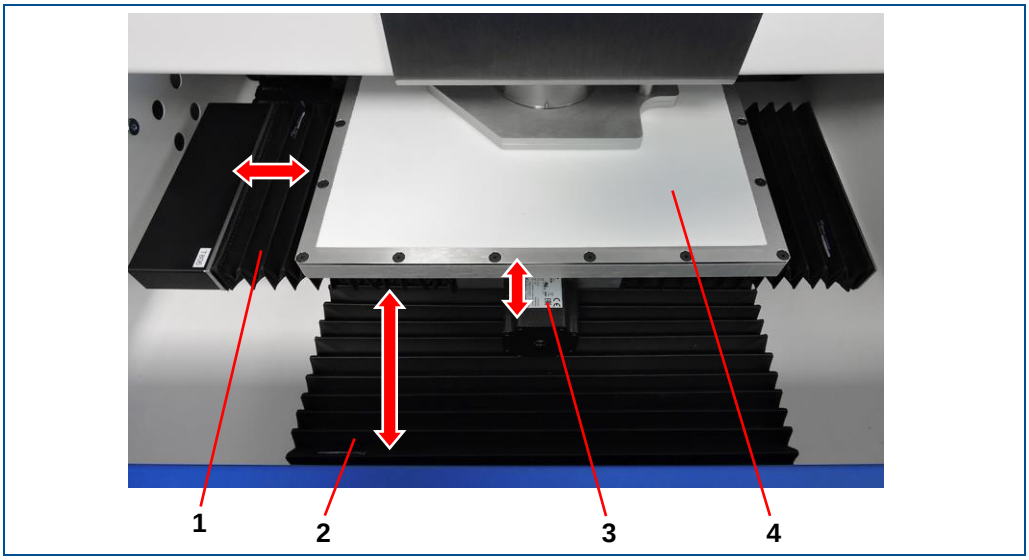


Fig. 14: Processing table

1 x axis
2 y axis
3 z axis
4 Vacuum table

3.4.5 Extraction hood

The extraction hood with integrated compressed-air nozzles extracts the detached copper during processing. The Teflon contact face of the extraction hood rests on the material creating a defined airflow.

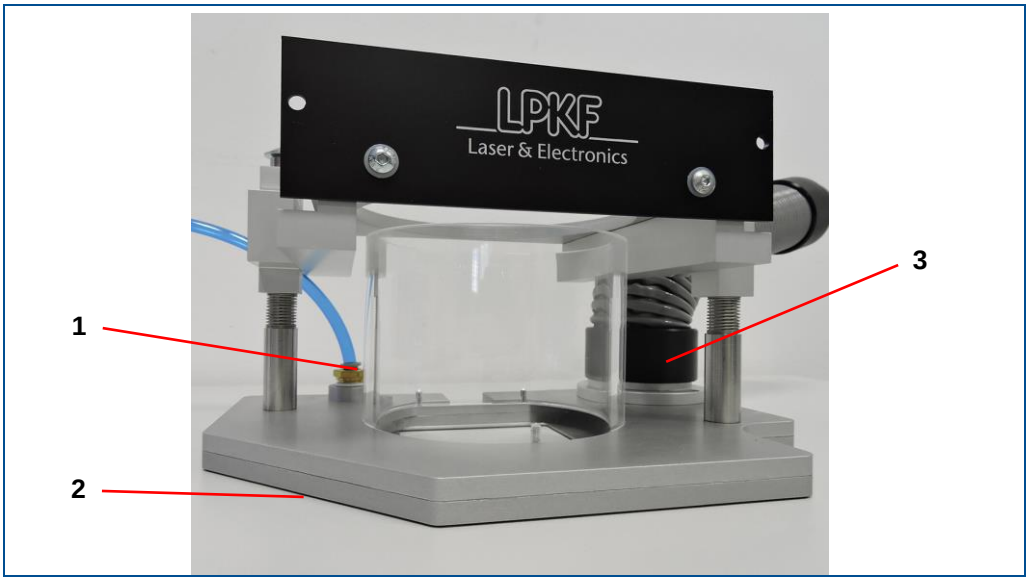


Fig. 15: Extraction hood

1 Connection for compressed-air
2 Teflon contact face
3 Connection for extraction hose

3.5 Optional modules, accessories, extras

The system can be equipped with the following accessories:

- Extraction system LMD 508 with prefilter unit
- Compressor MONSUN Fast R

Refer to the product catalog to find a list of all tools and optional modules available. For more information contact the LPKF sales department or your local representative.

Extraction system with prefilter unit

The extraction system LMD 508 with prefilter unit is used as a standard accessory. For a detailed description of the extraction system refer to the supplied manufacturer's manual.

⚠ WARNING

Health hazard by gases or dusts!

Processing materials with laser beams can produce gases or dusts hazardous to health.

- ▶ Process only materials that are approved by LPKF.
- ▶ Only work with an extraction system that is switched on and is working properly.

⚠ CAUTION

Health hazard by insufficient filtration!

Filters cannot be cleaned or reused. If you are using saturated, defective or no filters at all, filtration of particles that can be harmful to health is not guaranteed.

- ▶ Only operate the system with installed and working filters.
- ▶ Observe the recommended maintenance intervals and replace the filters in time.
- ▶ Dispose of the saturated filters properly. Observe the local disposal regulations.

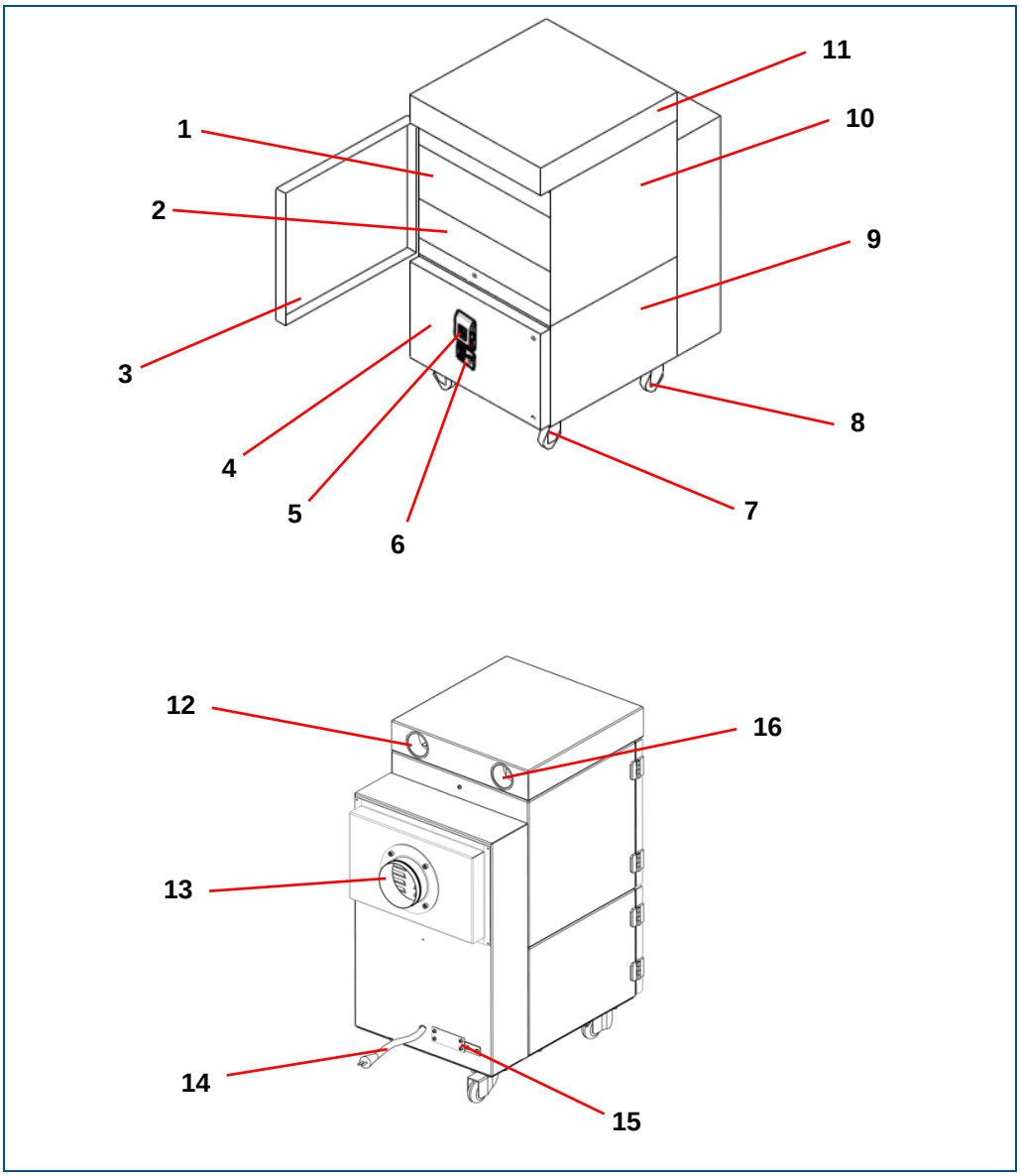


Fig. 16: Overview extraction system

1 Particle filter
2 Activated carbon filter
3 Filter door
4 Fan door
5 Antenna of the ControlUnit 2
6 Control panel
7 Caster wheel with brake
8 Caster wheel
9 Fan housing
10 Filter housing
11 Housing cover
12 Intake fitting
13 Exhaust muffler with exhaust fitting
14 Mains cable with mains plug
15 Cover or Harting socket or 9-pin D-sub socket
16 Intake fitting

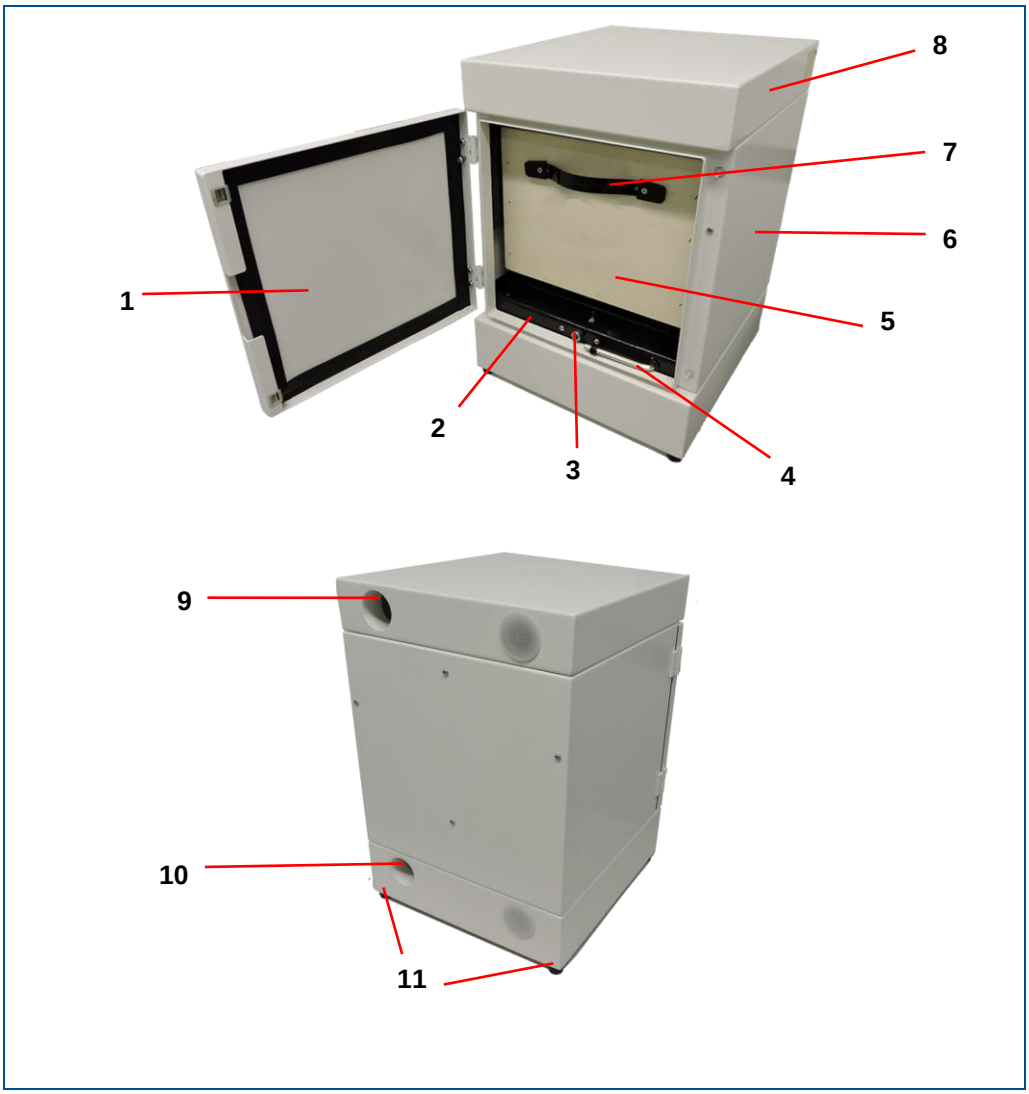


Fig. 17: Overview prefilter unit

1	Filter door	**7**	Handle of the filter drawer
2	Lifting mechanism	**8**	Housing cover
3	Locking screw for the lifting mechanism	**9**	Intake fitting
4	Hex key	**10**	Intake fitting
5	Filter drawer	**11**	Housing feet
6	Filter housing		

Compressor

The compressor MONSUN Fast RL can be used for producing compressed air. For a detailed description of the compressor refer to the supplied manufacturer's manual.

⚠ WARNING

Risk of injuries by pressurized components!

Pressurized components (e.g. compressed-air supply) can move uncontrollably in case of improper handling or in case of a defect and can cause serious injuries.

- ▶ Depressurize the components before working on them. De-energize the residual energies.
- ▶ Always ensure that there is no unintended escape of compressed air.
- ▶ Defective components that are under pressure when operating the system have to be replaced immediately by sufficiently qualified personnel.

Fig. 18: Compressor

If you are using other accessories, refer to the manufacturer's manual for more information.

3.6 Connections

The connectors are located at the lower left rear of the system and are described in this chapter.

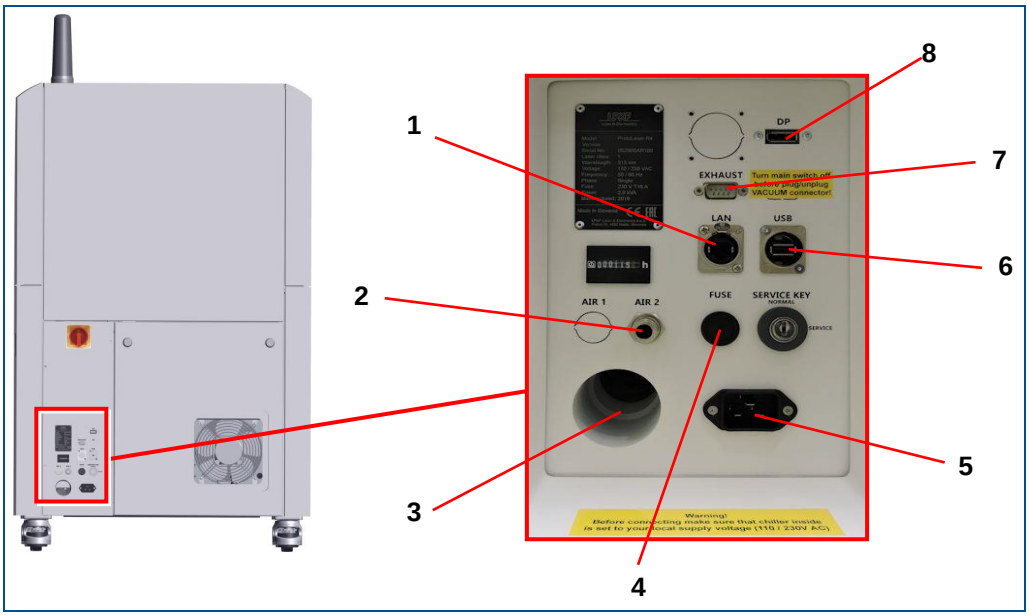


Fig. 19: Connectors

1 Network connector

2 Compressed-air connector (coupling for 8 mm outer tube diameter) for connecting to the compressed-air supply

3 Extraction socket, for connecting to the extraction system

4 Fuse

5 Socket, for connecting the mains cable

6 USB 3.0 socket, type A , for connecting the keyboard and mouse via the screen to the system.

7 9-pin D-sub connector, connector for the extraction system

8 DisplayPort connector, for connecting the system to the screen

3.6.1 Installing the extraction hood

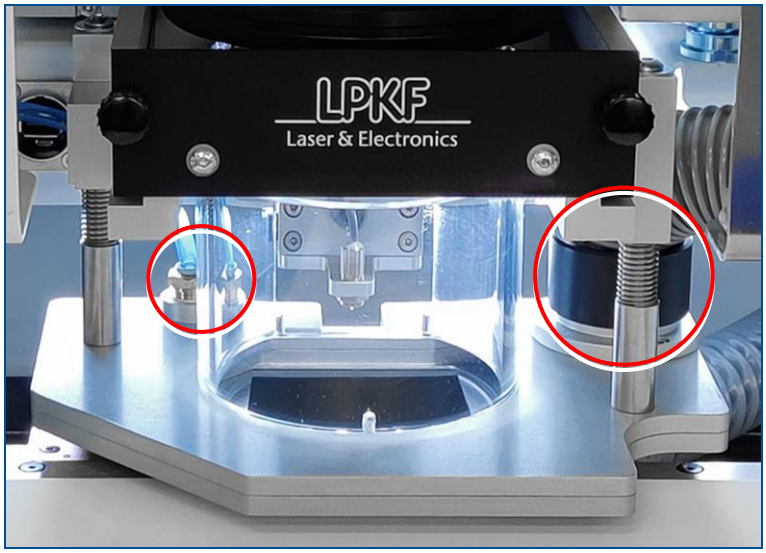


Fig. 20: Connections for compressed-air nozzles and extraction hood

Extraction manifold

The extraction manifold is at the right rear of the processing area. The control lever of the extraction manifold controls the vacuum in the extraction hood and on the processing table.

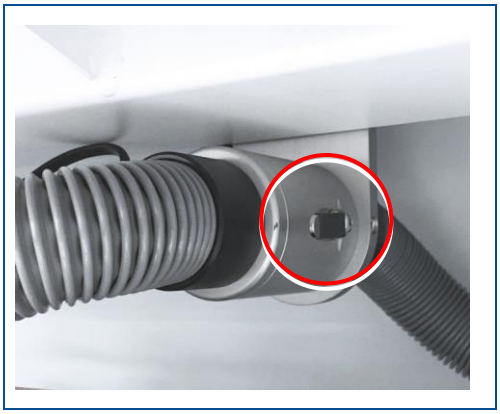


Fig. 21: Control lever in horizontal position

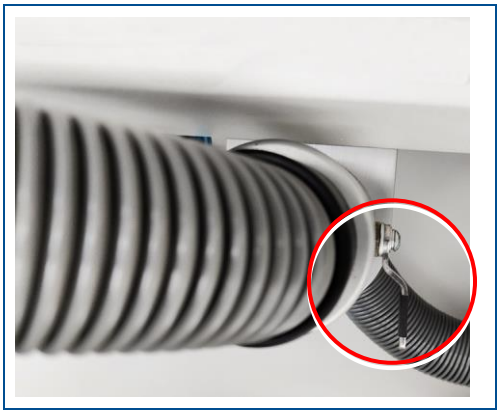


Fig. 22: Control lever in vertical position

The control lever is operated as follows:

- Turning the control lever towards the horizontal position — The vacuum in the extraction hood is increased and on the processing table it is reduced.
- Turning the control lever towards the vertical position — The vacuum in the extraction hood is reduced and on the processing table it is increased.

3.6.2 Power meter connector

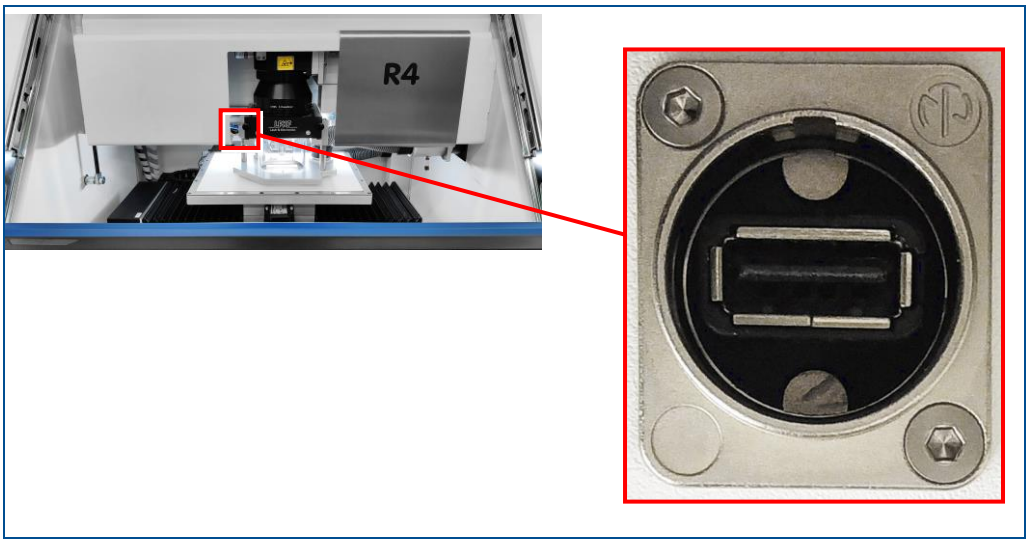


Fig. 23: USB port (power meter connector)

This port is used by the LPKF Service for connecting the power meter, if necessary.

3.6.3 Pin assignment

The system is equipped with a male 9-pole sub-D connector that provides remote control of the external extraction system. At this interface you have to connect the data cable for the extraction system to exchange control and status signals with the system.

NOTICE

Property damage by a different extraction system!

Extraction systems that are not approved by LPKF can cause system damage.

- ▶ Use extraction systems that are approved by LPKF in order to guarantee a safe use of the system and to avoid damage.
- ▶ Only use the delivered connection cable.
- ▶ If there is any doubt, contact the LPKF Service for checking compatibility of a different extraction system.

Pin	Type	Name	Description
1,2	Output	Start	Pin 1 and pin 2 not connected (max. 100 mA) Extraction system is started if pin 2 has 24 VDC.
3,4	Input	Filter full	Extraction filter full (contact closed if filter full)
5,6	Input	Extraction system is in process	Extraction system activated (contact closed if vacuum activated)
7	Output	Increase extraction power	Not connected
8	Output	Decrease extraction power	Not connected
9	Power supply	GND	Ground terminal for signal of pin 7 and pin 8 (24 V)

Table 11: Pin assignment

3.7 Displays and control elements

This chapter describes the displays and control elements of the system. First of all, make yourself familiar with the individual components of the system before starting the operation.

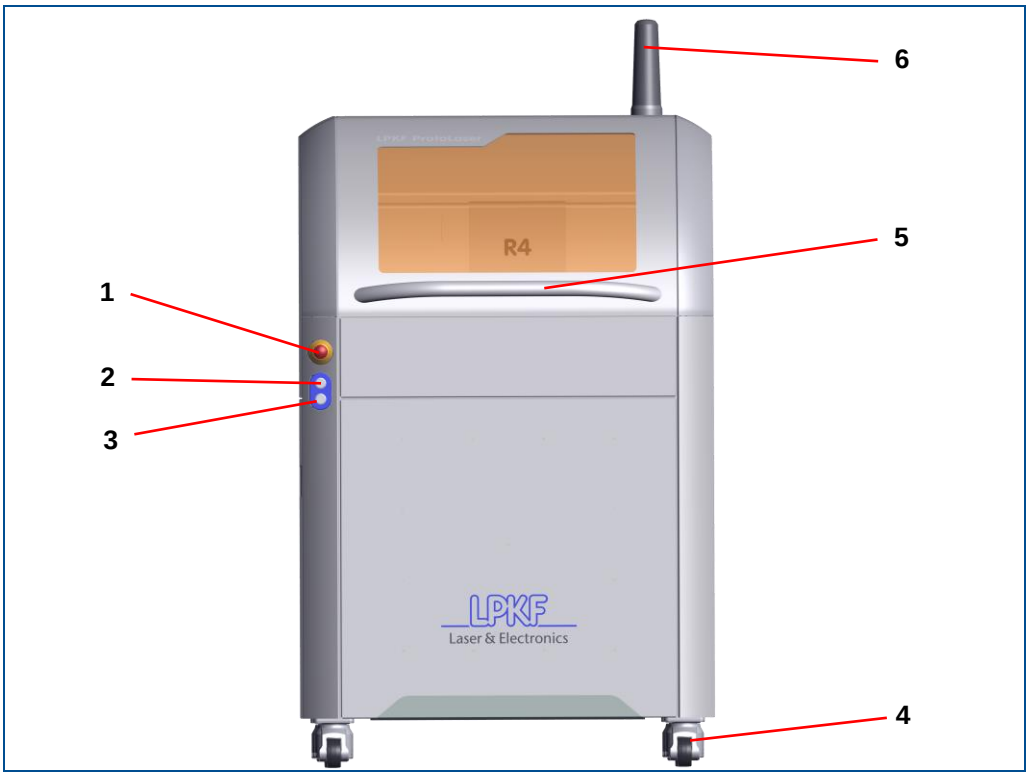


Fig. 24: Displays and control elements at the front of the system

1 Emergency stop button
2 On/Off switch
3 Button *ACK*
4 Adjustment lever of the leveling foot
5 Handle
6 Stack light

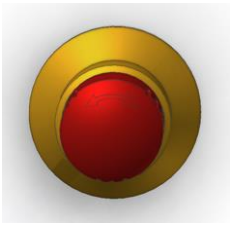
Figure	Description
	Pushing the emergency stop button (**1**) immediately switches off the laser and stops the motorized axes. This stop is only intended for an emergency.
	After switching on the main switch, the button for starting the system has to be pressed additionally. In daily operation of the system, this button (**2**) can be used for switching the system on and off. If the system is switched on, this button is lit blue.

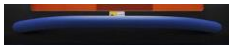
Figure	Description
	By pressing the button *ACK* (**3**), the operating personnel confirms that the system is in a fault-free state.
	The adjustment lever (**4**) with toggle function is used for height adjustment of the leveling foot and locking it.
	The handle (**5**) is used for opening and closing the cover.
	The stack light (**6**) indicates the system's operating state. The following operating states are displayed with the stack light: **Green: Ready for operation** The system is ready for operation or already in operation. No fault is present. **Orange: Service mode activated** Laser class 4 is possible because safety devices have been shut off. **Red: Fault** Work cannot be continued until the fault is successfully reset in the fault monitor. **Blinking red** The emergency stop button has been pushed.

Table 12: Displays and control elements at the system front

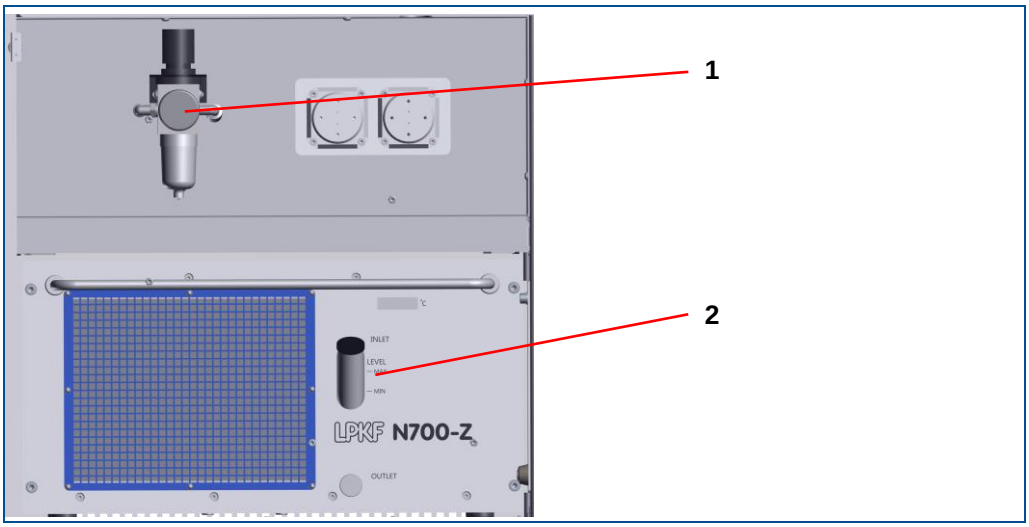


Fig. 25: Displays and control elements behind maintenance door

1 Compressed-air filter regulator with pressure gauge

2 Fill level indicator of chiller

Figure	Description
	The filter regulator (**1**) filters the compressed air and reduces the input pressure. The filter regulator is preset to a maximum permitted output pressure of **2.0 bar** (0.2 megapascal [MPa]).
	The fill level indicator (**2**) of the chiller shows the current fill level.

Table 13: Displays and control elements behind maintenance door

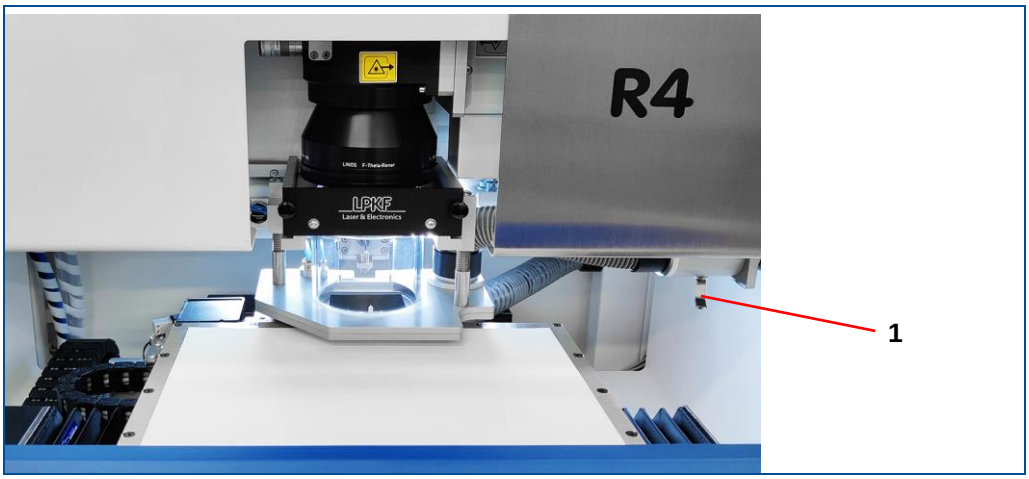


Fig. 26: Displays and control elements in processing area

1 Control lever of extraction manifold

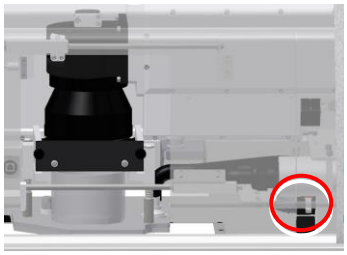
Figure	Description
	The control lever (1) of the extraction manifold controls the vacuum in the extraction hood and on the processing table.

Table 14: Displays and control elements in processing area

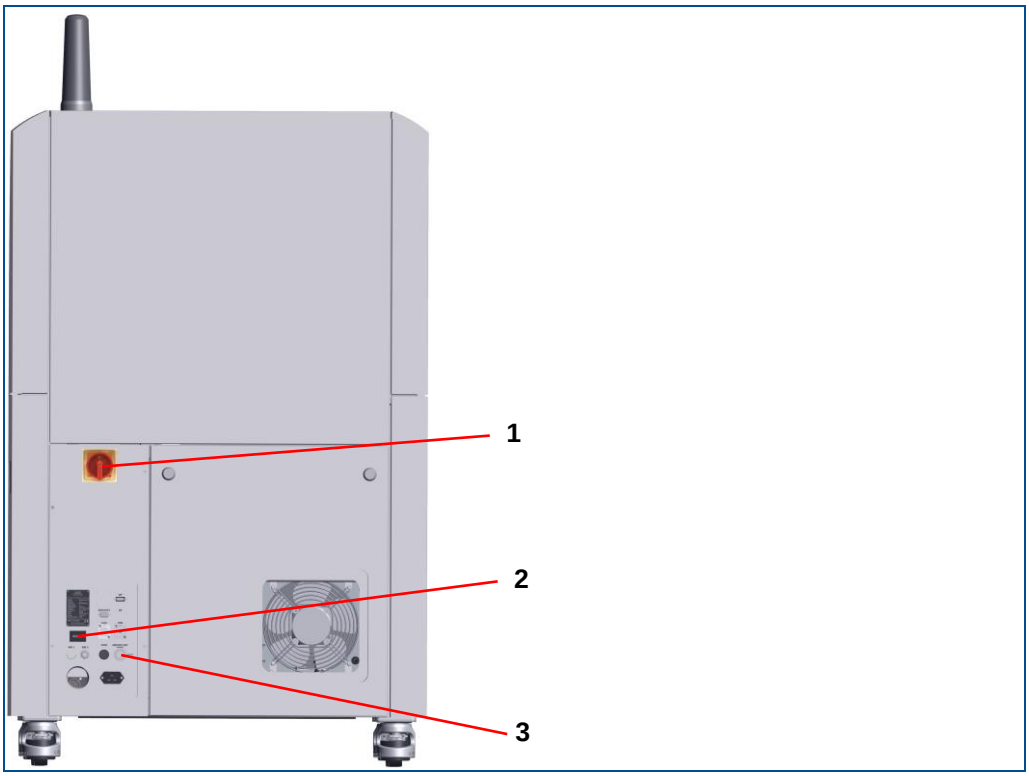


Fig. 27: Displays and control elements at the rear of the system

1 Main switch

2 Operating hours counter

3 Key switch *SERVICE KEY*

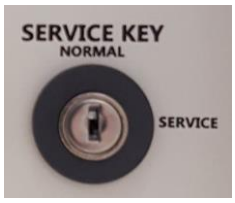
Figure	Description
	The main switch (**1**) switches on or off the mains power supply.
	The operating hours counter (**2**) displays the accumulated operating hours.
	The key switch *SERVICE KEY* (**3**) is located at the rear of the system and may only be used by authorized persons. The key switch *SERVICE KEY* switches the system into the service mode. The horizontal key position of the key switch *SERVICE KEY* switches on the service mode; the vertical key position of the key switch *SERVICE KEY* switches off the service mode.

Table 15: Displays and control elements at the rear of the system

3.8 Software

The system is operated with the preinstalled system software CircuitPro PL. The system software is used for preparing the layout data and for controlling the system.

For detailed information on operating the system software press F1 to invoke the help function.

System requirements CircuitPro PL

The following table lists the recommended system configuration for working with CircuitPro PL:

Component	System configuration
CPU	Dual Core 2.6 GHz LPKF discourages the use of the following CPU because it causes problems: • Intel Xeon
RAM	16 GB
Memory requirements	2 GB
Graphics card	With 1 GB dedicated memory (non-shared memory) LPKF discourages the use of the following graphics card because it causes problems: • Intel 82945G
Screen resolution	1680 × 1050 pixels
Operating system	Windows 10 (64bit)

Table 16: Recommended system configuration CircuitPro PL

The following table lists the minimum system configuration for working with CircuitPro PL:

Component	System configuration
CPU	2 GHz LPKF discourages the use of the following CPU because it causes problems: • Intel Xeon
RAM	4 GB
Memory requirements	2 GB
Graphics card	With 128 MB dedicated memory (non-shared memory) LPKF discourages the use of the following graphics card because it causes problems: • Intel 82945G
Screen resolution	1280 × 768 pixels
Supported operating systems	Windows 10 (64bit)

Table 17: Minimum system configuration CircuitPro PL

Switching on the system

1. Press the on/off button at the system front.

☐ The system is started up. The PC boots automatically.
The on/off button is lit.

2. Double-click on the desktop icon of LPKF CircuitPro PL.

Fig. 28: Desktop icon CircuitPro PL

☐ The following message is displayed:

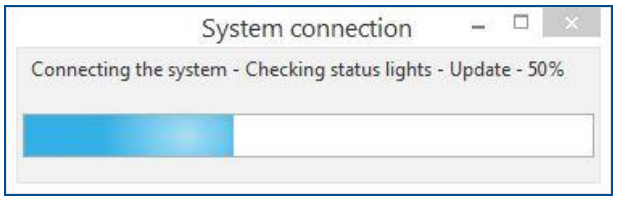


Fig. 29: Message *System connection*

☐ The system software recognizes the system automatically and establishes the connection. The following dialog is displayed:

Fig. 30: Dialog *Signal light check*

3. If all lamps of the stack light are lit, click on [Yes].

☐ The user guidance step *New* is displayed:

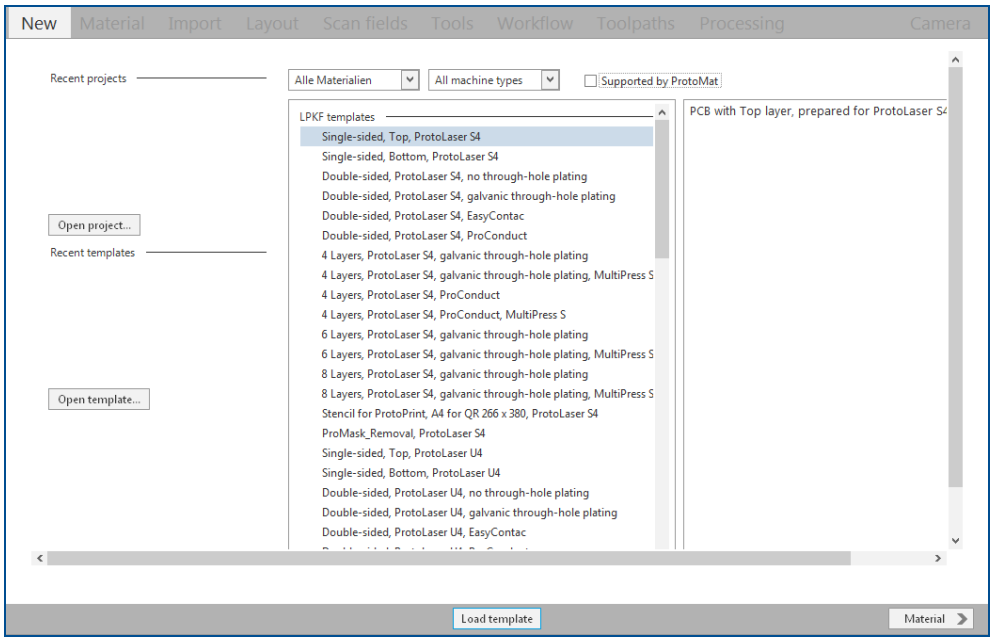


Fig. 31: User guidance step *New*

4. Select *Single-sided* from the drop-down list.

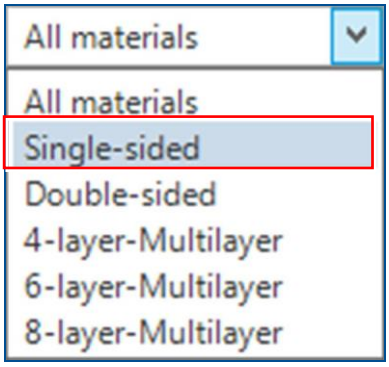


Fig. 32: Drop-down list material

5. Select your laser system from the drop-down list (in this example *PL R4*).

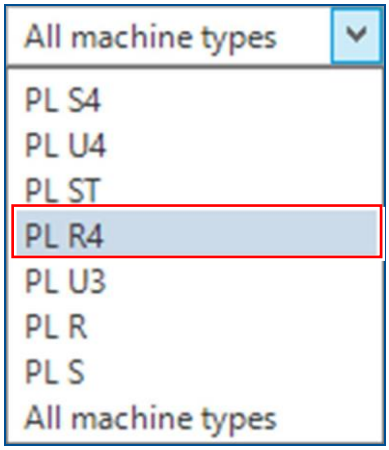


Fig. 33: Drop-down list system

☐ A list of templates for single-sided materials is displayed:

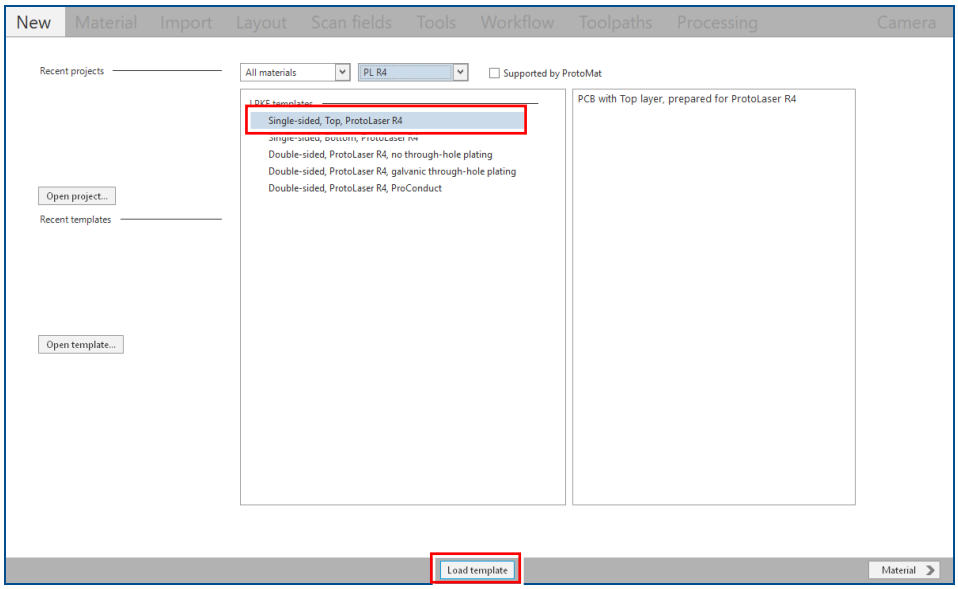


Fig. 34: List of templates

6. Select the template *Single-sided, Top, ProtoLaser R4*.
7. Click on [Load template] or double-click on the template.

☐ The user guidance step *Material* is displayed.

☑ The system has been switched on.

Connecting the system manually

If automatic connection of the system fails, you can connect the system manually with the system software: Click on *Processing* > *Connect to machine…* select your system in the drop-down list and click on [Connect].

The system requires a warm-up time of up to **20** minutes for the laser source to attain a constant diode temperature. The warm-up phase starts automatically when processing the first job.
You can continue to work in the user guidance step *Layout* during the warm-up phase.

Tips for selecting a template:

- Select the template according to the number of layers.
- Select the template according to the metallization type.
- Select the template according to the type of multi-layer press.

3.9 Modes of operation

The system can be operated in the following modes:

Production mode

The system is normally operated in the production mode. The stack light is lit **green**. In the production mode, the system can execute movements and emit laser radiation while the cover is closed.

Service mode

The service mode may only be activated by the LPKF Service because switching from laser class 1 to laser class 4 constitutes a hazard. The signal light is lit **orange**.

Switching between the modes of operation

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- Wear laser safety glasses

The key switch *SERVICE KEY* is located at the rear of the system and may only be used by authorized persons. The key switch switches the system into the service mode which deactivates the safety devices.

⚠ WARNING

Risk of injury by laser radiation!

As soon as the system is switched to the service mode it is classified as laser class 4.

- ▶ Always wear your personal protective equipment.
- ▶ Never look directly into the laser beam.

The horizontal key position of the key switch *SERVICE KEY* switches on the service mode; the vertical key position of the key switch *SERVICE KEY* switches off the service mode.

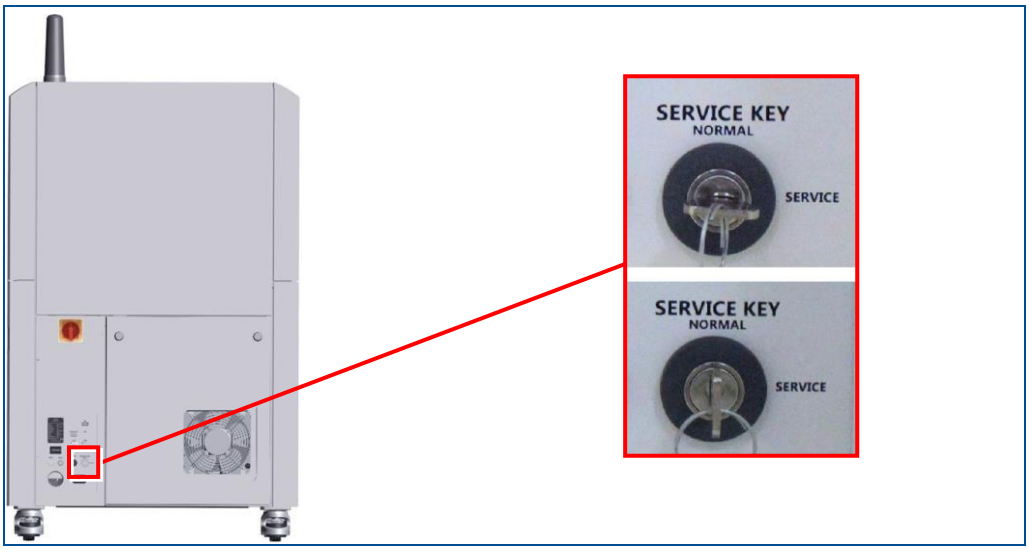


Fig. 35: Key switch *SERVICE KEY*

4 Transport and storage

This chapter contains important information on transport, packaging and storage of the system.

NOTICE

System damage by improper transport!

Improper transport can cause damage to the system.

- ▶ Transport the system cautiously to the place of installation.
- ▶ Observe the symbols on the packages.
- ▶ Remove the packaging only directly before system installation.

4.1 Transport inspection

Check the delivered goods immediately upon receipt for completeness and for transport damage.

If transport damage is evident or a ShockWatch® indicator or a TiltWatch® indicator has been activated, proceed as follows:

- ▶ Do not accept the delivery or only with reservations.
- ▶ Record the extent of damage on the transport documentation or on the delivery note of the transport company.
- ▶ Use photographs to document the damage.
- ▶ Initiate a complaint.

4.2 Packaging

The packaging is chosen according to the transport conditions.

The packaging is to protect the system from transport damage, corrosion, and other kinds of damage until installation.

- ▶ Keep the packaging in its original form.
- ▶ Only remove the packaging just before installation.

Handling packaging material

- ▶ Dispose of the packaging material according to the current laws and local regulations.

NOTICE

Environmental hazard by wrong disposal of packaging!

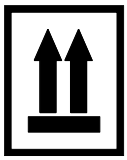
Wrong disposal of packaging material can cause environmental hazards.

- ▶ Dispose of the packaging material environmentally friendly.
- ▶ Observe the local disposal regulations and hire a specialized company for the disposal, if necessary.

- ▶ The system may only be shipped in the original packaging of LPKF. Contact the LPKF Service if you need the packaging.

4.2.1 Symbols on the packaging

Observe the following symbols on the packaging when transporting the system:



Top
The arrowheads of the symbol indicate the top side of the package. These always have to point upwards, otherwise, the contents could be damaged.

Keep dry
Protect packages against moisture and keep them dry.

Fragile
Identifies packages with fragile or sensitive contents. Handle the package with care, do not drop, and do not subject it to shocks.

4.2.2 Unpacking the system

The following describes how to unpack the system. Observe also the unpacking instructions.

⚠ CAUTION

Risk of injury by sharp edges!

When working with the leveling feet, sharp edges of the adjusting lever can cut your hands.

▶ Always wear protective gloves.

Unpacking the system

1. Remove the screws from the lid.
2. Lift off the lid.

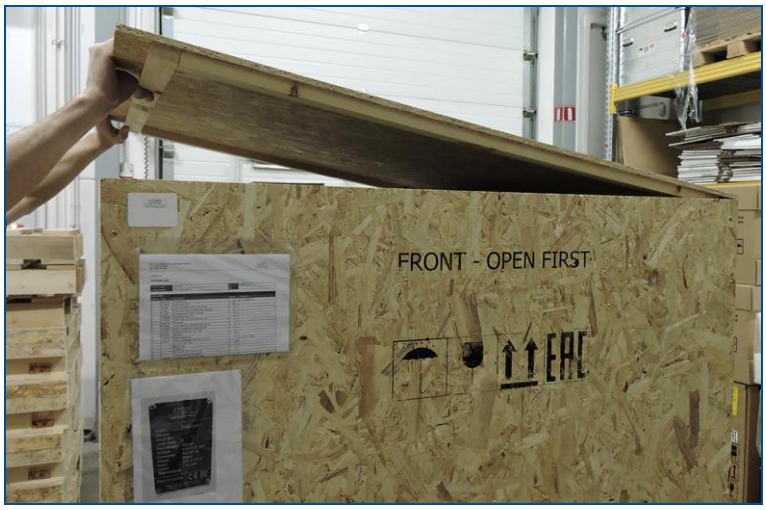


Fig. 36: Lifting off the lid

3. Remove the top padding material.

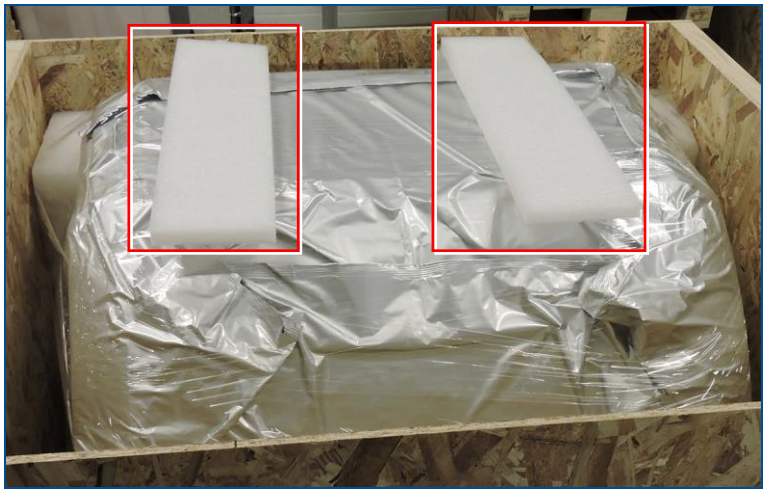


Fig. 37: Top padding material

4. Remove the screws from the front of the packaging.

5. Remove the front.

Fig. 38: Packaging without front

6. Remove the screws from the side and rear panels.
7. Remove the side and rear panels.

Fig. 39: Packaging without panels

8. Cautiously remove the stretch film and the edge protectors.

Fig. 40: Stretch film and edge protectors removed

9. Remove the screws from the two fastening brackets (**2**) of the front transport support (**1**) and from the rear transport support (**3**).

Fig. 41: Front/Rear transport supports

1 Front transport support

2 Fastening bracket

3 Rear transport support

10. Remove the front transport support and the rear transport support.

11. Cut off the welded parts of the foil using scissors.

Fig. 42: Cutting off the welded parts of the foil

12. Remove the foil.

Fig. 43: Foil removed

The transport ramps are on the inside of the front panel.

13. Remove the screws of the transport ramps.

Fig. 44: Transport ramps

14. Put the transport ramps onto the front edge of the box floor.
15. Align the transport ramps with the centers of the caster wheels of the system.

Fig. 45: Placing the transport ramps

16. Screw the transport ramps onto the box floor.

Fig. 46: Fastening the transport ramps

CAUTION! Risk of injury by sharp edges!
When working with the leveling feet, sharp edges of the adjusting lever can cut your hands.

▶ Always wear protective gloves.

17. Pull on the ring (**3**) to pull out the height adjustment lever (**2**) of the leveling foot.

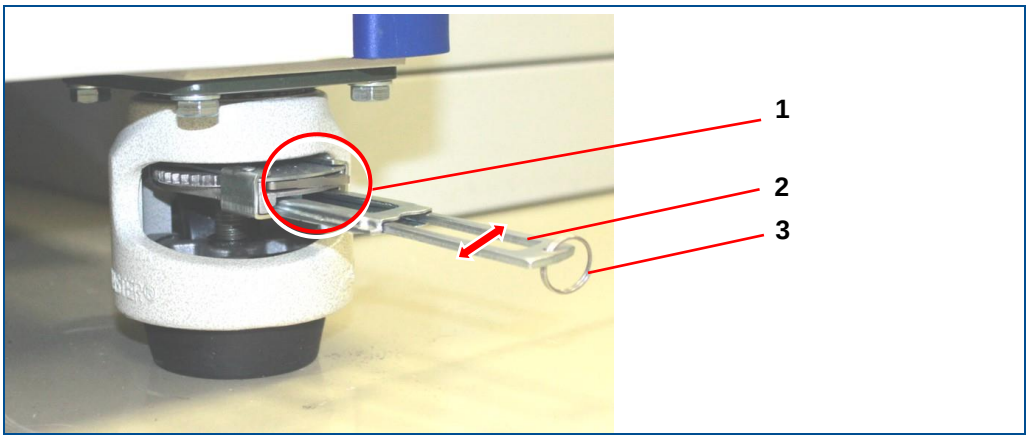


Fig. 47: Leveling foot

1 Rocker switch for raising/lowering the leveling foot

2 Height adjustment lever

3 Ring for pulling out the height adjustment lever

18. Push all rocker switches (**1**) **to the right** to lower the leveling feet and thus lift the system.
19. Adjust all leveling feet using the adjustment levers (**2**) until the system is lifted off the transport supports.
20. Remove the screws from the four fastening brackets (**1**) of the side transport supports (**2**).

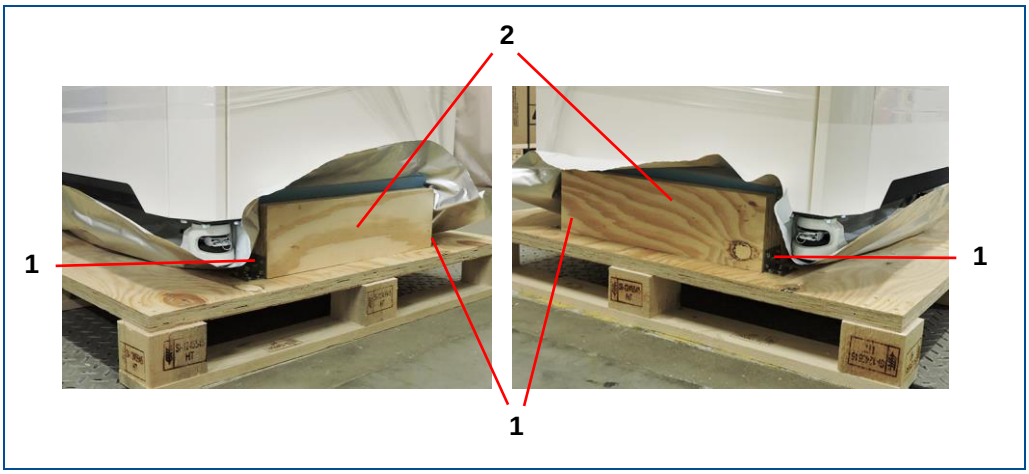


Fig. 48: Side transport supports

1 Fastening bracket

2 Side transport support

21. Remove the side transport supports (**2**).
22. Push all rocker switches (**1**) (see figure 47) **to the left** to raise the leveling feet and thus unlock the leveling feet.
23. Adjust all leveling feet using the adjustment levers (**3**) (see figure 47) until the system stands on all four wheels.
24. Push the adjustment levers (**2**) (see figure 47) back into their resting positions.
25. Cautiously roll the system from the box floor via the transport ramps.

☑ The system has been unpacked.

4.3 Transporting the system

Before transporting a system, the LPKF Service has to be contacted. The only exception is the transport over short distances (see the following chapter).

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- Wear safety shoes
- Wear protective gloves

Deactivate the system using the main switch at the rear of the system before transport. The cover must remain closed to prevent dirt from entering.

4.3.1 Moving the system over short distances

⚠ CAUTION

Risk of injury by sharp edges!

When working with the leveling feet, sharp edges of the adjusting lever can cut your hands.

▶ Always wear protective gloves.

NOTICE

Property damage by missing transport lock!

Transporting the system without installed transport locks can cause property damage.

▶ Only transport the system with installed transport locks.

The system has four leveling feet with wheels and is thus easy to transport. The system can be transported over short distances (e.g. within a room or a building) using the four leveling feet. To be able to move the system, the locks of the leveling feet have to be loosened first.

Loosening the locks of the leveling feet

CAUTION! Risk of injury by sharp edges!
When working with the leveling feet, sharp edges of the adjusting lever can cut your hands.

▶ Always wear protective gloves.

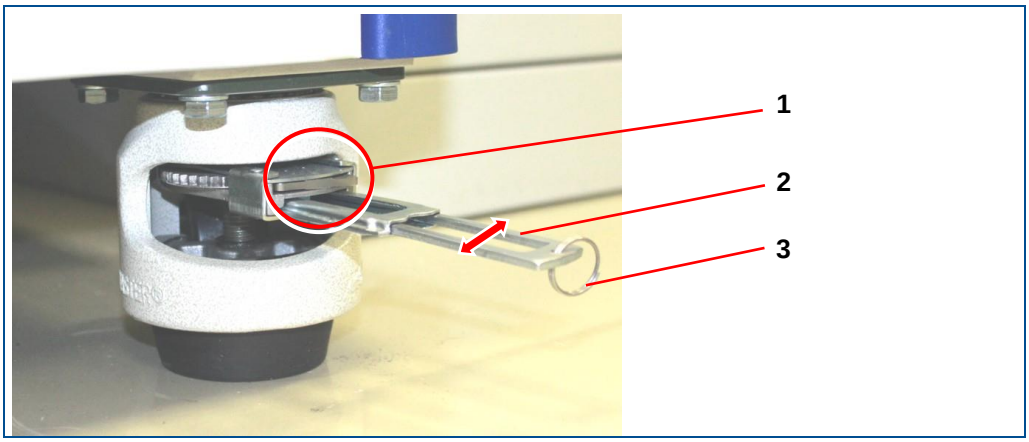


Fig. 49: Leveling foot

1 Reversing lever for adjusting the leveling feet upwards or downwards

2 Height adjustment lever

3 Ring for pulling out the adjusting lever.

1. Pull the ring (**3**) to pull out the height adjustment lever (**2**) of the leveling feet.
2. Adjust the reversing lever (**1**) to the **left** for turning the leveling feet upwards and for loosening their locks.
3. Repeat the steps 1 and 2 for the rest of the leveling feet until the locks are loosened.

☑ The locks of the leveling feet have been loosened.

Moving the system over short distances

1. Switch off the system and ensure that the locks of all leveling feet are disengaged.
2. Disconnect the following connections (see page 88):
   - Mains cable of the system
   - Mains cable of the extraction system
   - Control cable
   - Extraction hose
   - USB cable
   - Network cable
   - DisplayPort cable
   - Compressed-air supply

NOTICE! Property damage by missing transport lock!
Transporting the system without installed transport locks can cause property damage.
▶ Only transport the system with installed transport locks.

3. Move the system over a short distance to the desired place.

Carefully reconnect all connections mentioned above to the system before startup. Pay special attention to fastening the extraction hose.

4. Level the system (see page 72).
5. Secure the system at the place of destination with the locks of the leveling feet.

☑ The system has been moved over a short distance.

4.3.2 Leveling the system

After the final position for the system is determined, the system has to be leveled using the four leveling feet.

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites
- Processing table is at its center position.

Spare parts and auxiliaries
- Precision frame spirit level

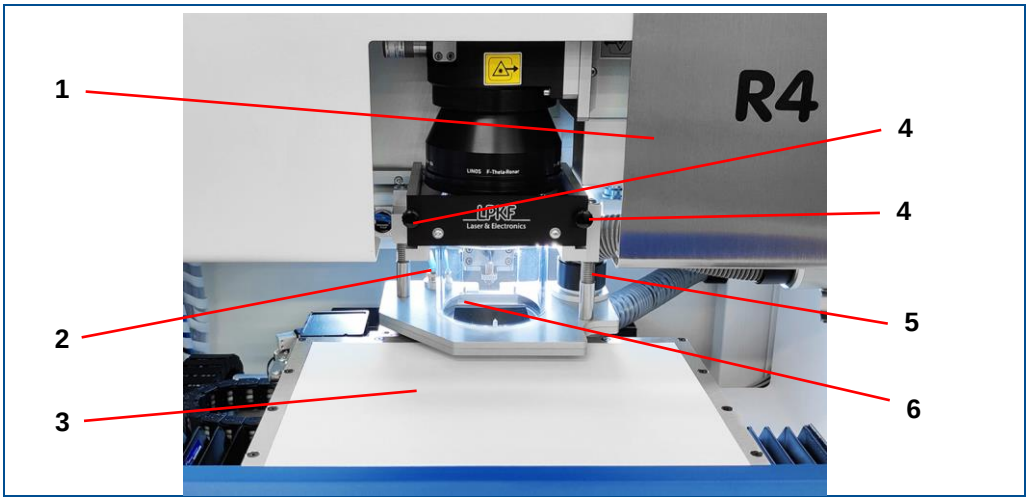


Fig. 50: System with open cover

1	Maintenance cover in processing area	**4**	Screw extraction hood
2	Compressed-air tube	**5**	Extraction hose
3	Sinter plate	**6**	Extraction hood

Leveling the system

1. Open the cover.
2. Open the maintenance door in the processing area (**1**).
3. Disconnect the compressed-air tube (**2**) and the extraction hose (**5**) from the extraction hood (**6**).
4. Remove the screws (**4**) of the extraction hood.
5. Pull out the extraction hood towards you.
6. Remove the sinter plate (**3**) from the processing table.

When opening the system for the first time, an acceptance sample and an information sheet are on the sinter plate.

7. Clean the processing table, if necessary.

CAUTION! Risk of injury by sharp edges!
When working with the leveling feet, sharp edges of the adjusting lever can cut your hands.
▶ Always wear protective gloves.

8. Pull on the ring (see page 71) to pull out the height adjustment lever of the leveling feet.
9. Perform one of the following steps:
   – Push the rocker switch **to the right** to **lower** the leveling foot.
   – Push the rocker switch **to the left** to **raise** the leveling foot.
10. Level the system with load on all leveling feet in x and y direction using a precision frame spirit level.

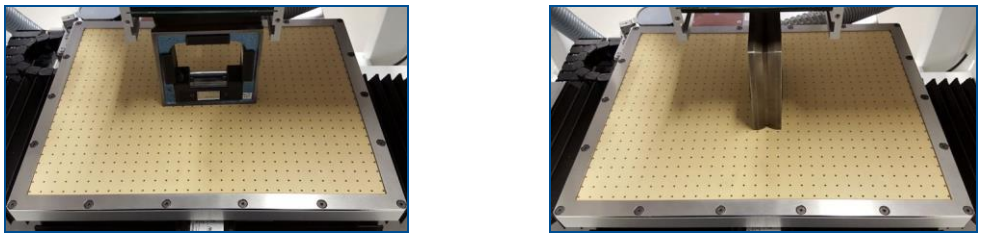


Fig. 51: Precision frame spirit level

11. Push the adjustment levers of all leveling feet back into their resting positions.
12. Reinsert the sinter plate.
13. Reassemble the mentioned components in reverse order.

☑ The system is leveled.

4.4 Storage

- Store the system in its original packaging according to the symbols on the packaging.
- Store the packages under the following conditions:
  - Do not store outdoors.
  - Store dry and dust-free.
  - Do not expose to aggressive substances.
  - Protect against sunlight.
  - Storage temperature: 10 °C - 40 °C (50 °F - 104 °F)
  - Relative humidity: max 60 %, non-condensing.
  - If storing for more than 3 months, check the general condition of all components and the packaging on a regular basis.

When putting the system out of operation and into storage over a longer period, ensure that the storage room is clean, almost dust-free, and has a sufficient loadbearing capacity.

5 First startup

This chapter contains important information on first startup of the system.

5.1 Safety

LPKF recommends to have the LPKF Service perform the first startup. For further information on an optional training contract or installation contract contact the LPKF Service.

Observe the following safety instructions for the first startup of the system:

⚠ WARNING

Accident hazard due to insufficiently qualified personnel!

Insufficiently qualified personnel cannot assess the risks of using the system and put themselves and others in danger.

- ▶ Allow only qualified personnel to use the system.
- ▶ Keep insufficiently qualified personnel out of the working area.

⚠ CAUTION

Tripping hazard by hoses and cables!

Hoses and cables are routed to the system. If the hoses and cables are laid inappropriately they pose a tripping hazard for the operating personnel.

- ▶ Always ensure that the hoses and cables do not pose a tripping hazard.

⚠ CAUTION

Health hazard by contact with chemicals!

Direct contact with the chemicals can cause serious damage to health.

- ▶ Always read the safety data sheets before working with chemicals and always observe the instructions given therein.
- ▶ Work in well-ventilated rooms.
- ▶ Wear your personal protective equipment.
- ▶ Avoid direct contact with the chemicals.
- ▶ Wash your hands thoroughly after work.
- ▶ Consult a physician in case of complaints after contact with chemicals.

NOTICE

Property damage by moisture during transport/storage!

When transporting or storing the system, moisture can cause damage to the system.

- ▶ Ensure that there is no moisture in the system.
- ▶ Before first startup of the system wait approx. 24 hours to allow the system to acclimatize.

5.2 Requirements of the place of installation

Check the system for transport damage before the installation is started. The system has to be transported to the desired place of installation. Transport the system in its packaging using a hand pallet truck. The total weight of the system has to be considered! Only when the system is at its place of installation it is leveled.

5.2.1 Climatic conditions

The following climatic conditions have to be ensured for operating the system:

Climatic conditions

Data	Value	Unit
Temperature range (operation)	22 ± 2 (~71.6 ± 3.6)	°C (°F)
Temperature range (storage, transport)	10 to 40, -20 to 50 (~50 to 104, -4 to 122)	°C (°F)
Max. humidity, non-condensing	< 60	%

5.2.2 Minimum required space

System dimensions

- Width 910 mm (~35.8 in)
- Depth 795 mm (~31.3 in)
- Height 1650 mm (~65.0 in)

Minimum required space for operation and maintenance

- Width 2375 mm (~93.5 in)
- Depth 2000 mm (~78.7 in)
- Height 1765 mm (~69.5 in)

An additional space of 750 mm (~29.5 in) is required at the system front to open the maintenance door. Do not block this area because it is a working space for operation and maintenance.

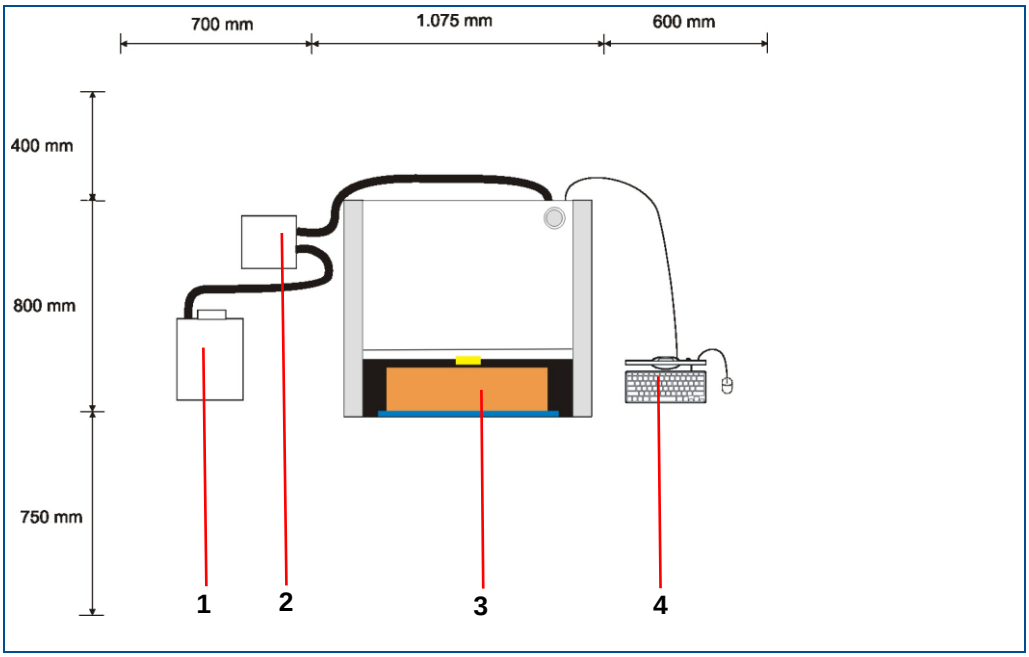


Fig. 52: Minimum required space

1 Extraction system
2 Prefilter unit
3 System
4 Screen, keyboard, and mouse (recommended position)

5.2.3 Workplace of the operating personnel

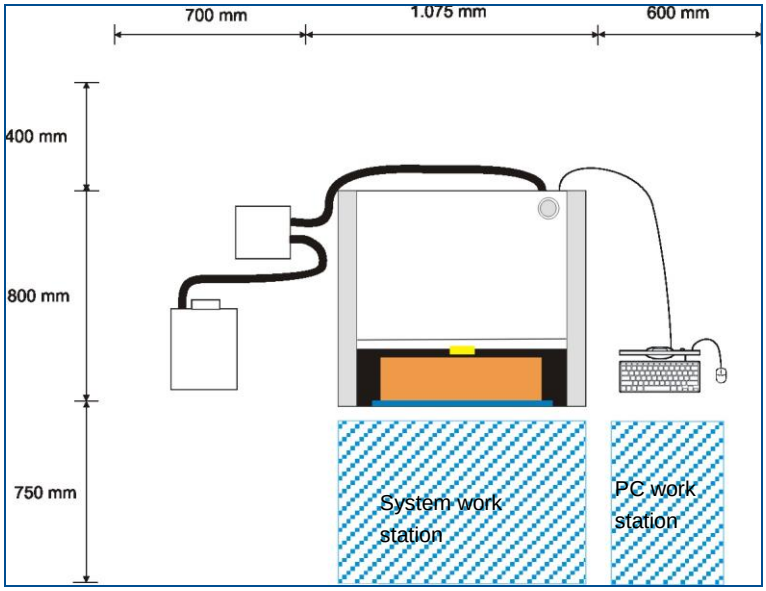


Fig. 53: Workplace of the operating personnel

The system may only be operated by one person. The system is operated according to its intended use at the following work stations:

- System work station

  The system work station is used for loading and unloading the system.
- PC work station

  The PC work station is used for monitoring the production and for controlling the system.

5.2.4 Floor

The floor has to be level and antistatic, and has to have a sufficient load-bearing capacity for the total weight of the system (390 (~860) kg/lbs).

LPKF recommends using flagstone for the flooring.

Load capacity

Data	Value	Unit
Min. distributed load	6.8	kN/m²
Minimum point load on an area of 0.00196 m²	0.975	kN

▶ The system should be installed on a vibration-damped floor.

LPKF will gladly advise you on suitable damping measures such as active and passive vibration-dampers or vibration-damping mats. LPKF assumes no liability for inaccuracies and/or damage due to inadequate vibration damping.

5.2.5 The system's center of gravity

The following figure shows the center of gravity of the system:

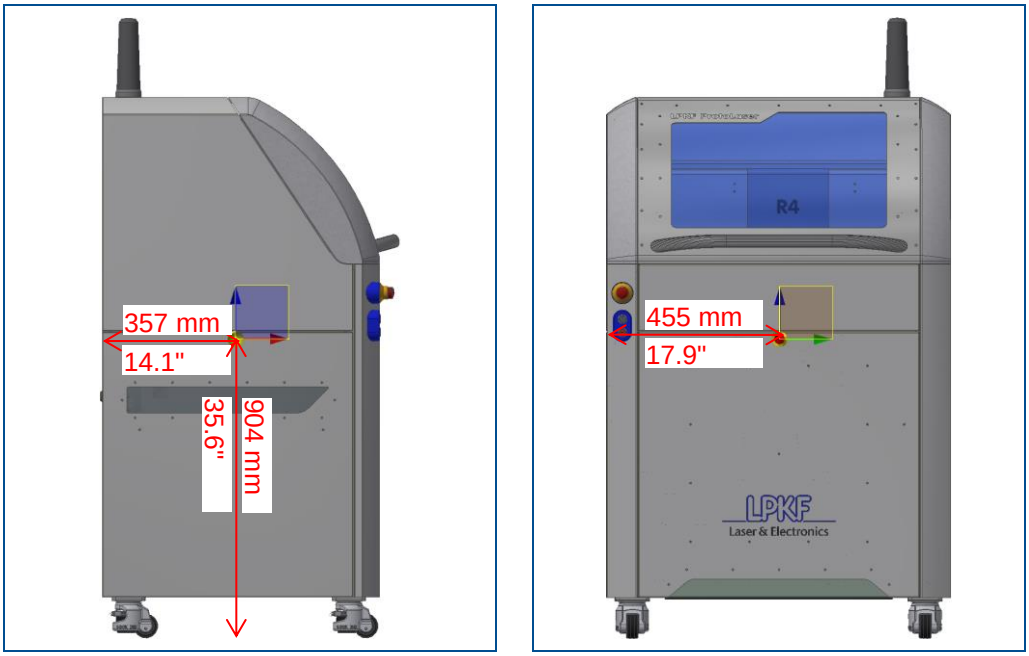


Fig. 54: Center of gravity of the system

5.2.6 Connections provided by the customer

The following connections have to be available for the first startup:

Electrical data

Data	Value	Unit
Power supply:		
Voltage	110/230 AC	V
Stability	+10/-15	%
Frequency	50/60	Hz
Nominal power	< 2.0	kVA
Electrical connection - socket	CEE 7/3 “Schuko socket“	-

Pneumatic data

Data	Value	Unit
Pressure	6	bar
Standard volume flow	128	l/min

Compressed-air purity acc. to ISO 8573-1:2010-04

Data	Value	Unit
Solid particles	1	Class
Water	4	Class
Oil	1	Class

5.3 Preparations

Before the system is installed, you have to consider and ensure the following:

- A suitable extraction system has to be provided. LPKF recommends the use of the LMD 508 extraction system. This is optionally available at LPKF.
- Provide sufficient space at the place of installation.
- Ensure tidiness and cleanliness at the place of installation.
- Provide the connection materials (hoses, tubes, cables etc.).
- The room has to be clean and almost dust-free.
- Stick the corresponding safety signs in your national language on top of the safety signs that have been applied to the system. Apply the safety signs in the language that is used at the workplace additionally.
- Ensure that the system is leveled (see page 72).
- Remove the transport locks of the system (see page 80).
- Fill the coolant into the chiller (see page 84).
- Check the local mains voltage setting of the chiller (see page 86).

5.3.1 Removing the transport locks

The transport locks have to be removed before the system can be put into operation. The chiller and the processing table are secured with transport locks.

NOTICE

Property damage by missing transport lock!

Transporting the system without installed transport locks can cause property damage.

▶ Only transport the system with installed transport locks.

Chiller

The chiller is secured with two transport brackets. The transport brackets are behind the front cover.

Removing the transport locks of the chiller

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- Mains cable of the system is not connected.

Spare parts and auxiliaries

- Hex key 5 mm

1. Pull on the lower left edge of the maintenance door to open it.

Fig. 55: Opening the maintenance door

2. Remove the screws (**2, 3, 6, 7**) that fasten the transport brackets (**8, 10**) to the base frame.

Put the **screw with rubber stopper** (**6**) aside, it will be used in one of the next steps.

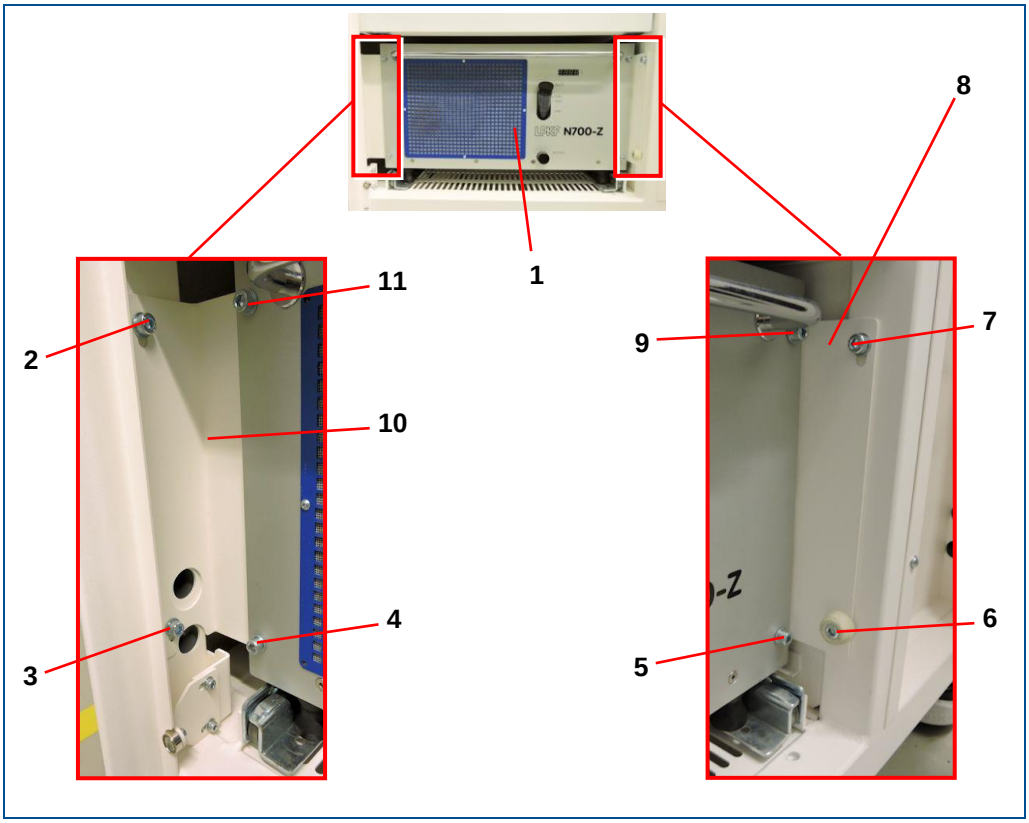


Fig. 56: Transport lock for chiller

1 Chiller
2 Screw (fastening transport bracket to base frame)
3 Screw (fastening transport bracket to base frame)
4 Screw (fastening transport bracket to chiller)
5 Screw (fastening transport bracket to chiller)
6 Screw with rubber stopper (fastening transport bracket to base frame)
7 Screw (fastening transport bracket to base frame)
8 Transport bracket
9 Screw (fastening transport bracket to chiller)
10 Transport bracket
11 Screw (fastening transport bracket to chiller)

3. Pull out the chiller until the transport brackets protrude from the base frame.
4. Remove the screws (**4, 5, 9, 11**) that fasten the transport brackets to the chiller.
5. Remove the transport brackets (**8, 10**).

6. Push the chiller into the base frame.

Pushing in the chiller is hampered by a detent at the full extent of the guiding rail.

☐ The chiller can be moved freely.

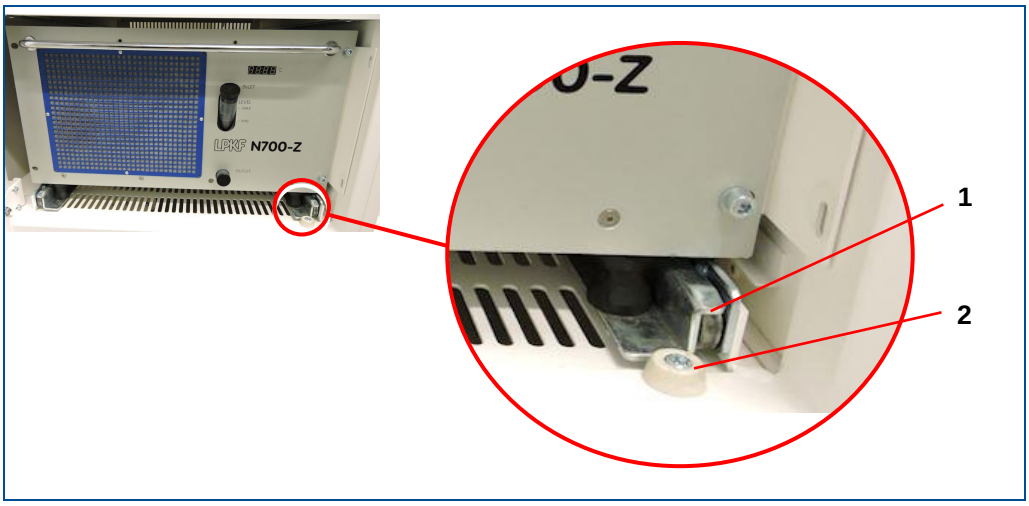


Fig. 57: Chiller

1 Guiding rail

2 Position of the screw with rubber stopper

7. Insert the screw with rubber stopper into the threaded hole in front of the guiding rail and fasten it to secure the chiller.
8. Close the maintenance door.

☑ The transport locks of the chiller have been removed.

Store the transport brackets in a dry place in immediate vicinity of the system. Reinstall the transport brackets for securing the chiller every time the system has to be transported.

Processing table

The processing table is secured with two bolts. The bolts are located beneath the bellows on the left and right side of the x axis.

Removing the transport locks of the processing table

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The mains cable of the system is not connected.

1. Open the cover.
2. Cautiously push the bellows of the x axis (**1**) to the side.

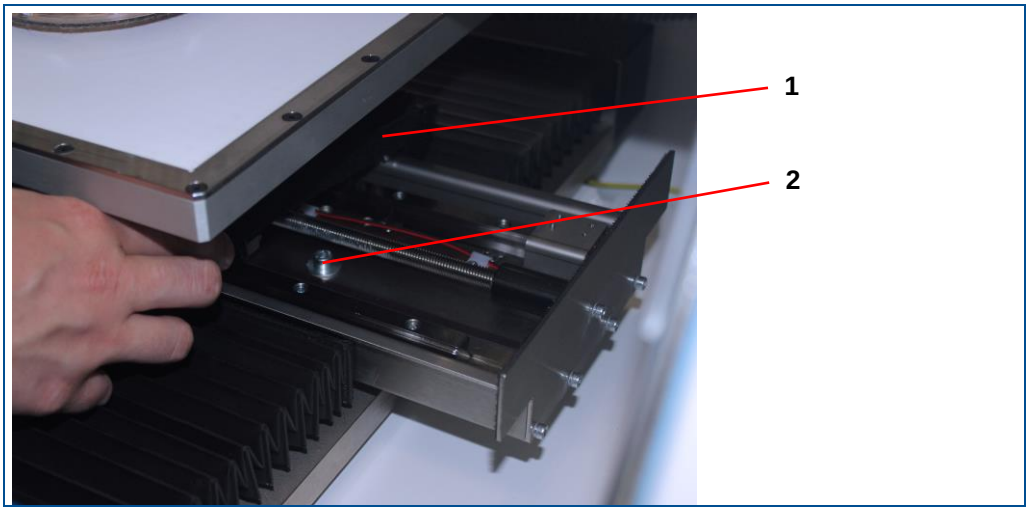


Fig. 58: x axis

1 Bellows of x axis, right side **2** Bolt

3. Pull out the bolt.

Fig. 59: Pulling out the bolt

4. Repeat steps 2 and 3 on the left side of the x axis.
5. Cover the mounting hole with the bellows.

☑ The transport locks of the processing table have been removed.

Store the transport brackets in a dry place in immediate vicinity of the system. Reinsert the bolts for securing the processing table every time the system has to be transported.

5.3.2 Filling the coolant

The chiller is located behind the front cover.

The coolant additive (EUROLUB Kühlerschutz D-30) that has been delivered in a separate container has to be mixed with distilled water and filled into the chiller before the system is operated.

The mixing ratio is: 1:6 (EUROLUB Kühlerschutz D-30:distilled water).

Filling in the coolant

Ensure that the following prerequisites are met before performing the described tasks:

Prerequisites

- Wear a respirator mask with gas filter for organic gases/vapors
- Wear safety glasses with side shields
- Wear chemical-resistant gloves
- Wear closed work clothing

Spare parts and auxiliaries

- Jerry can with spout
- EUROLUB Kühlerschutz D-30
- Distilled water

1. Pull on the lower left edge of the maintenance door to open it.

Fig. 60: Opening the maintenance door

2. Remove the cap of the filler neck (**1**).

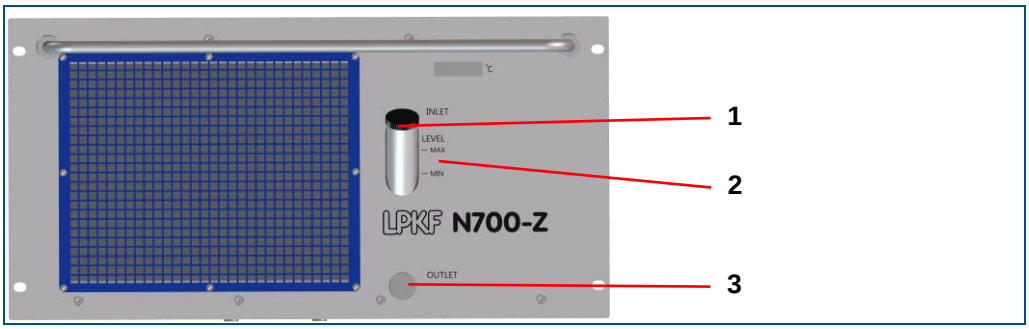


Fig. 61: Chiller

1 Filler neck
2 Fill level indicator
3 Drain valve

CAUTION! Health hazard by contact with chemicals!
Direct contact with chemicals may cause damage to health.
▶ Wear your personal protective equipment.

3. Fill the jerry can contained in the delivery with 0.7 l EUROLUB Kühlerschutz D-30 and 4.3 l distilled water.
4. Use the spout to fill the resulting coolant into the filler neck (**1**).
5. Fill coolant into the chiller until the fill level indicator (**2**) indicates a maximum fill level.
6. Screw the cap back onto the filler neck.
7. Close the maintenance door.
8. Store unused coolant according to the information in the safety data sheet.

☑ The coolant has been filled in.

5.3.3 Checking the local mains voltage of the chiller

Ensure that the mains voltage of the chiller is set to the local mains voltage (100 V / 110 V / 230 V) before connecting the system to the mains power supply.

The chiller is preset to a mains voltage of 230 V on delivery. If your local mains voltage is 100 V or 110 V, change the local mains voltage setting of the chiller.

NOTICE

Property damage due to incorrectly set mains voltage on the chiller!

An incorrectly set mains voltage can lead to property damage at the chiller.

▶ Set the chiller to your local mains voltage.

Changing the local mains voltage setting of the chiller

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- Mains cable of the system is not connected.

Spare parts and auxiliaries

- Control cabinet key
- Key for voltage selection

1. Insert the control cabinet key into the keyhole of the rear cover.
2. Turn the control cabinet key counter-clockwise by **180°**.

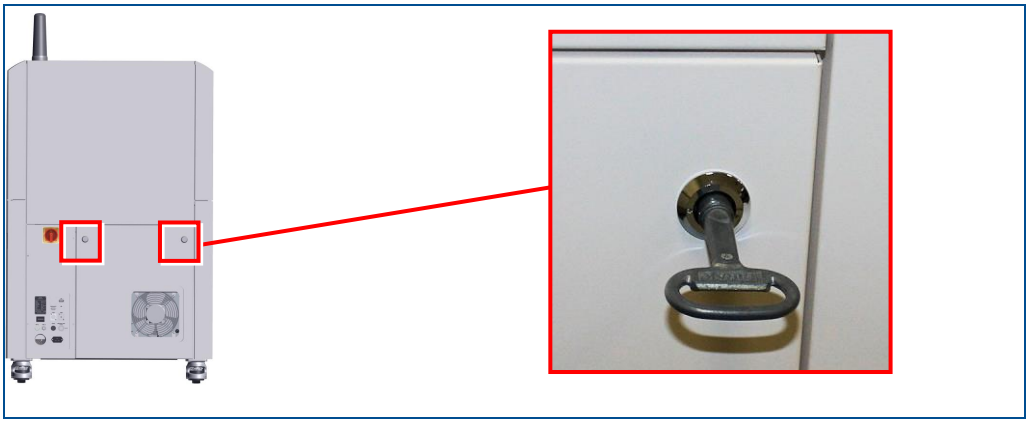


Fig. 62: Rear cover

3. Repeat steps 1 and 2 with the second keyhole of the rear cover.

4. Tilt the rear cover slightly forward and disconnect the grounding cable.

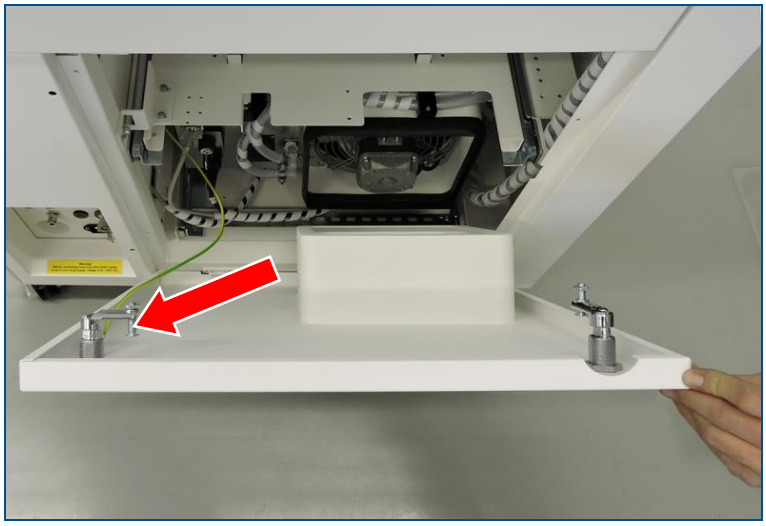


Fig. 63: Grounding cable

5. Lift the rear cover upwards and remove it.
6. Set the voltage with the key switch to the local mains voltage.

Fig. 64: Key switch for voltage selection

7. Remove the key from the key switch.
8. Reassemble the mentioned components in reverse order.

☑ The local mains voltage setting of the chiller has been changed.

Store the key in a dry place in immediate vicinity of the system.

5.4 Connecting the system

Once all preparations are concluded, the system is connected in the following order:

- Connecting the stack light
- Connecting the extraction system
- Connecting the compressed-air supply
- Connecting to the network
- Connecting the screen, keyboard, and mouse
- Connecting the system to the mains power supply

5.4.1 Connecting the stack light

Connect the stack light with the system and install it subsequently.

Material

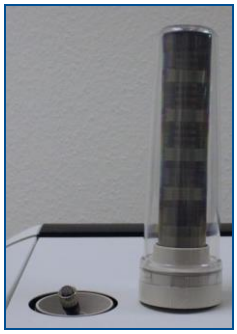


Fig. 65: Stack light

Connecting the stack light

1. Connect the cable of the system with the connector of the stack light:

Fig. 66: Connecting the cable

2. Insert the stack light into the socket.
   The markings of the stack light and of the socket must match up.

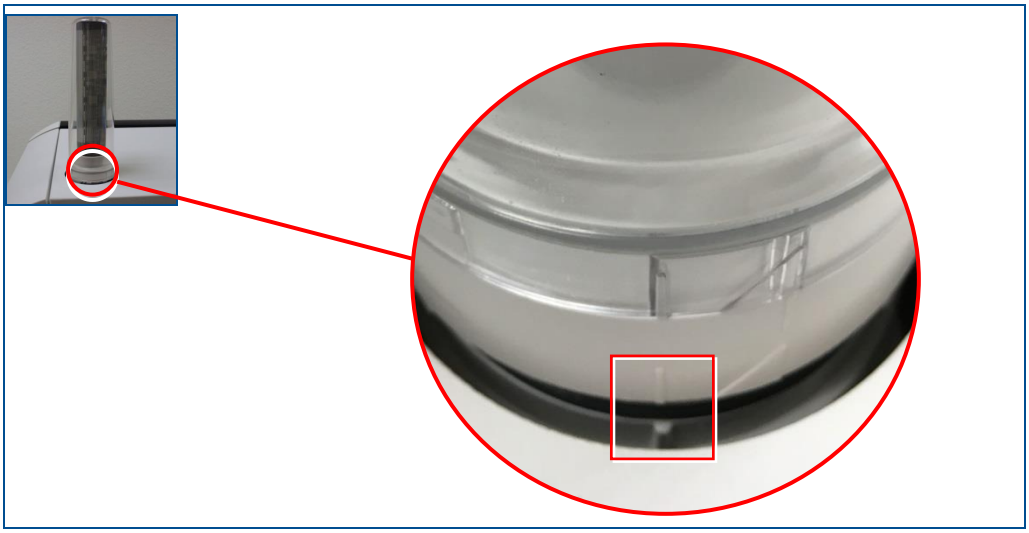


Fig. 67: Stack light markings

3. Fasten the stack light by turning it clockwise.

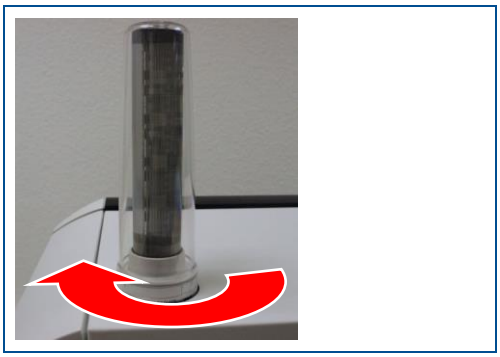


Fig. 68: Turning the stack light

☑ The stack light has been connected.

5.4.2 Connecting the extraction system

The extraction system is an optional accessory that can be ordered from LPKF. The following shows the required steps for connecting the LMD 508 and the prefilter unit:

Material

Fig. 69: Extraction hose and 9-pin D-sub connectors (male/female)

Connecting the extraction system

CAUTION! Tripping hazard due to hoses and cables!
Hoses and cables are connected to the system. If the hoses and cables are laid inappropriately, they pose a tripping hazard for the operating personnel.

▶ Always ensure that the hoses and cables do not pose a tripping hazard.

1. Connect the extraction hose of the extraction system with the prefilter unit.

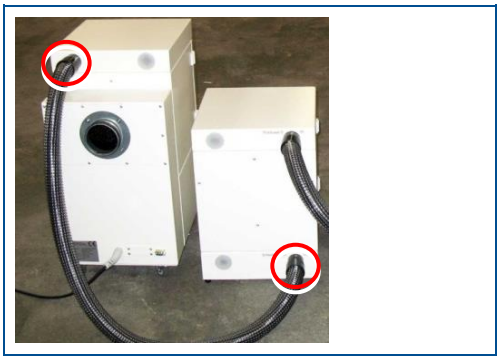


Fig. 70: Extraction system with prefilter unit

2. Connect the extraction hose of the prefilter unit with the system.

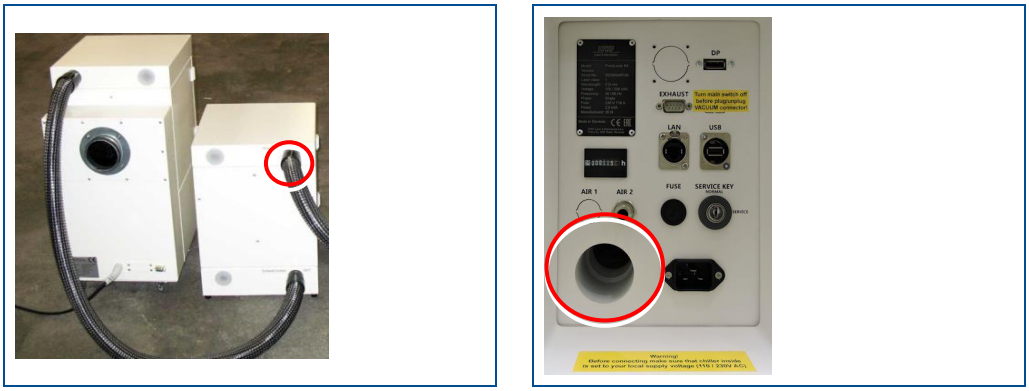


Fig. 71: Connector for the extraction system

3. Connect the (female) 9-pin D-sub connector with the system.

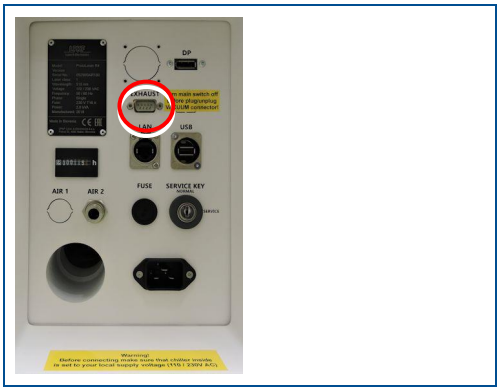


Fig. 72: Connector for the control cable

4. Connect the (male) 9-pin D-sub connector with the system.

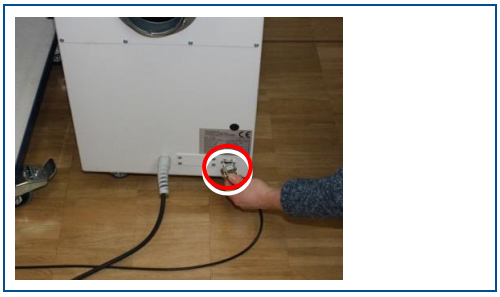


Fig. 73: Connector for the control cable

5. Connect the air outlet nozzle with your air outlet nozzle.

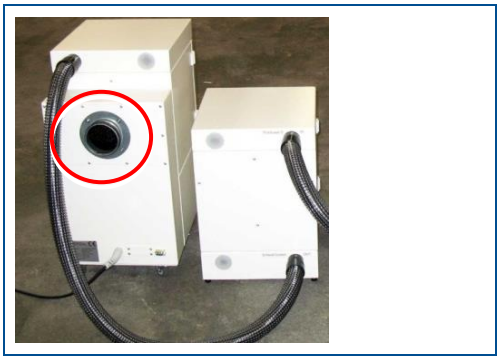


Fig. 74: Air outlet nozzle

6. Connect the extraction system to the mains power supply.

Fig. 75: Wall socket

☑ The extraction system has been connected.

LPKF recommends to set the rotation speed of the extraction system to 70 %. Adjust the follow-up time of the extraction system according to your requirements. For further information refer to the user manual of the extraction system.

5.4.3 Connecting the compressed-air supply

The system is connected to the compressed-air supply via a pneumatic tube.

Material

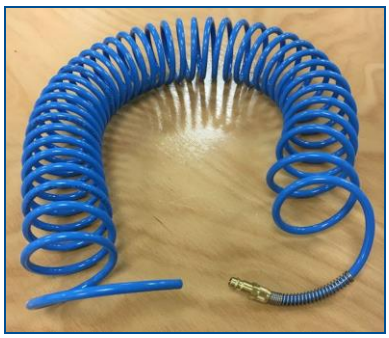


Fig. 76: Pneumatic tube

Connecting the compressed-air supply

CAUTION! Tripping hazard by hoses and cables!
Hoses and cables are routed to the system. If the hoses and cables are laid inappropriately they pose a tripping hazard for the operating personnel.
▶ Always ensure that the hoses and cables do not pose a tripping hazard.

1. Connect the pneumatic tube with the compressed-air connector (coupling for 8 mm (0.315") outer tube diameter) of the system.

Fig. 77: Connector for compressed-air tube

2. Connect the pneumatic tube with the compressed-air supply (maximum pressure: 6 bar).

☑ The compressed-air supply has been connected.

5.4.4 Connecting to the network

The system is connected to the network via a network cable.

Material

Fig. 78: Network cable

Connecting the network cable

CAUTION! Tripping hazard by hoses and cables!
Hoses and cables are routed to the system. If the hoses and cables are laid inappropriately they pose a tripping hazard for the operating personnel.
▶ Always ensure that the hoses and cables do not pose a tripping hazard.

1. Connect the network cable to the system.

Fig. 79: Connecting the network cable

2. Connect the network cable to your network.

Fig. 80: Network connector

☑ The network cable has been connected.

5.4.5 Connecting the screen, keyboard, and mouse

The screen is connected to the system via a DisplayPort cable and a USB cable type A/B. The keyboard and mouse are connected to the screen via a USB cable.

Material

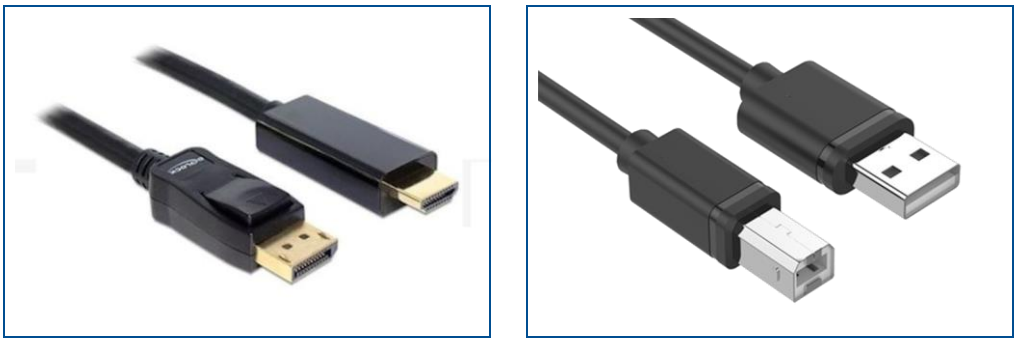


Fig. 81: DisplayPort to HDMI cable and USB A to USB B cable

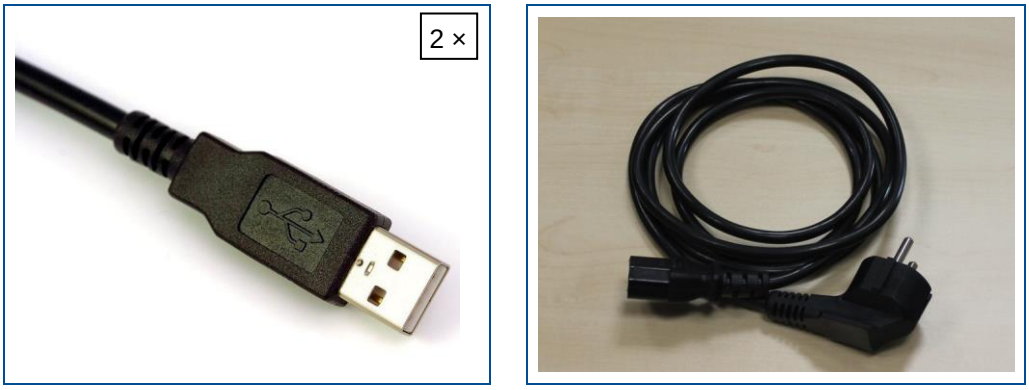


Fig. 82: USB A cable of the keyboard/mouse and mains cable

Connecting the screen, keyboard, and mouse

CAUTION! Tripping hazard by hoses and cables!
Hoses and cables are routed to the system. If the hoses and cables are laid inappropriately they pose a tripping hazard for the operating personnel.
▶ Always ensure that the hoses and cables do not pose a tripping hazard.

1. Connect the DisplayPort to HDMI cable to the system.

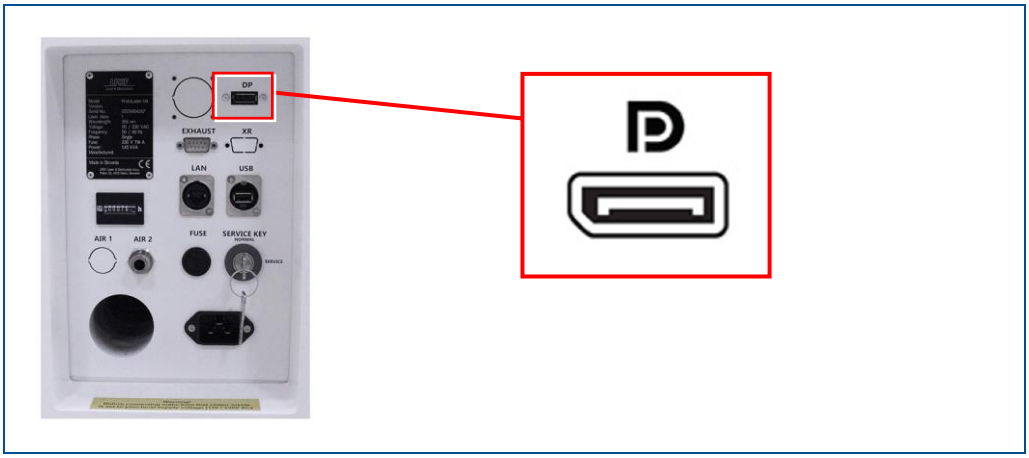


Fig. 83: DisplayPort connector

2. Connect the DisplayPort to HDMI cable to the screen.

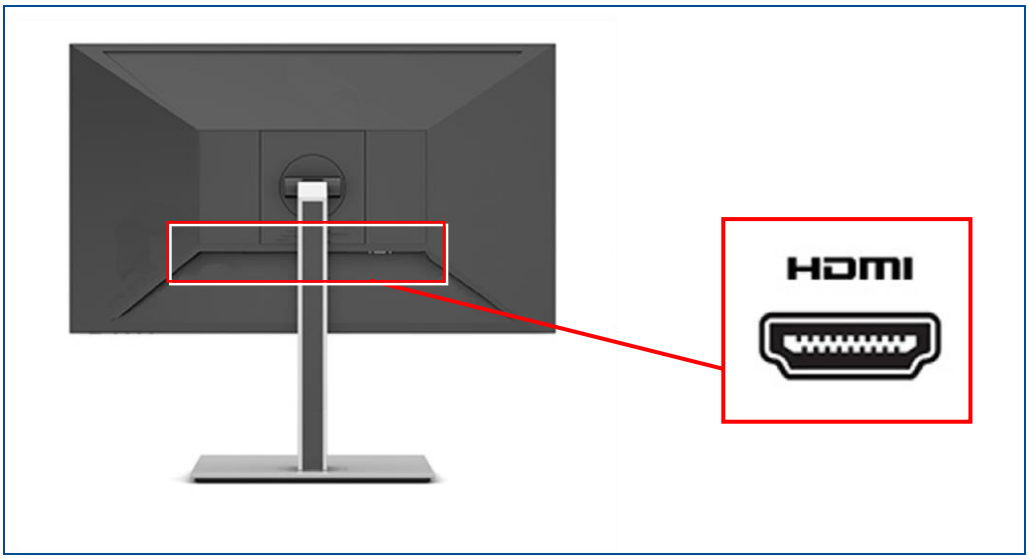


Fig. 84: HDMI connector

3. Connect the USB A to USB B cable to the system.

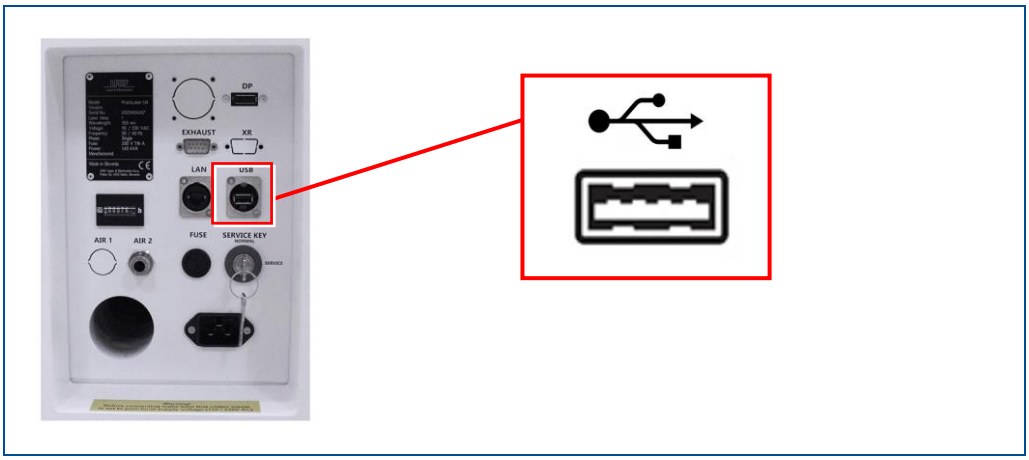


Fig. 85: USB A port

4. Connect the USB A to USB B cable to the screen.

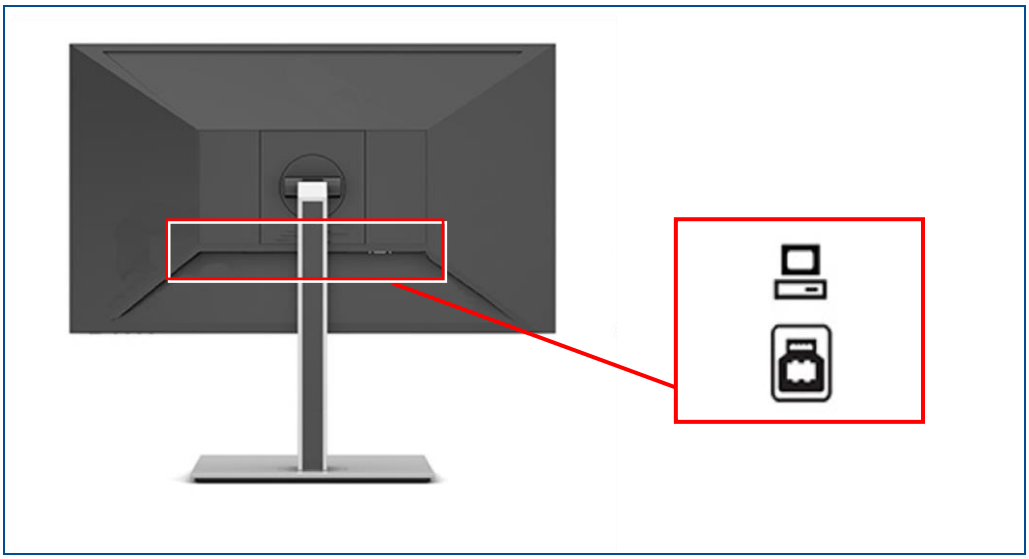


Fig. 86: USB B port

5. Connect the USB cable (type A plug) of the keyboard and the mouse to the screen.

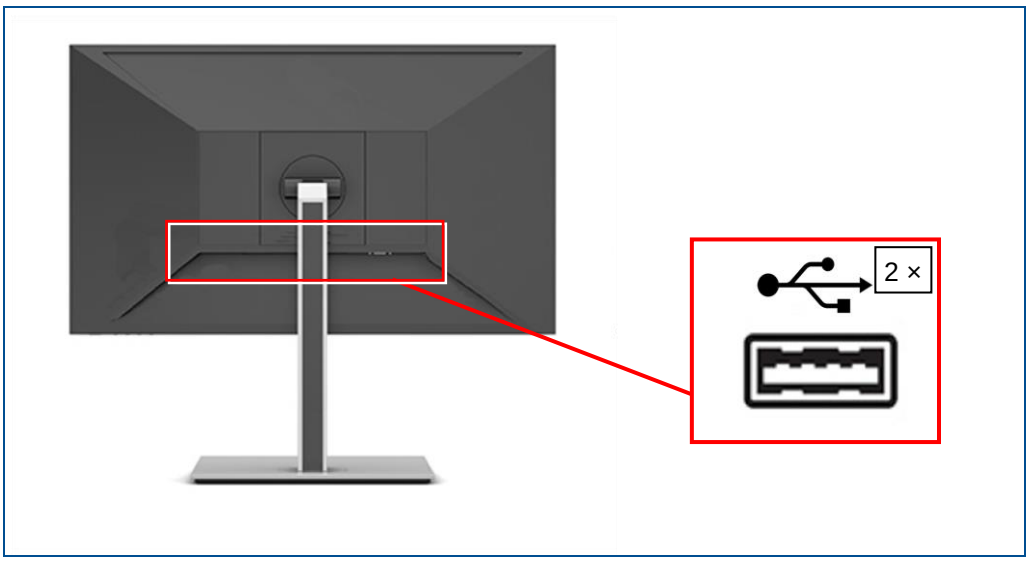


Fig. 87: USB A ports

6. Connect the mains cable to the screen.

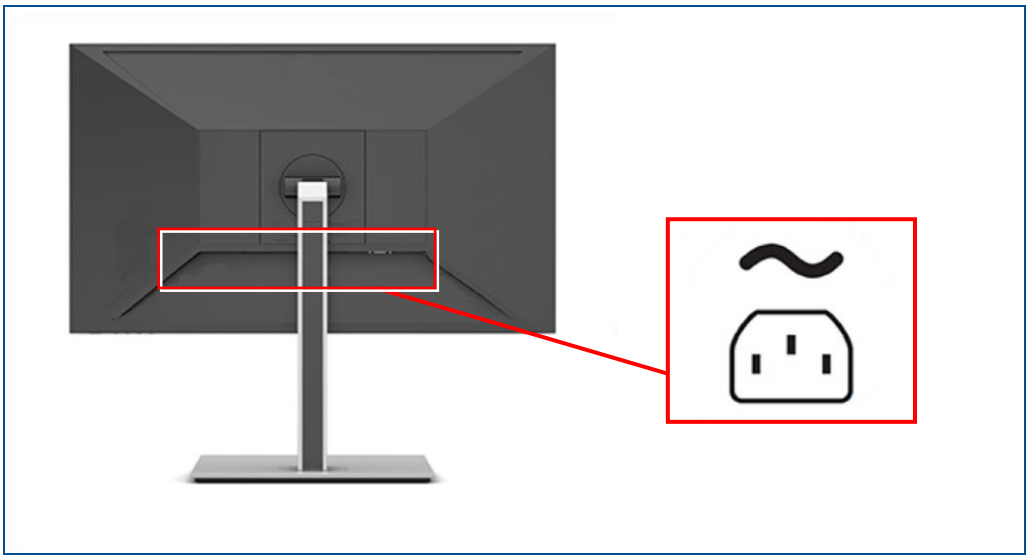


Fig. 88: Connector for mains cable

7. Plug the mains cable into the wall socket.

Fig. 89: Mains cable

☑ The screen, keyboard, and mouse are connected.

5.4.6 Connecting the system to the mains power supply

The system is connected to the mains power supply using a mains cable.

Material

Fig. 90: Mains cable

Connecting the mains cable

CAUTION! Tripping hazard by hoses and cables!
Hoses and cables are routed to the system. If the hoses and cables are laid inappropriately they pose a tripping hazard for the operating personnel.
▶ Always ensure that the hoses and cables do not pose a tripping hazard.

1. Connect the mains cable to the system.

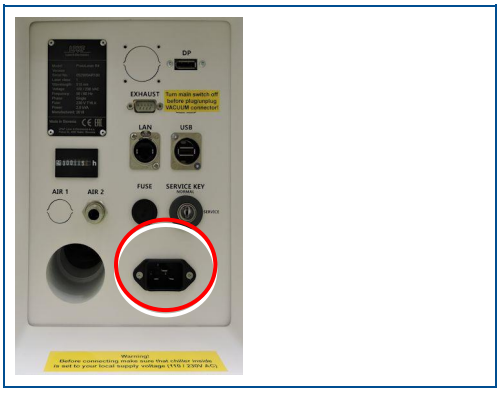


Fig. 91: Connector for mains cable

2. Plug the mains cable into the wall socket.

Fig. 92: Wall socket

☑ The mains cable has been connected.

5.4.7 Switching on the system with the main switch

The main switch of the system switches on or off the mains power supply.

Switching on the system with the main switch

1. Turn the main switch at the rear of the system to position *I ON*.

Fig. 93: Main switch set to *I ON*

☑ The mains power supply of the system is switched on.

6 Operating the system

This chapter contains important information on operating the system and the associated software programs.

For detailed information on operating the system software press F1 to invoke the help function.

6.1 Safety

⚠ WARNING

Risk of injury by laser radiation!

As soon as the system is switched into the service mode, the system is classified as laser class 4.

- ▶ Always wear the personal protective equipment.
- ▶ Never look directly into the laser beam.

⚠ WARNING

Health hazard by gases or dusts!

Processing materials with laser beams can produce gases or dusts hazardous to health.

- ▶ Process only materials that are approved by LPKF.
- ▶ Only work with an extraction system that is switched on and is working properly.

⚠ CAUTION

Health hazard by contact with dusts on laser-structured material!

Structuring with a laser can produce fine dusts that can deposit on the material. These dusts can cause sensitization and skin irritation on contact.

- ▶ Always wear chemical-resistant gloves when handling laser-structured material.

NOTICE

Property damage by items in the processing area!

When the system is switched on items in the processing area can cause property damage.

- ▶ Before switching on the system, always ensure that no items and no parts are in the processing area.

Switching off the system in an emergency

The emergency stop button switches off the laser immediately and stops the motorized axes. This stop is only intended for an emergency.

Stopping the system in an emergency

▶ Push the emergency stop button (see page 27).

☐ The power supply of the laser is switched off and the drives are de-energized.

☑ The system has been stopped in an emergency.

Restarting the system after an emergency stop

After pushing the emergency stop button you have to switch on the system properly to continue the production.

Restarting the system after an emergency

1. Unlock the emergency stop button by turning it.
2. Acknowledge the faults in the fault monitor.
3. Press the button *ACK* at the system front.

☑ The system is switched on after an emergency and the processing table is referenced again.

6.2 Preparations for use

Before working with the system check the following settings and conditions:

- The requirements for the place of installation (see page 76) have to be met.

If a cold system is brought into a warm environment, this can cause condensation on the optical elements of the laser head. Let the system that has been disconnected from the power supply **acclimatize for 24 hours** before you connect it to the power supply again.

- The following components have to be connected to the system and have to be ready for operation or switched on:
  - Pneumatic connection
  - Extraction system
  - Screen, keyboard, mouse
  - Power supply

Operate the system connected to an overcurrent protection device.

- Check whether the safety devices described on page 27 function properly.

6.3 Typical production process

This chapter describes a typical production process.

The following example describes how to produce an RF circuit board. This procedure as well as other applications are described in the how-to guides for **ProtoLaser U4/S4/R4**.

Weiterführende Informationen

The RF circuit board is produced using the hatching method.

Ensure that the following consumables and auxiliaries are available before performing the described tasks:

Consumables

- Base material aluminum oxide - Al_2O_3, 0.5 mm, 0/23 µm gold-plated

Auxiliaries

- LPKF Cleaner (order no. 115891)
- Oil-free compressed air
- Brush
- Tap water

The following steps are performed:

- Switching on the system
- Selecting a material
- Importing the data
- Multiplying the layout (optional)
- Creating fiducials
- Modifying the workflow settings
- Computing toolpaths and scan fields automatically
- Computing scan fields manually (optional)
- Configuring toolpaths manually (optional)
- Processing the PCB
- Stopping processing (optional)
- Switching off the system
- Cleaning the system
- Cleaning the PCB

Switching on the system

1. Press the on/off button at the system front.

☐ The system is started up. The PC boots automatically.
The on/off button is lit.

2. Double-click on the desktop icon of LPKF CircuitPro PL.

Fig. 94: Desktop icon CircuitPro PL

☐ The following message is displayed:

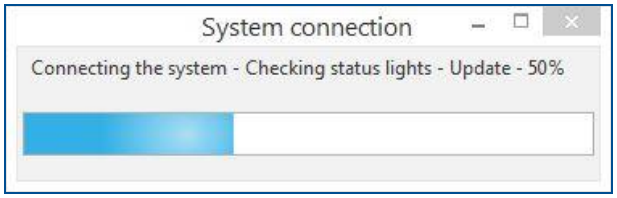


Fig. 95: Message *System connection*

☐ The system software recognizes the system automatically and establishes the connection. The following dialog is displayed:

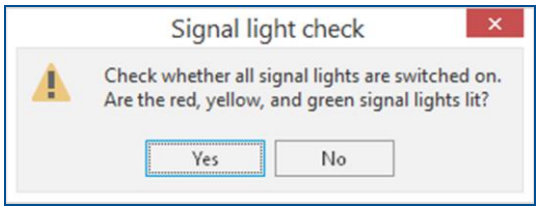


Fig. 96: Dialog *Signal light check*

3. If all lamps of the stack light are lit, click on [Yes].

☐ The user guidance step *New* is displayed:

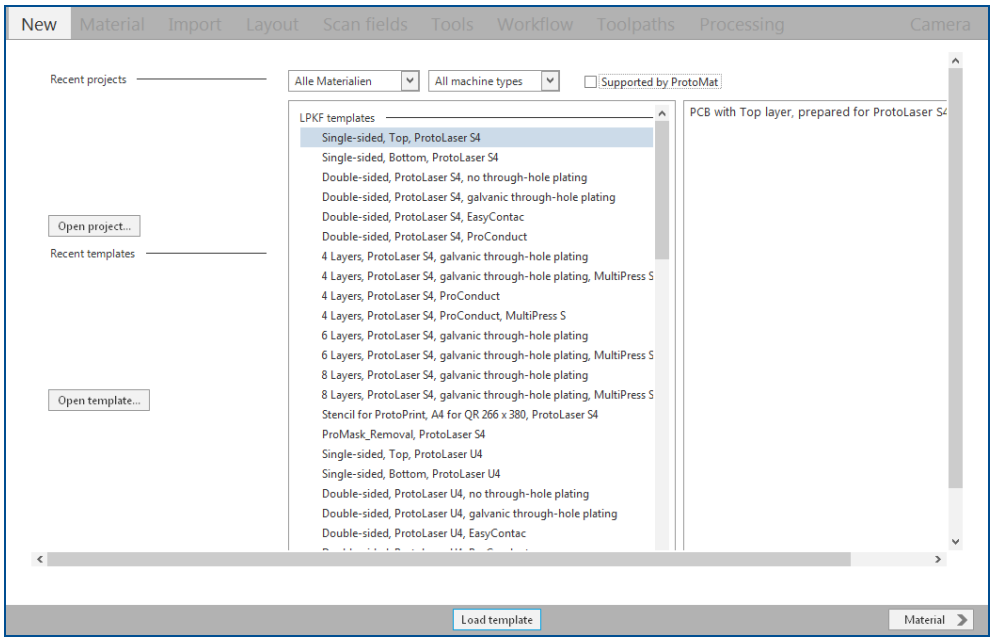


Fig. 97: User guidance step *New*

4. Select *Single-sided* from the drop-down list.

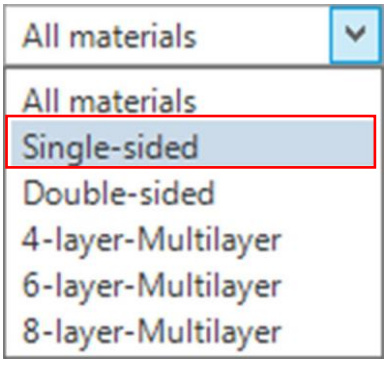


Fig. 98: Drop-down list material

5. Select your laser system from the drop-down list (in this example *PL R4*).

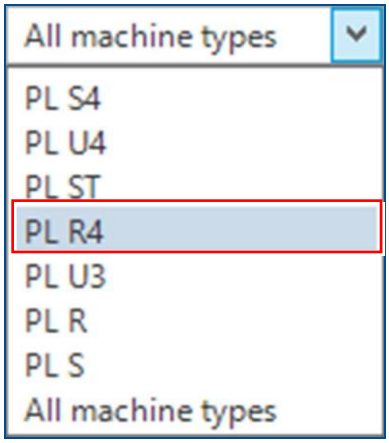


Fig. 99: Drop-down list system

☐ A list of templates for single-sided materials is displayed:

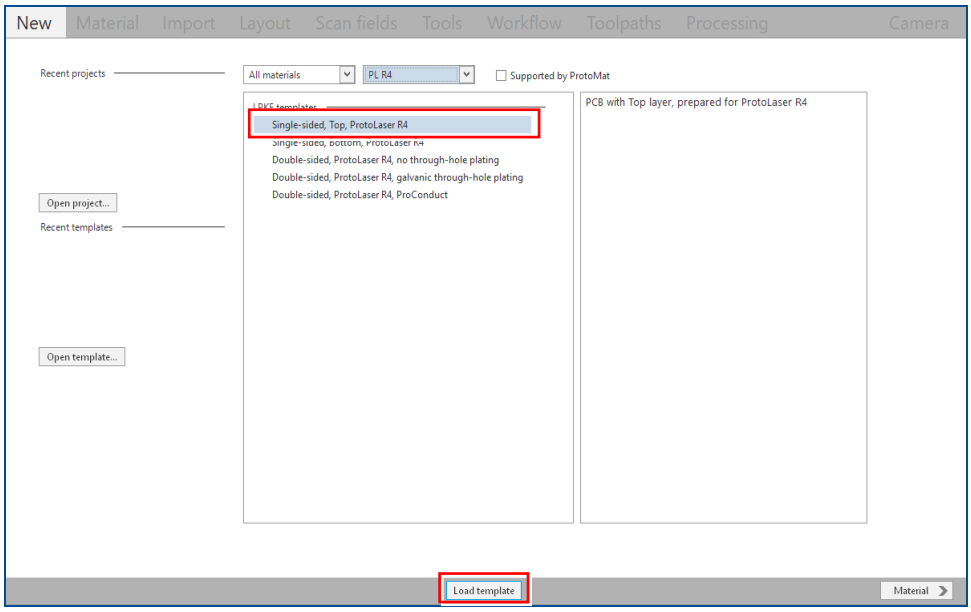


Fig. 100: List of templates

6. Select the template *Single-sided, Top, ProtoLaser R4*.
7. Click on [Load template] or double-click on the template.

☐ The user guidance step *Material* is displayed.

☑ The system has been switched on.

Connecting the system manually

If automatic connection of the system fails, you can connect the system manually with the system software: Click on *Processing* > *Connect to machine…* select your system in the drop-down list and click on [Connect].

The system requires a warm-up time of up to **20** minutes for the laser source to attain a constant diode temperature. The warm-up phase starts automatically when processing the first job.
You can continue to work in the user guidance step *Layout* during the warm-up phase.

Tips for selecting a template:

- Select the template according to the number of layers.
- Select the template according to the metallization type.
- Select the template according to the type of multi-layer press.

Selecting a material

1. In the user guidance step *Material*, select the Material *Al2O3_Au22 Sigle-sided, 0.5 mm, 22 µm*.

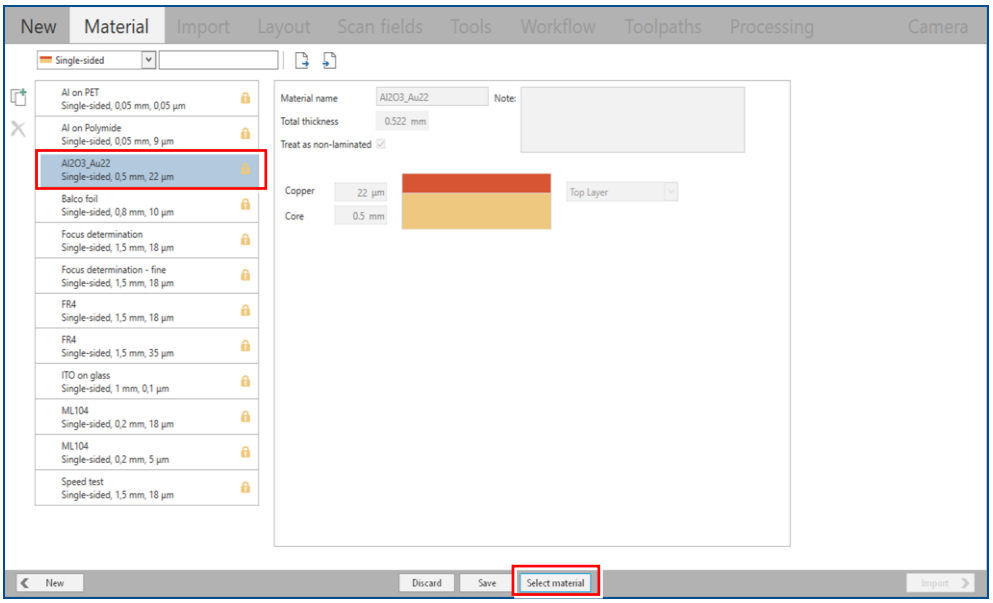


Fig. 101: User guidance step *Material*

2. Click on [Select material] or double-click on the material.

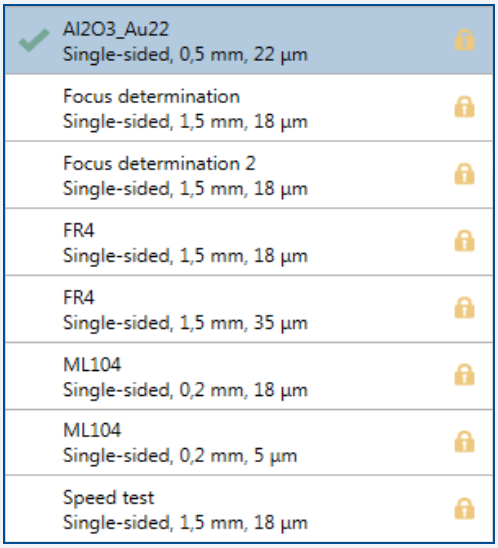
☐ The user guidance step *Import* appears.

☑ The material has been selected.

Selecting a material type

By selecting the *Material* you also select the tools with the laser parameters specific to the material.

Example of the composition of the material name:



- *Al2O3_Au22* – Material type
- *0.5 mm* – Material thickness
- *22 µm* – Copper layer thickness

Importing the data

1. In the user guidance step *Import* click on .
☐ The dialog *Open* is displayed.
2. Navigate to the folder that contains the data you want to import.
3. Select the files you want to import.
4. Click on [Open].
☐ The data are automatically assigned to the correct layers and the user guidance step *Import* is displayed:

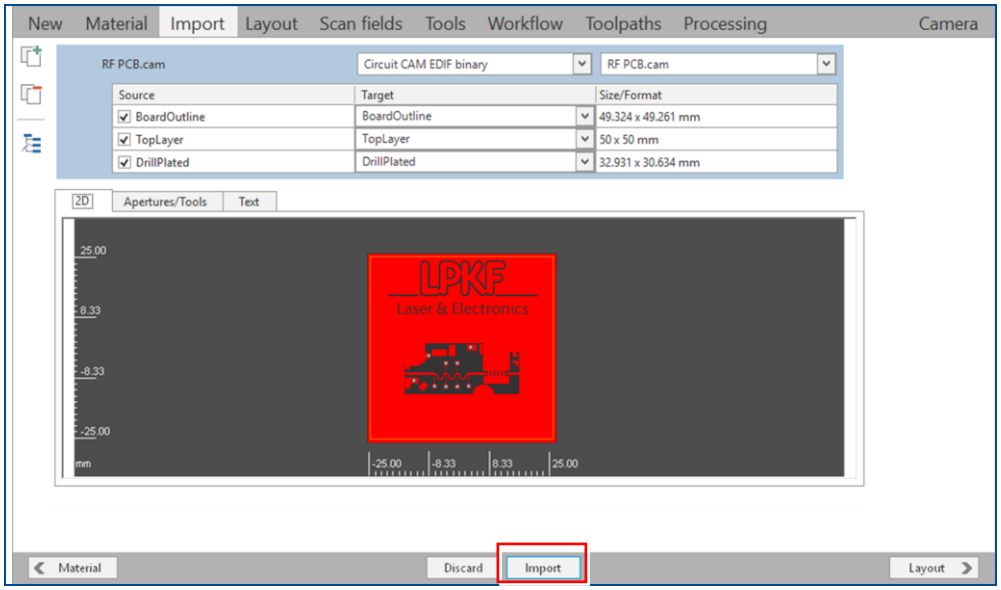


Fig. 102: User guidance step *Import* (example data)

5. Click on [Import].
☐ The user guidance step *Layout* is displayed:

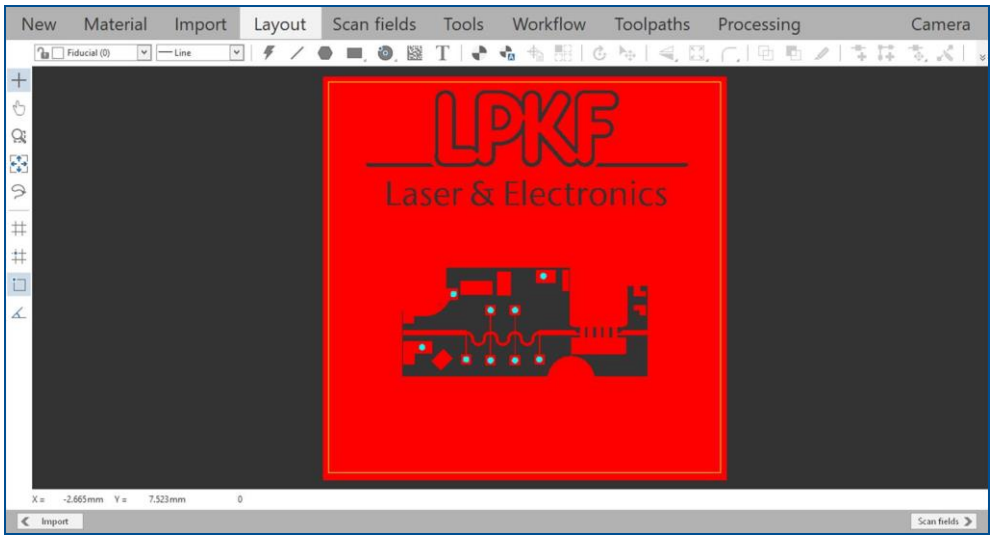
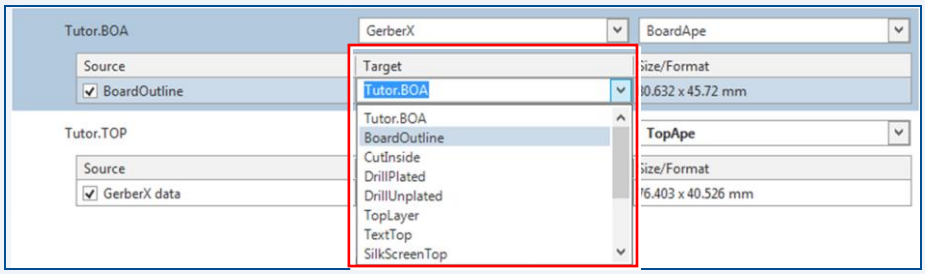


Fig. 103: User guidance step *Layout*

☑ The data have been imported.

Assigning the layers manually

If the data have not been assigned to the correct layers automatically, they can be assigned manually. In the drop-down list in the column *Target*, select which layer is to be assigned to the imported source data.



Multiplying the layout (optional)

If desired, you can multiply the layout. In this example multiplies of the layout are not necessary.

The functions *Step and repeat* and *Create instance type* are only available in the license level Advanced of CircuitPro PL. If you have any questions contact the LPKF sales department.

1. In the user guidance step *Layout* select the entire layout by pressing Ctrl + A.

☐ The layout is selected.

2. Right-click on the layout.

☐ The following context menu is displayed:

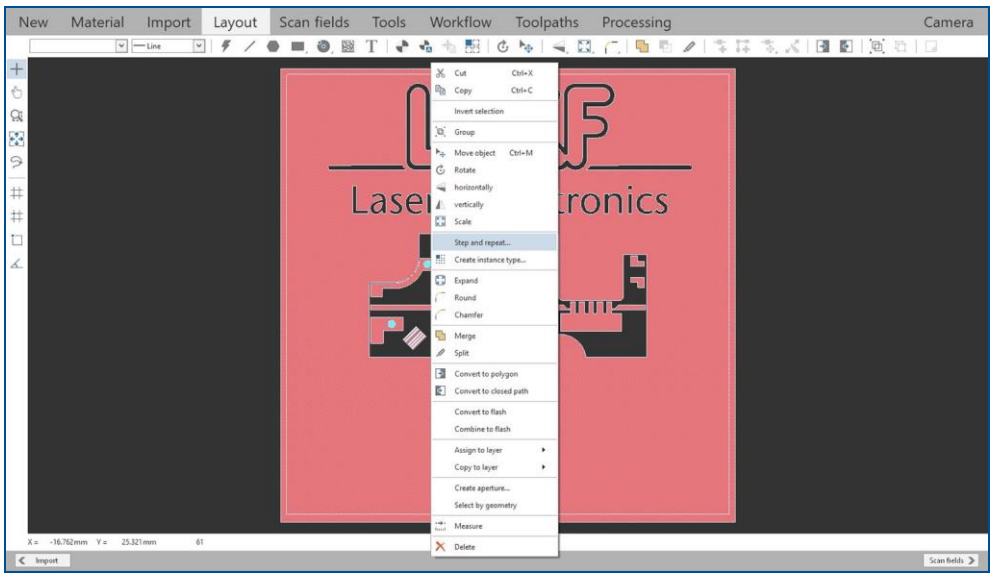


Fig. 104: Context menu *Step and repeat*

3. Click on *Step and repeat...*

☐ The following dialog is displayed:

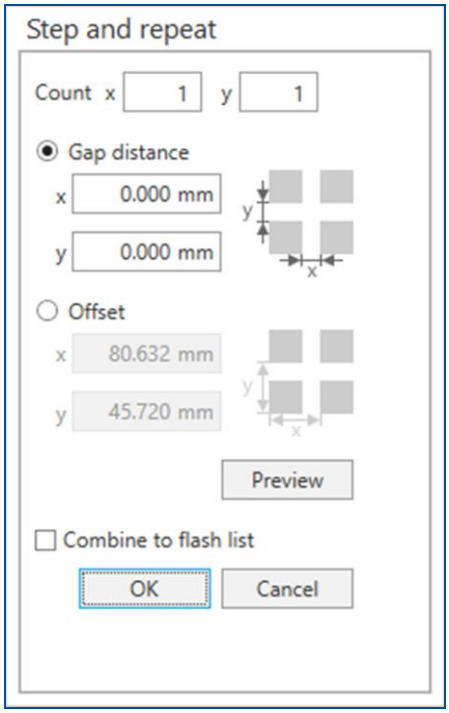


Fig. 105: Dialog *Step and repeat*

4. Enter the desired number of repetitions along each axis in the fields *Count*.

   For this example, four multiples of the layout have been made. Enter **2** counts for the x axis and **2** counts for the y axis.

Some space for cutout is required between the copies, so the *Gap distance* has to be specified for the x and y direction.

5. Enter *2 mm* in the fields *Gap distance*.

☐ After entering all the values, the dialog is displayed as follows:

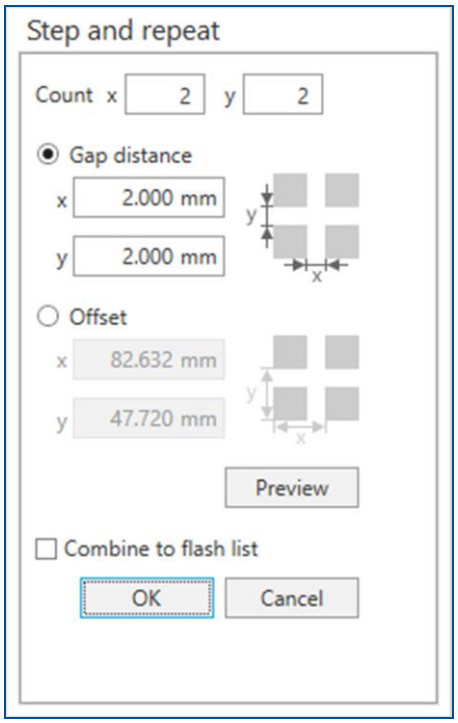


Fig. 106: Dialog *Step and repeat* after entering values

6. Click on [OK].

☐ The multiplied layouts are created.

7. In order to zoom out and get an overview of the multiplied layouts, perform one of the following steps:
   - Scroll the mouse wheel.
   - Press the Home key.
   - Click on  .

8. Press Esc or click anywhere on the black background to deselect the highlighted layout.

☐ The user guidance step *Layout* changes as follows:

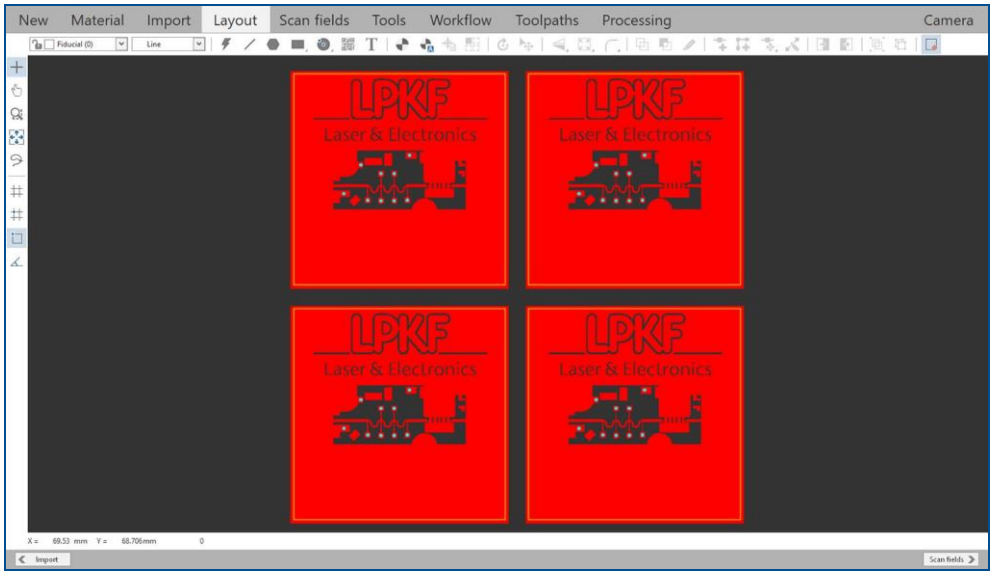


Fig. 107: Multiplied layout

☑ The layout has been multiplied.

Creating an instance type

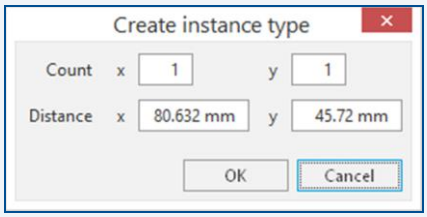
As an alternative to multiplying the layout data, you can use instances. The advantages are:

- Less memory is needed.
- The calculation of the toolpaths is speeded up.

You can create an instance type by performing the following steps:

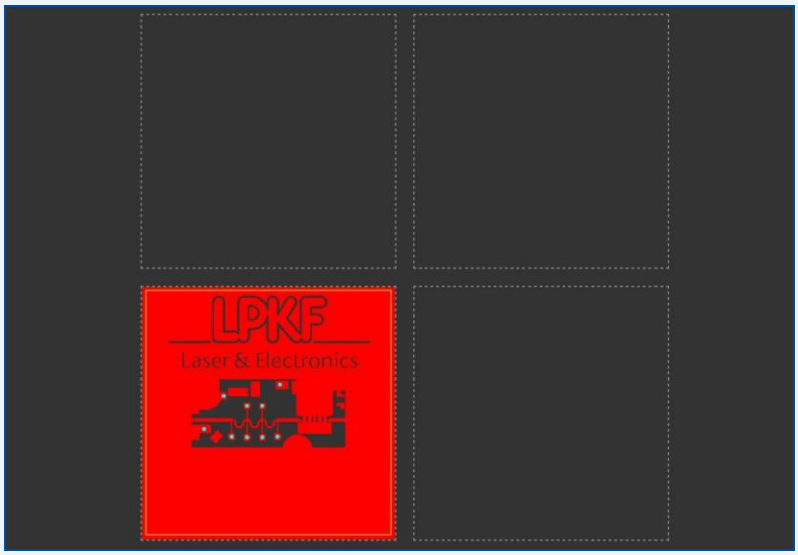
1. Select the entire layout by pressing Ctrl + A.
2. Click on *Insert* > *Create instance type* or on .

☐ The following dialog is displayed:



3. Enter the desired number of instances in the input fields *Count*.
   For this example, enter **2** counts for the x axis and **2** counts for the y axis.
4. Increase the entered values in the input fields *Distance* by **2** mm.
5. Click on [OK].

☐ The instance type is created:



Creating fiducials

The function *Automatic fiducial creation* is only available in the license level Advanced of CircuitPro PL. If you have any questions contact the LPKF sales department.

1. In the user guidance step *Layout* click on *Insert > Automatic fiducial creation* or click on .

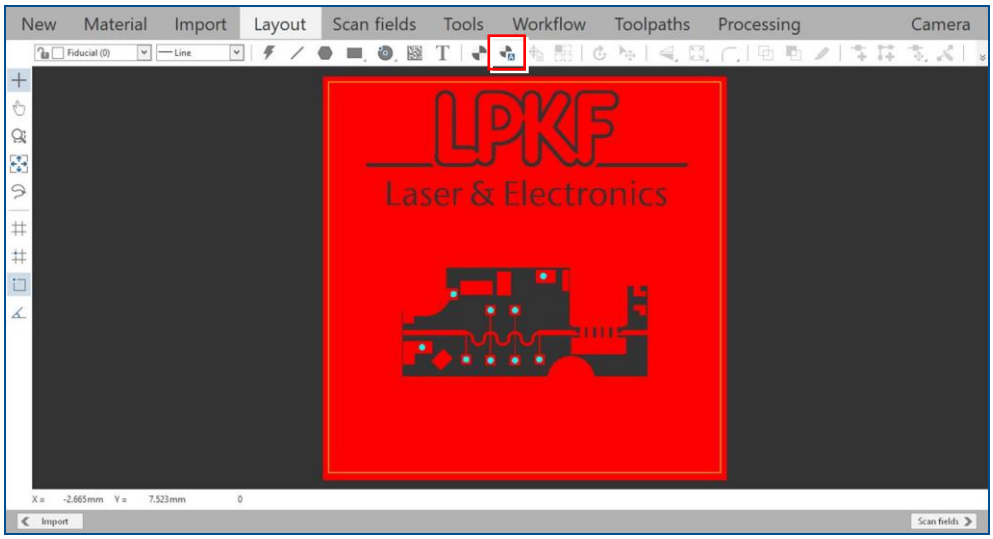


Fig. 108: Create fiducials automatically

☐ The following dialog is displayed:

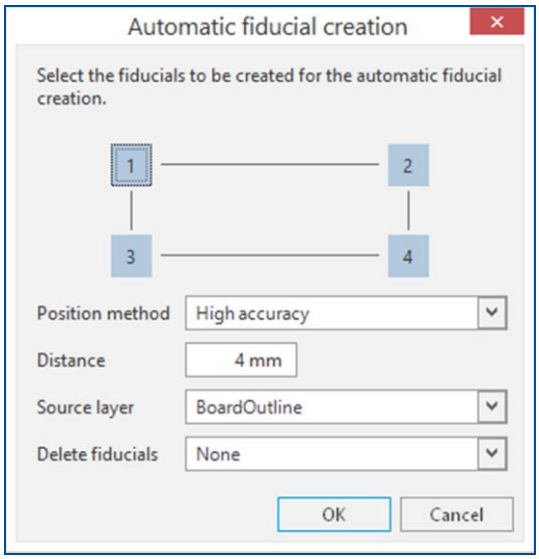


Fig. 109: Dialog *Automatic fiducial creation*

For optimum alignment results it is recommended to create four fiducials and to place them outside the outer contour.
Using three fiducials is a good way to avoid wrong orientation of the base material.
At least two fiducials are required for correct operation of the process; arrange them diagonally.

2. Adapt the settings for the fiducials.

   In this example four fiducials with a distance of 4 mm from the board outline are created.

3. Click on [OK].

☐ The fiducials are automatically added to the layout:

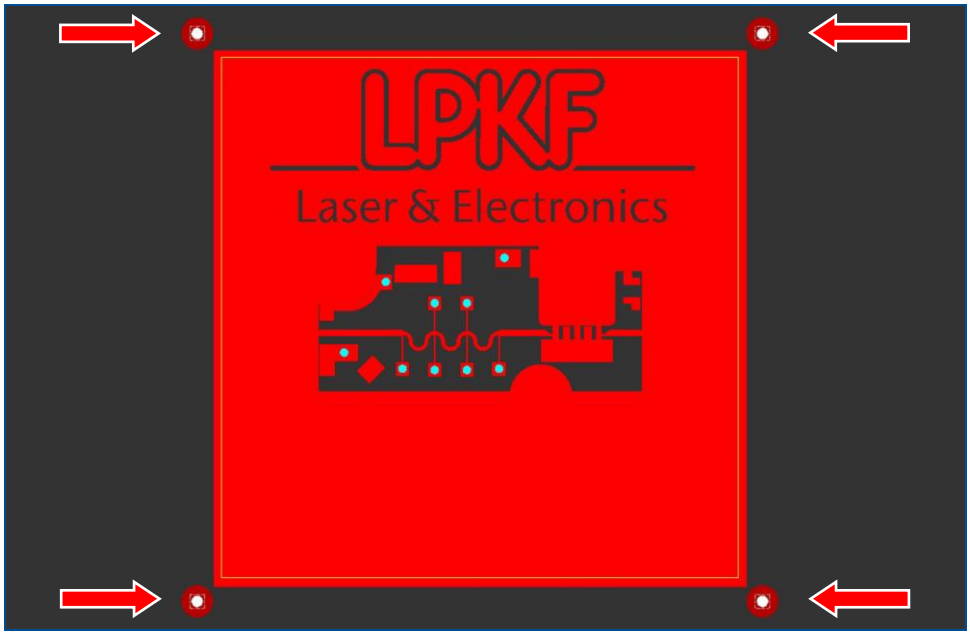


Fig. 110: Fiducials created

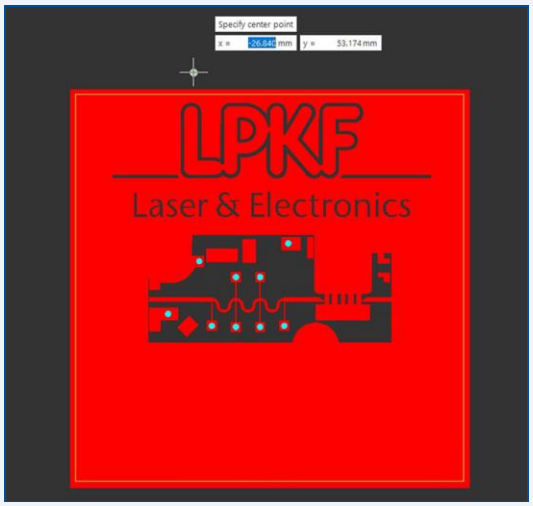
☑ The fiducials have been created.

Creating fiducials manually

You can add fiducials to the layout manually by performing the following steps:

1. Click on *Insert* > *Fiducial* or click on .

☐ The input fields for *Specify center point* are displayed:



2. To insert the fiducial, perform one of the following steps:
   - Click on a desired point in the layout.
   - Enter the values for *x* and *y* in the input fields.
3. Repeat step 2 for all other fiducials.
4. Press Esc to close the function.

Before processing an RF PCB, the workflow settings need to be modified.

Modifying the workflow settings

1. Switch to the user guidance step *Workflow*.

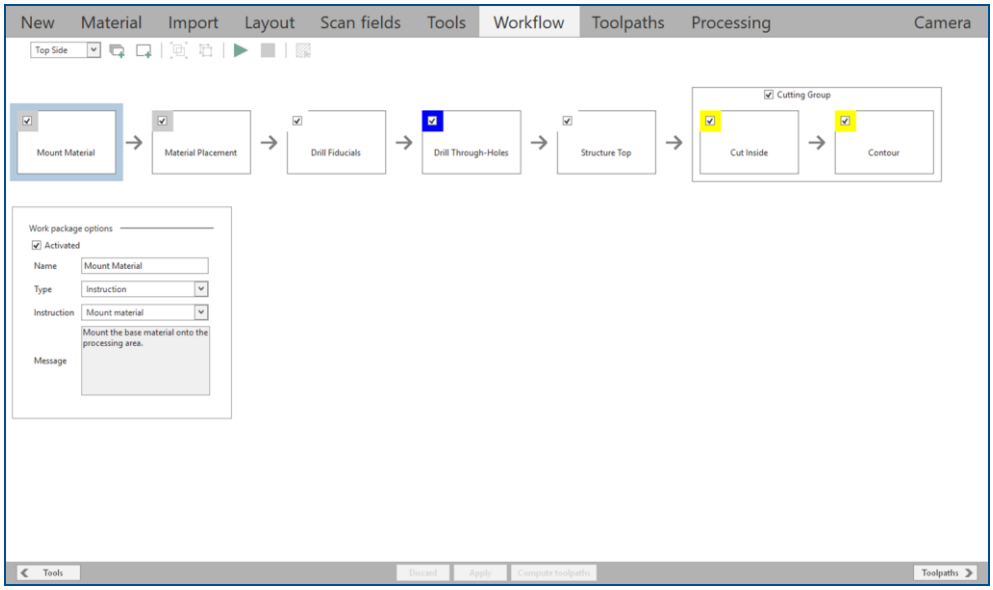


Fig. 111: User guidance step *Workflow*

2. Select the work package *Structure Top*.

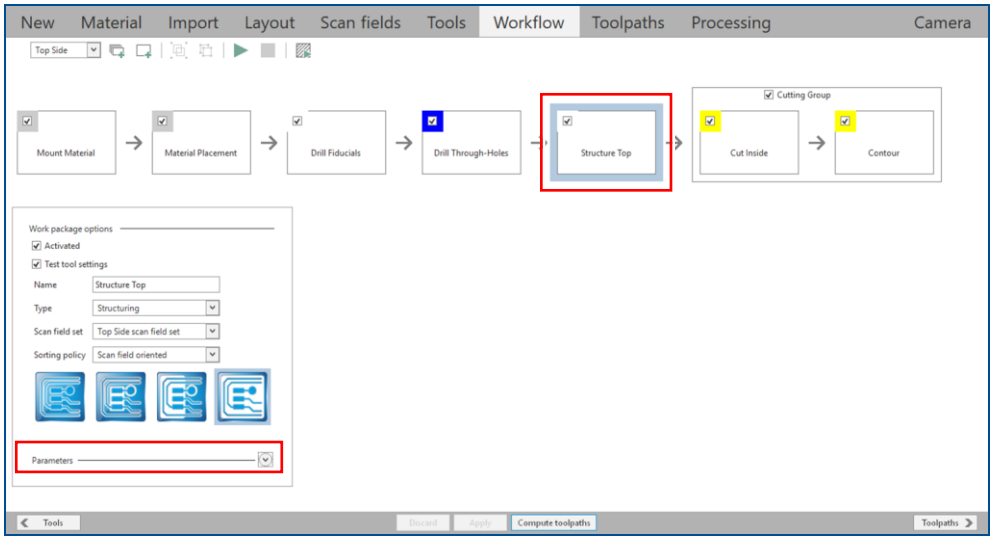


Fig. 112: Work package *Structure Top* selected

3. Expand the group *Parameters*.

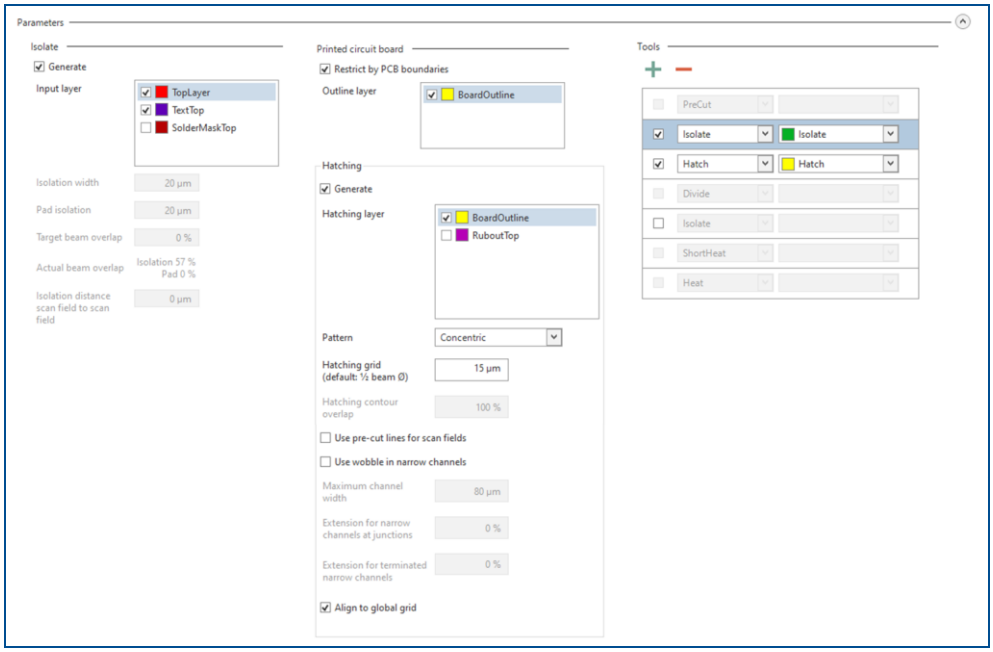


Fig. 113: Group *Parameters*

4. In the sub-group *Hatching*, select the entry *xy parallel* from the drop-down list *Pattern*.
5. Enter *7.5 µm* in the input field *Hatching grid*.

☐ The sub-group *Hatching* changes as follows:

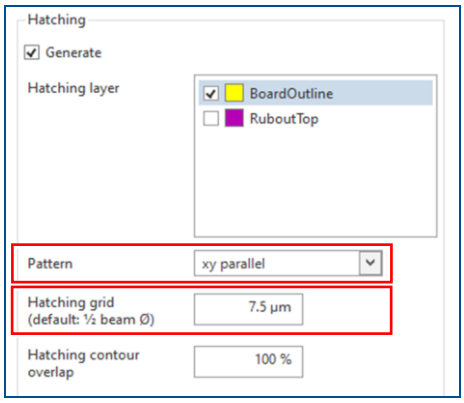


Fig. 114: Sub-group *Hatching*

The order of the tools *Isolate* and *Hatch* needs to be reversed for this how-to example.

6. Select the tool *Isolate*.

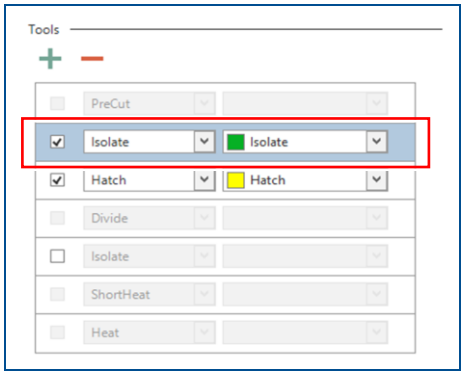


Fig. 115: Tool selected

7. Move it to the second position using drag & drop.

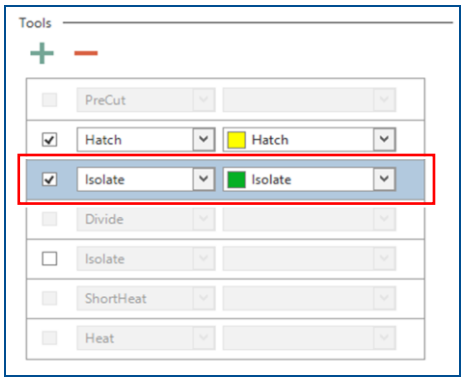


Fig. 116: Tool moved

Alternatively, you can change the order of the tools via the drop-down lists.

☐ The order of the tools *Isolate* and *Hatch* has been reversed.

8. Click on [Apply].

☑ The workflow settings have been modified.

Computing toolpaths and scan fields automatically

1. Switch to the user guidance step *Scan fields*.
2. Click on [Compute scan fields] or on .

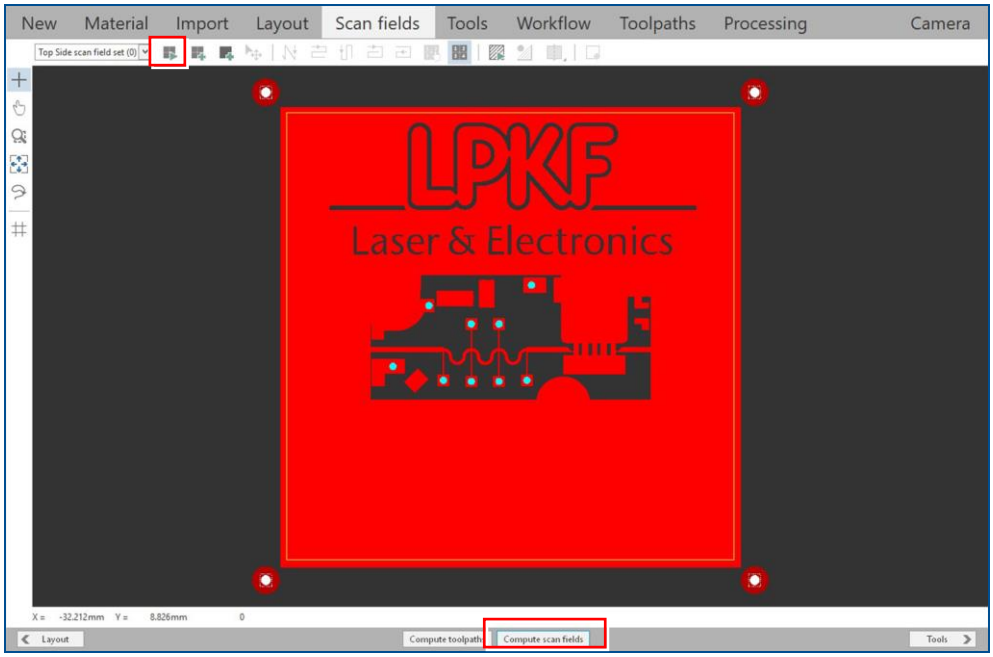


Fig. 117: Compute scan fields

3. The following dialog is displayed:

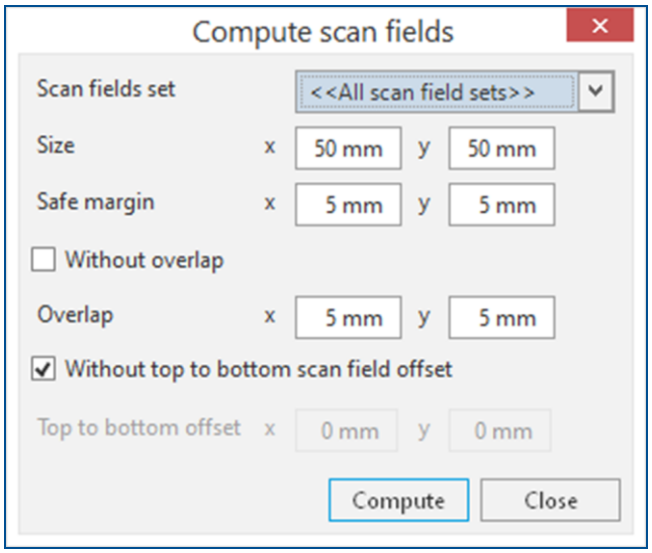


Fig. 118: Dialog *Compute scan fields*

4. Adapt the settings for the scan fields, if necessary. In this example, the default settings are used.
5. Click on [Compute].

☐ The scan fields are computed automatically.

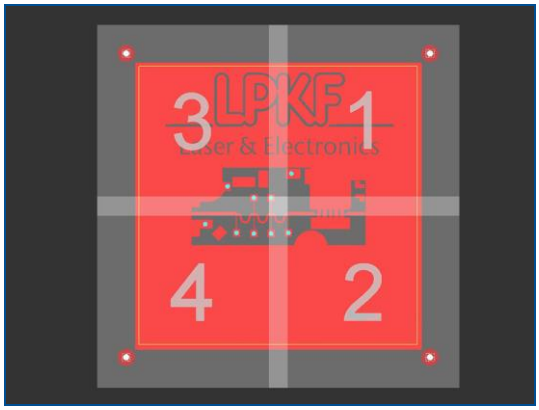


Fig. 119: Scan fields computed

6. Click on [Compute toolpaths] or on .

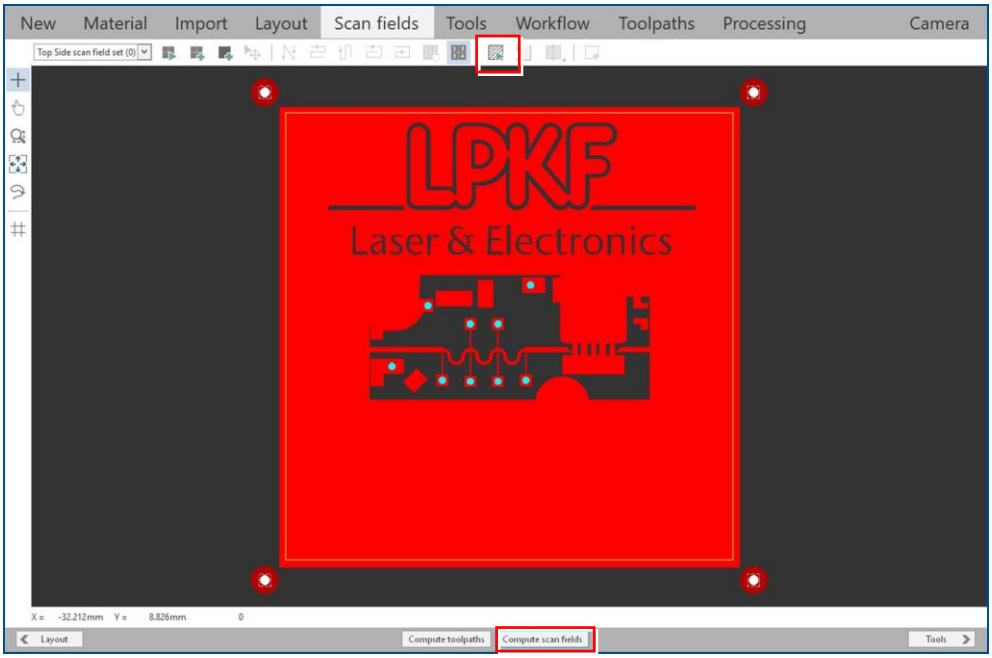


Fig. 120: Compute toolpaths

☐ The following message is displayed:

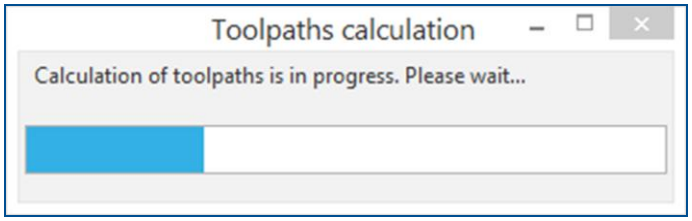


Fig. 121: Message *Toolpaths calculation*

☐ The toolpaths are computed automatically with default settings.
The following message is displayed:

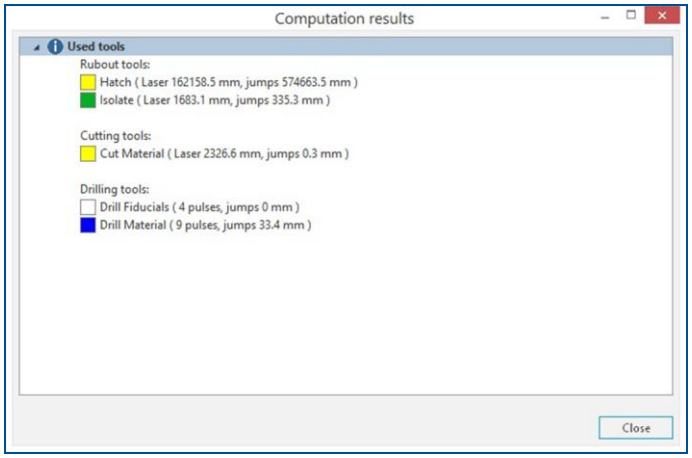


Fig. 122: Message *Computation results*

7. Check the computation results for any possible warnings or errors and make corrections, if required.
8. Click on [Close].

☑ The toolpaths and scan fields have been computed.

If you do not want to compute the toolpaths and scan fields with the default settings, you can adapt the settings according to your needs (see *Computing scan fields manually* on page 119 and *Configuring toolpaths manually* on page 121).

Computing scan fields manually (optional)

1. Switch to the user guidance step *Scan fields*.
2. Click on [Compute scan fields] or on .

☐ The dialog *Compute scan fields* is displayed.

3. Select *Top Side scan field set* from the drop-down list.

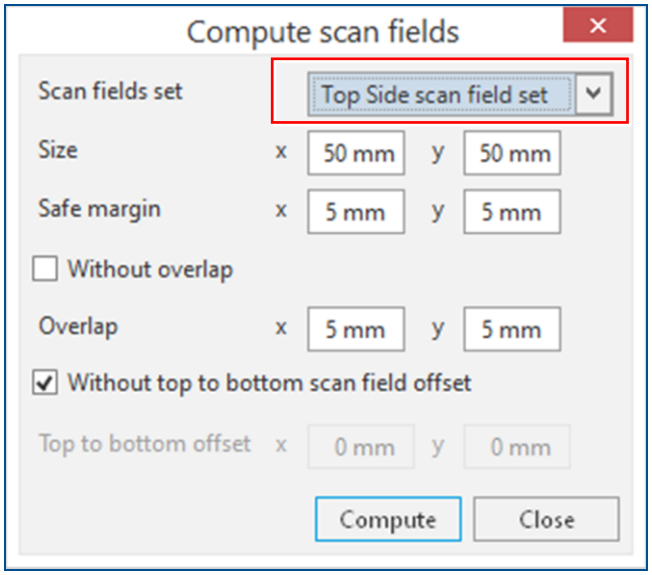


Fig. 123: *Top Side scan field set* selected

Alternatively, in the pane *Workflow setup*, right-click in the group *Scan fields* on *Top Side scan field set* and click on the context menu item *Compute*.

4. Adapt the settings, if necessary.
5. Click on [Compute].

☐ The scan fields for the *Top Side* are computed.

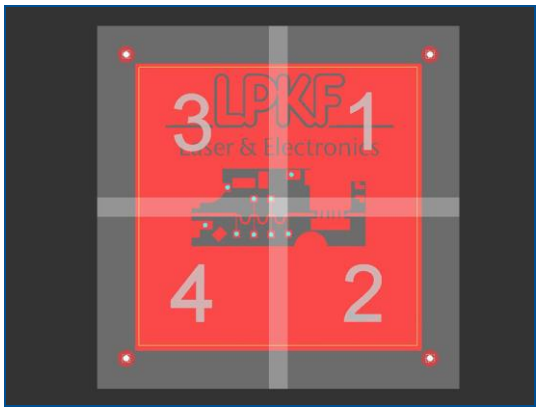


Fig. 124: Scan fields *Top Side*

6. Repeat the steps 2 to 5 for the *Fiducials scan field set*.

☐ The scan fields for the *Fiducials* are computed.

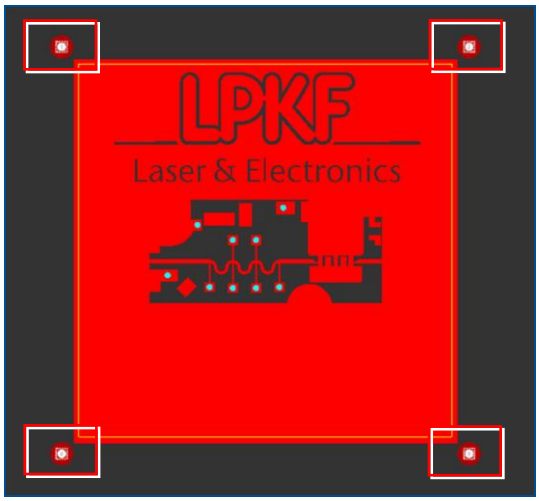


Fig. 125: Scan fields *Fiducials*

☑ The scan fields have been computed.

Configuring toolpaths manually (optional)

1. Switch to the user guidance step *Workflow*.

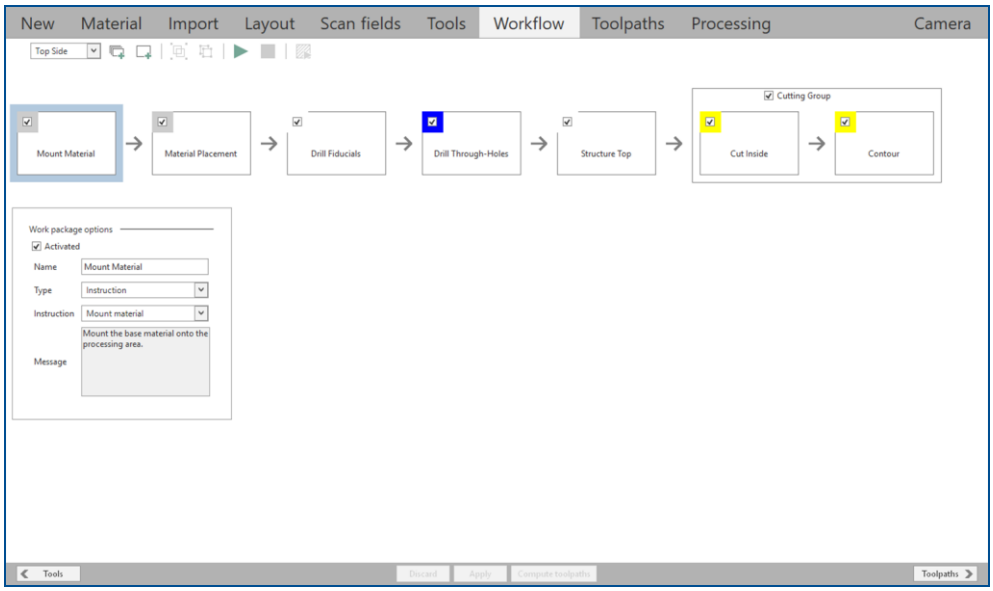


Fig. 126: User guidance step *Workflow*

2. Select the work package *Drill Fiducials*.

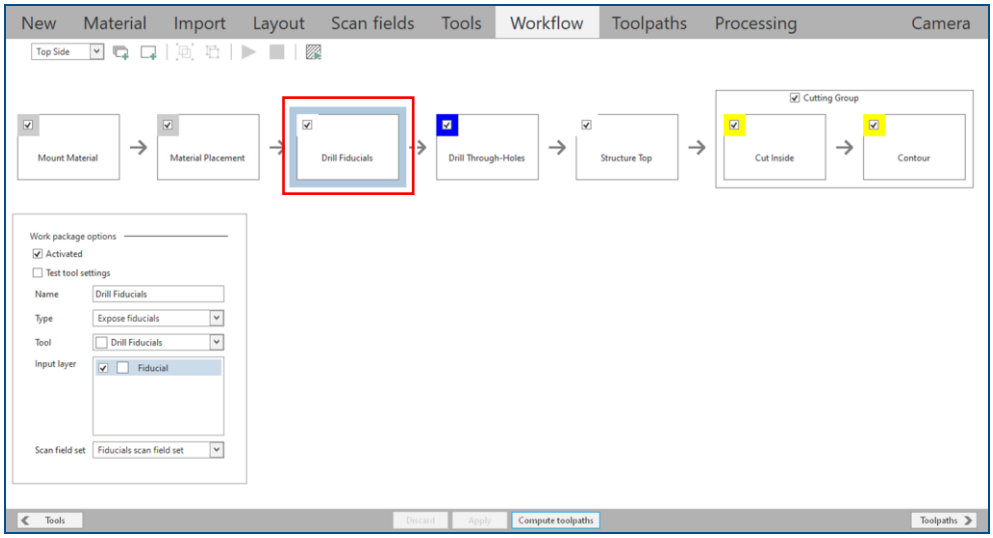


Fig. 127: Work package *Drill Fiducials* selected

3. Adapt the settings, if necessary.

4. Select the work package *Drill Through-Holes*.

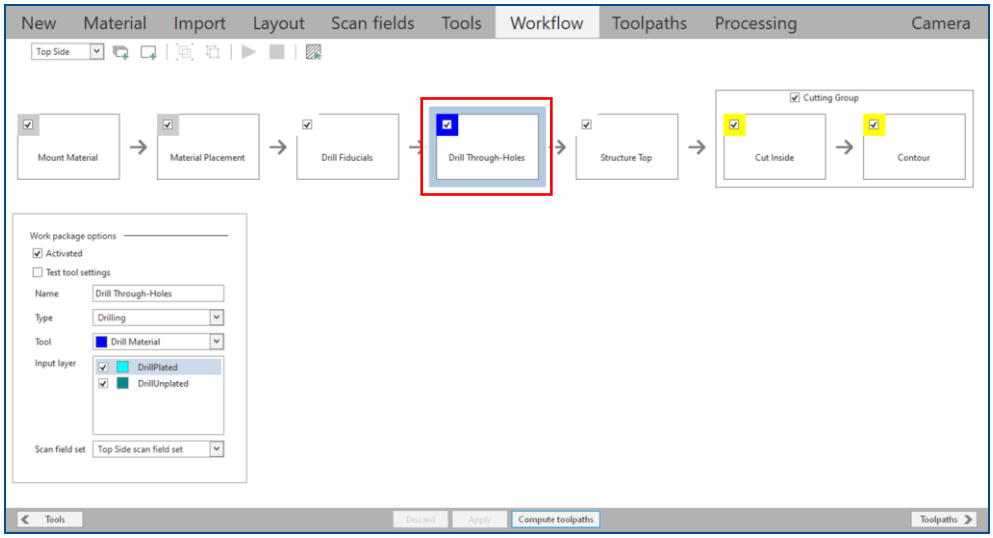


Fig. 128: Work package *Drill Through-Holes* selected

5. Adapt the settings, if necessary.
6. Select the work package *Structure Top*.

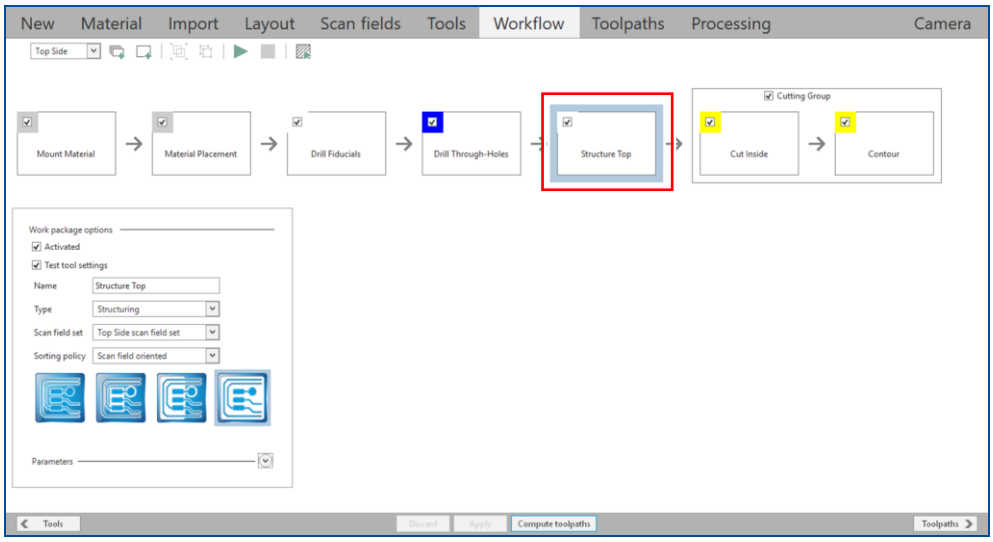


Fig. 129: Work package *Structure Top* selected

7. Adapt the settings, if necessary.
8. Click on [Apply].

☐ The workflow settings are modified.

9. Switch to the user guidance step *Toolpaths*.
10. Click on [Compute toolpaths] or on  .

☑ The toolpaths have been configured manually.

Computing toolpaths for individual work packages

You can compute the toolpaths for each individual work package. Select the work package, adapt its settings, and click on [Compute toolpaths]. The *Computation results* for the work package are displayed in a dialog.

Processing the PCB

Clean the material surface with LPKF Cleaner, if discoloration (oxide layer) is discernible. Thus, a surface is achieved that always has the same characteristics.

1. Switch to the user guidance step *Processing*.

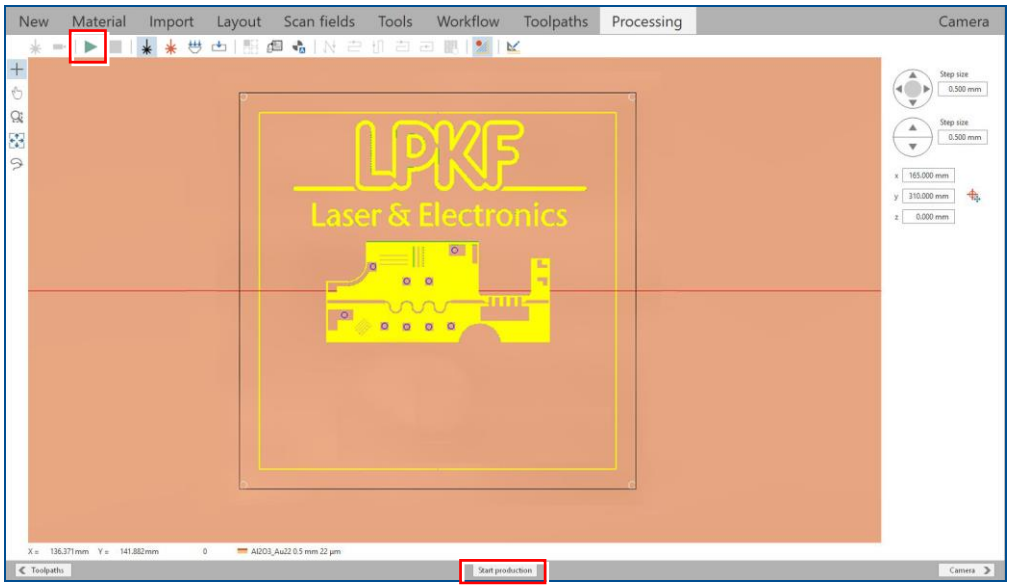


Fig. 130: User guidance step *Processing*

2. Click on ▶ or click on [Start production].

☐ The following message is displayed:

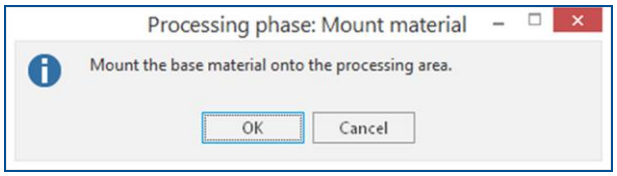


Fig. 131: Dialog *Processing phase: Mount material*

3. Open the cover.
4. Place the base material onto the processing table.
5. Click on .

☐ The base material is fastened onto the processing table by vacuum.

If the base material is bent too much and the vacuum does not allow to fasten it correctly, fasten it with adhesive tape.

6. Close the cover.
7. Click on [OK].

☐ The following dialog is displayed:

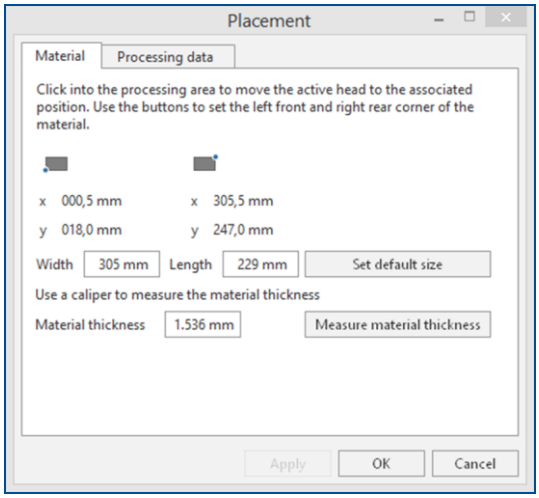


Fig. 132: Dialog *Placement*

8. Move the dialog *Placement* to get a better overview.
9. Switch to the view *Camera*.
10. Move the processing table using the arrow buttons or double-clicks in the camera image until the left front corner of the material is displayed:

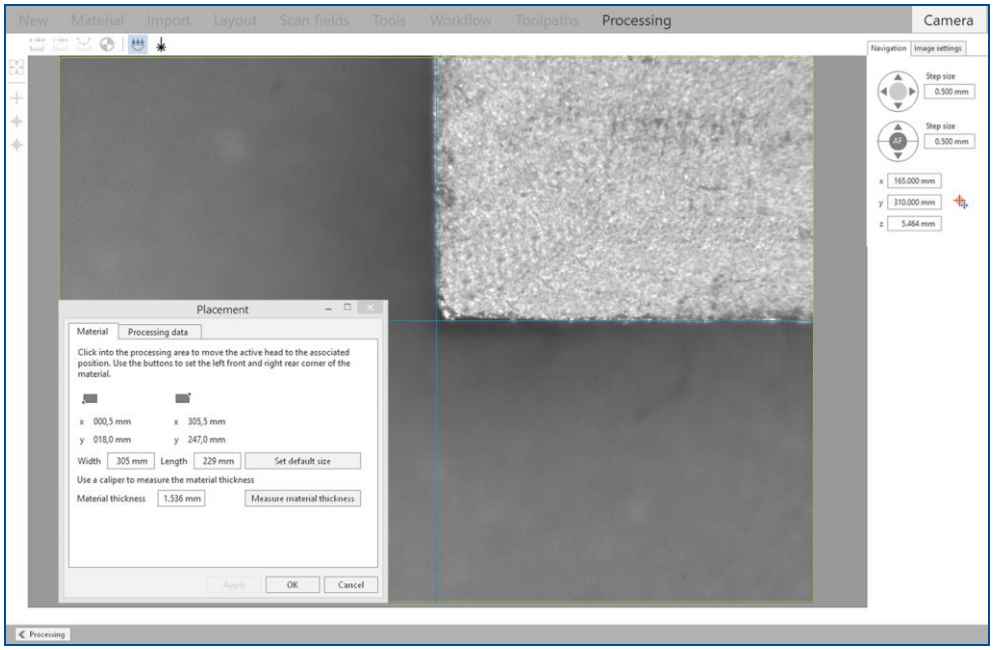


Fig. 133: Left front corner of the material in view *Camera*

11. In the dialog *Placement* click on  to confirm the position.
12. Move the processing table using the arrow buttons or double-clicks in the camera image until the right rear corner of the material is displayed in the view *Camera*.
13. In the dialog *Placement* click on to confirm the position.

☐ The position of the base material on the processing table is determined.

14. Click on the tab *Processing data*.

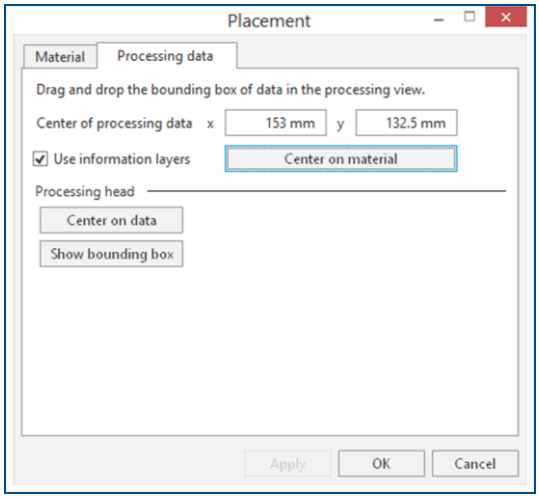


Fig. 134: Dialog *Placement* | *Processing data*

15. Place the processing data.

    The processing data can be moved using drag & drop or by entering the values in the fields *x* and *y*. Click on [Center on material] to place the processing data on the center of the base material.

16. Click on [OK].

☐ The laser system starts the material thickness measurement. The following message is displayed:

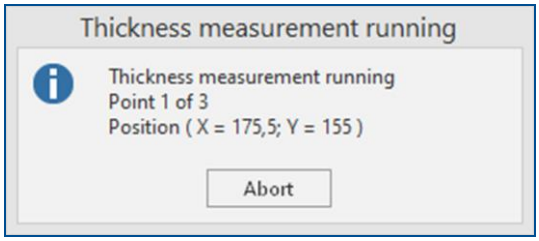


Fig. 135: Message *Thickness measurement running*

When finished, the following message is displayed:

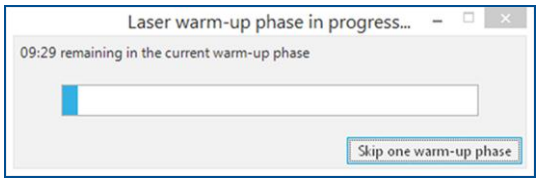


Fig. 136: Message *Laser warm-up phase in progress*

After warm-up, the fiducials and the through-holes are drilled and the following dialog is displayed:

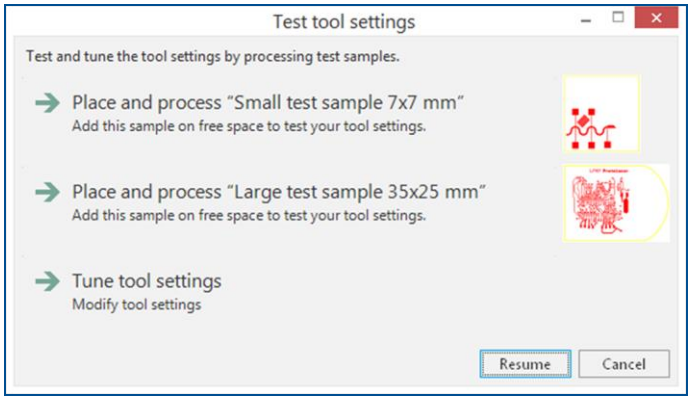


Fig. 137: Dialog *Test tool settings*

In this example, the testing and setting the tools is to be skipped.

17. Click on [Resume].

☐ The Top side (*TopLayer*) is structured and the following message is displayed:

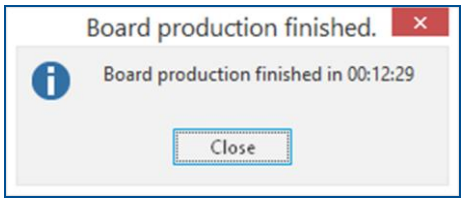


Fig. 138: Message *Board production finished*

18. Click on [Close].
19. Open the cover.

CAUTION! Health hazard by contact with dusts on laser-structured material!
Structuring with a laser can produce fine dusts that can deposit on the material. These dusts can cause sensitization and skin irritation on contact.

▶ Always wear chemical-resistant gloves when handling laser-structured material.

20. Remove the PCB from the system.

☑ The PCB has been processed.

Stopping processing (optional)

▶ Click on *Processing* > *Stop processing* or click in the user guidance step *Processing* on ■.

☑ Processing has been stopped.

Switching off the system

1. Click on *File* > *Exit*.

☐ The connection to the system is disconnected and the system software is closed.

2. Perform one of the following steps:
   - In the Windows user interface, click on *Start* > *Shut down*.
   - Press the On/Off switch at the system front briefly.

☐ The operating system is shut down.

☑ The system has been switched off.

Cleaning the system

The processing area has to be cleaned if heavily soiled.

▶ Use a vacuum cleaner to remove chips and residues from the processing area.

☑ The system has been cleaned.

Cleaning the PCB

CAUTION! Health hazard by contact with dusts on laser-structured material!
Structuring with a laser can produce fine dusts that can deposit on the material. These dusts can cause sensitization and skin irritation on contact.

▶ Always wear chemical-resistant gloves when handling laser-structured material.

1. Check for any remaining copper strips on the PCB that should have been removed by laser.
2. Spray the board with LPKF Cleaner and use a brush to clean it.
3. Rinse the PCB with tap water and dry it with compressed air.
4. If the board is still not free of unwanted copper strips, apply a piece of adhesive tape that does not leave glue residues on the PCB and pull it off. Any remaining copper strips should attach to the tape.

☑ The PCB has been cleaned.

Residual copper strips

If despite all cleaning any copper strips still remain on the PCB, check the material type and the tool library used.

6.4 Special tasks

This chapter describes tasks that are not part of the typical production process.

The following tasks are described:

- Switching off the system with the main switch
- Replacing the sinter plate
- Performing a power measurement

Switching off the system with the main switch

1. Close the system software.

☐ The connection to the system is disconnected and the system software is closed.

2. Perform one of the following steps:
   - In the Windows user interface, click on *Start* > *Shut down*.
   - Press the on/off button at the front of the system.

☐ The operating system is shut down.

3. Turn the main switch at the rear of the system to position *0 OFF*.

Fig. 139: Main switch set to *0 OFF*

☑ The mains power supply of the system is switched off.

Replacing the sinter plate

If the sinter plate has become unusable due to wear or burns, it has to be replaced.

Ensure that the following spare parts and auxiliaries are available before performing the described tasks:

Spare parts and auxiliaries

- Sinter plate (order code: 10055362)

1. In the *Processing* view, click on .

☐ The system moves to the loading position.

2. Open the cover.
3. Remove the sinter plate.
4. Clean the processing table, if necessary.
5. Insert the new sinter plate.
6. Close the cover.

☑ The sinter plate has been replaced.

Performing a power measurement

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisite

- The Advanced user is logged on.

1. Click on *Processing* > *Laser beam diagnostics* > *Power measurement* or in the user guidance step *Processing* on .

☐ The following dialog is displayed.

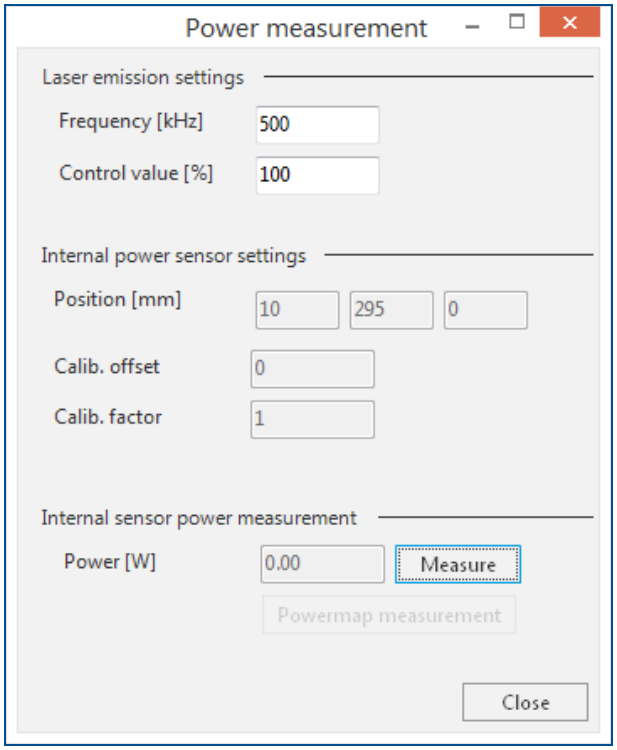


Fig. 140: Dialog *Power measurement*

☐ The following message is displayed:

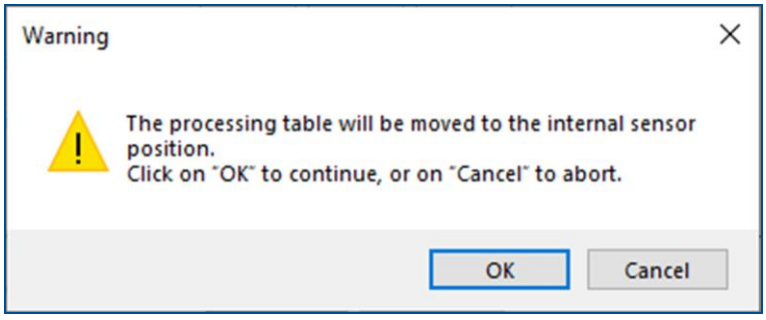


Fig. 141: Warning

2. Click on [OK].

☐ The processing table moves to the position of the internal sensor.

3. Click on [Measure].

☐ The following message is displayed:

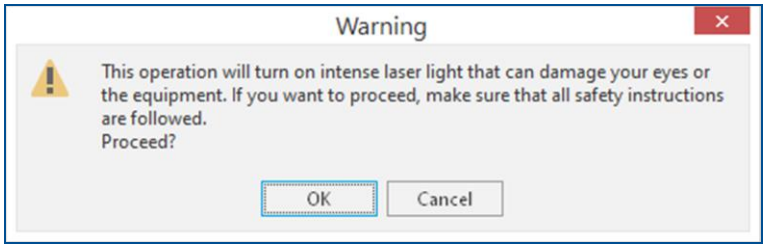


Fig. 142: Warning

4. Click on [OK].

☐ All buttons are greyed out for 10 seconds.

The button [Measure] changes to the button [Stop]. The measured value appears in the field *Power [W]*.

5. Click on [Stop].
6. Execute one of the following steps:
   - If the measured value in the field *Power [W]* is OK, proceed with step 15.
   - If the measured value in the field *Power [W]* is Not OK, execute the following steps:
7. Click on [Powermap measurement].

☐ The following dialog is displayed.

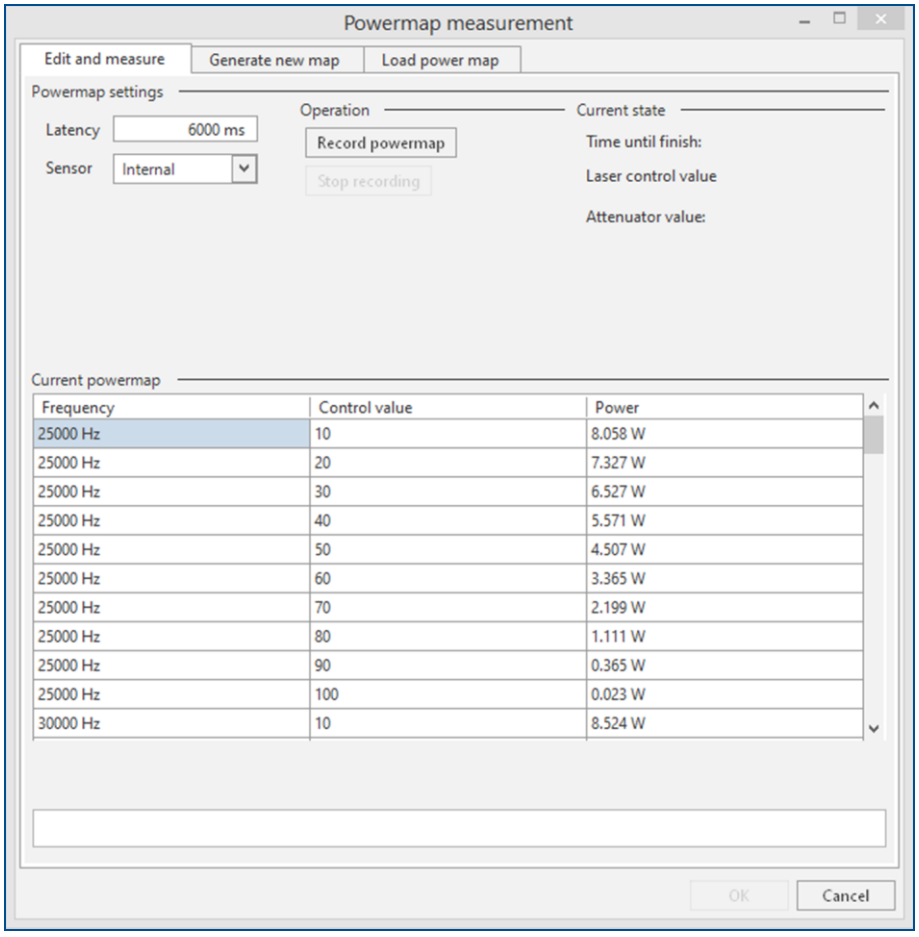


Fig. 143: Dialog *Powermap measurement*

Creating a powermap can take approx. 30 minutes.

8. Click on [Record powermap].

☐ The following message is displayed:

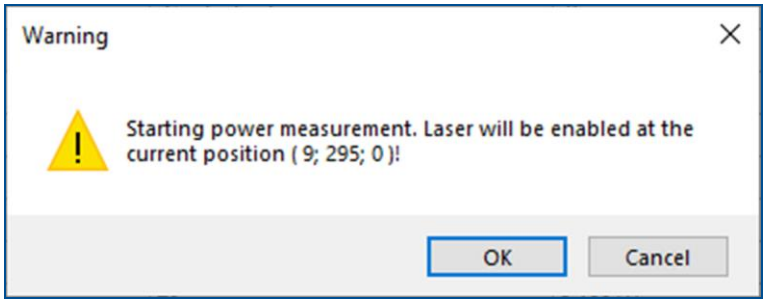


Fig. 144: Warning

9. Click on [OK].

☐ The powermap is generated.

10. Click on [OK].
11. Click on [Measure].

☐ The following message is displayed:

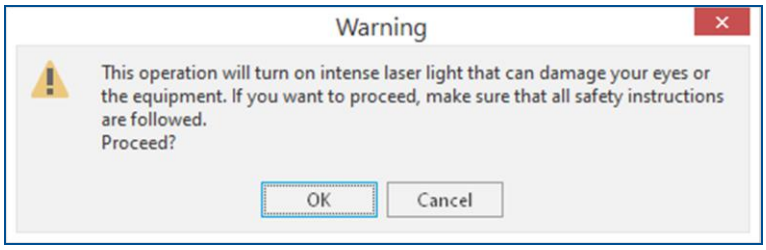


Fig. 145: Warning

12. Click on [OK].

☐ All buttons are greyed out for 10 seconds.

The button [Measure] changes to the button [Stop]. The measured value appears in the field *Power [W]*.

13. Click on [Stop].
14. Execute one of the following steps:
    - If the measured value in the field *Power [W]* is OK, proceed with step 15.
    - If the measured value in the field *Power [W]* is Not OK, contact the LPKF service.
15. Repeat the power measurement with changed values in the fields *Frequency [kHz]* and *Control value [%]*.

    If the measured values in the field *Power [W]* are OK, click on [Close].

☑ The power measurement has been performed.

7 Maintenance

This chapter contains important information about maintenance of the system.

Proper maintenance and the proper operation of the corresponding supply units such as the extraction system and the compressed-air supply are basic requirements for a smooth function of the system. Maintenance must be performed and documented in accordance with the manufacturer's instructions and on a regular basis.

Each maintenance task and each service has to be recorded in the logbook with date, operating hours, as well as the tasks that have been executed.

The system is designed for a service life of 10 years used in continuous operation. The specified maintenance intervals are valid for continuous operation at 7 days a week.

7.1 Safety

Follow the safety instructions below for your own protection and for the protection of other persons in the vicinity of the maintenance work. The maintenance personnel must ensure that the described prerequisites for the planned maintenance tasks are fulfilled and they must observe the special warning messages for the individual maintenance tasks.

Contact the LPKF Service for maintenance or repair tasks that go beyond the tasks described in the maintenance schedule for the maintenance personnel of the operator.

⚠ DANGER

Danger to life by missing safety devices!

Missing or deactivated safety devices while operating the system can cause serious injuries or even death.

- ▶ Always ensure that all safety devices are functioning properly and are switched on.

⚠ DANGER

Danger to life by electrical shock!

Any physical contact to energized components or cables can cause death by electrical shock and/or fire.

- ▶ Switch off the system with the main switch before starting any maintenance work.
- ▶ Disconnect the external components from the power supply.
- ▶ Secure the system and the components against unintended restart.

⚠ WARNING

Health hazard by vapors and dusts during cleaning tasks!

Dust particles can be swirled up when cleaning the interior of the system. These can cause sensitization/irritation and breathing difficulties on contact.

- ▶ Always wear the protective equipment for working with hazardous substances and chemicals when cleaning the interior of the system.

⚠ CAUTION

Health hazard by contact with chemicals!

Direct contact with the chemicals can cause serious damage to health.

- ▶ Always read the safety data sheets before working with chemicals and always observe the instructions given therein.
- ▶ Work in well-ventilated rooms.
- ▶ Wear your personal protective equipment.
- ▶ Avoid direct contact with the chemicals.
- ▶ Wash your hands thoroughly after work.
- ▶ Consult a physician in case of complaints after contact with chemicals.

⚠ WARNING

Health hazard by vapors and dusts during maintenance tasks!

The extraction system absorbs the vapors and dusts produced during production. These can be released when replacing the filters of the extraction system and they can cause sensitization/irritation.

- ▶ Always wear the protective equipment for working with hazardous substances and chemicals when performing maintenance on the extraction system.

NOTICE

Damage by lubricants and aggressive liquids!

Contact with lubricants and aggressive liquids damages the linear scales.

- ▶ Ensure that no lubricants and aggressive liquids come into contact with the linear scales!

NOTICE

Property damage by incorrect cleaning!

Cleaning the system with compressed air or cleaning the housing with aggressive cleaning agents and materials can cause damage.

- ▶ Never use compressed air for cleaning.
- ▶ Never use aggressive cleaning agents for cleaning the housing.
- ▶ Use exclusively cotton wool for cleaning the laser protective pane.

Switching off the system in an emergency

The emergency stop button switches off the laser immediately and stops the motorized axes. This stop is only intended for an emergency.

Stopping the system in an emergency

▶ Push the emergency stop button (see page 27).

☐ The power supply of the laser is switched off and the drives are de-energized.

☑ The system has been stopped in an emergency.

Restarting the system after an emergency stop

After pushing the emergency stop button you have to switch on the system properly to continue the production.

Restarting the system after an emergency

1. Unlock the emergency stop button by turning it.
2. Acknowledge the faults in the fault monitor.
3. Press the button *ACK* at the system front.

☑ The system is switched on after an emergency and the processing table is referenced again.

7.2 Personal protective equipment

The following protective equipment must be worn when performing startup and maintenance tasks:

- Laser safety glasses with a rating of DI LB5 + RM LB6 for 515 nm, protection class 6
- Respirator half mask according to EN 141/143, protection class P3
- Safety shoes, protection class 1
- Protective gloves, protection class 2
- Safety glasses, protection class 2
- Safety goggles, protection class 2
- Latex lab gloves, protection class 1

Personal protective equipment for working with hazardous substances and chemicals

- Respirator mask with gas filter for organic gases/vapors (boiling point > 65 °C, e.g. EN 14387 type A), protection class P3
- Safety glasses with side shields (e.g. EN166), protection class 2
- Chemical-resistant gloves, protection index 6 nitrile rubber (NBR) - 0.4 mm thickness (e.g. EN 374), protection class 3
- Closed work clothing

▶ Always read the safety data sheets before working with hazardous substances and chemicals and always observe the instructions given therein.

7.3 Maintenance schedules

The following tables provide an overview of the maintenance tasks that have to be performed by properly trained personnel.

7.3.1 Maintenance schedule for the maintenance personnel of the operator

The operating hours counter is at the rear of the system (see page 52).

Component/Assembly	Interval	Task to be performed	Remark
System			
Extraction hood	Every week	Visual check	See page 139
System (interior and housing)	After 40 operating hours	Clean	See page 140.
Drive spindle linear guides	After 1000 operating hours or at least once a year	Cleaning, lubricating	See page 151.
Coolant	After 1000 operating hours or at least once a year	Replace	See page 153.
Fuse	If required	Replace	See page 160.
Zero air generator	In case the humidity in the laser resonator exceeds 10 % or after 1000 operating hours or at least once a year	Replace desiccant	See page 158.
Filters			
Coolant filter	After 250 operating hours or at least once every three months	Clean	See page 142.
Air filter of the chiller	After 250 operating hours or at least once every three months	Clean	See page 145.
Air filter of the chiller	After 1000 operating hours or at least once a year	Replace	See page 146.
Processing head			
Protection glass of the processing head	Every week	Visual check	See page 137.
Protection glass of the processing head	If required	Clean	See page 147.
Protection glass of the processing head	After 1000 operating hours or at least once a year	Replace	See page 155.
Extraction system LMD 508 (optional)			
Pre-filter unit, pocket filter G4	Visual inspection after 1000 operating hours and replacement if necessary.	Visual check, replace	See page 161.
Prefilter mat	In case of dropping extraction power or when replacing the particle filter.	Replace	See page 162.

Component/Assembly	Interval	Task to be performed	Remark
Particle filter	Daily visual check of the dust indicator of the filter. Replace if the extraction power is decreasing.	Visual check, replace	See page 162.
Activated carbon filter	Replace when replacing the particle filter or if gases escape on the clean air side.	Replace	See page 164.
Compressor (optional)			
MONSUN Fast R	Refer to the user manual of the manufacturer.	Maintenance	Refer to the user manual of the manufacturer.

Table 18: Maintenance schedule for the maintenance personnel of the operator

7.3.2 Maintenance schedule for the LPKF Service

NOTICE

Property damage by unauthorized use!

Unauthorized use can cause system damage.

▶ Always have the LPKF Service perform the maintenance and service tasks listed in the following.

Component/Assembly	Interval	Task to be performed	Remark
Laser source	Every 2 years	Maintenance of the laser source by the LPKF Service	

Table 19: Maintenance schedule for the LPKF Service

7.4 Maintenance tasks for the maintenance personnel of the operator

This chapter contains a detailed description of the individual maintenance tasks that may only be performed by the maintenance personnel of the operator. For information on maintenance tasks of the extraction system refer to the manufacturer's user manual.

Checking the protection glass at the processing head visually

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Wear chemical-resistant gloves.

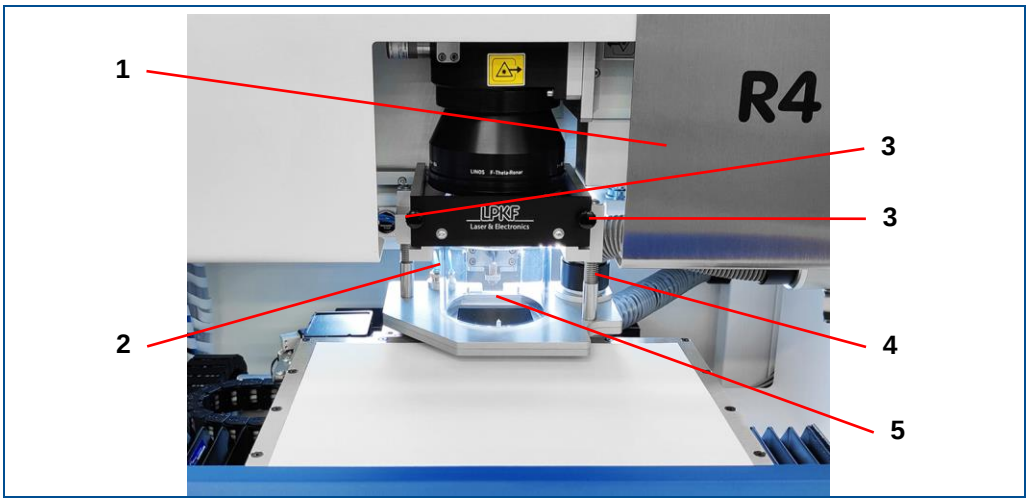


Fig. 146: System with open cover

1	Maintenance cover in processing area	**4**	Extraction hose
2	Compressed-air tube	**5**	Extraction hood
3	Screw extraction hood		

1. Open the cover.
2. Open the maintenance cover in the processing area (**1**).
3. Disconnect the compressed-air tube (**2**) and the extraction hose (**4**) from the extraction hood (**5**).
4. Remove the screws (**3**) of the extraction hood.
5. Pull out the extraction hood towards you.

6. Pull out the lighting ring towards you.

Fig. 147: Lighting ring

7. Check the protection glass of the processing head for dirt and damage.

Fig. 148: Protection glass

8. Clean or replace the protection glass if it is dirty or damaged. Further information can be found on page 147 and on page 155.
9. Reassemble the mentioned components in reverse order.

☑ The protection glass at the processing head has been checked visually.

Visual check of the extraction hood

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Wear a respirator mask, protection class P3
- Wear safety goggles.
- Wear chemical-resistant gloves.

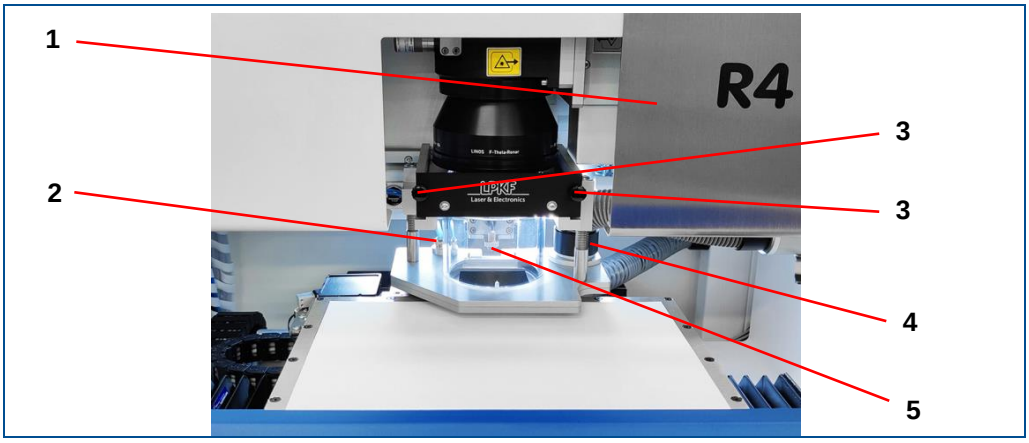


Fig. 149: System with open cover

1	Maintenance cover in processing area	**4**	Extraction hose
2	Compressed-air tube	**5**	Extraction hood
3	Screw extraction hood		

1. Open the cover.
2. Open the maintenance door in the processing area (**1**).
3. Disconnect the compressed-air tube (**2**) and the extraction hose (**4**) from the extraction hood (**5**).
4. Remove the screws (**3**) of the extraction hood.
5. Pull out the extraction hood towards you.
6. Check the extraction hood for dirt.

WARNING! Health hazard by vapors and dusts during cleaning tasks!
Dust particles can be swirled up when cleaning the interior of the system. These can cause sensitization/irritation and breathing difficulties on contact.

▶ Always wear the protective equipment for working with hazardous substances and chemicals when cleaning the interior of the system.

7. Clean the extraction hood if it is dirty.
8. Reassemble the mentioned components in reverse order.

☑ The extraction hood has been checked visually.

Cleaning the system

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The processing table is in the material loading position.
- Wear chemical-resistant gloves - when cleaning the interior.
- Wear a particle filter mask - when cleaning the interior.

Spare parts and tools

- Vacuum cleaner - for cleaning the interior
- Cotton wool - for cleaning the laser protective pane
- Antistatic cloth (e.g. microfiber) - for cleaning the housing
- Water (to dampen the cotton wool and the cloth) - for cleaning the laser protective pane and housing

1. Open the cover.

WARNING! Health hazard by vapors and dusts during cleaning tasks!
Dust particles can be swirled up when cleaning the interior of the system. These can cause sensitization/irritation and breathing difficulties on contact.
▶ Always wear the protective equipment for working with hazardous substances and chemicals when cleaning the interior of the system.

2. Vacuum the interior of the system using a vacuum cleaner:

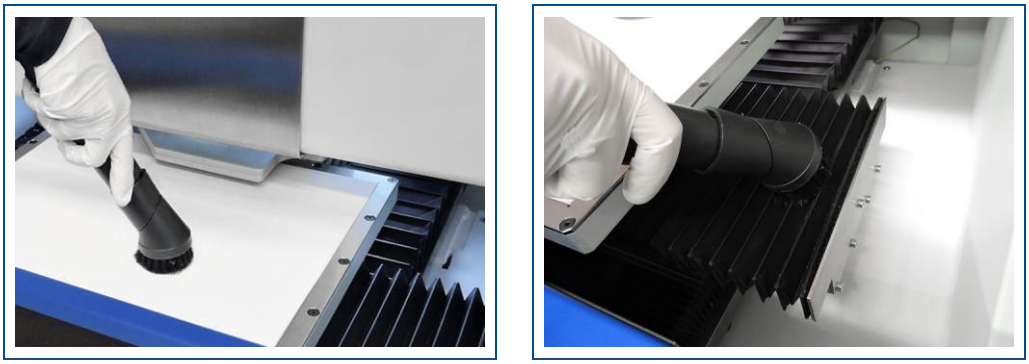


Fig. 150: Cleaning the interior

3. Close the cover.

NOTICE! Property damage by incorrect cleaning!
Cleaning the laser protective pane with aggressive materials could damage its surface.
▶ Use exclusively cotton wool for cleaning the laser protective pane.

4. Clean the laser protective pane with a slightly damp piece of cotton wool:

Fig. 151: Cleaning the laser protective pane

5. Clean the housing with a slightly damp cloth:

Fig. 152: Cleaning the housing

☑ The system has been cleaned.

Cleaning the coolant filter

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Wear safety glasses with side shields.
- Wear chemical-resistant gloves.

Spare parts and auxiliaries

- Control cabinet key
- Tweezers

1. Insert the control cabinet key into the keyhole of the rear cover.
2. Turn the control cabinet key counter-clockwise by 180°.

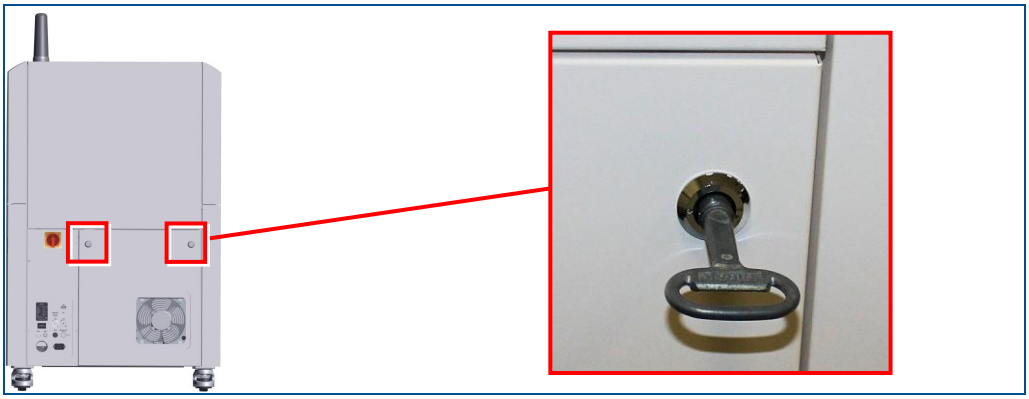


Fig. 153: Rear cover

3. Repeat steps 1 and 2 with the second keyhole of the rear cover.
4. Tilt the rear cover slightly forward and disconnect the grounding cable.

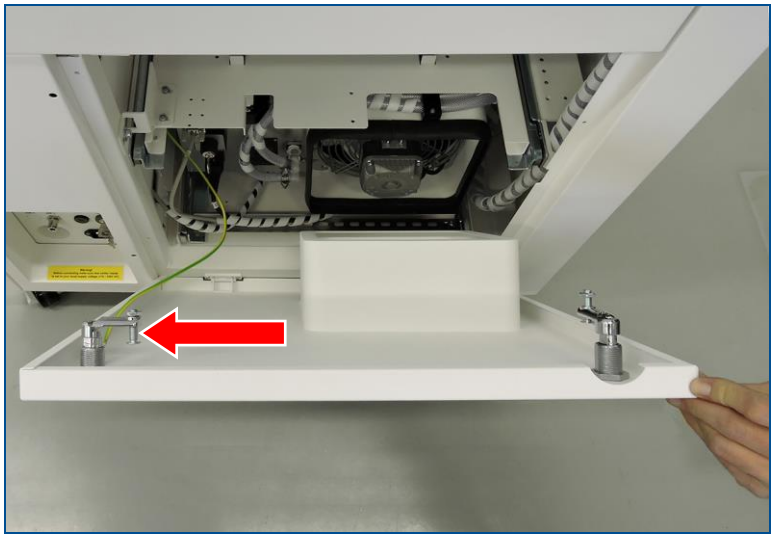


Fig. 154: Disconnecting the grounding cable

5. Lift the rear cover upwards and remove it.

6. Remove the filter cap.

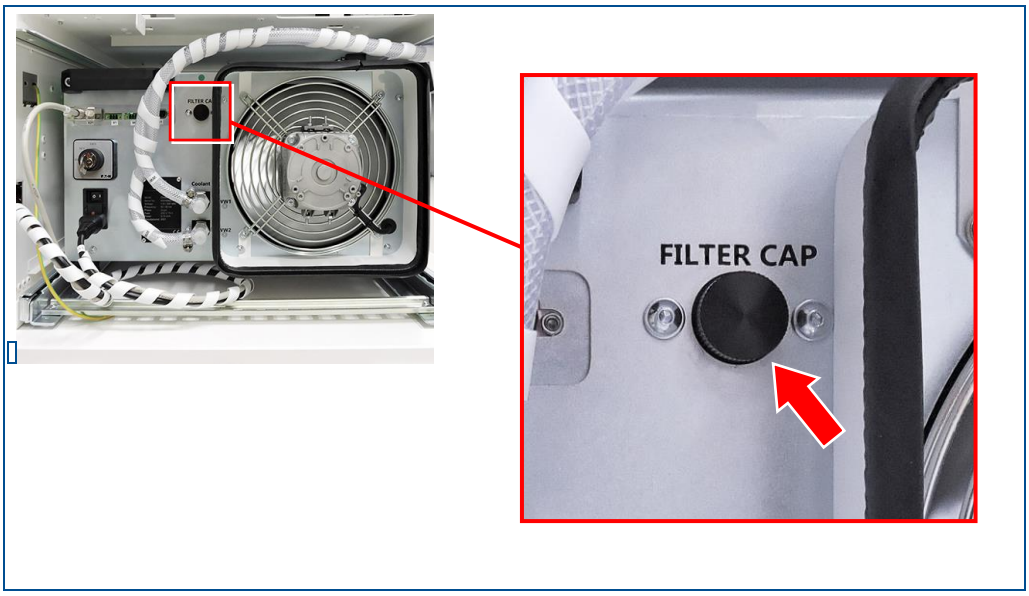


Fig. 155: System without rear cover

CAUTION! Health hazard by contact with chemicals!
Direct contact with chemicals can cause serious damage to health.
▶ Wear safety glasses with side shields and chemical-resistant gloves.

7. Use tweezers to pull out the coolant filter.

Fig. 156: Pulling out the coolant filter

8. Clean the coolant filter with running water.

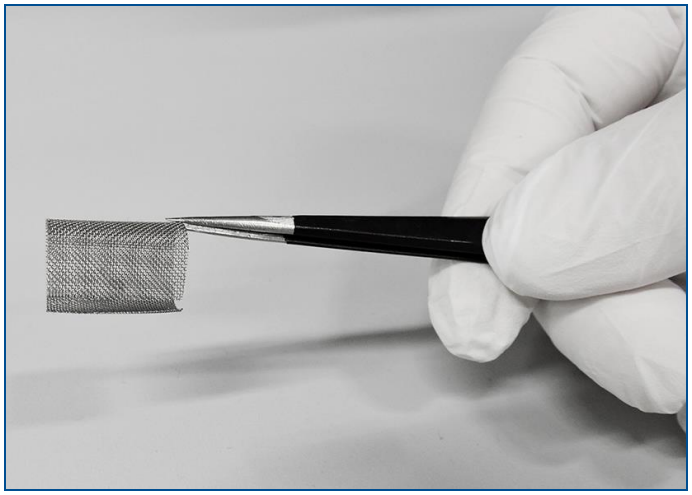


Fig. 157: Coolant filter

9. Reassemble the mentioned components in reverse order.

☑ The coolant filter has been cleaned.

Repeat the cleaning of the coolant filter two or three times to remove all contaminants. Start the system between the cleaning procedures for approx. 5 minutes.

Cleaning the air filter of the chiller

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Wear chemical-resistant gloves.
- Wear a particle filter mask.

Spare parts and auxiliaries

- Vacuum cleaner

1. Pull on the lower left edge of the maintenance door to open it.

Fig. 158: Opening the maintenance door

2. Vacuum the air filter thoroughly with a vacuum cleaner.

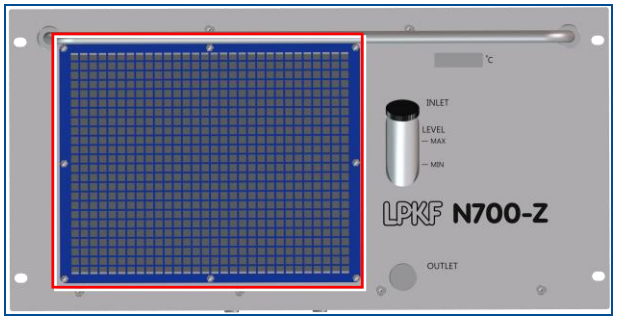


Fig. 159: Air filter of the chiller

3. Close the maintenance door.

☑ The air filter has been cleaned.

Replacing the air filter of the chiller

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Wear chemical-resistant gloves.
- Wear a particle filter mask.

Spare parts and auxiliaries

- Hex key 2 mm
- Replacement filter

1. Pull on the lower left edge of the maintenance door to open it.

Fig. 160: Opening the maintenance door

2. Remove the screws from the cover.

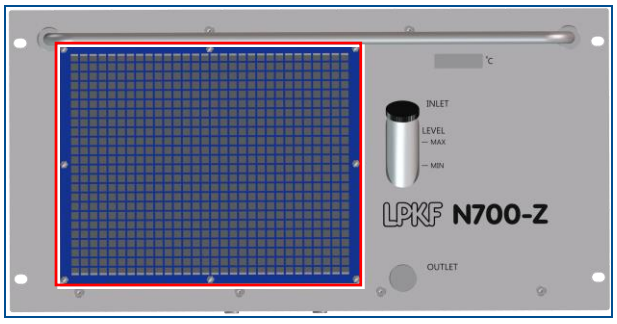


Fig. 161: Air filter of the chiller

3. Remove the cover.
4. Remove the air filter.
5. Insert a new air filter.
6. Put the cover on and fasten it with the previously removed screws.
7. Close the maintenance door.

☑ The air filter has been replaced.

Cleaning the protection glass of the processing head

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Ensure good ventilation/extraction at the workplace, otherwise wear a respirator mask.
- Wear safety glasses with side shields.
- Wear chemical-resistant gloves.

Spare parts and auxiliaries

- Lens-cleaning tissue
- Isopropyl alcohol

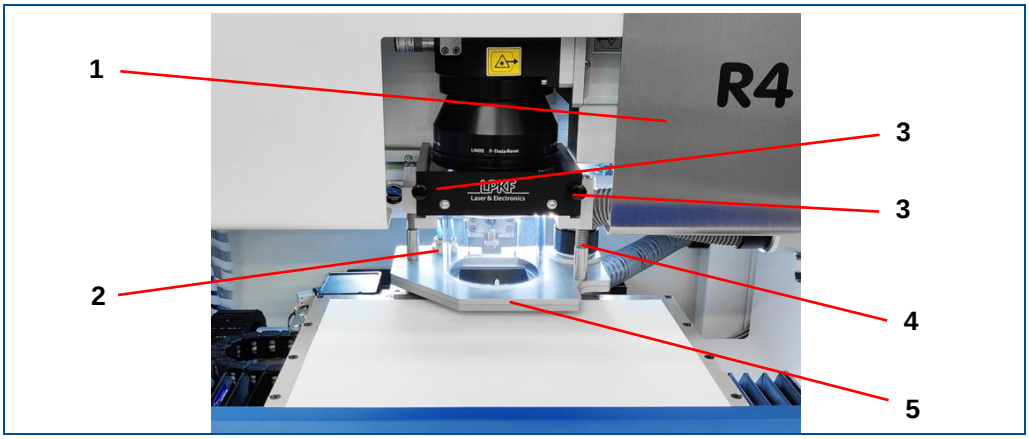


Fig. 162: System with open maintenance cover

1 Maintenance cover in processing area
2 Compressed-air tube
3 Screw extraction hood
4 Extraction hose
5 Extraction hood

1. Open the cover.
2. Open the maintenance cover in the processing area (**1**).
3. Disconnect the compressed-air tube (**2**) and the extraction hose (**4**) from the extraction hood (**5**).
4. Remove the screws (**3**) of the extraction hood.
5. Pull out the extraction hood towards you.

6. Pull out the lighting ring towards you.

Fig. 163: Lighting ring

Always wear gloves when touching the protection glass. Fingerprints contain aggressive acids that etch the surface leaving traces that cannot be removed.

7. Unscrew the lens clockwise.

Fig. 164: Unscrewing the lens

8. Cautiously place the lens onto the lens-cleaning tissue.
9. Unscrew the fastening ring clockwise.

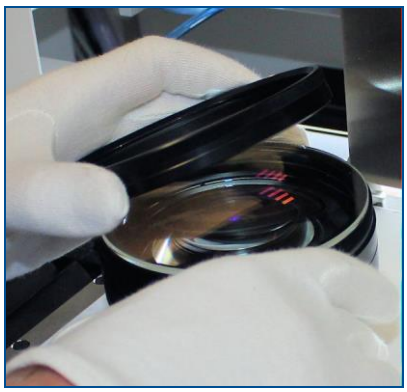


Fig. 165: Fastening ring

10. Remove the protection glass.

A seal is fitted between the protection glass and the lens. The seal is seated in the groove of the lens. Ensure that the seal is between the protection glass and the lens when assembling the lens.

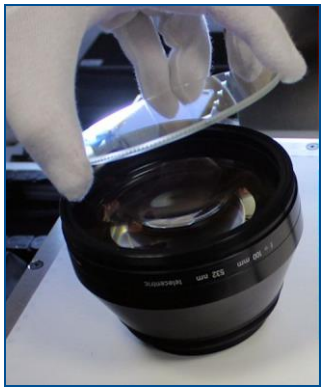


Fig. 166: Removing the protection glass

11. Cover the lens and the protection glass with lens-cleaning tissue.

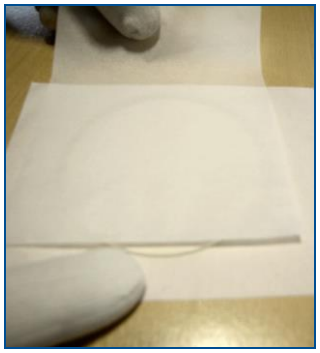


Fig. 167: Covering the lens and the protection glass

CAUTION! Health hazard by contact with chemicals!
Direct contact with chemicals can cause serious damage to health.
▶ Wear safety glasses with side shields and chemical-resistant gloves.

12. Sprinkle the protection glass with common isopropyl alcohol.

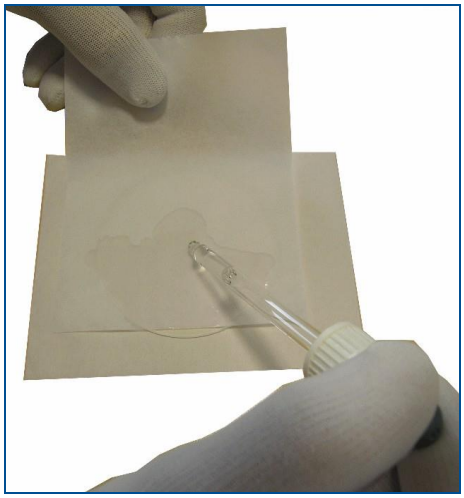


Fig. 168: Sprinkling the protection glass

Quickly pull off the moist lens-cleaning tissue so that no film develops on the protection glass.

13. Hold the protection glass firmly and pull the lens-cleaning tissue across with the other hand.

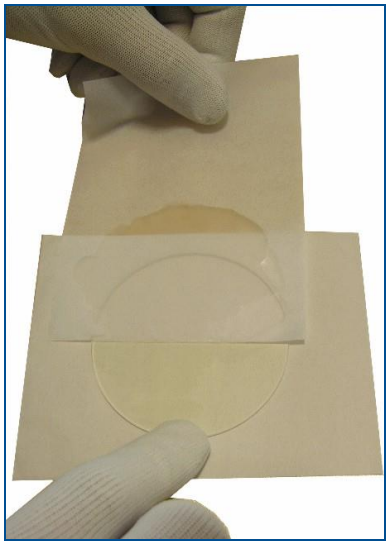


Fig. 169: Cleaning the protection glass

14. Repeat the cleaning procedure with a new lens-cleaning tissue until the protection glass is clean and no streaks or droplets are visible.
15. Reassemble the mentioned components in reverse order.
16. Close the maintenance cover in the processing area.

☑ The protection glass of the processing head has been cleaned.

Cleaning and lubricating the drive spindles and the linear guides

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- Wear latex lab gloves.

Spare parts and auxiliaries

- Special ball bearing grease Dynalub 510
- Lubricant ISOFLEX TOPAS 5051
- Cotton cloth
- Wooden lab spatula

1. Turn on the system and start the system software.
2. Move the processing table to the right rear position.

For detailed information on operating the system software invoke the help function by pressing F1.

3. Open the cover.
4. Push the bellows (**2**) of the x axis to the right.

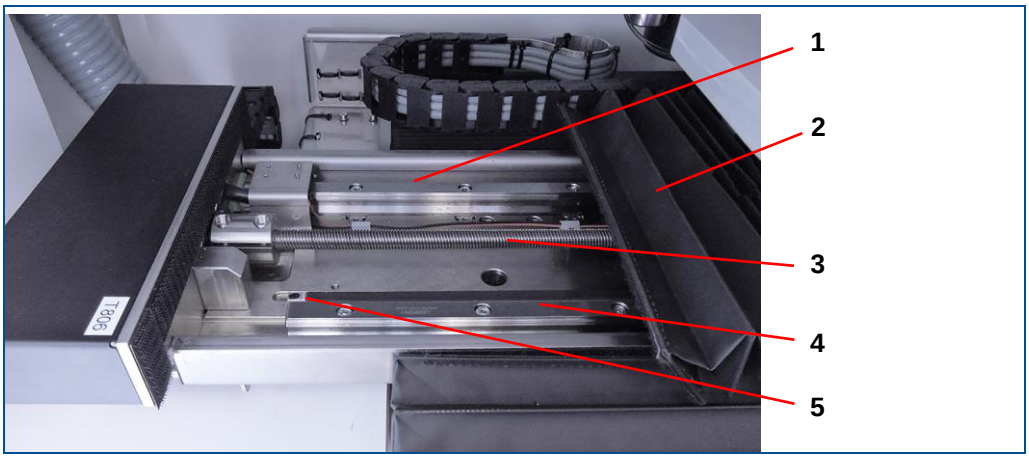


Fig. 170: x axis

1 Linear guide
2 Bellows of x axis
3 Drive spindle
4 Linear guide
5 Linear scale

NOTICE! System damage due to aggressive liquids and lubricants!
Contact with aggressive liquids and lubricants damages the linear scales.

▶ Ensure that no aggressive liquids and lubricants come into contact with the linear scales!

5. Clean the drive spindle (**3**) and the linear guides (**1, 4**) with a cotton cloth.
6. Put some lubricating grease (**ISOFLEX TOPAS 5051**) on a wooden lab spatula.
7. Apply a thin lubricant film to the **drive spindle** using the wooden lab spatula; avoid overdosage.
8. Put some lubricating grease (**special ball bearing grease Dynalub 510**) on a wooden lab spatula.
9. Apply a thin lubricant film to the **linear guiding rails** using the wooden lab spatula, avoid overdosage.
10. Cover the opening with the bellows.

11. Push the bellows (**2**) of the y axis to the rear.

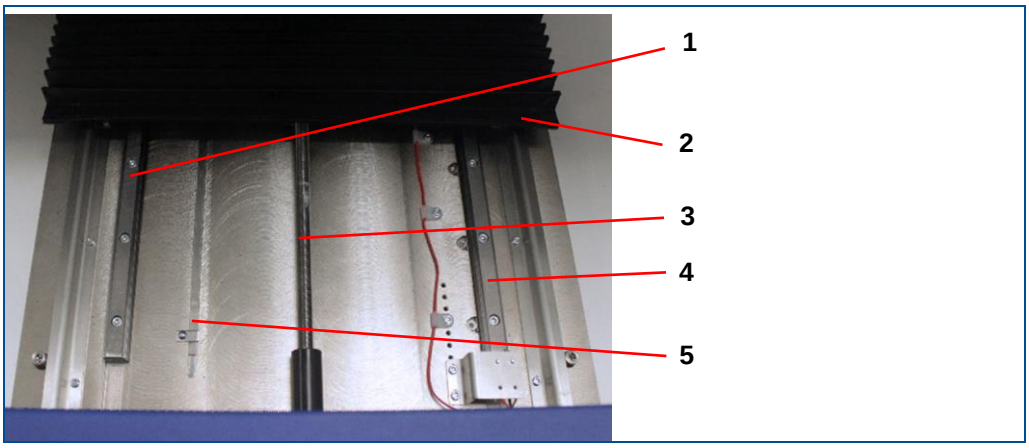


Fig. 171: y axis

1	Linear guide	**4**	Linear guide
2	Bellows of y axis	**5**	Linear scale
3	Drive spindle		

12. Repeat the steps 5 - 9 on the y axis.
13. Cover the opening with the bellows.
14. Close the cover.
15. Move the processing table to the left front position.
16. Open the cover.
17. Push the bellows of the x axis to the left.
18. Repeat steps 5 - 9.
19. Cover the opening with the bellows.
20. Push the bellows of the y axis to the rear.
21. Repeat the steps 5 - 9 on the y axis.
22. Cover the opening with the bellows.

☑ The drive spindles and the linear guides have been cleaned and lubricated.

Replacing the coolant

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Wear a respirator mask with gas filter for organic gases/vapors.
- Wear chemical-resistant gloves.
- Wear safety glasses with side shields.
- Closed work clothing

Spare parts and auxiliaries

- Hex key 5 mm
- Coolant

  The mixing ratio of the coolant is: 1:6 (EUROLUB Kühlerschutz D-30:distilled water).

1. Pull on the lower left edge of the maintenance door to open it.

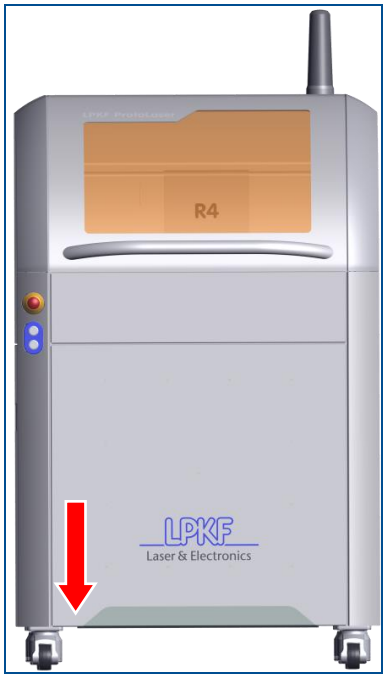


Fig. 172: Opening the maintenance door

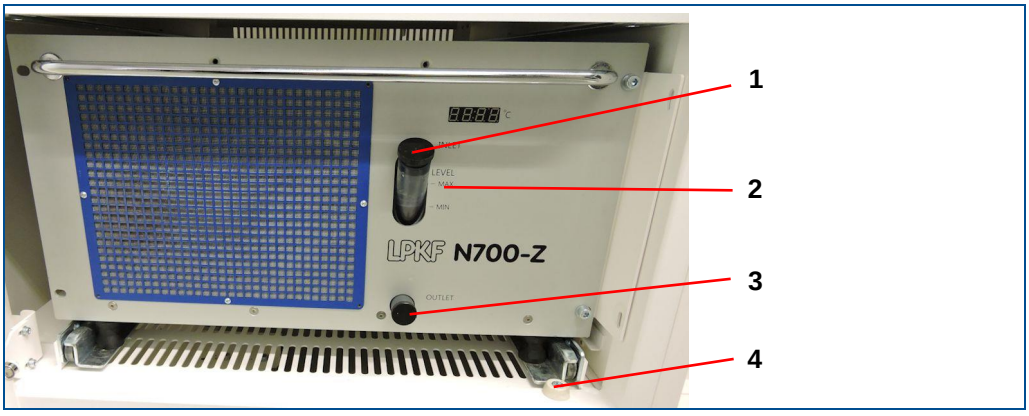


Fig. 173: Chiller

1	Filler neck	**3**	Drain valve
2	Fill level indicator	**4**	Screw with rubber stopper

2. Remove the screw with rubber stopper (**4**).

3. Cautiously pull the chiller out of the base frame until locked at full extension.
4. Place a suitable collection container under the drain valve (**3**) of the chiller.

Fig. 174: Coolant

CAUTION! Health hazard by contact with chemicals!
Direct contact with chemicals can cause serious damage to health.
▶ Wear your personal protective equipment.

5. Remove the cap of the drain valve.

☐ The coolant flows into the collection container.

Dispose of the coolant according to your local environmental regulations.

6. Screw the cap back onto the drain valve.
7. Remove the cap of the filler neck (**1**).
8. Fill the jerry can contained in the delivery with 0.7 l EUROLUB Kühlerschutz D-30 and 4.3 l distilled water.
9. Use the spout to fill the resulting coolant into the filler neck (**1**).
10. Fill coolant into the chiller until the fill level indicator (**2**) indicates a maximum fill level.
11. Screw the cap back onto the filler neck.
12. Reassemble the mentioned components in reverse order.
13. Close the maintenance door.
14. Store the unused coolant according to the information in the safety data sheet.

☑ The coolant has been replaced.

Replacing the protection glass of the processing head

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Ensure good ventilation/extraction at the workplace, otherwise wear a respirator mask.
- Wear chemical-resistant gloves.

Spare parts and auxiliaries

- Lens-cleaning tissue
- Replacement protection glass

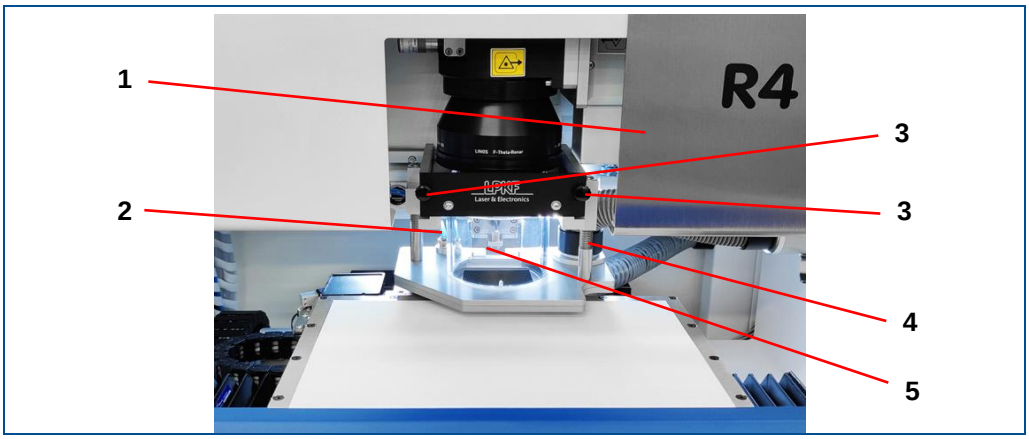


Fig. 175: System with open maintenance cover

1 Maintenance cover in processing area
2 Compressed-air tube
3 Screw extraction hood
4 Extraction hose
5 Extraction hood

1. Open the cover.
2. Open the maintenance cover in the processing area (**1**).
3. Disconnect the compressed-air tube (**2**) and the extraction hose (**4**) from the extraction hood (**5**).
4. Remove the screws (**3**) of the extraction hood.
5. Pull out the extraction hood towards you.

6. Pull out the lighting ring towards you.

Fig. 176: Lighting ring

Always wear gloves when touching the protection glass. Fingerprints contain aggressive acids that etch the surface leaving traces that cannot be removed.

7. Unscrew the lens clockwise.

Fig. 177: Unscrewing the lens

8. Cautiously place the lens onto the lens-cleaning tissue.
9. Unscrew the fastening ring clockwise.

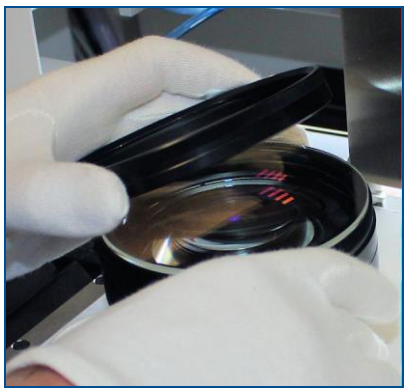


Fig. 178: Fastening ring

10. Remove the protection glass.
11. Place a new protection glass onto the lens.

A seal is fitted between the protection glass and the lens. The seal is seated in the groove of the lens. Ensure that the seal is between the protection glass and the lens when assembling the lens.

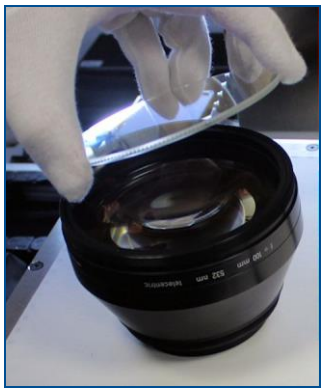


Fig. 179: Placing the protection glass onto the lens

12. Reassemble the mentioned components in reverse order.
13. Close the maintenance cover in the processing area.

☑ The protection glass of the processing head has been replaced.

Replacing the desiccant

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- Maintenance must be carried out in a clean environment.
- The system is switched off at the main switch and secured against restart.
- The system is disconnected from the power supply.

Spare parts and auxiliaries

- Filter unit *DESICCANT* order code:10100797
- Hex key 3 mm
- Latex laboratory gloves

1. Pull on the lower left edge of the maintenance door to open it.

Fig. 180: Opening the maintenance door

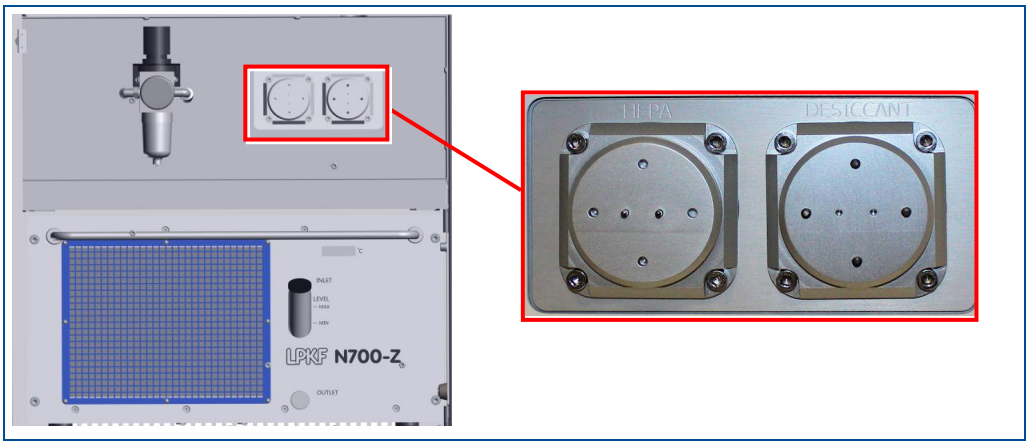


Fig. 181: Zero air generator

2. Remove the four screws on the cover of the filter unit *DESICCANT*.

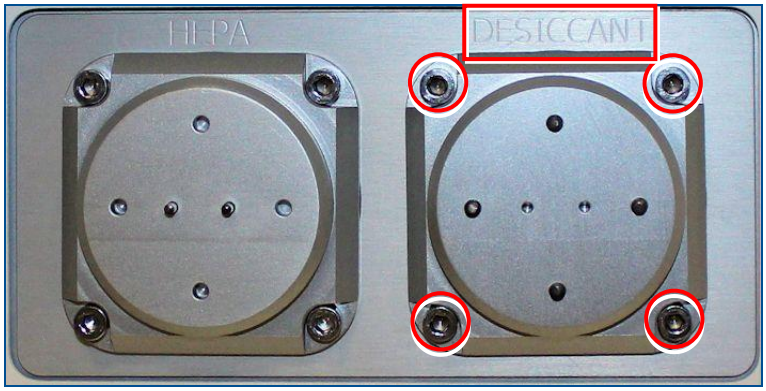


Fig. 182: Filter unit *DESICCANT*

3. Remove the cover and the O-ring.
4. Unscrew the filter unit together with the cover.

   Turn the cover and use the cylinder pins on the front of the cover to unscrew the filter unit.

Fig. 183: Unscrewing the filter unit *DESICCANT*

5. Insert a new filter unit.
6. Screw the filter unit together with the cover.
7. Insert the cover and the new O-ring.
8. Tighten the four screws on the filter unit cover.
9. Close the maintenance door.

☑ The desiccant has been replaced.

Replacing the fuse

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.

Spare parts and auxiliaries

- Flat-bladed screwdriver
- Fuse (250 VAC; T16,0 A; FST; 5 × 20 mm; according to EN 60127-2-3)

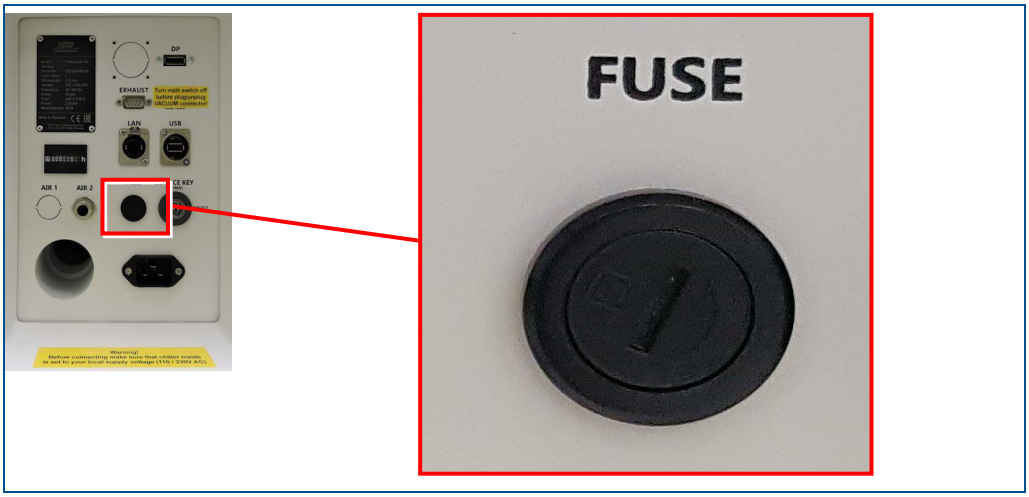


Fig. 184: Fuse holder at the rear of the system

1. Pull the mains plug from the socket.
2. Use a flat-bladed screwdriver to unscrew the fuse holder counterclockwise.
3. Pull out the fuse holder with the fuse.

Fig. 185: Fuse holder with fuse

4. Replace the fuse.
5. Reinsert the fuse holder with the new fuse.
6. Use a flat-bladed screwdriver to tighten the fuse holder clockwise.
7. Plug the mains plug into the socket.

☑ The fuse has been replaced.

Replacing the bag filter G4

WARNING! Health hazard by vapors and dusts during maintenance tasks!
The extraction system absorbs the vapors and dusts produced during production. These can be released when replacing the filters of the extraction system and they can cause sensitization/irritation.

▶ Always wear the protective equipment for working with hazardous substances and chemicals when performing maintenance tasks on the extraction system.

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Wear the personal protective equipment for working with hazardous substances.

Spare parts and auxiliaries

- Bag filter G4
- Hex key (in filter door)

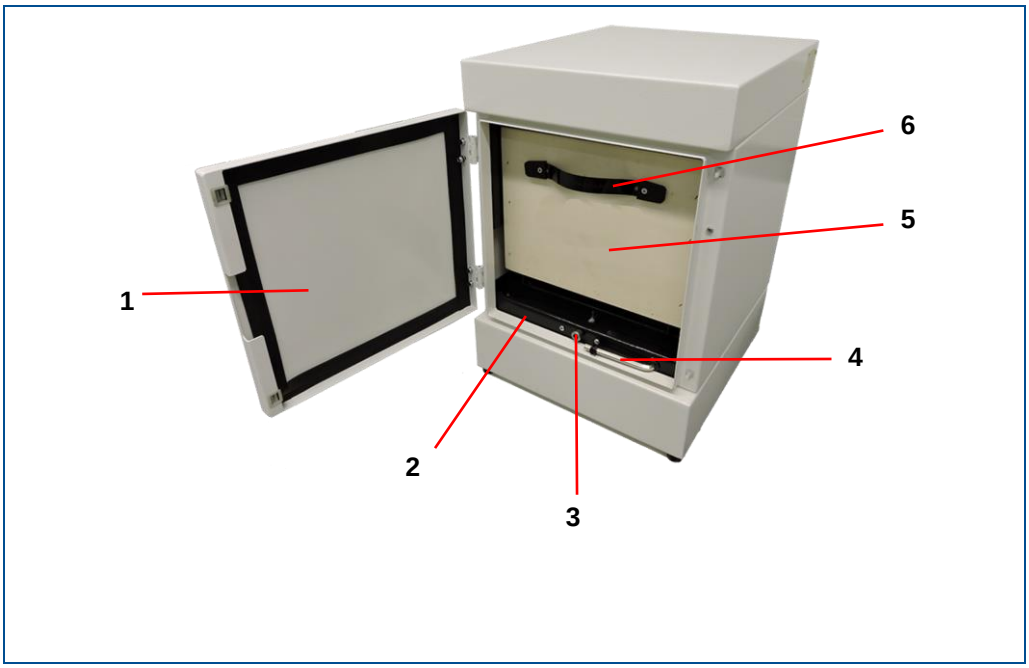


Fig. 186: Overview prefilter unit

1	Filter door	**4**	Hex key
2	Lifting mechanism	**5**	Filter drawer
3	Locking screw for the lifting mechanism	**6**	Handle of the filter drawer

1. Open the filter door (**1**) of the prefilter unit.
2. Loosen the locking screw (**3**) using the enclosed hex key (**4**).
3. Use the handle of the filter drawer (**6**) and pull out the filter drawer (**5**).
4. Remove the old bag filter G4 from the filter drawer.
5. Insert a new bag filter G4 into the filter drawer.
6. Reinsert the filter drawer into the lifting mechanism (**2**).
7. Tighten the locking screw (**3**) of the lifting mechanism (**2**) to fasten the filter drawer.
8. Close the filter door.
9. Connect the extraction system to the power supply.

☑ The bag filter G4 has been replaced.

Replacing the particle filter

WARNING! Health hazard by vapors and dusts during maintenance tasks!
The extraction system absorbs the vapors and dusts produced during production. These can be released when replacing the filters of the extraction system and they can cause sensitization/irritation.

▶ Always wear the protective equipment for working with hazardous substances and chemicals when performing maintenance tasks on the extraction system.

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Wear the personal protective equipment for working with hazardous substances.

Spare parts and auxiliaries

- Particle filter
- Prefilter mat
- Hex key (in filter door)

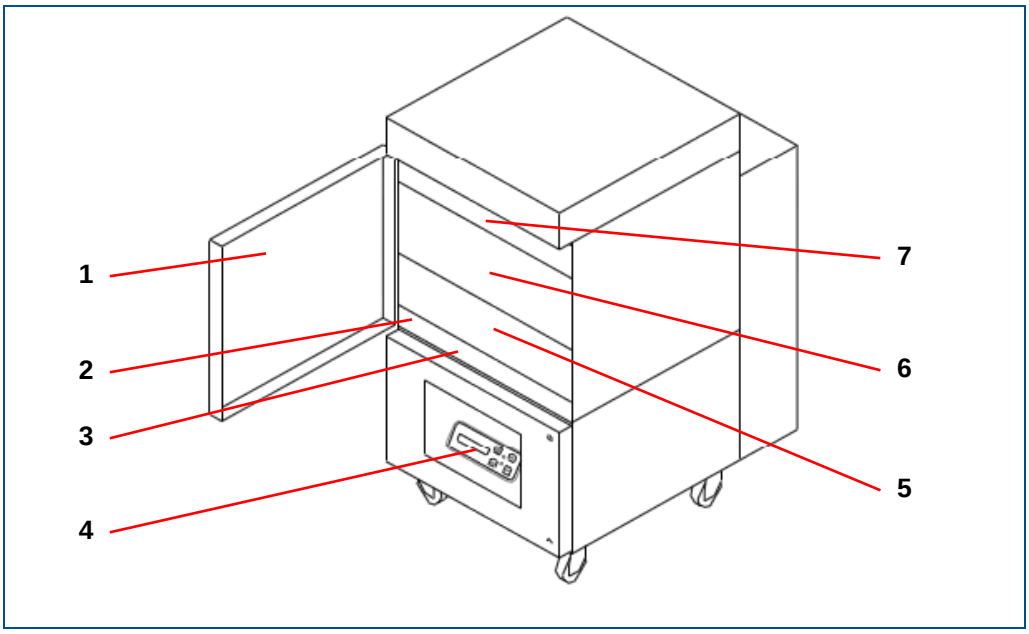


Fig. 187: Overview extraction system

1	Filter door	**5**	Activated carbon filter
2	Lifting mechanism	**6**	Particle filter
3	Locking screw for the lifting mechanism	**7**	Prefilter mat
4	Air filter control with display		

1. Open the filter door (**1**).
2. Loosen the locking screw (**3**) using the enclosed hex key.

You can use the magnetic frame included in the delivery and an air-tight plastic sack to prevent contamination of the surrounding area when replacing the filter.
To do this, put the opening of the plastic sack through the magnetic frame and attach the frame to the filter opening. Grab the used filter through the plastic sack, pull the filter into the sack, and seal the plastic sack.

3. Pull out the particle filter (**6**) together with the prefilter mat (**7**).
4. Insert a new particle filter with a new prefilter mat into the lifting mechanism.
5. Tighten the locking screw (**3**) of the lifting mechanism (**2**) to fasten the particle filter.
6. Close the filter door.
7. Connect the extraction system to the power supply.

☑ The particle filter has been replaced.

Replacing the activated carbon filter is similar to replacing the particle filter. You can save time if you replace both filters in one turn when the system is shut down.

Replacing the activated carbon filter

WARNING! Health hazard by vapors and dusts during maintenance tasks!
The extraction system absorbs the vapors and dusts produced during production. These can be released when replacing the filters of the extraction system and they can cause sensitization/irritation.

▶ Always wear the protective equipment for working with hazardous substances and chemicals when performing maintenance tasks on the extraction system.

Ensure that the following prerequisites are fulfilled before performing the described tasks:

Prerequisites

- The system is switched off at the main switch and secured against restart.
- Wear the personal protective equipment for working with hazardous substances.

Spare parts and auxiliaries

- Activated carbon filter
- Hex key (in filter door)

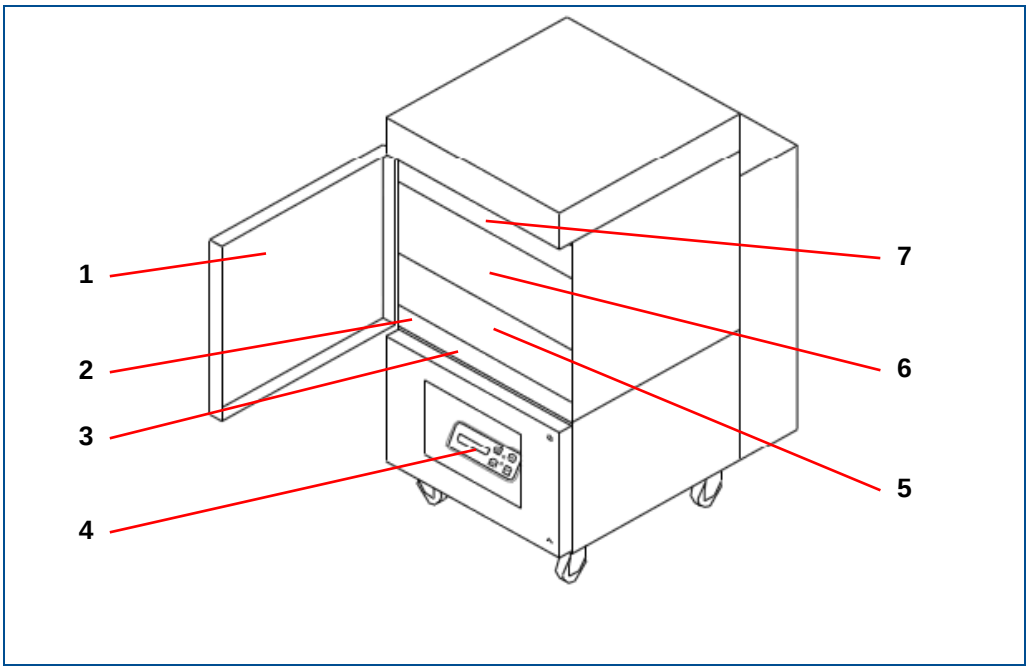


Fig. 188: Overview extraction system

1	Filter door	**5**	Activated carbon filter
2	Lifting mechanism	**6**	Particle filter
3	Locking screw for the lifting mechanism	**7**	Prefilter mat
4	Air filter control with display		

1. Open the filter door (**1**).
2. Loosen the locking screw (**3**) using the enclosed hex key.

You can use the magnetic frame included in the delivery and an air-tight plastic sack to prevent contamination of the surrounding area when replacing the filter.
To do this, put the opening of the plastic sack through the magnetic frame and attach the frame to the filter opening. Grab the used filter through the plastic sack, pull the filter into the sack, and seal the plastic sack.

3. Pull out the activated carbon filter (**5**).
4. Insert a new activated carbon filter into the filter mount.
5. Lift the lifting mechanism (**2**) and tighten the locking screw (**3**) to fasten the activated carbon filter.
6. Close the filter door.
7. Connect the extraction system to the power supply.

☑ The activated carbon filter has been replaced.

8 Troubleshooting

This chapter contains an overview of possible faults and measures for troubleshooting.

If faults occur that cannot be eliminated by the following messages contact the LPKF Service.

8.1 Fault display

The stack light (see page 27) of the system indicates occurring faults. The software displays faults in the *Fault monitor* pane.

Fault monitor

The pane *Fault monitor* contains a list of all faults. These can refer for example to error messages during workpiece production or to a problem while starting the system.

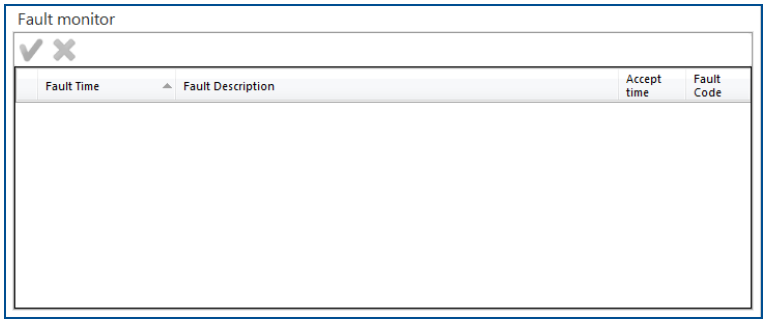


Fig. 189: Fault monitor

Column	Description
Fault Time	Displays the time and date when the error occurred.
Fault description	Detailed description of the fault that occurred.
Acceptance time	Time when the fault was acknowledged.
Fault Code	Error code

Table 20: Fault monitor

Icon	Name	Description
	Accept all	All errors not yet acknowledged are acknowledged automatically.
	Clear all	All errors already acknowledged are deleted from the list.

Table 21: Icons in fault monitor

8.2 Actions in case of an error

Errors that have occurred can be cleared in the pane *Fault monitor*.

Clearing faults

1. Read the description of the fault in the *Fault monitor* pane.
2. Click on ✔.

☐ The system automatically corrects the faults and is initialized. The operation mode indicated by the stack light changes to green (ready for operation). The cleared faults are removed from the *Fault monitor* pane.

☑ The fault has been cleared.

If the faults still exist after initialization, restart the system software. If you have any questions contact the LPKF Service.

8.3 Fault table

The following table contains possible faults and proposals how to clear them.

Error message	Error description
Control unit	
0 - 699	Contact the LPKF Service!
700	Exception
701	Connection lost
702	Synchronization lost
703	Deadline (too late)
704	Event lost
705	Buffer overrun
706	Limit switch fault
707	Hardware fault
708	Delete mode
709	Encoder fault
710	I/O event occurred (critical)
711	CanOpen event occurred (critical).
712	Excessive temperature or overcurrent occurred at output stage (self-protection) The controller has been switched off.
713	The control error abs(reference - control_variable) is too large (larger than ac_max_control_error). The controller has been switched off.
714	The sensor of the axis controller did not have a valid signal. At the moment only used in SENSOR_MODE_POSITION_IP (internal interpolation of an analog encoder signal). The controller has been switched off.
715	Supply voltage of motors too low The controller has been switched off.

Error message	Error description
716	Lower limit of the movement area reached (softframe error).
717	Upper limit of the movement area reached (softframe error).
718	The controller received a move command but the status of the axis controller was 'OFF' (switched off). The move could not be executed.
719	The modeled motor temperature has exceeded the permitted maximum temperature. The controller has been switched off to prevent damage by excessive temperature.
Laser module	
4210	Low coolant fill level Fill coolant into the chiller. Restart the system. If the fault persists or reoccurs contact the LPKF service!
4212	Insufficient flow rate Check the coolant filter and the connectors of the coolant tube. Restart the system. If the fault persists or reoccurs contact the LPKF service!
4213	Coolant temperature too high The ambient temperature of the chiller may exceed the operating range. Check the ambient conditions. Restart the system. If the fault persists or reoccurs contact the LPKF service!
4214	Coolant temperature too low The ambient temperature of the chiller may be outside the operating range. Check the ambient conditions. Restart the system. If the fault persists or reoccurs contact the LPKF service!
4739	Lock Close the cover. Restart the system. If the fault persists or reoccurs contact the LPKF service!
4766	Chiller fault Check whether the chiller is switched on. Restart the system. If the fault persists or reoccurs contact the LPKF service!
4774	Humidity of interior too high Replace the desiccant. If the fault persists or reoccurs contact the LPKF service!

Table 22: Fault table

8.4 Saturation of the filters of the zero air generator

This chapter describes the measures to be taken if the filters of the zero air generator are saturated. Troubleshooting is different after regular use of the system or at first startup of the system (one-time event). Both examples are described below.

The filters of the zero air generator are a closed loop air filtering system, which keeps the air in the laser resonator clean of moisture, fine particles (dust), and hydrocarbons. At the same time they are constantly monitoring the **humidity level** in the laser resonator. When the humidity in the laser resonator **exceeds** 10 %, the system software displays a **warning** to check the filters.

Saturation of the filters of the zero air generator after regular use of the system

The filters of the zero air generator are scheduled to be replaced annually. Replacing the filters of the zero air generator annually should ensure that the humidity in the laser resonator remains below 10 %. However, if the system is operated under unfavorable conditions, the filters may become saturated sooner than expected.

If the humidity in the laser resonator exceeds 10 %, the following warning is displayed:

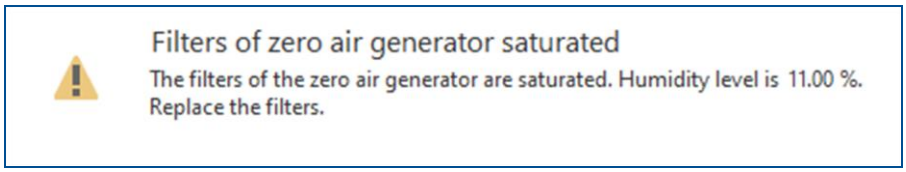


Fig. 190: Warning *Filters of zero air generator saturated*

Replace the filters. The filters **must be replaced before** the **humidity reaches 30 %** (in the interval between 10 % and 30 %).

The warning *Filters of zero air generator saturated* will constantly be displayed, if you do not replace the filters of the zero air generator and continue working with the system (the displayed value of the humidity level will be increasing).

Once the humidity exceeds 30 %, the following warning is displayed:

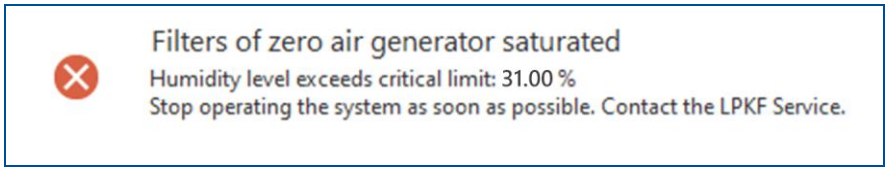


Fig. 191: Humidity level exceeds critical limit

Stop working with the system as quickly as possible and **contact the LPKF Service**! If you continue to work with the system, your risk damaging the laser source.

The system will be locked at next start-up (the warm-up phase will not be performed).

Saturation of the filters of the zero air generator at first startup of the system

At first startup of the system (or after a longer period of non-operation without the system being connected to the power supply), it is possible that the humidity in the laser resonator rises above 30 % (despite the filters not being saturated).

In such a case, the following warning is displayed (the displayed value of the humidity level could be different):

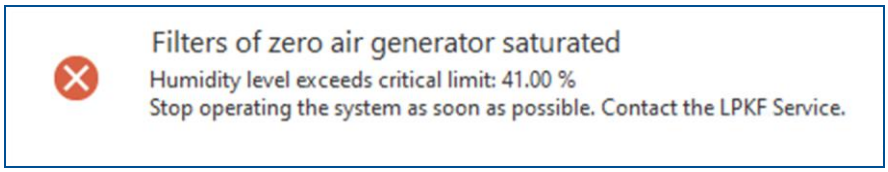


Fig. 192: Humidity level exceeds critical limit

Once the main switch is switched on, the zero air generator starts to decrease the humidity in the laser resonator. Keep the system switched on at the main switch but do not work with the system. Once the humidity has dropped below 10 %, you can start using the system. The warning message disappears automatically. If it continues to be displayed, contact the LPKF Service.

8.5 Processing quality

This chapter describes typical faults that reduce the processing quality, and their measures for troubleshooting.

An inappropriate material selection in the system software and associated inappropriate settings of the tool parameters are the most common reason for losses in the processing quality. To counter that, the **tool parameters** have to be set.

For detailed information on setting the tool parameters invoke the help function by pressing F1 or refer to the **TechNote ProtoLaser: Optimizing the processing quality**.

8.5.1 Typical processing faults

There are two typical processing faults:

- A conductive layer that has been removed incompletely;
- Burn-in effects on the material.

Incompletely removed conductive layer

The following reasons can lead to a conductive layer that is incompletely removed:

- The conductive layer has not been cut on the entire rubout area;
- The heating performance is too weak or too fast;
- In the system software, the wrong material type is selected.

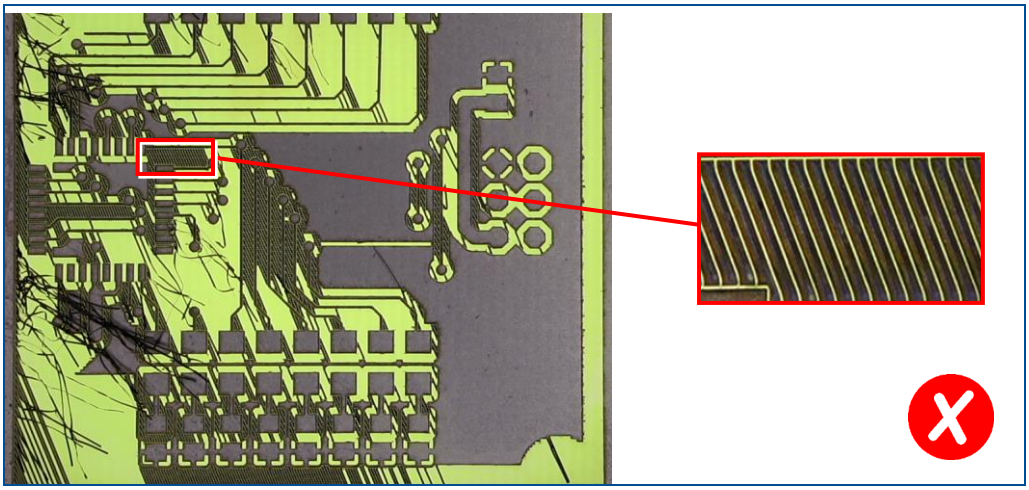


Fig. 193: Incompletely removed conductive layer

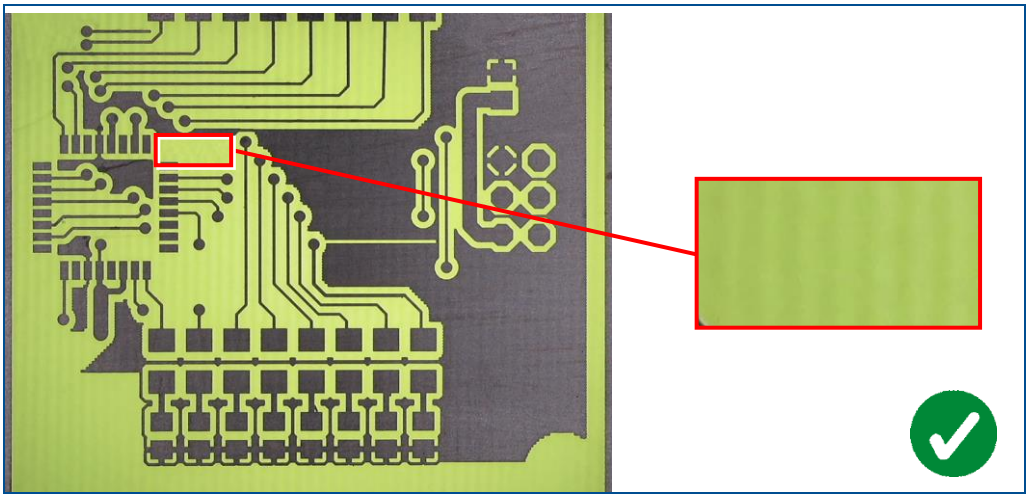


Fig. 194: Completely removed conductive layer

The following table contains the most common processing faults and remedial measures:

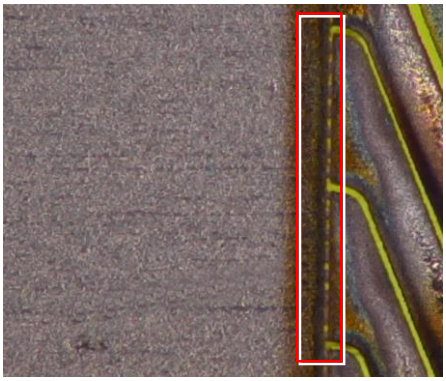
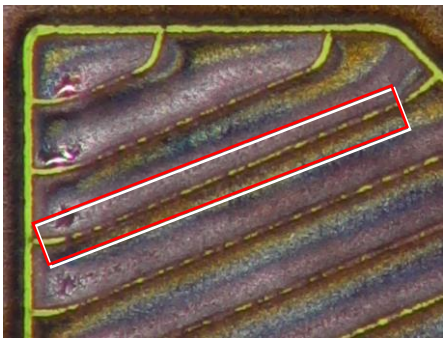
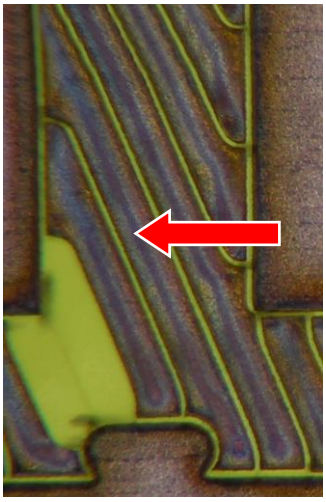
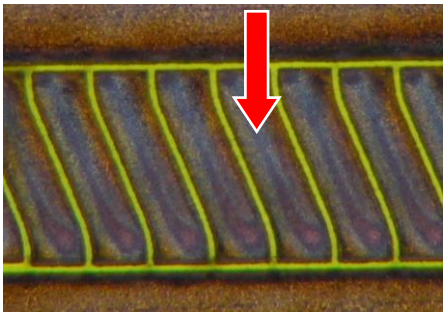
Figure	Fault	Remedy
	The isolation channel is not completely cut - thus, the stripes of the conductive layer are not delaminated.	Reduce the *Mark speed* of the tool *Isolate* in steps of 5 % to 10 %.
	The hatching line is not completely cut - the stripes of the conductive layer are not delaminated.	Reduce the *Mark speed* of the tool *Hatch* in steps of 5 % to 10 %.
	The isolation channel and the hatching line are completely cut but the stripes of the conductive layer are not delaminated.	Reduce the *Mark speed* of the tool *Heat* in steps of 10 %.
	The isolation channel and the hatching line are completely cut but the short stripes of the conductive layer are not delaminated.	Reduce the *Mark speed* of the tool *Short Heat* in steps of 10 %. (The threshold value for the short heat stripe is set by default to 0.5 mm.)

Table 23: Processing quality | Incompletely removed conductive layer

Burn-in effects on the material

The following reasons can lead to burn-in effects on the material:

- The structuring procedure is too slow;
- The laser power is too high;
- In the system software, the wrong material type is selected.

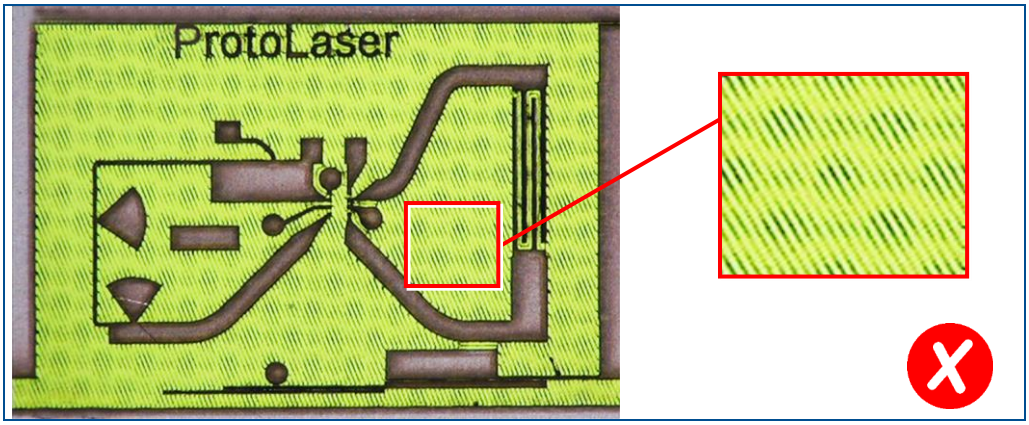


Fig. 195: Burn-in effects

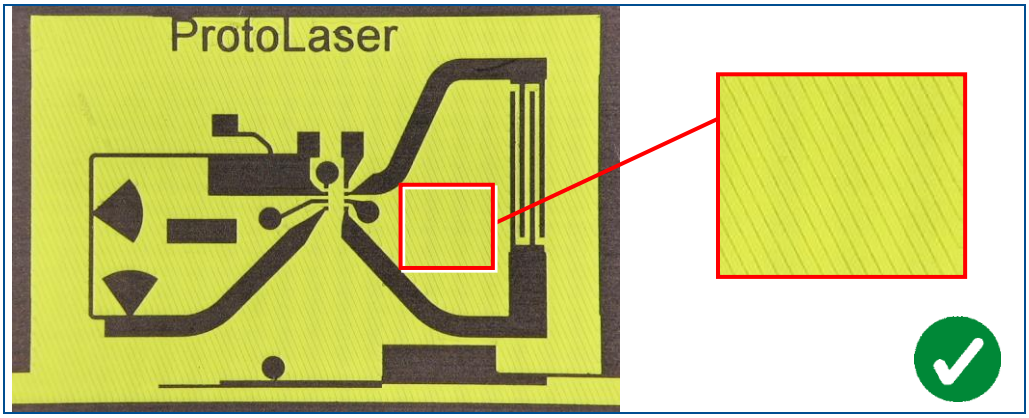


Fig. 196: No burn-in effects

The following table contains the most common processing faults and remedial measures:

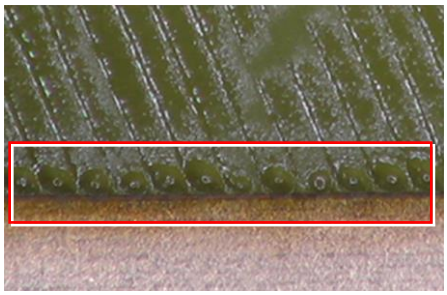
Figure	Fault	Remedy
	Burn-in effects of isolation channels and hatching lines.	Increase the *Mark speed* of the tool *Hatch* and the tool *Isolate* in 10 % steps.
	Burn-in effects (e.g. “check marks”) at the end of the heat lines.	Reduce the *Laser off delay* of the tool *Heat* in steps from 20 µs to 50 µs (this value can be negative).

Table 24: Processing quality | Burn-in effects on the material

9 Disassembly and disposal

This chapter describes the disassembly and the disposal of the system.

The following tasks may only be performed by the **maintenance personnel of the operator**.

9.1 Safety

NOTICE
Environmental hazard by improper disposal of the system! Improper disposal of the system can cause hazards to the environment. ▶ Dispose of the system properly or contact the LPKF Service.

9.2 Preparations

Before disassembling the system:

- Switch off the system.
- Disconnect all external components and de-energize the residual energy.
- Remove all operating materials, auxiliary materials, and consumables and dispose them of in an ecological way.

9.3 Disposing of the system

In case there is no agreement on return of goods or an agreement on dispose of the system, the operator is obligated to dispose of the delivered goods at its own expense according to the current laws and local regulations.

10 Appendix

This chapter contains navigation elements of the document.

10.1 List of figures

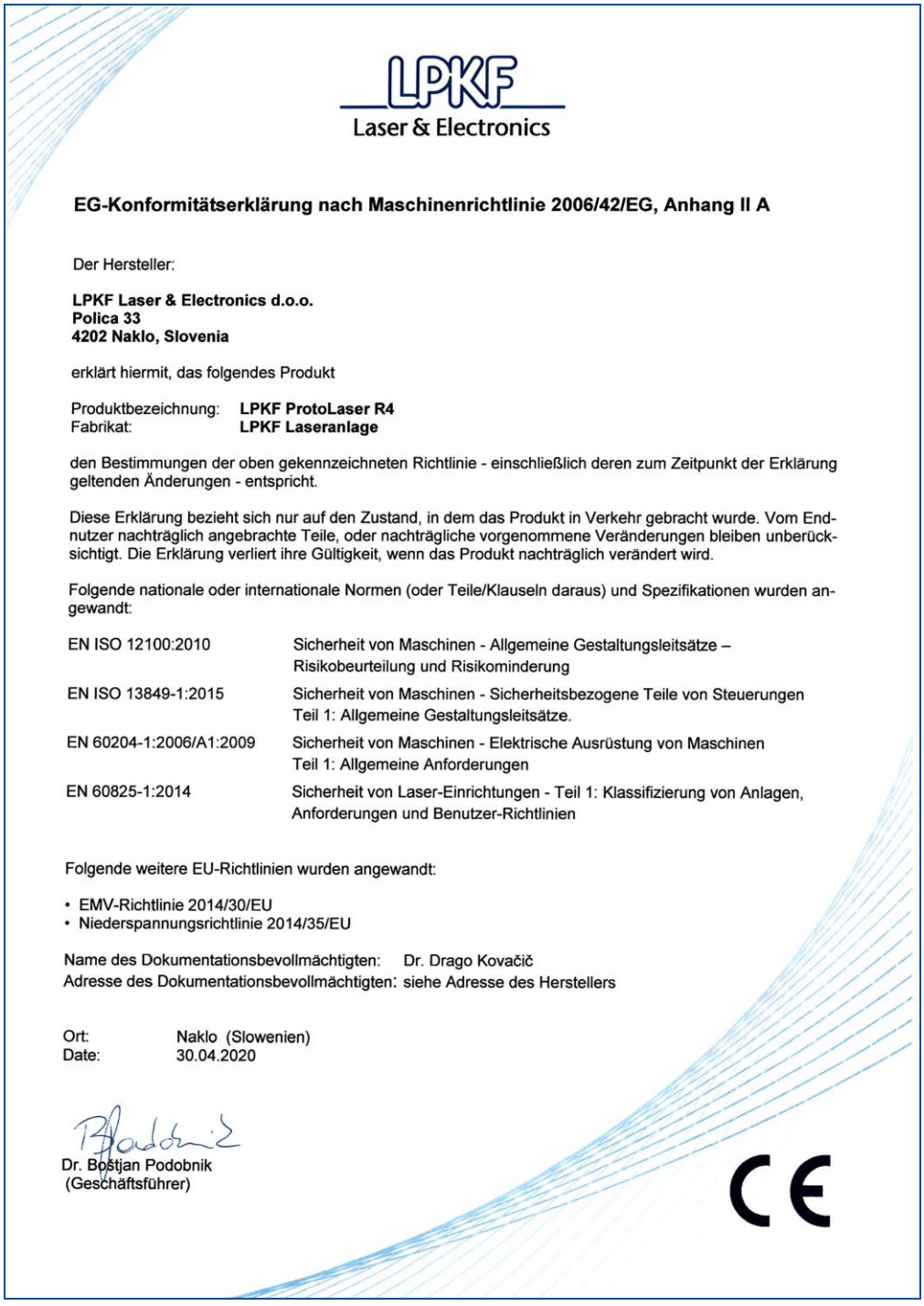
10.2 List of tables

10.3 Index

T

W

10.4 EC Declaration of conformity



LPKF
Laser & Electronics

EG-Konformitätserklärung nach Maschinenrichtlinie 2006/42/EG, Anhang II A

Der Hersteller:

LPKF Laser & Electronics d.o.o.
Polica 33
4202 Naklo, Slovenia

erklärt hiermit, das folgendes Produkt

Produktbezeichnung: **LPKF ProtoLaser R4**
Fabrikat: **LPKF Laseranlage**

den Bestimmungen der oben gekennzeichneten Richtlinie - einschließlich deren zum Zeitpunkt der Erklärung geltenden Änderungen - entspricht.

Diese Erklärung bezieht sich nur auf den Zustand, in dem das Produkt in Verkehr gebracht wurde. Vom Endnutzer nachträglich angebrachte Teile, oder nachträgliche vorgenommene Veränderungen bleiben unberücksichtigt. Die Erklärung verliert ihre Gültigkeit, wenn das Produkt nachträglich verändert wird.

Folgende nationale oder internationale Normen (oder Teile/Klauseln daraus) und Spezifikationen wurden angewandt:

EN ISO 12100:2010	Sicherheit von Maschinen - Allgemeine Gestaltungsleitsätze – Risikobeurteilung und Risikominderung
EN ISO 13849-1:2015	Sicherheit von Maschinen - Sicherheitsbezogene Teile von Steuerungen Teil 1: Allgemeine Gestaltungsleitsätze.
EN 60204-1:2006/A1:2009	Sicherheit von Maschinen - Elektrische Ausrüstung von Maschinen Teil 1: Allgemeine Anforderungen
EN 60825-1:2014	Sicherheit von Laser-Einrichtungen - Teil 1: Klassifizierung von Anlagen, Anforderungen und Benutzer-Richtlinien

Folgende weitere EU-Richtlinien wurden angewandt:

- EMV-Richtlinie 2014/30/EU
- Niederspannungsrichtlinie 2014/35/EU

Name des Dokumentationsbevollmächtigten: Dr. Drago Kovačič
Adresse des Dokumentationsbevollmächtigten: siehe Adresse des Herstellers

Ort: Naklo (Slowenien)
Date: 30.04.2020

Dr. Boštjan Podobnik
(Geschäftsführer)

CE

Fig. 197: Declaration of conformity (original)

LPKF
Laser & Electronics

EC Declaration of conformity according to machinery directive 2006/42/EC Annex II A

The manufacturer/distributor

LPKF Laser & Electronics d.o.o.
Polica 33
4202 Naklo, Slovenia

hereby declares that the following product

Product designation: **LPKF ProtoLaser R4**
Product type: **LPKF Laser system**

conforms to the requirements of the directive stated above - including the amendments in force at the time of the declaration.

This declaration is only valid for the state of the product at the time of delivery. Any parts added by the user or other later modifications are excluded. The declaration becomes invalid if the product is modified after delivery.

The following national or international standards (or parts/clauses) and specifications were applied:

EN ISO 12100:2010	Safety of machinery - General principles for design - Risk assessment and risk reduction
EN ISO 13849-1:2015	Safety of machinery - Safety-related parts of control systems Part 1: General principles for design.
EN 60204-1:2006/A1:2009	Safety of machinery - Electrical equipment of machines Part 1: General requirements.
EN 60825-1:2014	Safety of laser products - Part 1: Equipment classification and requirements.

The following additional EC directives were applied:

- EMC directive 2014/30/EU
- Low voltage directive 2014/35/EU

Name of the documentation representative: Dr. Drago Kovačič
Address of the documentation representative: see address of manufacturer

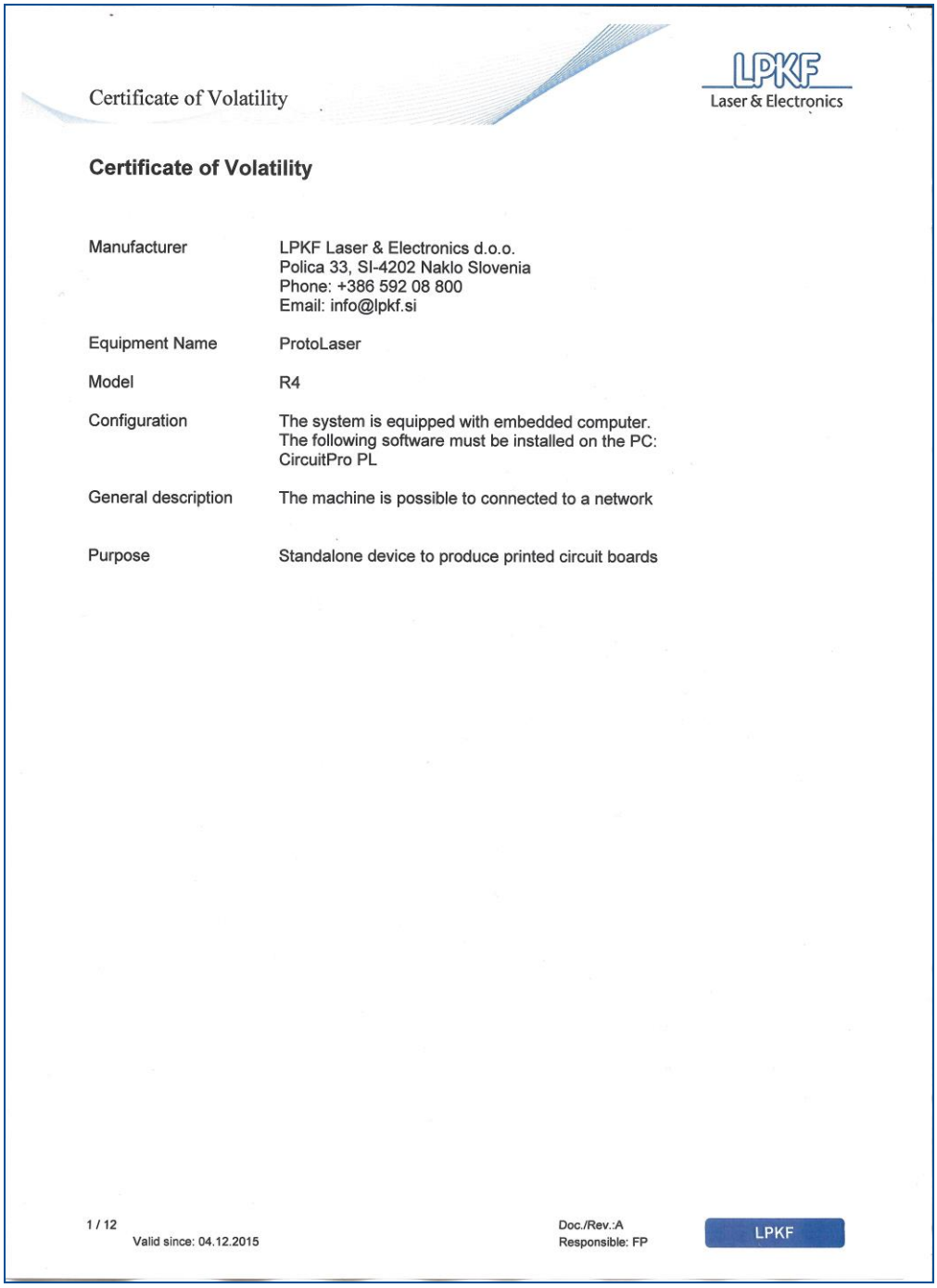
Location: Naklo (Slovenia)
Date: 30.04.2020

Dr. Boštjan Podobnik
(Managing Director)

CE

Fig. 198: Declaration of conformity (original)

10.5 Certificate of Volatility



Certificate of Volatility

LPKF Laser & Electronics

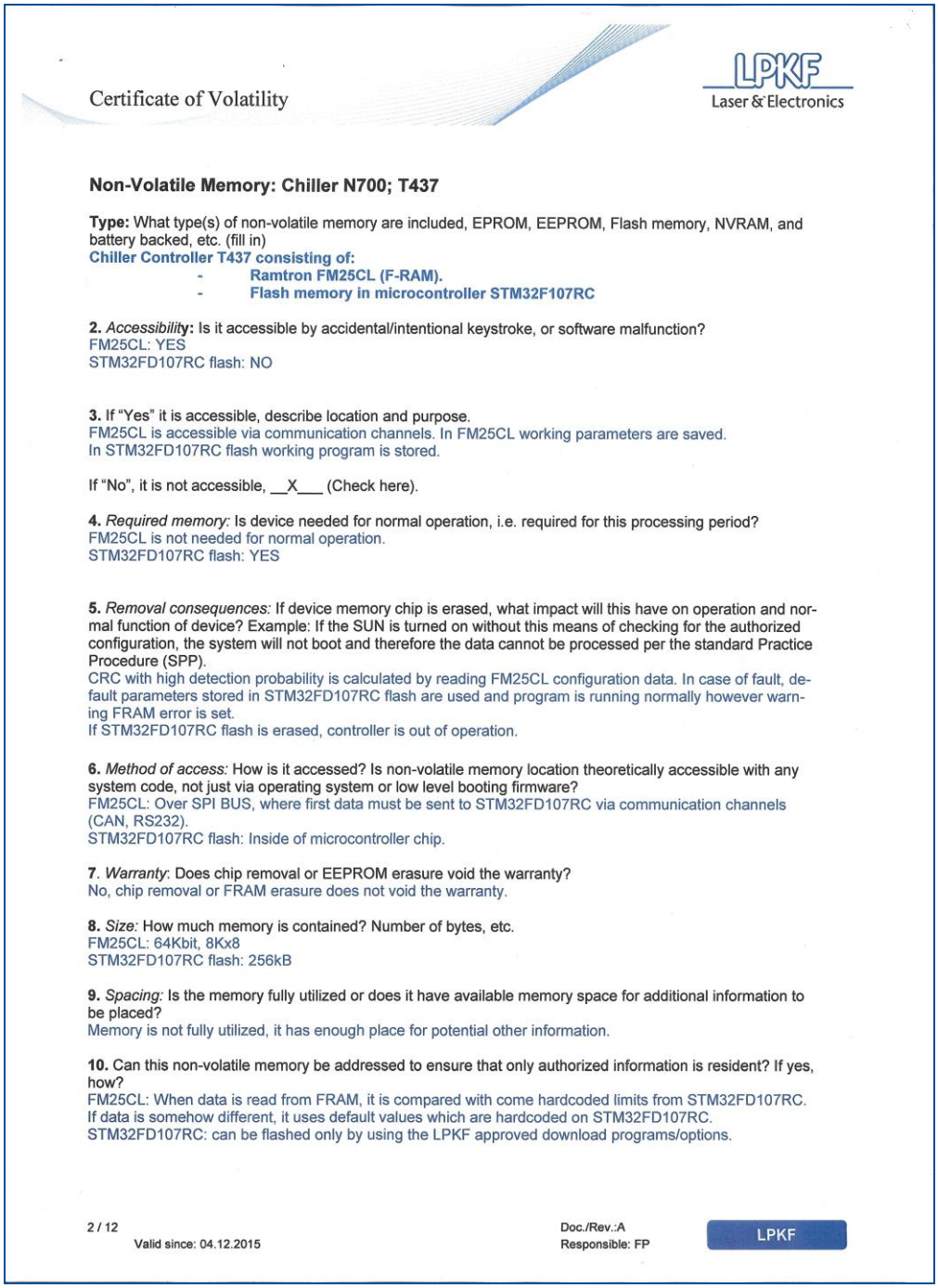
Certificate of Volatility

Manufacturer	LPKF Laser & Electronics d.o.o. Polica 33, SI-4202 Naklo Slovenia Phone: +386 592 08 800 Email: info@lpkf.si
Equipment Name	ProtoLaser
Model	R4
Configuration	The system is equipped with embedded computer. The following software must be installed on the PC: CircuitPro PL
General description	The machine is possible to connected to a network
Purpose	Standalone device to produce printed circuit boards

1 / 12
Valid since: 04.12.2015

Doc./Rev.:A
Responsible: FP

LPKF



Certificate of Volatility

LPKF Laser & Electronics

Non-Volatile Memory: Chiller N700; T437

Type: What type(s) of non-volatile memory are included, EPROM, EEPROM, Flash memory, NVRAM, and battery backed, etc. (fill in)
Chiller Controller T437 consisting of:
- **Ramtron FM25CL (F-RAM).**
- **Flash memory in microcontroller STM32F107RC**

2. *Accessibility*: Is it accessible by accidental/intentional keystroke, or software malfunction?
FM25CL: YES
STM32FD107RC flash: NO

3. If "Yes" it is accessible, describe location and purpose.
FM25CL is accessible via communication channels. In FM25CL working parameters are saved.
In STM32FD107RC flash working program is stored.

If "No", it is not accessible, __X___ (Check here).

4. *Required memory:* Is device needed for normal operation, i.e. required for this processing period?
FM25CL is not needed for normal operation.
STM32FD107RC flash: YES

5. *Removal consequences:* If device memory chip is erased, what impact will this have on operation and normal function of device? Example: If the SUN is turned on without this means of checking for the authorized configuration, the system will not boot and therefore the data cannot be processed per the standard Practice Procedure (SPP).
CRC with high detection probability is calculated by reading FM25CL configuration data. In case of fault, default parameters stored in STM32FD107RC flash are used and program is running normally however warning FRAM error is set.
If STM32FD107RC flash is erased, controller is out of operation.

6. *Method of access:* How is it accessed? Is non-volatile memory location theoretically accessible with any system code, not just via operating system or low level booting firmware?
FM25CL: Over SPI BUS, where first data must be sent to STM32FD107RC via communication channels (CAN, RS232).
STM32FD107RC flash: Inside of microcontroller chip.

7. *Warranty*: Does chip removal or EEPROM erasure void the warranty?
No, chip removal or FRAM erasure does not void the warranty.

8. *Size:* How much memory is contained? Number of bytes, etc.
FM25CL: 64Kbit, 8Kx8
STM32FD107RC flash: 256kB

9. *Spacing:* Is the memory fully utilized or does it have available memory space for additional information to be placed?
Memory is not fully utilized, it has enough place for potential other information.

10. Can this non-volatile memory be addressed to ensure that only authorized information is resident? If yes, how?
FM25CL: When data is read from FRAM, it is compared with come hardcoded limits from STM32FD107RC. If data is somehow different, it uses default values which are hardcoded on STM32FD107RC.
STM32FD107RC: can be flashed only by using the LPKF approved download programs/options.

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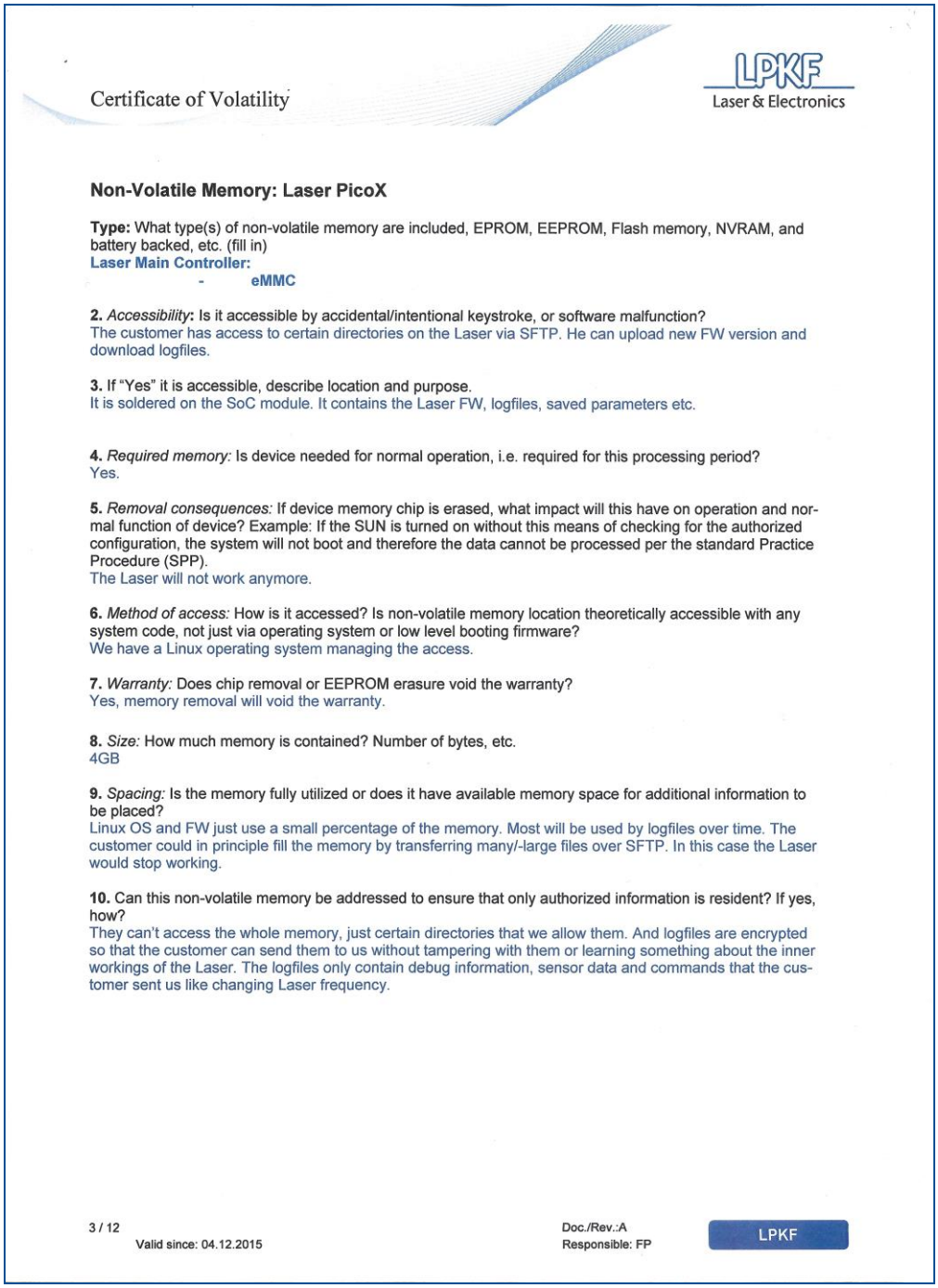
Valid since: 04.12.2015
Doc./Rev.:A
Responsible: FP
LPKF



Certificate of Volatility

LPKF Laser & Electronics

Non-Volatile Memory: Laser PicoX

Type: What type(s) of non-volatile memory are included, EPROM, EEPROM, Flash memory, NVRAM, and battery backed, etc. (fill in)
Laser Main Controller:
- **eMMC**

2. *Accessibility*: Is it accessible by accidental/intentional keystroke, or software malfunction?
The customer has access to certain directories on the Laser via SFTP. He can upload new FW version and download logfiles.

3. If "Yes" it is accessible, describe location and purpose.
It is soldered on the SoC module. It contains the Laser FW, logfiles, saved parameters etc.

4. *Required memory:* Is device needed for normal operation, i.e. required for this processing period?
Yes.

5. *Removal consequences:* If device memory chip is erased, what impact will this have on operation and normal function of device? Example: If the SUN is turned on without this means of checking for the authorized configuration, the system will not boot and therefore the data cannot be processed per the standard Practice Procedure (SPP).
The Laser will not work anymore.

6. *Method of access:* How is it accessed? Is non-volatile memory location theoretically accessible with any system code, not just via operating system or low level booting firmware?
We have a Linux operating system managing the access.

7. *Warranty:* Does chip removal or EEPROM erasure void the warranty?
Yes, memory removal will void the warranty.

8. *Size:* How much memory is contained? Number of bytes, etc.
4GB

9. *Spacing:* Is the memory fully utilized or does it have available memory space for additional information to be placed?
Linux OS and FW just use a small percentage of the memory. Most will be used by logfiles over time. The customer could in principle fill the memory by transferring many/-large files over SFTP. In this case the Laser would stop working.

10. Can this non-volatile memory be addressed to ensure that only authorized information is resident? If yes, how?
They can't access the whole memory, just certain directories that we allow them. And logfiles are encrypted so that the customer can send them to us without tampering with them or learning something about the inner workings of the Laser. The logfiles only contain debug information, sensor data and commands that the customer sent us like changing Laser frequency.

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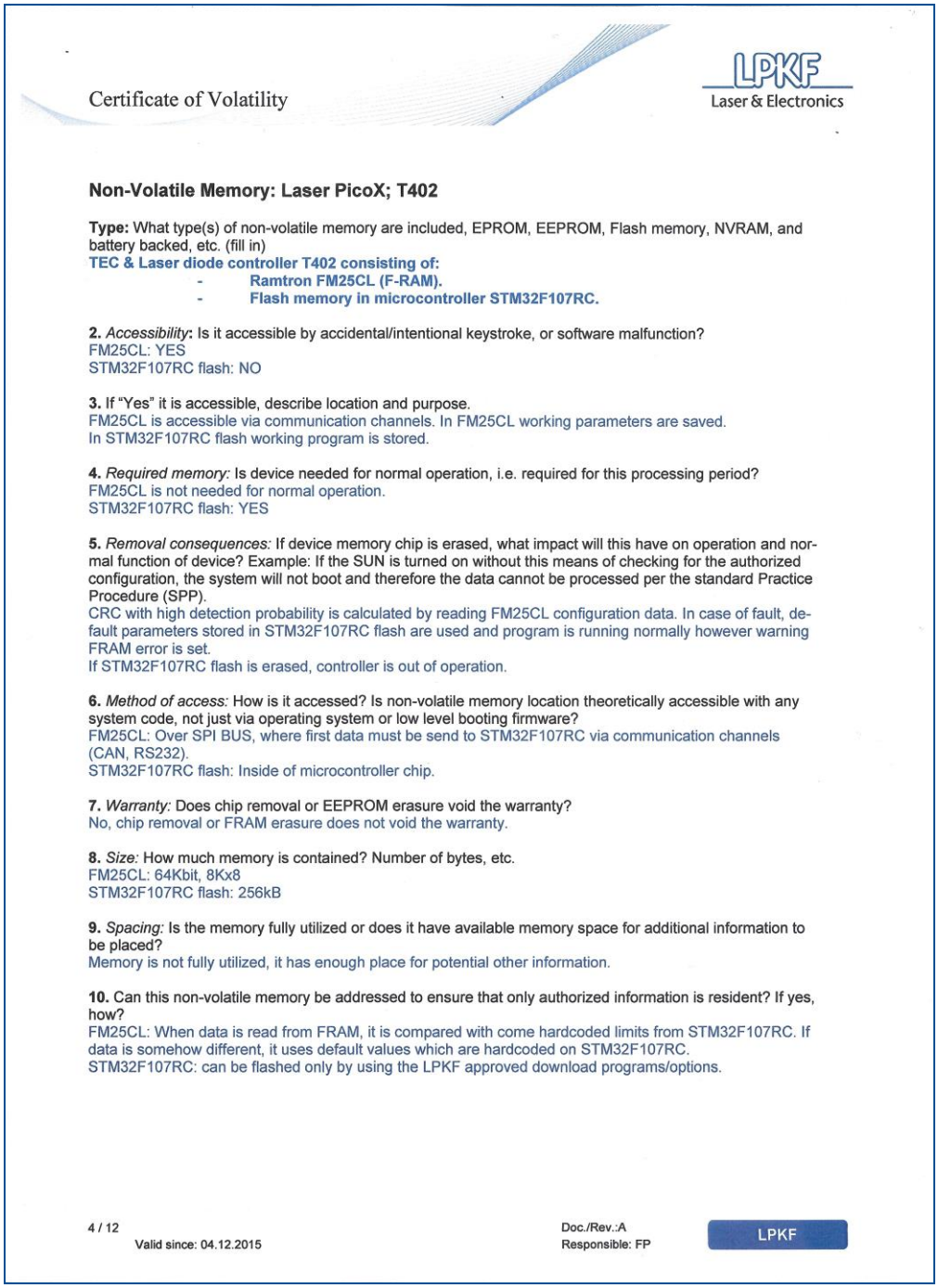
Valid since: 04.12.2015

Doc./Rev.:A
Responsible: FP

LPKF



Certificate of Volatility

LPKF Laser & Electronics

Non-Volatile Memory: Laser PicoX; T402

Type: What type(s) of non-volatile memory are included, EPROM, EEPROM, Flash memory, NVRAM, and battery backed, etc. (fill in)
TEC & Laser diode controller T402 consisting of:
- **Ramtron FM25CL (F-RAM).**
- **Flash memory in microcontroller STM32F107RC.**

2. *Accessibility*: Is it accessible by accidental/intentional keystroke, or software malfunction?
FM25CL: YES
STM32F107RC flash: NO

3. If "Yes" it is accessible, describe location and purpose.
FM25CL is accessible via communication channels. In FM25CL working parameters are saved.
In STM32F107RC flash working program is stored.

4. *Required memory:* Is device needed for normal operation, i.e. required for this processing period?
FM25CL is not needed for normal operation.
STM32F107RC flash: YES

5. *Removal consequences:* If device memory chip is erased, what impact will this have on operation and normal function of device? Example: If the SUN is turned on without this means of checking for the authorized configuration, the system will not boot and therefore the data cannot be processed per the standard Practice Procedure (SPP).
CRC with high detection probability is calculated by reading FM25CL configuration data. In case of fault, default parameters stored in STM32F107RC flash are used and program is running normally however warning FRAM error is set.
If STM32F107RC flash is erased, controller is out of operation.

6. *Method of access:* How is it accessed? Is non-volatile memory location theoretically accessible with any system code, not just via operating system or low level booting firmware?
FM25CL: Over SPI BUS, where first data must be send to STM32F107RC via communication channels (CAN, RS232).
STM32F107RC flash: Inside of microcontroller chip.

7. *Warranty:* Does chip removal or EEPROM erasure void the warranty?
No, chip removal or FRAM erasure does not void the warranty.

8. *Size:* How much memory is contained? Number of bytes, etc.
FM25CL: 64Kbit, 8Kx8
STM32F107RC flash: 256kB

9. *Spacing:* Is the memory fully utilized or does it have available memory space for additional information to be placed?
Memory is not fully utilized, it has enough place for potential other information.

10. Can this non-volatile memory be addressed to ensure that only authorized information is resident? If yes, how?
FM25CL: When data is read from FRAM, it is compared with come hardcoded limits from STM32F107RC. If data is somehow different, it uses default values which are hardcoded on STM32F107RC.
STM32F107RC: can be flashed only by using the LPKF approved download programs/options.

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Valid since: 04.12.2015

Doc./Rev.:A
Responsible: FP

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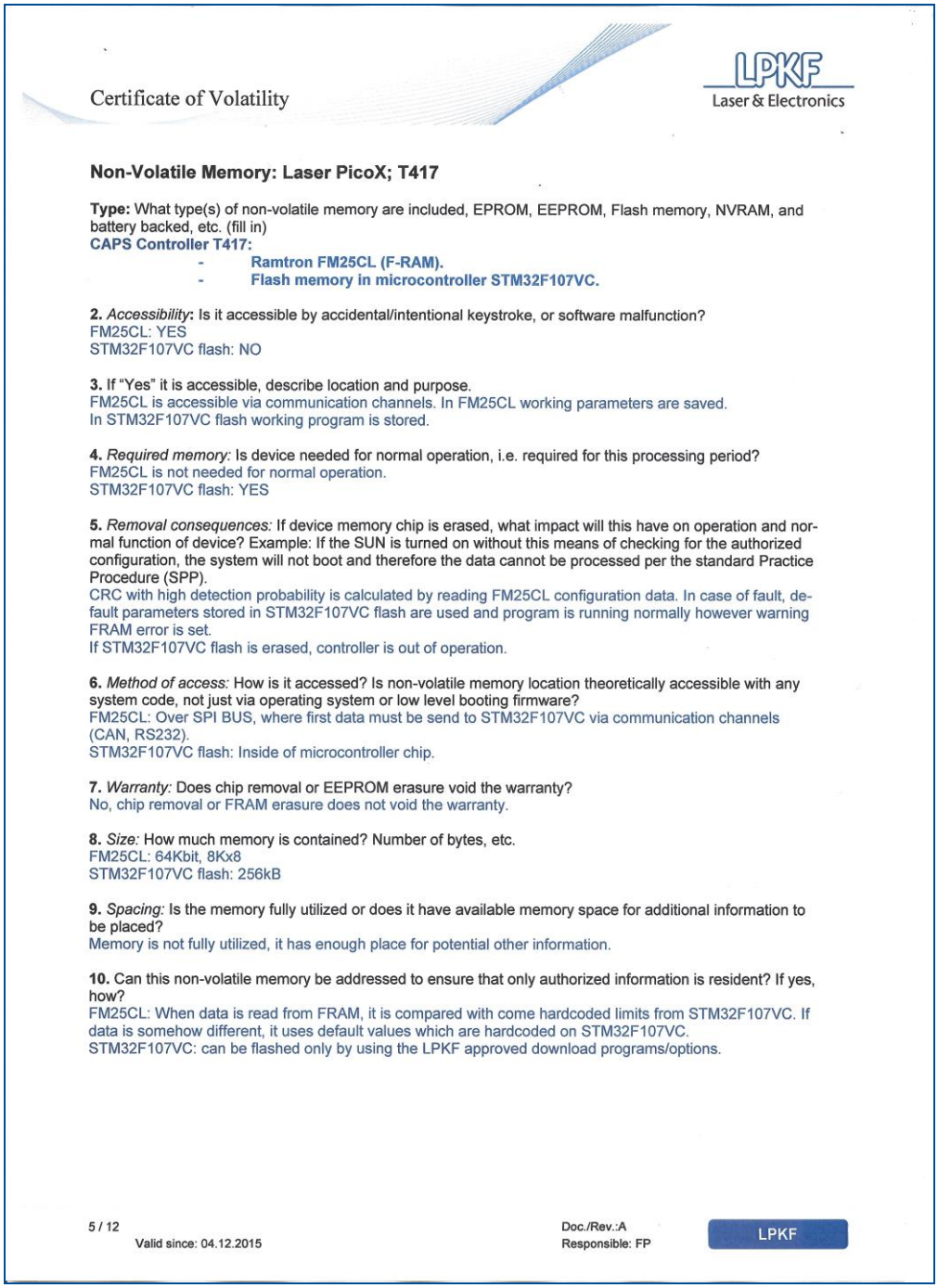

Certificate of Volatility

LPKF Laser & Electronics

Non-Volatile Memory: Laser PicoX; T417

Type: What type(s) of non-volatile memory are included, EPROM, EEPROM, Flash memory, NVRAM, and battery backed, etc. (fill in)
CAPS Controller T417:
- **Ramtron FM25CL (F-RAM).**
- **Flash memory in microcontroller STM32F107VC.**

2. *Accessibility*: Is it accessible by accidental/intentional keystroke, or software malfunction?
FM25CL: YES
STM32F107VC flash: NO

3. If "Yes" it is accessible, describe location and purpose.
FM25CL is accessible via communication channels. In FM25CL working parameters are saved.
In STM32F107VC flash working program is stored.

4. *Required memory:* Is device needed for normal operation, i.e. required for this processing period?
FM25CL is not needed for normal operation.
STM32F107VC flash: YES

5. *Removal consequences:* If device memory chip is erased, what impact will this have on operation and normal function of device? Example: If the SUN is turned on without this means of checking for the authorized configuration, the system will not boot and therefore the data cannot be processed per the standard Practice Procedure (SPP).
CRC with high detection probability is calculated by reading FM25CL configuration data. In case of fault, default parameters stored in STM32F107VC flash are used and program is running normally however warning FRAM error is set.
If STM32F107VC flash is erased, controller is out of operation.

6. *Method of access:* How is it accessed? Is non-volatile memory location theoretically accessible with any system code, not just via operating system or low level booting firmware?
FM25CL: Over SPI BUS, where first data must be send to STM32F107VC via communication channels (CAN, RS232).
STM32F107VC flash: Inside of microcontroller chip.

7. *Warranty:* Does chip removal or EEPROM erasure void the warranty?
No, chip removal or FRAM erasure does not void the warranty.

8. *Size:* How much memory is contained? Number of bytes, etc.
FM25CL: 64Kbit, 8Kx8
STM32F107VC flash: 256kB

9. *Spacing:* Is the memory fully utilized or does it have available memory space for additional information to be placed?
Memory is not fully utilized, it has enough place for potential other information.

10. Can this non-volatile memory be addressed to ensure that only authorized information is resident? If yes, how?
FM25CL: When data is read from FRAM, it is compared with come hardcoded limits from STM32F107VC. If data is somehow different, it uses default values which are hardcoded on STM32F107VC.
STM32F107VC: can be flashed only by using the LPKF approved download programs/options.

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Valid since: 04.12.2015

Doc./Rev.:A
Responsible: FP

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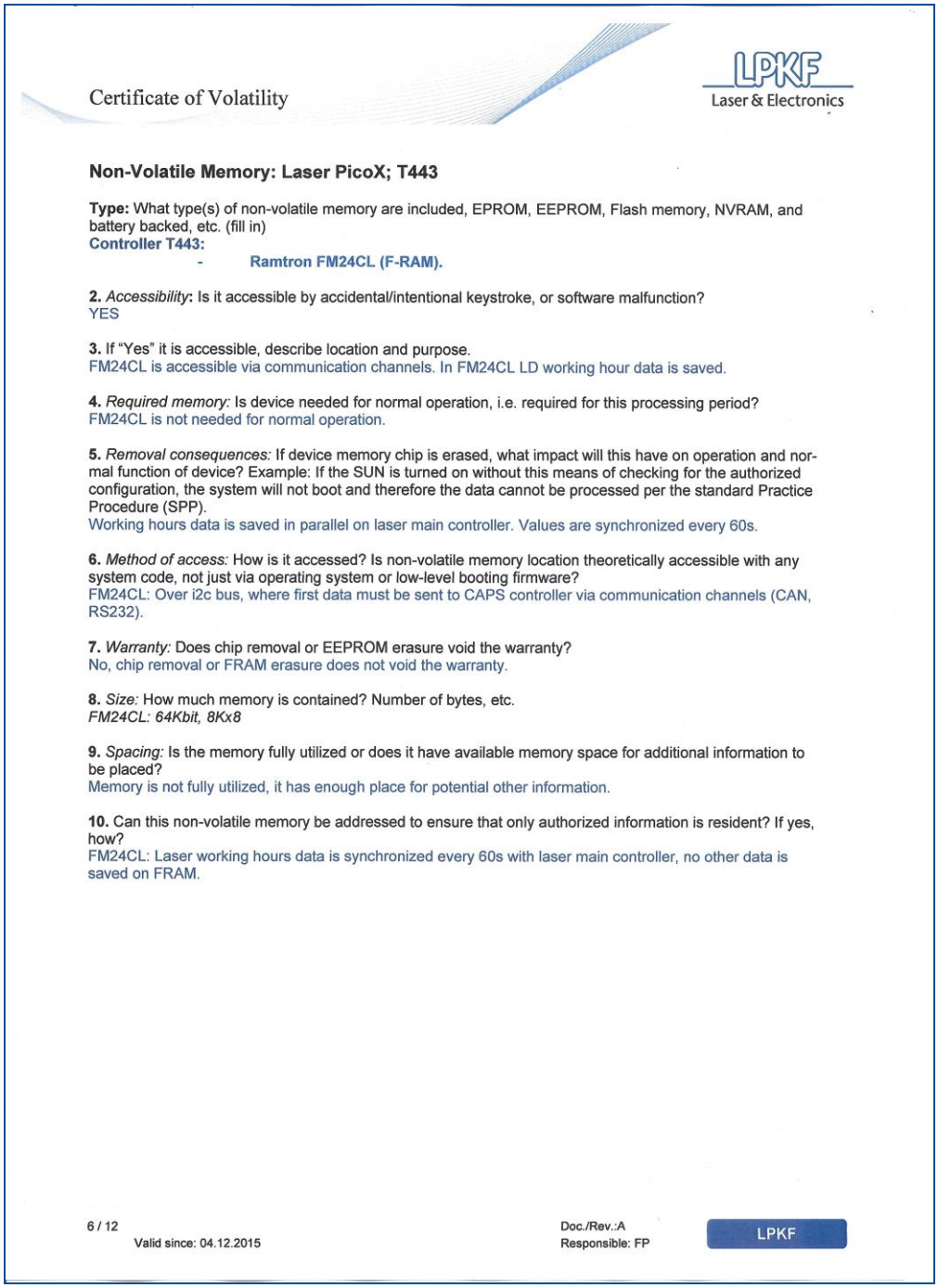

Certificate of Volatility

LPKF Laser & Electronics

Non-Volatile Memory: Laser PicoX; T443

Type: What type(s) of non-volatile memory are included, EPROM, EEPROM, Flash memory, NVRAM, and battery backed, etc. (fill in)
Controller T443:
- **Ramtron FM24CL (F-RAM).**

2. *Accessibility*: Is it accessible by accidental/intentional keystroke, or software malfunction?
YES

3. If "Yes" it is accessible, describe location and purpose.
FM24CL is accessible via communication channels. In FM24CL LD working hour data is saved.

4. *Required memory:* Is device needed for normal operation, i.e. required for this processing period?
FM24CL is not needed for normal operation.

5. *Removal consequences:* If device memory chip is erased, what impact will this have on operation and normal function of device? Example: If the SUN is turned on without this means of checking for the authorized configuration, the system will not boot and therefore the data cannot be processed per the standard Practice Procedure (SPP).
Working hours data is saved in parallel on laser main controller. Values are synchronized every 60s.

6. *Method of access:* How is it accessed? Is non-volatile memory location theoretically accessible with any system code, not just via operating system or low-level booting firmware?
FM24CL: Over i2c bus, where first data must be sent to CAPS controller via communication channels (CAN, RS232).

7. *Warranty:* Does chip removal or EEPROM erasure void the warranty?
No, chip removal or FRAM erasure does not void the warranty.

8. *Size:* How much memory is contained? Number of bytes, etc.
FM24CL: 64Kbit, 8Kx8

9. *Spacing:* Is the memory fully utilized or does it have available memory space for additional information to be placed?
Memory is not fully utilized, it has enough place for potential other information.

10. Can this non-volatile memory be addressed to ensure that only authorized information is resident? If yes, how?
FM24CL: Laser working hours data is synchronized every 60s with laser main controller, no other data is saved on FRAM.

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Valid since: 04.12.2015

Doc./Rev.:A
Responsible: FP

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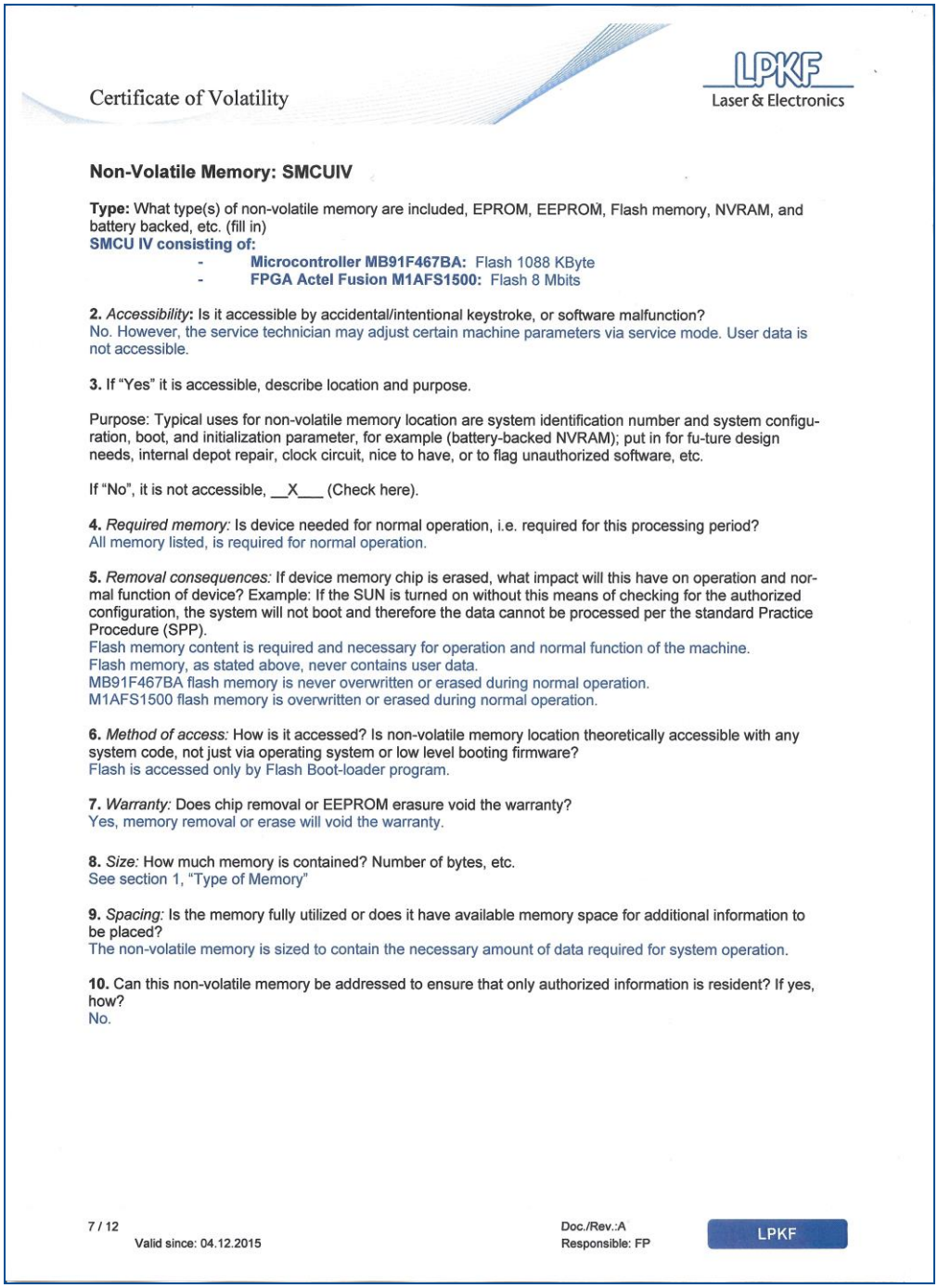

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Non-Volatile Memory: SMCUIV

Type: What type(s) of non-volatile memory are included, EPROM, EEPROM, Flash memory, NVRAM, and battery backed, etc. (fill in)
SMCU IV consisting of:

- **Microcontroller MB91F467BA:** Flash 1088 KByte
- **FPGA Actel Fusion M1AFS1500:** Flash 8 Mbits

2. *Accessibility*: Is it accessible by accidental/intentional keystroke, or software malfunction?
No. However, the service technician may adjust certain machine parameters via service mode. User data is not accessible.

3. If "Yes" it is accessible, describe location and purpose.

Purpose: Typical uses for non-volatile memory location are system identification number and system configuration, boot, and initialization parameter, for example (battery-backed NVRAM); put in for fu-ture design needs, internal depot repair, clock circuit, nice to have, or to flag unauthorized software, etc.

If "No", it is not accessible, __X___ (Check here).

4. *Required memory:* Is device needed for normal operation, i.e. required for this processing period?
All memory listed, is required for normal operation.

5. *Removal consequences:* If device memory chip is erased, what impact will this have on operation and normal function of device? Example: If the SUN is turned on without this means of checking for the authorized configuration, the system will not boot and therefore the data cannot be processed per the standard Practice Procedure (SPP).
Flash memory content is required and necessary for operation and normal function of the machine.
Flash memory, as stated above, never contains user data.
MB91F467BA flash memory is never overwritten or erased during normal operation.
M1AFS1500 flash memory is overwritten or erased during normal operation.

6. *Method of access:* How is it accessed? Is non-volatile memory location theoretically accessible with any system code, not just via operating system or low level booting firmware?
Flash is accessed only by Flash Boot-loader program.

7. *Warranty:* Does chip removal or EEPROM erasure void the warranty?
Yes, memory removal or erase will void the warranty.

8. *Size:* How much memory is contained? Number of bytes, etc.
See section 1, "Type of Memory"

9. *Spacing:* Is the memory fully utilized or does it have available memory space for additional information to be placed?
The non-volatile memory is sized to contain the necessary amount of data required for system operation.

10. Can this non-volatile memory be addressed to ensure that only authorized information is resident? If yes, how?
No.

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Non-Volatile Memory: R-cont; T486

Type: What type(s) of non-volatile memory are included, EPROM, EEPROM, Flash memory, NVRAM, and battery backed, etc. (fill in)

- **Ramtron FM25CL (F-RAM).**
- **Flash memory in microcontroller STM32F107VC.**

2. *Accessibility*: Is it accessible by accidental/intentional keystroke, or software malfunction?
FM25CL: YES
STM32F107VC flash: NO

3. If "Yes" it is accessible, describe location and purpose.
FM25CL is accessible via communication channels.
In FM25CL working parameters are saved.
In STM32F107RC flash working program is stored.

4. *Required memory:* Is device needed for normal operation, i.e. required for this processing period?
FM25CL: NO
STM32F107RC flash: YES

5. *Removal consequences:* If device memory chip is erased, what impact will this have on operation and normal function of device? Example: If the SUN is turned on without this means of checking for the authorized configuration, the system will not boot and therefore the data cannot be processed per the standard Practice Procedure (SPP).
CRC with high detection probability is calculated by reading FM25CL configuration data. In case of fault, default parameters stored in STM32F107VC flash are used and program is running normally however warning FRAM error is set.
If STM32F107VC flash is erased, controller is out of operation

6. *Method of access:* How is it accessed? Is non-volatile memory location theoretically accessible with any system code, not just via operating system or low level booting firmware?
FM25CL: Over SPI BUS, where first data must be send to STM32F107VC via communication channels (CAN, RS232).
STM32F107VC flash: Inside of microcontroller chip.

7. *Warranty*: Does chip removal or EEPROM erasure void the warranty?
No, chip removal or FRAM erasure does not void the warranty

8. *Size:* How much memory is contained? Number of bytes, etc.
FM25CL: 64Kbit, 8Kx8
STM32F107VC flash: 256kB

9. *Spacing:* Is the memory fully utilized or does it have available memory space for additional information to be placed?
Memory is not fully utilized, it has enough place for potential other information.

10. Can this non-volatile memory be addressed to ensure that only authorized information is resident? If yes, how?
FM25CL: When data is read from FRAM, it is compared with come hardcoded limits from STM32F107VC. If data is somehow different, it uses default values which are hardcoded on STM32F107VC.
STM32F107VC: can be flashed only by using the LPKF approved download programs/options.

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Valid since: 04.12.2015

Doc./Rev.:A
Responsible: FP

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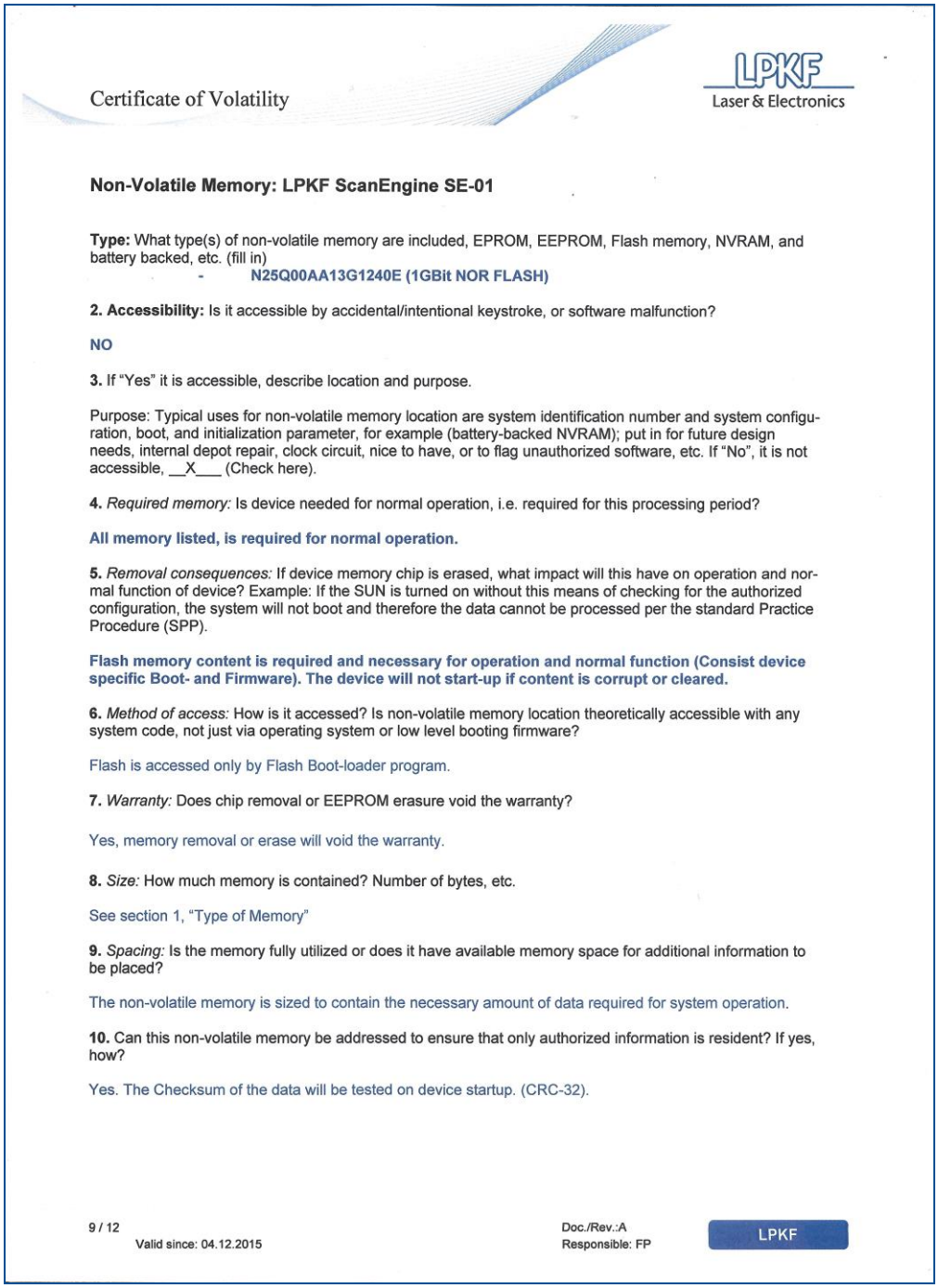

Certificate of Volatility

LPKF Laser & Electronics

Non-Volatile Memory: LPKF ScanEngine SE-01

Type: What type(s) of non-volatile memory are included, EPROM, EEPROM, Flash memory, NVRAM, and battery backed, etc. (fill in)

- **N25Q00AA13G1240E (1GBit NOR FLASH)**

2. Accessibility: Is it accessible by accidental/intentional keystroke, or software malfunction?

NO

3. If "Yes" it is accessible, describe location and purpose.

Purpose: Typical uses for non-volatile memory location are system identification number and system configuration, boot, and initialization parameter, for example (battery-backed NVRAM); put in for future design needs, internal depot repair, clock circuit, nice to have, or to flag unauthorized software, etc. If "No", it is not accessible, __X___ (Check here).

4. *Required memory:* Is device needed for normal operation, i.e. required for this processing period?

All memory listed, is required for normal operation.

5. *Removal consequences:* If device memory chip is erased, what impact will this have on operation and normal function of device? Example: If the SUN is turned on without this means of checking for the authorized configuration, the system will not boot and therefore the data cannot be processed per the standard Practice Procedure (SPP).

Flash memory content is required and necessary for operation and normal function (Consist device specific Boot- and Firmware). The device will not start-up if content is corrupt or cleared.

6. *Method of access:* How is it accessed? Is non-volatile memory location theoretically accessible with any system code, not just via operating system or low level booting firmware?

Flash is accessed only by Flash Boot-loader program.

7. *Warranty:* Does chip removal or EEPROM erasure void the warranty?

Yes, memory removal or erase will void the warranty.

8. *Size:* How much memory is contained? Number of bytes, etc.

See section 1, "Type of Memory"

9. *Spacing:* Is the memory fully utilized or does it have available memory space for additional information to be placed?

The non-volatile memory is sized to contain the necessary amount of data required for system operation.

10. Can this non-volatile memory be addressed to ensure that only authorized information is resident? If yes, how?

Yes. The Checksum of the data will be tested on device startup. (CRC-32).

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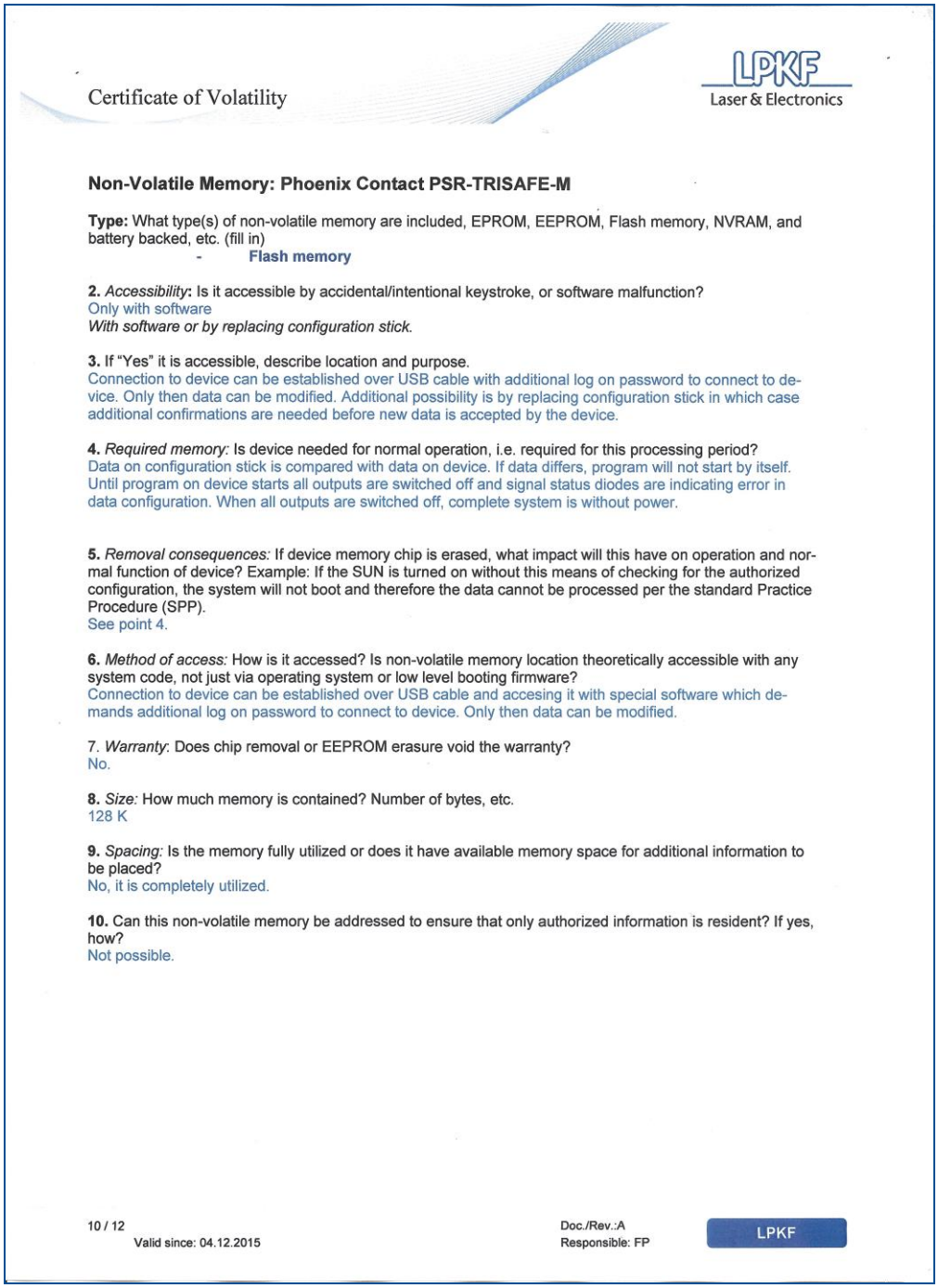

Certificate of Volatility

LPKF Laser & Electronics

Non-Volatile Memory: Phoenix Contact PSR-TRISAFE-M

Type: What type(s) of non-volatile memory are included, EPROM, EEPROM, Flash memory, NVRAM, and battery backed, etc. (fill in)

- **Flash memory**

2. *Accessibility*: Is it accessible by accidental/intentional keystroke, or software malfunction?
Only with software
With software or by replacing configuration stick.

3. If "Yes" it is accessible, describe location and purpose.
Connection to device can be established over USB cable with additional log on password to connect to device. Only then data can be modified. Additional possibility is by replacing configuration stick in which case additional confirmations are needed before new data is accepted by the device.

4. *Required memory:* Is device needed for normal operation, i.e. required for this processing period?
Data on configuration stick is compared with data on device. If data differs, program will not start by itself. Until program on device starts all outputs are switched off and signal status diodes are indicating error in data configuration. When all outputs are switched off, complete system is without power.

5. *Removal consequences:* If device memory chip is erased, what impact will this have on operation and normal function of device? Example: If the SUN is turned on without this means of checking for the authorized configuration, the system will not boot and therefore the data cannot be processed per the standard Practice Procedure (SPP).
See point 4.

6. *Method of access:* How is it accessed? Is non-volatile memory location theoretically accessible with any system code, not just via operating system or low level booting firmware?
Connection to device can be established over USB cable and accesing it with special software which demands additional log on password to connect to device. Only then data can be modified.

7. *Warranty*: Does chip removal or EEPROM erasure void the warranty?
No.

8. *Size:* How much memory is contained? Number of bytes, etc.
128 K

9. *Spacing:* Is the memory fully utilized or does it have available memory space for additional information to be placed?
No, it is completely utilized.

10. Can this non-volatile memory be addressed to ensure that only authorized information is resident? If yes, how?
Not possible.

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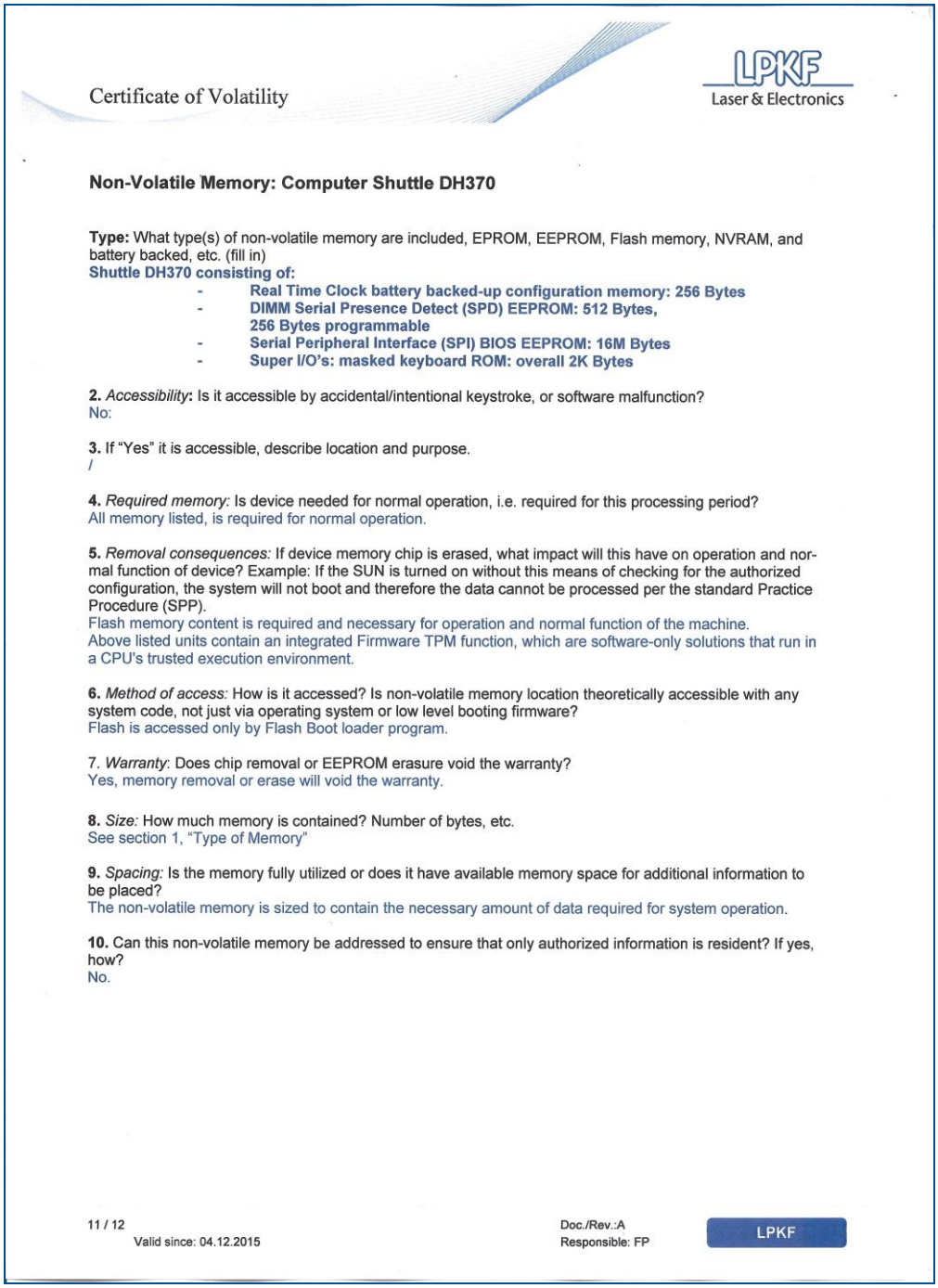

Certificate of Volatility

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Non-Volatile Memory: Computer Shuttle DH370

Type: What type(s) of non-volatile memory are included, EPROM, EEPROM, Flash memory, NVRAM, and battery backed, etc. (fill in)
Shuttle DH370 consisting of:

- **Real Time Clock battery backed-up configuration memory: 256 Bytes**
- **DIMM Serial Presence Detect (SPD) EEPROM: 512 Bytes, 256 Bytes programmable**
- **Serial Peripheral Interface (SPI) BIOS EEPROM: 16M Bytes**
- **Super I/O's: masked keyboard ROM: overall 2K Bytes**

2. *Accessibility*: Is it accessible by accidental/intentional keystroke, or software malfunction?
No:

3. If "Yes" it is accessible, describe location and purpose.
/

4. *Required memory:* Is device needed for normal operation, i.e. required for this processing period?
All memory listed, is required for normal operation.

5. *Removal consequences:* If device memory chip is erased, what impact will this have on operation and normal function of device? Example: If the SUN is turned on without this means of checking for the authorized configuration, the system will not boot and therefore the data cannot be processed per the standard Practice Procedure (SPP).
Flash memory content is required and necessary for operation and normal function of the machine.
Above listed units contain an integrated Firmware TPM function, which are software-only solutions that run in a CPU's trusted execution environment.

6. *Method of access:* How is it accessed? Is non-volatile memory location theoretically accessible with any system code, not just via operating system or low level booting firmware?
Flash is accessed only by Flash Boot loader program.

7. *Warranty*: Does chip removal or EEPROM erasure void the warranty?
Yes, memory removal or erase will void the warranty.

8. *Size:* How much memory is contained? Number of bytes, etc.
See section 1, "Type of Memory"

9. *Spacing:* Is the memory fully utilized or does it have available memory space for additional information to be placed?
The non-volatile memory is sized to contain the necessary amount of data required for system operation.

10. Can this non-volatile memory be addressed to ensure that only authorized information is resident? If yes, how?
No.

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Responsible: FP

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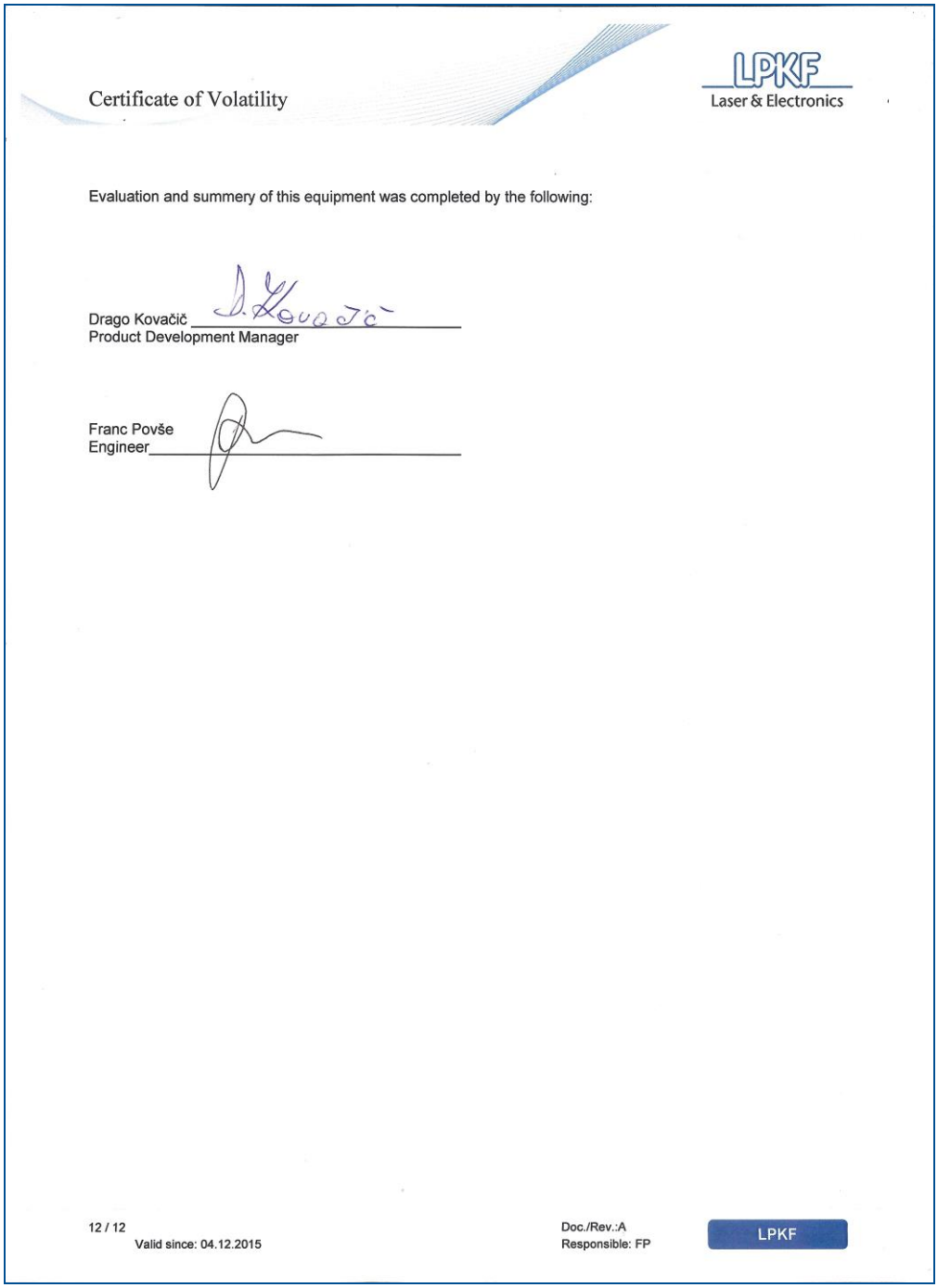

Certificate of Volatility

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Evaluation and summery of this equipment was completed by the following:

Drago Kovačič
Product Development Manager

Franc Povše
Engineer

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Fig. 199: Certificate of Volatility