User Manual

COMPex*Pro*®

01/2016

Part Number: D154688 [AA]
Document Code: A_CPro5F_AA

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1 INTRODUCTION

This User Manual is a part of the instructions for use that accompany COMPex*Pro*® excimer laser devices. These instructions promote the intended safe and efficient use of the laser device and contain the information that needs to be known before starting work. Following these instructions should reduce the risk of injury to persons as well reduce the risk of damage, malfunction or inefficient operation of the laser device.

The instructions for use consist of more the one document. Each document has been prepared for a specific target group and will be made available to this group of persons by Coherent, their authorized representative or the laser unit manufacturer (system integrator).

The COMPex*Pro* instructions for use consists of the following separate documents:

– User Manual

– Site Preparation Manual.

– Interfacing Manual

– Service Manual

Installation, de-installation, servicing and detailed troubleshooting shall only be performed by correspondingly trained and instructed service personnel. Consequently, the target group for the Service Manual is strictly limited to skilled personnel that have successfully completed a dedicated Coherent advanced training course for COMPex*Pro* excimer laser devices.

The COMPex*Pro* excimer laser device can be used as a subsystem within a laser product (laser assembly or laser unit as defined in ISO 11145). Consequently, the laser device's instructions for use are to be used in conjunction with other instruction manuals that describe the complete system or further system elements. In addition, it is to be supplemented by the respective national rules and regulations for accident prevention and environmental protection.

The User Manual should contain all relevant information about used or resultant gases and chemicals that are potentially hazardous. Therefore for each gas, the respective gas supplier Material Safety Data Sheet (MSDS) should be attached to this manual.
The final user is responsible for ensuring that respective Material Safety Data Sheet (MSDS) provided by the currently applicable gas supplier is attached to this manual.

1.1 The User Manual

This User Manual:

- describes the physical and chemical hazards related to the laser device, the means of protection against these hazards and the safety features incorporated in the design of the laser device.
- briefly describes the purpose and operation as well as the primary features, system elements, subsystems and fundamental laser control routines of the laser device.
- describes the fundamental operation of the laser device through the handheld keypad.
- describes the service procedures for the laser device which can be performed by the end user. This includes a time schedule for all periodic routine replacement procedures and a basic troubleshooting section.

1.1.1 Described Laser Devices

This manual describes the laser device versions COMPex*Pro* 50, COMPex*Pro* 102, COMPex*Pro* 110, COMPex*Pro* 201 and COMPex*Pro* 205 that were produced after January 2016.

1.1.2 Intended Audience

The User Manual is intended for all persons that are to work on or with the laser device. It assumes that the reader has participated in an introductory training course which has taught them the safe operation of the COMPex*Pro* laser device.

None of the procedures described in this manual requires the defeating of safety interlocks. Where specific training is required to perform procedures, this is clearly indicated at the beginning of the corresponding section.

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1.1.3 Availability and Use

The COMPex*Pro* User Manual must always be available wherever the laser device is in use. It must be read and applied by any person in charge of carrying out work with and on the laser device, such as

– operation (including setting up, troubleshooting in the course of work, removal of production waste, care and disposal of consumables,

– service (maintenance, inspection, repair) and/or

– transport.

1.1.4 Numbering of Chapters, Pages and Instructions

The pages of this manual are numbered continuously. The page number appears in the lower outside corner of every page.

The chapters are numbered continuously. The name of the chapter appears in the upper outside corner of every even page. Each chapter ends with an even page number. Consequently, certain even pages at the ends of chapters will be intentionally left blank.

Each step within a procedure is sequentially numbered. Each procedure starts with the step number one.

1.1.5 Typographic Conventions

Menu commands, enquiries and prompts are written in uppercase letters enclosed by quotation marks.

– Example: “ARE YOU SURE (YES/NO)?”

Single keys on the keyboard and terminal buttons to be pressed or touched are written in angled brackets.

– Example: Touch <YES> to confirm and to continue.

Examples are written in non-proportional, upper-case letters to simulate the appearance of computer monitor displays or printer output.

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1.1.6 Trademarks

The trademarks used in this manual are the properties of their respective owners and are used for identification purposes only:

– Coherent and the Coherent Logo are registered trademarks of Coherent Inc., USA

– COMPex*Pro*, LAMBDA PHYSIK and NovaTube are registered trademarks of Coherent LaserSystems GmbH & Co. KG.

– Gyrolok is a registered trademark of Hoke Inc., USA.

– SNOOP is a registered trademark of the Swagelok Company, USA

In the following sections of this manual, no mention is made of patents, trademark rights or other proprietary rights which may attach to certain words. The absence of such mention, however, in no way implies that the words in question are exempt from such rights.

1.1.7 Cited Standards

Unless otherwise stated, all technical standards cited in this manual relate to the latest version of the standard that is applicable at the date of the publication of this manual.

In many cases, cited international standards (ISO and IEC standards) have been adopted wholly or in part by national or regional standards authorities and are known locally under the designation assigned by this authority. For instance, the IEC 60825-1 has been adopted by the European Committee for Standardization as the standard EN 60825-1 and, in turn, by various national standards authorities as standards such as DIN EN 60825 (Germany) and BS EN 60825 (United Kingdom). The exact content, number and revision date of a national standard may, however, vary from that of the corresponding international standard. For further information, please contact the publisher of the respective national standard.

1.1.8 Software Versions

The information in this manual relates to the laser control software LCS version 3.21 and the handheld keypad software CTERM 4.71.

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1.2 Safety

1.2.1 Laser Safety Classification

IEC-60825-1, FDA 21 CFR 1040.10 and 1040.11 and ANSI Z-136.1 indicate the requirements and procedures that are to be followed to ensure the safe use of laser products. These standards and regulations classify each laser product according to the potential hazards arising in its use. In each case, the laser class indicates the accessible emission limit (AEL), i.e. the maximum emission level that humans can access.

The lowest laser class is Class 1 and the highest is Class 4:

– Class 1 laser products are laser products that are safe under reasonably foreseeable conditions of operation.

– Class 4 laser products are laser products that permit human access to emission levels that represent an acute hazard to the eyes and skin from direct and scattered radiation.

Within this classification, the COMPex*Pro*, as a stand-alone laser device, is a Class 4 laser product. It must, consequently, be regarded as a potential hazard to the human operator. The laser beam must also be regarded as a potential fire hazard.

When a Class 4 laser device is integrated in a laser product that has been designed and engineered to prevent human access to laser emission exceeding Class 1 levels during normal operation, the laser product can be classified as a Class 1 laser product. Such a Class 1 laser product must have a protective housing and safety interlocks on all removable housing access panels. Laser operation shall only be possible when all access panels are in place and human access to hazardous levels of laser radiation (including scattered laser radiation) is prevented.

Wherever technically feasible, the product or system into which the laser device is integrated should be designed and engineered as a Class 1 laser product. Nevertheless, the high power laser device incorporated in such a laser product remains a Class 4 laser product. If access panels are removed and safety interlocks defeated (e.g. to perform servicing, adjustment or alignment work), there is the risk of exposure to Class 4 laser radiation.

The laser safety classification of the laser product into which the COMPex*Pro* is integrated is to be indicated by the laser product manufacturer (system integrator). For further information, please refer to the system integrator's documentation.

To assist with the alignment of the beam path, a laser product may be equipped with a Class 2 or Class 3R (IEC 60825-1) pilot or alignment laser. Such lasers are low power products (max. 5 mW for Class 3R) that emit laser radiation in the visible wavelength range from 400 nm to 700 nm, where the risk of eye injury remains low due to the blink reflex.

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1.2.2 Gas Hazard Communication

The EU regulation 1272/2008 provides the criteria for the classification of substances and mixtures, and the rules on labelling for hazardous substances and mixtures. Of the health hazards that are addressed in this regulation, the acute inhalation toxicity of gas mixtures containing halogen gas are of the greatest relevance to operators of excimer lasers. Depending on the type and concentration of the halogen gas, the gas mixture in an excimer laser is classified as being either toxic or harmful according to EU 1272/2008, annex 1, part 3.1 (acute toxicity).

The excimer laser gas mixtures that are typically used with the COMPex*Pro* laser device are classified as follows:

– Gas mixtures with a concentration of less than 1% fluorine or hydrogen chloride are classified as being harmful. This is the typical concentration in the laser tube, premix gas cylinder and premix gas supply line.

– Gas mixtures with a concentration of 4.5% hydrogen chloride are classified as being harmful. This is the typical concentration in the halogen gas cylinder and supply line if a XeCl-version laser is being supplied from separate gas supply lines.

– Gas mixtures with a concentration of 5% fluorine are classified as being toxic. This is the typical concentration in the halogen gas cylinder and supply line if a F-version laser is being supplied from separate gas supply lines.

Whenever there is the risk of exposure to the 5% halogen gas mixture contained in the gas cylinder or supply lines, the safety labeling and warning messages will indicate a toxic substances hazard. This shall be interpreted as a harmful substances hazard when the laser device is being suppled with a premix gas or a gas mixtures with a concentration of 4.5% hydrogen chloride.

1.2.3 Safety Information

Chapter 2 of this manual (SAFETY) describes the physical hazards related to the excimer laser device, the means of protection against these hazards and the safety features incorporated in the design of the laser device. This chapter must be read by all persons entrusted with any sort of work on the laser device.

Never start to follow the procedures detailed in this manual unless you have read and fully understood the information in the Safety Chapter.

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1.2.4 Signal Words and Symbols in this Manual

The COMPex*Pro* documentation may contain sections in which particular hazards are defined or special attention is drawn to particular conditions. These sections are indicated with signal words in accordance with ANSI Z-535.6 and safety symbols (pictorial hazard alerts) in accordance with ANSI Z-535.3 and ISO 7010.

1.2.4.1 Signal Words

Four signal words are used in the COMPex*Pro* documentation: DANGER, WARNING, CAUTION and NOTICE.

The signal words DANGER**,** WARNING and CAUTION designate the degree or level of hazard when there is the risk of injury:

DANGER
Indicates a hazardous situation which, if not avoided, <u>will</u> result in <u>death or serious injury</u>.

WARNING
Indicates a hazardous situation which, if not avoided, <u>could</u> result in <u>death or serious injury</u>.

CAUTION
Indicates a hazardous situation which, if not avoided, could result in <u>minor or moderate injury</u>.

The signal word “NOTICE” is used when there is the risk of property damage:

NOTICE
Addresses practices <u>not</u> related to <u>personal injury</u>.

Messages relating to hazards that could result in both personal injury and property damage are considered safety messages and not property damage messages.

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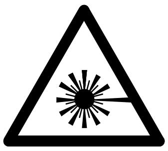
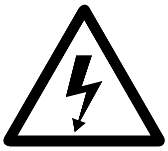
1.2.4.2 Symbols

The signal words **DANGER**, **WARNING**, and **CAUTION** are always emphasized with a safety symbol that indicates a special hazard, regardless of the hazard level:

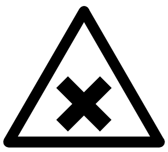


This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by laser radiation.



This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by electricity.

This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by toxic substances.



This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by harmful substances.

This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by flammable substances.

This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by general circumstances.

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1.3 Laser Terminology

ISO 11145 (“Optics and Optical Instruments - Lasers and Laser Related Equipment - Vocabulary and Symbols”) contains a list of laser terminology.

To prevent misunderstandings, the COMPex*Pro* documentation strictly differentiates between “laser” and “laser device” (see Figure 1). Thus “start laser device” means that the power is off and shall be turned on. To “start the laser” means to switch on the laser beam and start laser operation.

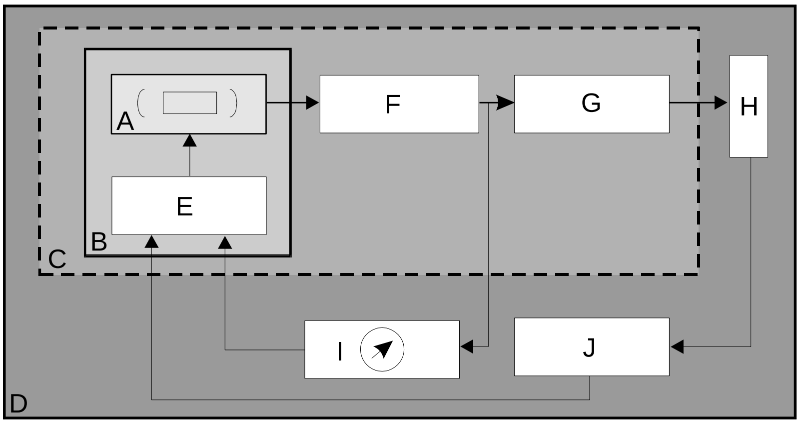

Figure 1: *Laser components according to ISO 11145*

Key and Definitions to Figure 1:

A Laser
Consists of an amplifying medium capable of emitting coherent radiation with wavelengths up to 1 mm by means of stimulated emission.

B Laser Device
A laser (A), where the radiation is generated, together with essential additional facilities (E) that are necessary to operate the laser (e.g. cooling, power and gas supply).

C Laser Assembly
Laser device (B) together with specific, normally optical, mechanical and/or electrical system components for beam handling and forming (F: e.g. mirrors, lenses; G: e.g. telescope, focussing).

D Laser Unit
One ore more laser assemblies (C) together with measurement and control systems (I) and handling systems (J: robotics, workpiece positioning).

H Workpiece

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In addition to the terminology used by ISO 11145, IEC 60825-1 uses the term “laser product”. This term relates to any product or assembly of components which constitutes or is intended to incorporate a laser. In other words, the term “laser product” can be used in conjunction with any of the definitions contained in ISO 11145.

1.4 Units of Measurements

In this manual, units of measurement are used according to the metric system and the international system of units (SI), e.g. meter, millimeter, square meter, cubic meter, liter, kilogram, bar, pascal.

Temperatures are primarily indicated in degrees celsius (°C).

The water hardness is indicated in parts per million (ppm; American Hardness).

1.5 Feedback Regarding Documentation

If you have any comments regarding the documentation provided to you, please contact us.

When you contact us, please provide us with:

– the document code,
– the date of issue,
– the page number, section number and, where applicable, the procedure step number,
– a description of any errors,
– a proposal for improvements.

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2 SAFETY

Never switch on or attempt to operate, maintain or service the COMPex*Pro* laser device before reading, understanding and fully familiarizing yourself with the contents of this chapter.

This chapter is divided into three sections:

– General Safety Aspects (Section 2.1), which explains aspects relating to the safe handling of the laser device.

– Special Safety Aspects (Section 2.2), which outlines the specific hazards when working with and on the laser device and describes the safety measures that minimize these hazards.

– Overview of safety-relevant labels (Section 2.3), which shows the position of and describes the safety labels.

2.1 General Safety Aspects

2.1.1 Safety Compliance

The equipment has been tested and found to comply with the currently applicable standards and recommendations for laser product safety.

All Coherent excimer laser devices are compatible with the international laser safety standard IEC 60825-1.

In addition, the COMPex*Pro* complies with the following standards:

– IEC 61010 (Safety requirements for electrical equipment for measurement, control, and laboratory use)

– EN 61000-6-3 (Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments)

– EN 61000-6-2 (Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments)

– 2006/95/EC (Low Voltage Directive)

– 97/23/EEC (Pressure Equipment Directive)

– 2002/95/EC (Restriction of Hazardous Substances Directive)

– CE conformity

To legally enter the USA, a laser product must have been registered by the FDA (Food and Drug Administration). The accession number for the COMPex*Pro* laser device is 7810443-39.

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2.1.2 Designated Use

The COMPex*Pro* laser device has been built in accordance with state-of-the-art standards and recognized safety rules. Nevertheless, its use may constitute a risk to life and limb of the user or of third parties or cause damage to other material property. The specific hazards resulting from the use of the laser device are described in Section 2.2.

The laser device shall only be used in technically perfect condition and in accordance with its designated use and the instructions set out in this manual, and only by safety conscious persons who are fully aware of the risks involved in operating the laser device. Any functional disorders, especially those affecting the safety of the laser device, should therefore be rectified immediately.

The lifetime of the COMPex*Pro* laser device is limited to ten years.

The COMPex*Pro* laser device is a UV laser light source that is primarily designed for use in medium duty-cycle industrial and high-end scientific applications such as pulsed-laser deposition (PLD), precise material processing and solid sampling for material research. Using the laser device for purposes other than those mentioned above is considered contrary to its designated use. The manufacturer/ supplier cannot be held liable for any damage resulting from such use. The risk of such misuse lies entirely with the user.

Operating the laser device within the limits of its designated use also involves observing the instructions set out in this manual and complying with the inspection and maintenance directives.

Any unauthorized modifications to the laser device principally results in the loss of liability from Coherent concerning all subsequent damage that may occur.

2.1.3 Organizational Requirements

In accordance with the valid national regulations for prevention of accidents (in Germany: BGV B2, in the USA: ANSI Z 136.1) a responsible person should be designated as the Laser Safety Officer (LSO) with the responsibility to effect the knowledgeable evaluation of laser hazards and to monitor and enforce their control.

The specific hazards that are present during the installation, operation, maintenance set-up and servicing of an excimer laser device (see Section 2.2 on page 15) should be addressed by a locally applicable risk management plan in which the respective personal responsibilities are clearly indicated.

The User Manual must always be at hand at the place of use of the laser device.

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In addition to the User Manual, observe and instruct the user in all generally applicable legal and other mandatory regulations relevant to accident prevention and environmental protection. These compulsory regulations may also deal with the handling of hazardous substances, the issuing and/or wearing of personal protective equipment and waste management.

All persons that work on the laser device must have read the User Manual and in particular the safety instructions before beginning work. Reading the instructions after work has begun is too late. The need to read the User Manual also applies to persons that only occasionally work on the laser device, e.g. during setting up, service or maintenance.

Use personal protective equipment (PPE), e.g. protective eyewear, wherever required by the circumstances or by law.

Ensure that all safety-relevant labels are attached to the laser device in accordance with the label location diagrams in Section 2.3. Make sure that these labels are always complete and perfectly legible. If any labels are missing, immediately inform Coherent.

Never make any modifications, additions or conversions which might affect safety without the manufacturer’s approval. This also applies to the installation and adjustment of additional safety equipment.

Never modify the software of programmable control systems.

Spare parts must comply with the technical requirements specified by the manufacturer. Spare parts from original equipment manufacturers can be relied upon to do so.

Adhere to prescribed intervals or those specified in the instruction manual for routine checks and inspections.

For the execution of maintenance work, always use tools and equipment that are suitable for the specific task.

All interlock defeat keys provided with the laser device must be assigned to a responsible person, personalized and locked away. Only specifically trained and authorized persons that are fully aware of the hazards relating to their use shall have access to interlock defeat keys.

2.1.4 Selection and Qualification of Personnel

Make sure that only authorized persons work on or with the laser device. Statutory minimum age limits must be observed.

Employ only trained or specifically instructed staff and set out clearly the individual responsibilities of each person regarding operation, set-up, maintenance and repair.

Do not allow persons that are being trained or instructed to work on or with the laser device unless they are being permanently supervised by an experienced person.

Work on the electrical system and equipment of the laser device shall only be carried out by a skilled electrician or by instructed persons under the supervision and guidance of a skilled electrician and in accordance with electrical engineering rules and regulations.

Work on gas fueled equipment shall only be carried out by specially trained and instructed personnel.

2.1.5 Specific Operational Phases

Take the necessary precautions to ensure that the laser device is only used when in a safe and reliable state.

Before starting the laser device ensure that nobody is at risk.

Only operate the laser device if all protective and safety oriented devices, such as removable safety devices, emergency shut off equipment and exhausters, are in place and fully functional.

To prevent injury or serious material damage in case of emergencies, immediately switch off the laser device with an Emergency Off (EMO) switch. After use of the EMO switch, always contact appropriate safety or maintenance personnel (e.g. laser safety officer) before restarting the laser device.

In the event of malfunctions or changes in the operating behavior, immediately switch off and lock out the laser device’s main switch, and report the event to the competent authority or person (e.g. Coherent Service). Ensure that any defects are rectified immediately.

Never switch off or remove suction and ventilation devices when the laser device is in operation.

Observe the adjustment, maintenance and inspection activities and intervals set out in the instruction manual, including information on the replacement of parts and equipment. These activities shall only be carried out by authorized and correspondingly trained persons.

Brief operating personnel before beginning special operations and maintenance work, and appoint a person to supervise the activities.

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Regardless of the work that is to be performed on or with the laser device (e.g. operation, set-up, adjustment, maintenance, inspection, service and repair), always observe the start up and shut down procedures set out in the instruction manual as well as the information on maintenance activities.

Ensure that the maintenance area is adequately secured before employees perform any servicing or maintenance. The laser device is to be stopped, isolated from all potentially hazardous energy sources and locked out and/or tagged out where the unexpected energization or start-up of the laser device or release of stored energy could cause injury.

Always tighten any screwed connections that have been loosened during maintenance and repair.

Any safety devices removed for set up, maintenance or repair purposes must be refitted and checked immediately upon completion of the maintenance and repair work.

Ensure that all consumables and replacement parts are disposed of safely, with minimum environmental impact and in accordance with the valid national and local regulations for waste disposal. For further information about the disposal of specific components, please contact Coherent.

2.2 Specific Safety Aspects

This section contains the following information:

– Section 2.2.1 describes the hazards inherent to the Class 4 excimer laser device,

– Section 2.2.2 describes Personal Protective Equipment requirements

– Section 2.2.3 describes how operators or users of the laser device are to protect themselves against the inherent hazards,

– Section 2.2.4 summarizes the safety features incorporated in the design of the laser device to provide protection against the inherent hazards.

– Section 2.2.5 describes engineering and organizational measures that are required at the plant to ensure safe laser operation.

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2.2.1 Physical Hazards

This section describes the main hazards that are inherent to the Class 4 excimer laser device. When the hazard is only present during particular operational phases, this will be indicated in the respective description.

2.2.1.1 Laser Radiation

The COMPex*Pro* as a stand-alone laser device is classified as a Class 4 laser product. Class 4 is the most powerful (and potentially hazardous) category of laser products (see Section 1.2.1 on page 5).

In most cases, the radiation of an excimer laser is within the ultra-violet spectrum and, consequently, invisible.

Laser radiation is emitted as a narrow beam of almost parallel rays, the intensity of which will remain high even at some distance of the laser.

Although excimer laser radiation is nonionizing, damage can still occur to living tissue, if exposed for too long, as a result of heat produced during radiation absorption.

Direct and scattered radiation from a Class 4 laser is to be considered as an acute hazard to the eyes and skin. In general, the maximum permissible radiation exposure for the skin is several times greater than for the eye. Safety measures with regard to the radiation hazard are, therefore, mainly based on dangers for the eye. Nevertheless, chronic skin exposure may have long-term adverse health effects which are not fully understood at the time.

A potential chemical hazard originates from interaction between the laser beam and an obstruction. The high irradiance could result in the liberation of hazardous fumes, gases, dusts and aerosols. In addition, the heat generated is sufficient to ignite many materials.

Not only is the direct laser beam hazardous, but uncontrolled reflections of laser light also constitute a potential hazard. This risk is excluded when the laser beam is contained within a protective enclosure. However, when personnel are working in an open beam situation (e.g. during maintenance or service actions), protective measures must be taken.

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2.2.1.2 Fire

The high output power Class 4 laser device is a potential source of ignition for a wide range of materials. The intense beam of the laser can directly ignite combustible materials (e.g. paper, wood, cloth) or vapors from many fluids and solvents (e.g. cleaning agents used for maintenance).

Never use the laser device in potentially explosive atmospheres as it contains components that do not conform to the ATEX 95 equipment directive (European Union directive 94/9/EC).

In case of fire in the area of the laser device, fire fighters have to take into account the secondary hazard of halogen gases described in Section 2.2.1.4.

2.2.1.3 High Voltage / Electric Energy

High voltages within the laser device that exceed the Safety Extra Low Voltage levels (SELV) of 42 VAC or 60 VDC introduce the potential hazard of electric shock and might cause serious injury by passing electricity through the body.

The equipment is provided with a protective housing. Therefore, accidental contact with current-carrying conductors during normal operation is impossible. However, if an appropriate protective cover is removed, potentially lethal hazards exist when the housing interlocks are defeated. There is also the risk of contact with residual voltages during servicing when the protective cover is removed.

2.2.1.4 Halogen Gas

The gas system of an excimer laser is supplied with a halogen gas mixture that contains fluorine or hydrogen chloride (depending on the wavelength of the laser, see Section 4.6.2 on page 97 for exact specifications). This is further diluted with other gases in the laser. However, halogen gas is still present in sufficient quantities in the gas supply to cause serious injury in case of leaks or if not correctly handled and used. For further information about the classification of the gas mixture in the laser device, please refer to Section 1.2.2 on page 6.

Fluorine and hydrogen chloride are characterized by an extremely stinging smell in very low concentrations. They are extremely reactive and highly toxic gases which can cause severe chemical and thermal burns and, in sufficient concentrations, can cause death due to respiratory damage and pulmonary edema.

The workplace concentration of halogen gas shall, therefore, never exceed the maximum permissible exposure limit. This limit is defined by the administration responsible for occupational safety and health at the installation site. For example, in the United States, this limit is the general industry permissible exposure limit (PEL) set by the U.S. Department of Labor Occupational Safety and Health Administration (OSHA).

Please refer to documents such as the gas supplier's Material Safety Data Sheet (MSDS) or the International Chemical Safety Card (ICSC) for the respective halogen gas (available from the International Labour Organization, ILO) for more precise health hazard information. Make sure that applicable legal limits for personal exposure to halogen gas are never exceeded. Consult the locally responsible occupational safety and health administration for further information.

The possibility of over-pressure of the gas mixture containing halogen creates potential hazards with the risk of leakage from the laser tube and gas pipes. In the event of a leak occurring, the release of halogen gas constitutes the greatest hazard.

The worst-case accidental release scenario is the sudden release of the complete contents of the halogen gas cylinder (the exact halogen concentration is indicated in Section 4.6.2 on page 97). The risk of exposure to a leaking halogen gas mixture in the area of the laser device increases when the housing covers are removed and/or the exhaust is disabled.

Further potential chemical hazards exist due to the formation of hydrofluoric acid or hydrochloric acid if the halogen gas comes into contact with water. Make sure that fire fighters are aware of this additional hazard when fighting fires involving halogen gases.

Hydrofluoric acid (in the form of KHF_2) or hydrochloric acid can also be formed in the halogen filter used in the system due to the appropriate halogen gas coming into contact with the hygroscopic components of the filter.

2.2.1.5 Ozone

The formation of ozone due to the interaction of the ultra-violet light with oxygen constitutes a potential hazard when operating the laser at wavelengths shorter than approx. 240 nm (i.e. 193 nm). Ozone is reported to have a pleasant, clover-like odor. Exposure to ozone can cause irritation to the eyes and respiratory tract, asthmatic reactions, impaired vigilance and performance and can even result in pulmonary edema.

The workplace concentration of ozone shall, therefore, never exceed the maximum permissible exposure limit defined by the administration responsible for occupational safety and health at the installation site. For example, in the United States, this limit is the general industry permissible exposure limit (PEL) set by the U.S. Department of Labor Occupational Safety and Health Administration (OSHA).

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Please refer to the International Chemical Safety Card (ICSC) for Ozone (available from the International Labour Organization, ILO) for more precise health hazard information. Make sure that applicable legal limits for personal exposure to ozone are never exceeded. Consult the locally responsible occupational safety and health administration for further information.

2.2.1.6 Asphyxiant Gases

Apart from the halogen gas described in Section 2.2.1.4, the excimer laser gas consists of a mixture of simple asphyxiant gases. A large proportion of neon and small proportion of helium is mixed with either argon, krypton or xenon (depending on the wavelength of the laser, see Section 4.6.2 on page 97 for exact specifications). In addition, the laser tube is filled with helium during certain maintenance actions and neon for transport. Nitrogen is used to purge the beam path.

The asphyxiant gases that are used with the excimer laser device are non-toxic gases that reduce or displace the normal oxygen concentration in breathing air. Breathing of oxygen-depleted air can cause unconsciousness or death by asphyxiation (suffocation). As asphyxiant gases are relatively inert, colorless and odorless, persons may not realize that they are in danger until it is too late.

The risk of exposure to the asphyxiant gas hazard is at its highest in case of a leakage or escape of gas in a confined space. This scenario will rapidly decrease the concentration of oxygen in the air.

Nitrogen represents a particular hazard as it produces an oxygen-deficient environment close to the ground. Consequently if a person becomes unconscious and falls to the ground their condition will rapidly worsen.

Please refer to documents such as the gas supplier’s Material Safety Data Sheet (MSDS) or the International Chemical Safety Card (ICSC) for the respective asphyxiant gas (available from the International Labour Organization, ILO) for more precise health hazard information. Ensure that there is adequate ventilation in the area of the laser device.

2.2.1.7 Over-Pressure

According to the definition contained in the European directive for pressure equipment (2014/68/EU), the laser tube in the COMPex*Pro* laser device is a pressure vessel. The laser tube is supplied with the required operating gases from an external gas supply system that also operates with over-pressure. Internal pressure monitoring devices prevent malfunctions during normal operation. In case of emergencies, a rupture disk prevents bursting of the pressure vessel. Nevertheless, the potential hazard of a sudden release of pressure exists during maintenance and servicing operations as well as when installing or de-installing the laser device.

To ensure conformity with 2014/68/EU, the gas mixture in the laser tube has to be classified as being within the limits for fluids in Group 2. This means that the halogen concentration of the gas mixture in the laser tube shall be such that it remains within the threshold where the gas can be classified as being harmful (see Section 1.2.2 on page 6). In cases where a gas mixture that is classified as toxic is connected to the laser device, the laser device manufacturer shall provide safety accessories that protect the pressure equipment against the allowable limits being exceeded.

Also take into account that the operating gases are commonly shipped and stored in compressed gas cylinders. These can be extremely hazardous if misused. In addition to the chemical hazard of the cylinder contents (for example, halogen gas), there is also the hazard associated with the high pressure inside the cylinder. For further information, please refer to gas supplier’s Material Safety Data Sheet (MSDS).

2.2.1.8 Tipping, Crushing and Pinching

The weight of the laser device and its submodules creates a crushing hazard during transport, installation and servicing. When exchanging heavy modules, such as the laser tube, there is an increased risk of the laser device tipping.

The risk of the laser device tipping or crushing will be significantly increased by a seismic event. Consequently, particular protective measures are required when the laser device is to be operated in an area that is susceptible to seismic activity.

A pinching hazard exists when closing the access covers or during module exchange procedures.

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2.2.1.9 Noise

Under normal operating conditions with the laser device housing closed, noise levels remain below 80 dBA.

When operating the laser device with the housing open (to perform certain servicing work), the noise exposure exceeds 80 dB(A) and, under certain circumstances, can exceed 85 dB(A).

Noise exposures that are loud enough and last long enough can cause noise-induced hearing loss (NIHL). NIHL is a permanent and irreversible condition resulting in a loss of hearing ability.

An eight hour time-weighted average exposure to sound levels that equal or exceed 85 dB(A) is considered as critical. Further information about permissible noise exposures and necessary preventive measures is contained in directives, regulations and standards such as the EU Directive 2003/10/EC, OSHA 1910.95, EN 61010-1 and SEMI S2.

2.2.1.10 Electromagnetic Interference

The electrical circuits within the laser device are an inherent source of electromagnetic interference (EMI). Filters within the laser device as well as an EMI shielded housing provide electromagnetic compatibility according to EN 61000-6-4 during normal operation with all housing covers closed. Nevertheless, we cannot ensure that the inherent levels of EMI will not disturb artificial pacemakers in the immediate vicinity of the laser device.

If the laser is operated with the housing covers removed, EMI is no longer contained within the housing. This can indirectly cause injury through the malfunctioning of devices in the area of the laser device. Should operation of the open laser device be necessary (e.g. for maintenance or servicing), always correspondingly inform and obtain permission from the plant management.

2.2.2 Personal Protective Equipment

This section outlines personal protective equipment (PPE) that may be required during specific operational phases of a Class 4 excimer laser device or in case of an emergency. This includes the items listed below:

– Protective eyewear (see Section 2.2.2.1 on page 22)

– Skin protection (see Section 2.2.2.2 on page 23)

– Protective gloves (see Section 2.2.2.2 on page 23)

– Dust mask (see Section 2.2.2.3 on page 23)

– Hearing protection (see Section 2.2.2.4 on page 24)

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The indicated subsections provide information on the basis of the hazards inherent to Class 4 excimer laser devices and commonly applied risk management procedures. Exact PPE requirements depend on local regulations and the conditions under which the laser device is operated, maintained and serviced.

All persons that are required to use PPE should be instructed in the correct use of the equipment. Any necessary maintenance work and maintenance intervals must be observed to ensure that the equipment remains in a ready-to-use condition at all times. For further information, please refer to the equipment suppliers' instructions.

2.2.2.1 Protective Eyewear

Laser Radiation

If work on open Class 4 laser equipment is necessary (e.g. alignment or servicing), everyone in the area of the laser shall be ordered to wear appropriate protective eyewear. The mandatory protective eyewear provides protection against direct radiation, reflected radiation and scattered radiation within the respective wavelength range.

Contact a manufacturer of protective eyewear for information about appropriate eyewear. Specifications needed to select the appropriate protective eyewear are:

– laser wavelength,
– laser power,
– beam size,
– repetition rate
– max. pulse duration.

IEC 60825-1 stipulates that eye protection designed to provide adequate protection against the specific wavelength of the laser should be used in all hazard areas where Class 4 lasers are in use. The laser protective eyewear shall be clearly labeled (e.g. with the optical density and wavelength) to ensure the proper choice of eyewear with a particular laser. To avoid confusion, keep laser protective eyewear separate from other safety glasses and other personal protective equipment. ANSI Z136-1 suggests color coding or some other form of distinctive identification of laser protective eyewear for situations when rapid eyewear identification is required.

The filter in the protective eyewear only provides protection for a narrow band of wavelengths. Therefore, always make sure that you are wearing the appropriate eyewear. Using the wrong type of eyewear is dangerous. It can be worse to have improper eyewear and a false sense of security than to have no eyewear and take precautions based on the absence of protection.

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Halogen Gases

Gas suppliers also usually specify that suitable safety glasses should be worn when handling equipment containing halogen gases. Such safety glasses are to be made of chemical resistant materials that are suitable for impact or particle hazards. For further information consult the halogen gas supplier’s Material Safety Data Sheet (MSDS).

2.2.2.2 Skin Protection / Protective Clothing

Laser Radiation

Although the skin can withstand a considerably higher radiation intensity than the eyes, tissue may be burned to a greater or lesser degree, depending on the radiation time and the irradiation intensity.

ANSI Z136-1 stipulates that when using excimer lasers operating in the ultraviolet range, the use of skin cover shall be employed if chronic (repeated) exposures are anticipated at exposure levels at or near the applicable maximum permissible exposure limit for the skin.

If there is the risk of harmful skin exposure, cover the skin e.g. by wearing suitable protective clothing and/or use “sun screen” creams. Most gloves will provide some protection against laser radiation. Tightly woven fabrics and opaque gloves provide the best protection. A laboratory jacket or coat can provide protection for the arms.

When choosing protective clothing, take into account that Class 4 lasers present a potential fire hazard. Protective clothing should, therefore, be made from materials that will not be ignited by the laser radiation.

Halogen Gases

Protective gloves are also required when exchanging the halogen filter or working on or with other equipment containing halogen gas. The type of gloves to be worn depends on the exact work to be performed and the gas mixture being used. Consult the appropriate Material Safety Data Sheet (MSDS) for more information. This MSDS will also specify any other protective clothing (e.g. chemical resistant aprons or suits) that should be worn when handling equipment containing halogen gas mixtures.

2.2.2.3 Dust Mask

The halogen filter in the laser device’s vacuum line contains impregnated activated carbon. When the halogen filter is used or handled correctly, there is no risk of hazardous dust being released. In the unlikely event of dusts being released, a dust mask with a suitable filter should be worn.

For further information, consult the institute responsible for occupational safety and health at the installation location (for example, NIOSH, National Institute for Occupational Safety and Health, in the USA).

2.2.2.4 Hearing Protection

Individual hearing protectors (e.g. ear defenders) should be worn when performing servicing work that requires operation of the laser device with an open housing. Make sure that individual hearing protectors are available for all persons that are working in the area of the open laser device. The type of hearing protection to be chosen depends on the operating environment and local regulations.

Depending on the overall noise level in the area of the laser device, further protective measures may be necessary. For further information consult the applicable occupational noise exposure regulations and directives.

2.2.3 Safe Working Practices

This section describes how operators or users of the excimer laser device are to protect themselves against the inherent hazards. It contains behavior guidelines that minimize the risks relating to the physical hazards described in Section 2.2.1.

2.2.3.1 Laser Radiation Safety Precautions

Particular attention is to be given to the following precautions when working on or with an open Class 4 laser (e.g. during set-up and servicing activities):

- Only qualified personnel shall be permitted to operate the laser.
- Report all incidents of exposure to laser radiation to your supervisor.
- Always wear appropriate laser protective eyewear and protect the skin against the effects of ultraviolet laser radiation.
- Even when wearing protective eyewear, never look directly into the beam; the intense laser radiation may destroy the protective filter.
- Avoid indirect viewing of direct or reflected laser radiation. Specular reflections (from reflective surfaces) can be as dangerous as the direct laser beam.
- Do not view the beam through optical instruments unless the optics are designed to filter the laser wavelength.

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- Avoid contact between the skin and the beam or specular reflections of the beam. Reflections of the beam may be as dangerous as the beam itself.
- Ensure that there are no objects in the beam path that may cause uncontrolled reflection or scattering of the laser beam.
- Ensure that all personnel in the area observe proper safety precautions.
- Use lasers only in approved applications and locations. Take adequate precautions to prevent unauthorized personnel from entering the area where a Class 4 laser is operating.
- Ensure that the all laser radiation warning devices (e.g. lamps) that are connected to the laser device are correctly working.
- Do not use lasers around untrained personnel who may injure themselves inadvertently.
- Do not assume that the laser system is aligned. Misaligned optics can cause unintended exposure.
- Ensure that all measures to secure the working area of an open laser remain implemented even when the laser has been switched to the off mode.
- Local and national regulations governing the safe use of lasers should be adhered to all times.

2.2.3.2 Fire Prevention

Observe the following instructions and precautions to minimize the fire hazard in the working area of the laser device:

- Always keep a fire extinguisher or provide an equivalent fire fighting system in the area of the laser device in case a fire occurs (see Section 2.2.5.4 on page 40).
- Flammable items must be isolated from the laser beam and from the laser system.
- There should be no paper (circuit diagrams, leaflets or even posters on the wall), curtains (unless coated with fire retardant), wooden panels or similar materials in the area of the open laser. These items can be easily set on fire by direct or reflected laser radiation.
- Never operate the laser device in a potentially explosive atmosphere.
- Take into account that many fluids and solvents (e.g. cleaning agents used for maintenance) are combustible. Vapors from these materials can be ignited by the intense beam of the laser. Prevent the laser beam from coming into contact with flammable materials used in the laser area.

- Move containers of flammable materials out of the area of the laser system and shield them from the beam with opaque materials. Under no circumstances should these solutions and vapors be placed in the beam path or near the laser system.
- Only use beam stops made of non flammable materials (not asbestos!).

2.2.3.3 Electrical Safety Precautions

High voltages greater than mains voltage are generated within the laser device. Always act in accordance with the following precautions to prevent electric shocks when working on or with the laser device:

- Work on the electrical system or equipment shall only be carried out by a skilled electrician himself or by specially instructed personnel under the control and supervision of such an electrician and in accordance with the applicable electrical engineering rules.
- Local safety regulations must always be strictly complied with.
- Make sure that the laser device is always properly grounded.
- Connect the laser device to the overall system's Emergency Off (EMO) circuit in such a way that the mains power to the laser device will be disconnected when the overall system's EMO function is activated.
- Fault finding and troubleshooting in high voltage circuits shall only be performed by trained personnel.
- Never open any electrical module or disconnect any high voltage cables (e.g. cables connected to the HV power supply and gas purifier) unless the mains power cord has been disconnected and the high voltage capacitors are completely discharged.
- Take into account that capacitors may remain energized for at least ten minutes after disconnecting the mains power.
- If the laser device is completely shut down for maintenance and repair work, it must be secured against inadvertent starting. Ensure that the electrical system is locked-out and tagged-out prior to servicing by locking the key switch of the laser device and tagging appropriate warning signs. Secure the complete working area with a safety chain and a warning sign in accordance with locally applicable safety regulations.
- Before starting any work, check the de-energized parts for the presence of power and ground or short circuit them in addition to insulating adjacent live parts and elements.
- Cut off the mains power to parts of the laser device on which inspection, maintenance and repair work is to be carried out.
- If work on or near any live conductor is necessary this shall only ever be carried out in the presence of a second person who can cut off the mains power in case of danger. Use insulated tools only.

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- Only use original fuses with the specified current rating.
- Inspect and check the electrical equipment of the laser device at regular intervals. Defects such as loose connections or scorched cables must be rectified immediately. This is particularly important in the case of high voltage cables.
- Prevent the ingression of fluids or dust into the laser device. Note the IP rating indicated in Section 4.7.2 on page 115. Never soak the laser device or use spray bottles for cleaning.

2.2.3.4 Gas and Chemical Safety Precautions

The final user is responsible for providing an external gas installation that fulfils local gas safety regulations and the requirements of the locally applicable risk management plan.

The properties of compressed gases, such as pressure and diffusibility, make their handling hazardous. Laser gas mixtures invariably contain components which are corrosive, toxic and oxidizing. Therefore, extreme care must be taken when handling these mixtures.

As a general guide to safe working practices, observe the following precautions when working with gas equipment. Always follow these guidelines and take additional precautions as instructed.

- All persons that work on or with the laser device shall be familiar with the locally applicable risk management plan respecting the handling and accidental release of halogen gas mixtures.
- Whenever stipulated by local requirements, always install an appropriate halogen monitoring and leak alarm system in the area of the laser device and gas supply system. For further information, contact the gas supplier and locally responsible health and safety administration.
- Fluorine and hydrogen chloride have a pungent, irritating odor. When this smell is sensed or a halogen leak is suspected, always follow the locally applicable evacuation and containment plan.
- Ensure that there is no indication of a halogen gas leak inside the laser device before removing the housing covers and/or interrupting the exhaust flow. A possible indication of a leak is when the laser tube pressure is outside of the permitted range. Whenever a leak is suspected, always purge the gas lines and laser tube before opening the housing.
- Personnel should work in pairs and within sight and sound of each other, although not necessarily in the same working area. Only trained and competent personnel should be permitted to handle gas cylinders and pressure regulators.
- Always strictly observe local safety regulations concerning the emission of chemical vapors as well as the recommendations made in this chapter and throughout this manual.

- Any equipment that has contained halogen should be thoroughly purged with helium or argon and evacuated prior to opening.
- The necessary over-pressure of the gas mixture containing halogens increases the risk of a release of halogen gas due to a leak from the laser tube and/or gas pipes. The most vulnerable parts are the laser tube optics. Consequently, the equipment must be used in such a way that the beam exit is not directed at personnel.
- Avoid repeated bending and excessive vibration of gas piping and equipment.
- All areas containing pressurized halogen gas mixtures should be inspected for leaks periodically. In the event of a leak occurring, the release of halogen gas constitutes the greatest hazard.
- All leaks should be repaired immediately, but not while the system contains a halogen gas mixture.
- Adequate laser device ventilation is essential. Ensure that all ventilators in the area of the laser device are correctly operating.
- Gas cylinder valves should be closed except while filling the laser, or when running the laser in the constant energy mode (EGY Const.).
- Always wear protective gloves and glasses when changing halogen filters as they are hygroscopic and contain oxidizing agents.
- In the event of impregnated activated carbon dust being released from the halogen filter always wear a dust mask with an appropriate filter.
- A needle valve or cut-off valve should be installed in the halogen gas line. The additional valve is to be located near the gas cylinder to protect the gas line and pressure regulator against corrosion and provide additional gas protection. Do not solely rely on the main gas cylinder valve to provide adequate protection.
- The pressure regulator, situated between the external gas cylinder and the laser device, should be checked regularly.7
- Ozone is formed when operating the laser at wavelengths shorter than approx. 240 nm (i.e. 193 nm). This should be removed with a proper air exhaust or by flushing the beam path with Nitrogen or Argon. In addition, ensure that the shielding of the external beam path will not allow ozone to escape into the adjacent working area.
- Interaction between the high irradiance of the laser beam and materials in the beam path could result in the liberation of hazardous fumes, gases, dusts and aerosols. When performing the risk analysis for the laser machining process, determine if such hazardous by-products are produced and provide a suitable means of safe extraction from the working area.

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2.2.3.5 Pressure Equipment Safety

Observe the following pressure equipment safety precautions:

- The laser shall only be operated with the housing closed.
- In accordance with the European Pressure Equipment Directive, Coherent recommends that the laser tube is checked by a specialist every five years. Call Coherent Service for further information.
- Never unscrew any component or cover attached to the laser tube or gas system before ensuring that the laser tube and/or gas system is adequately depressurized.

2.2.4 Constructional Safety Features

This section summarizes the safety features incorporated in the design of the COMPex*Pro* laser device to provide protection against the inherent hazards. These safety features are to be taken into account by the system integrator when planning the overall system.

The section first describes safety features that provide protection against multiple hazards and then summarizes the features that are provided to minimize the risks relating to the specific hazards described in Section 2.2.1.

When, respecting any of the features described in this section, the system integrator or operator has to take further action to minimize a remaining risk, this will be clearly indicated in the corresponding section.

2.2.4.1 Fully-Interlocked Protective Housing

In accordance with IEC 60825-1, the COMPex*Pro* is equipped with a fully-interlocked protective housing. This prevents access to laser radiation exceeding Class 1 levels[a], protects against accidental contact with high voltages or current-carrying conductors, ensures electromagnetic compatibility and minimizes the risk of exposure to halogen gas.

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a. Providing that the additional engineering measures described in Section 2.2.5 on page 39 are correctly implemented and maintained.

All service panels are equipped with interlocks (see Figure 2) which will immediately shut off the high voltage and, consequently, the laser beam as well as shut-off the internal halogen gas supply if the corresponding panel is removed during operation. Additionally, the use of tools is required to remove each of the service panels.

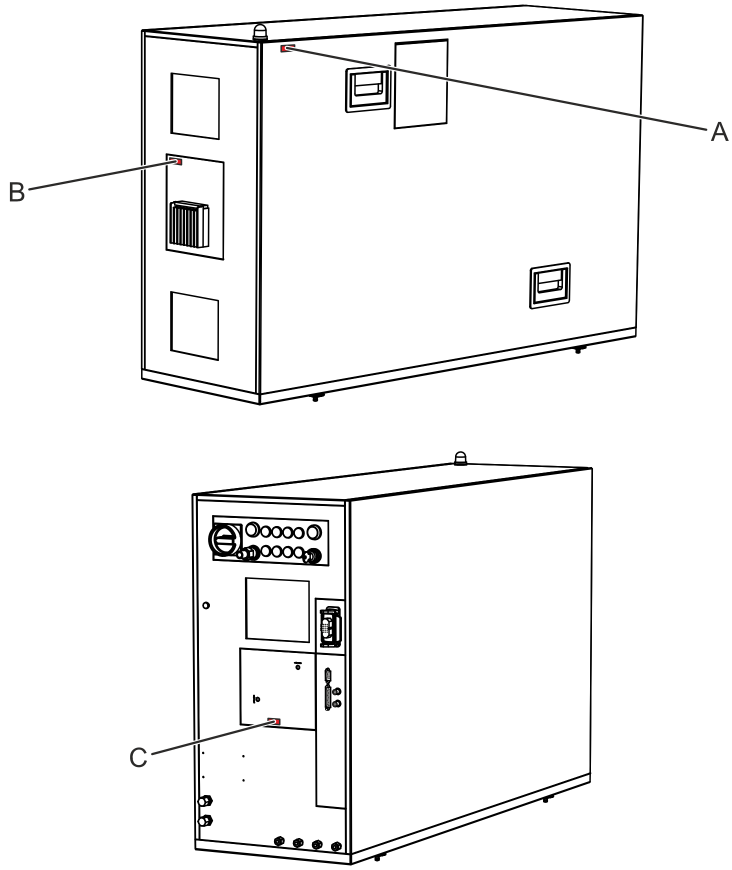

Figure 2: *Location of cover interlocks*

Key to Figure 2:

A	Service panel interlock
B	Front mirror access panel interlock
C	Rear mirror access panel interlock

No service panels need to be removed to operate or routinely maintain the laser device when laser radiation is being emitted.

When, in exceptional circumstances, servicing work on an open laser device is unavoidable, dedicated and correspondingly marked interlock defeat keys are provided to override the housing interlocks. These keys shall only be made available to trained and authorized persons that are fully aware of the hazards relating to their use. They are to be locked away to prevent unauthorized use. It is mechanically impossible to refit a service panel when the corresponding interlock defeat key is inserted.

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2.2.4.2 Remote Interlock Connector

The “Remote” connector on the connection side of the laser device (see Figure 3, A) enables the laser device’s Emergency Stop (EMS) circuit to be linked to an external safety circuit.

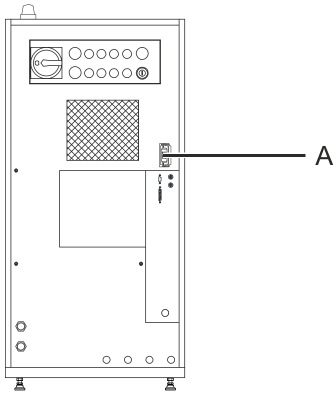

Figure 3: *Remote connection*

The HV power supply and, consequently, emission of laser radiation as well as the opening of the halogen valve is only enabled when one pair of contacts is open and another pair of contacts is closed (level d according to ISO 13849-1). If the status of either or both of the contacts is changed during laser operation (i.e. a remote interlock is activated), the HV power supply will be immediately shut down, thereby stopping laser emission, and the halogen valve will close. For further information about the laser device’s emergency shutdown function, please refer to Section 2.2.4.6 on page 33.

Contacts for the connection of an external laser radiation warning lamp and the input of an alarm signal are also provided in the “Remote” connector.

For further information about the Remote connector, please refer to Section 4.7 on page 115.

2.2.4.3 Key Control and Lockout Facility

The laser device can only be switched on with the key-switch (see Figure 4, A). This prevents inadvertent or unauthorized starting of the laser. It cannot be operated with the key in the OFF position and the key cannot be removed in the ON position.

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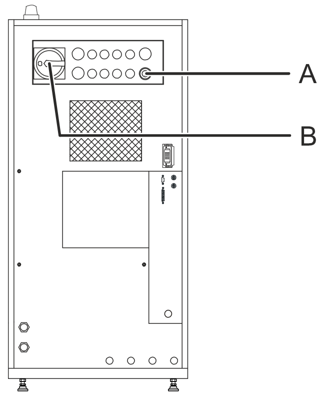

Figure 4: *Key switch and main switch*

The main switch (B) is designed to enable the insertion of a lockout device that corresponds with OSHA 29 CFR 1910.147 when the switch is set to OFF. This ensures that the laser device can be locked out to perform servicing or maintenance.

2.2.4.4 Warning Lights

The laser device is equipped with the following warning lights:

– White laser radiation warning light (see Figure 5, A) illuminates when laser radiation is being emitted or can be emitted. The light will, consequently, continue to light for five seconds after emission has stopped.

– Green mains voltage warning light (B) illuminates when mains voltage is applied to the laser device.

– White control voltage warning light (C) illuminates when the control voltage (24 V) is switched on.

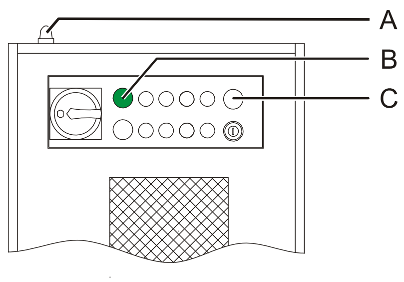

Figure 5: *Warning lights*

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The handheld keypad is equipped with a laser radiation warning LED (see Figure 6, A) that lights whenever the radiation warning light on the laser head is illuminated.

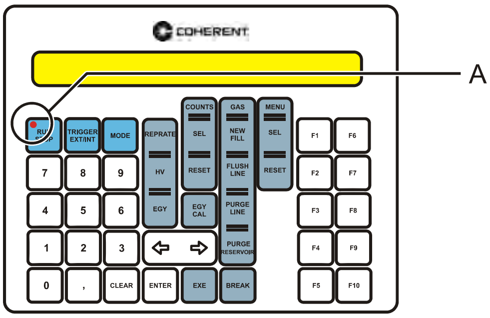

Figure 6: *Laser radiation LED on handheld keypad*

2.2.4.5 Over-Temperature Switch

The laser tube is fitted with a hardware over-temperature switch. If the temperature of the laser tube exceeds a predetermined limit, the HV power supply will be immediately shut down, thereby stopping laser emission, and the halogen valve will close.

2.2.4.6 Emergency Shutdown Function

An *Emergency Stop* circuit (see Figure 7) is provided in the form of cover interlocks (see Section 2.2.4.1), the remote interlock connector (see Section 2.2.4.2) and hardware switches (see Section 2.2.4.5) that are linked to the safety control module. If the Emergency Stop circuit is interrupted, the safety control module is set to off. This switches off the HV power supply, thereby inhibiting laser emission, and closes the halogen gas valve. After removing the cause of the interruption, e.g. by resetting the external contact (e.g. door switch) or re-installing the housing cover, the laser device can be manually restarted.

An *Emergency Off (EMO)* function is provided through the main switch (see Section 6.5 on page 164). When integrated into a laser system, the COMPex*Pro* should be connected to the overall system's EMO circuit in such a way that the mains power to the laser device will be disconnected when the overall system's EMO function is activated. This measure assumes that the COMPex*Pro* laser device receives its mains power from the overall system.

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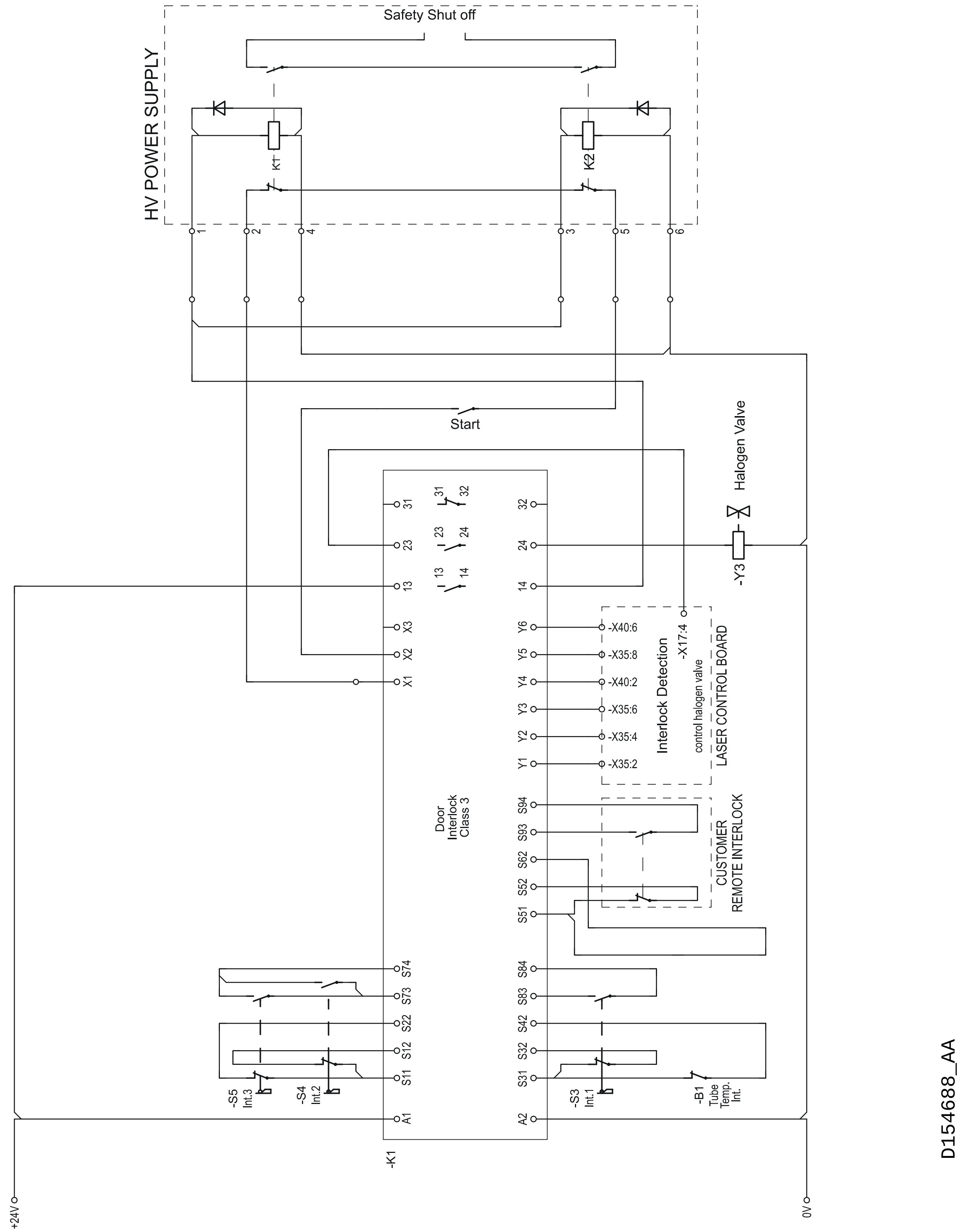

Figure 7: *Emergency Stop circuit*

2.2.4.7 Summary of Laser Radiation Safety Features

In accordance with IEC 60825-1, the COMPex*Pro* is equipped with a number of safety features that minimize the risk of human access to hazardous levels of laser radiation.

- Fully-interlocked protective housing (see Section 2.2.4.1).
- Remote interlock connector (see Section 2.2.4.2).
- Key controlled laser device operation (see Section 2.2.4.3).
- Laser radiation warning lights (see Section 2.2.4.4) that illuminate when the laser can emit radiation. Additionally, emission of radiation can be recognized by an inherent clicking noise, the frequency of which increases as the repetition rate increases.
- Emergency Stop circuit that immediately stops the emission of laser radiation in an emergency (see Section 2.2.4.6).
- Manually operated beam shutter (see Figure 8, A) enables the beam exit from the laser housing to be closed.

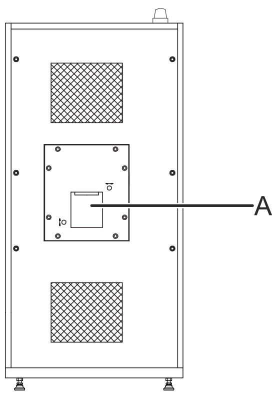

Figure 8: *Beam shutter*

- A hand-held keypad that is supplied as standard with the laser device can be connected to a dedicated serial interface port. This enables the laser to be operated without exposure to Class 4 laser radiation. A laser radiation warning LED on the handheld keypad lights whenever the laser can emit radiation.
- Laser radiation warning labels according to IEC 60825-1 are affixed to the housing and covers of the laser device (see Section 2.3.1 on page 43).
- The laser device has been designed to enable resonator alignment without exposure to excimer laser radiation.

2.2.4.8 Summary of Electrical Safety Features

The following safety features protect the user from the potentially lethal hazards associated with high voltage power sources:

- Fully-interlocked protective housing (see Section 2.2.4.1).
- Remote interlock connector (see Section 2.2.4.2).
- Emergency Stop circuit that immediately shuts down the HV power supply in an emergency (see Section 2.2.4.6).
- Main switch with fast acting magnetic circuit breakers, a lockable disconnect means and an Emergency Off function (see Section 2.2.4.3).
- Key controlled laser device operation (see Section 2.2.4.3).
- Mains voltage warning light (see Section 2.2.4.4).
- Fully protected or grounded enclosures within the laser device prevent inadvertent contact with potentially lethal voltages.
- High voltage warning labels are prominently displayed on all high voltage modules inside the laser device.
- For servicing the capacitors can be discharged through a shortcut plate to ground.
- Multinorm (e.g HAR, UL and CSA) recognized AC power wiring rated at 600 V. Black or brown is used for line phases, blue or white is used for neutral and green or yellow-green is used for ground (depending on the mains power version).
- A yellow-green grounding conductor is included in every AC power module. All power connectors have grounding pins that make first and break last.
- All ground conductors are equipped with a ring lug and external tooth lock washer.
- Fuses are used to provide branch circuit protection against low level faults.
- AC power and signal lines are never combined in the same connector and are always separated by double insulation.
- All external low voltage (24 V) lines conform to the VDE 0551 safety standard.

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2.2.4.9 Summary of Gas Handling / Over-Pressure Safety Features

The excimer laser device has the following gas handling and over-pressure safety features:

- Fully-interlocked protective housing (see Section 2.2.4.1).
- Remote interlock connector (see Section 2.2.4.2) with additional contacts that enable the input of an external gas warning signal.
- Emergency Stop circuit that immediately closes the halogen valve in an emergency to prevent halogen gas from entering the laser device (see Section 2.2.4.6).
- The pressure vessel is designed in accordance with the European “Pressure Equipment Directive” (97/23/EEC).
  Every pressure vessel is tested according to the European “Pressure Equipment Directive” (97/23/EEC).
- If the pressure in the laser tube rises above the maximum permitted pressure, a built-in rupture disk releases the over-pressure via the halogen filter into the exhaust.
- A halogen filter fully absorbs all of the halogen exhausted during the gas exchange procedures. No toxic or harmful gases will leave the laser device. The halogen filter filling ratio is monitored by the laser control software which indicates when the filter requires replacement.
- Gas valves are electrically operated, normally closed.
- Whenever required due to the configuration of the laser device, hardware and software safety features prevent the halogen concentration in the laser tube from exceeding the upper limit for harmful gases (see Section 1.2.2 on page 6):
  - A laser tube pressure sensor and a gas manifold pressure sensor provide separate readings whenever gas is filled into the laser tube. If the deviation between the two sensor readings is too high, the gas action will be interrupted with an interlock.
  - A hardware time-delay relay that operates independently of the laser control software ensures that the halogen gas valve will automatically close after a pre-determined time period.
  - The laser control software continually monitors the halogen concentration in the laser tube and prevents additional halogen from being filled if the halogen concentration limit is exceeded.
- The gas manifold pressure sensor also detects excess or insufficient pressures in the external gas supply lines.
- A powerful ventilation system causes continuous underpressure in the tube chamber during laser operation. This prevents toxic or harmful gas from escaping into the ambient air in case of a leak.

  Nevertheless, to remain below the general industry permissible exposure limit for halogen gas even in a worst-case situation, the laser device has to be connected to a suitable air extraction system

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(see Section 2.2.5.5 on page 40). Never operate the laser unless it is correctly connected to the air extraction system.

The exhaust enclosure is designed to ensure ventilation of all components.

- A halogen protection cover is provided as an accessory with the laser device. This is fitted to the halogen or premix gas connection to ensure that no halogen gas can escape in case of a leak at the gas connection.

2.2.4.10 Summary of Fire Prevention Features

The fire safety features designed into the laser device eliminate the use of materials which are combustible or produce toxic vapors as well as preventing flames from spreading or burning materials from dripping. The design incorporates the following specific fire safety features:

- No easily inflammable materials touch potential sources of ignition or hot surfaces.
- Except for electrical wire insulation polyvinyl chloride (PVC) is not used.
- No ventilation holes in fire break enclosures are in excess of 5 mm (0.20") in diameter. Hole arrays are used as required.
- Only material rated UL 94-V1 or better is used.

2.2.4.11 Summary of Mechanical Safety Features

Mechanical safety design provides protection against any hazards which could cause physical injury or burns. Specific mechanical safety features are listed below.

- Exposed corners are radiused.
- Air fans have grill guards with openings less than 6.4 mm (0.25 in).
- The laser center of gravity is centrally located within the enclosure to minimize tipping hazard.
- Threaded holes are provided in the base of the housing to allow suitable seismic anchorage of the laser device.
- Rotating parts within the laser device are protected by covers that can only be removed with corresponding tools. If the purpose of the cover is not evident, a suitable warning label is attached to the cover.

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2.2.4.12 Materials Safety

The materials used in the laser device and its subassemblies and components have been chosen in accordance with the EU Restriction of Hazardous Substances (RoHS) directive. In addition, no asbestos or polychlorinated biphenyl (PCB) is used.

2.2.5 Plant Requirements

This section describes the measures that are required to safely install and integrate the COMPex*Pro* into its working environment. It is the responsibility of the final user to ensure implementation according to local regulations and within the context of a risk management plan.

2.2.5.1 Beam Shielding

The entire beam path including the target area must be hermetically sealed by a suitable enclosure (see Section 1.2.1 on page 5). Threaded holes are provided at the beam exit aperture to enable mechanical attachment of the enclosure (see Section 4.6.6 on page 109). Use fastening elements that require tooling to facilitate their removal. Any removable elements of the enclosure, such as access panels, shall be equipped with interlocks that prevent operation of the laser system unless the respective element is properly secured.

2.2.5.2 Hardwired Interlock Circuit

The laser device has a provision for the connection of hardwired interlock signals (see Section 2.2.4.2 on page 31). Depending on locally applicable safety regulations and operator demands, the system integrator shall connect external detection devices and/or switches to the corresponding connections.

The EMS circuit within the laser device fulfills the requirements of performance level d according to ISO 13849-1. The external EMS circuit that is provided and connected by the user has to fulfill the requirements of at least the performance level d. Cables for the external EMS circuit should have an adequate wire cross section and be laid so that they are protected. The switches that are used shall not reduce the performance level of the overall circuit.

The external interlock circuit should be configured so that the SELV (separated extra low voltage) requirements regarding separation from circuits that carry dangerous voltages are complied with.

For further information about the interfacing of the laser device, please refer to the separate Interfacing Manual.

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2.2.5.3 Laser Area Warning Signs

Make sure that the laser radiation warning lamp and warning labels on the laser device are clearly visible.

Ensure that warning signs indicating the laser enclosed area (according to locally applicable standards, e.g. IEC 60825-1) are in place.

The customer is responsible for providing an external laser radiation indicator (e.g. warning lamp) in addition to the laser radiation warning light fitted to the laser device (see Section 2.2.4.4 on page 32). This indicator has to be connected to the corresponding remote connector outputs (see Section 4.7 on page 115). Before starting the laser device, always ensure that the external laser radiation indicator is connected and correctly operating.

2.2.5.4 Fire Extinguisher

Always keep a fire extinguisher or provide an equivalent fire fighting system in the area of the laser device. The fire extinguisher or fire fighting system should be suitable for fighting “shock risk” classes of fire and be chosen according to local fire safety regulations. For further information, consult the fire safety officer that is responsible for the installation site.

2.2.5.5 Air Extraction System

To remain below the general industry permissible exposure limit for halogen gas even in a worst-case situation, the laser device exhaust has to be connected to a suitable air extraction system. Make sure that the exhaust is not connected to a system used to process breathing air (e.g. air conditioning or ventilating systems). Never operate the laser unless it is correctly connected to the air extraction system.

The fundamental design of the air extraction system (i.e. the edges, corners and transitions within the system) should ensure that no unnecessary air flow noises can occur.

Even when the laser device is switched off, preventative measures are necessary to ensure that no halogen gas escapes from the area of the laser device into the surrounding environment in a worst-case situation. To ensure that the specified exhaust flow rate is present at all times, a suitable monitoring system is required for the external exhaust system. The final user is responsible for the provision and installation of a suitable external exhaust monitoring system as well as providing the specified ventilation. In addition, the external exhaust system should also contain a smoke detector. We also recommend the inclusion of a halogen sensor.

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Should an insufficient exhaust flow rate, smoke or excess halogen levels be detected, the complete system, including the laser device, has to be immediately switched to a safe state through a mechanism provided by the customer. This safety shutdown system has to be connected to the laser device through the corresponding two channel inputs of the Remote connector (see Section 4.7 on page 115). An appropriate signal indicating the cause of the safety shutdown can also be sent through the Remote connector.

The system integrator / system operator should carry out their own risk analysis of the air extraction system together with the required monitoring and safety shutdown devices. The design, implementation and operation of the air extraction system falls within the responsibility of the system operator.

2.2.5.6 Halogen Exposure Monitor

The design of the laser device is such that apart from the measures described in Section 2.2.5.5 no additional halogen exposure controls or protective devices are required for the laser device under normal operating and maintenance conditions.

Nevertheless, the instructions provided by halogen gas suppliers as well as generally applicable occupational safety and health regulations normally stipulate the use of additional exposure controls and personal protective equipment at sites where halogen gases are in use. Such instructions and regulations outline, for instance, requirements and procedures in case of an accidental release of a halogen gas mixture or when handling gas cylinders.

It is the responsibility of the final user of the laser device to incorporate the recommendations and instructions provided by the halogen gas supplier as well as locally applicable directives and regulations into the appropriate work instructions and risk management plan. For further information, consult the institute responsible for occupational safety and health at the installation location (for example, NIOSH, National Institute for Occupational Safety and Health, in the USA) and the gas supplier.

2.2.5.7 Gas Supply Line Pressure / Flow Restrictors

The end user is responsible for the safe and correct installation of the external gas supply and handling system. The line pressure at the laser device’s gas inlet connections shall never exceed 7 bar (abs.). In addition, the gas flow in each line shall also not exceed the specified upper limit of the flow rate range (see Section 4.6.2 on page 97). The end user, therefore, has to provide suitable control devices and fail-safe means of pressure and flow limitation to ensure that there is no risk of excess pressure or flow at the respective gas inlet connections.

2.2.5.8 Seismic Protection

For installations in areas that are susceptible to seismic activity, the end user is responsible for appropriately securing the laser device within their facility. Alternatively, the system integrator is responsible if the laser device is to be installed as part of a system.

For the exact configuration of the protective devices, always follow local regulatory requirements and take into account the center of mass of the laser device and site vulnerability of the facility or plant (e.g. soil conditions and total system design). Provision is to be made for the following:

– anchors to prevent movement or overturning of the laser device during a seismic event.

– suitable strain relief devices for all supply lines. These are to control the risks through leakage or escape of gases, liquids and electricity etc. during a seismic event.

Specific information required for configuring suitable anchoring devices is contained in Section 4.5.4 on page 95.

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2.3 Safety Labels

This section describes the location and purpose of the safety-relevant labels attached to the COMPex*Pro* laser device.

If warning labeling is missing or incomplete, persons are not made aware of potential exposure to specific hazards. Make sure that all warning labels are affixed to the laser device according to the plans given in this chapter.

Misuse or improper handling of the laser device can cause serious or, in certain situations, even lethal injuries. Therefore, never put the laser device into operation if the labeling is incomplete. Immediately replace missing labels or inform Coherent of their absence

To simplify the ordering of labels, the appropriate Coherent part number is indicated behind the position number of the corresponding label.

2.3.1 Labels on Outside of Laser Device

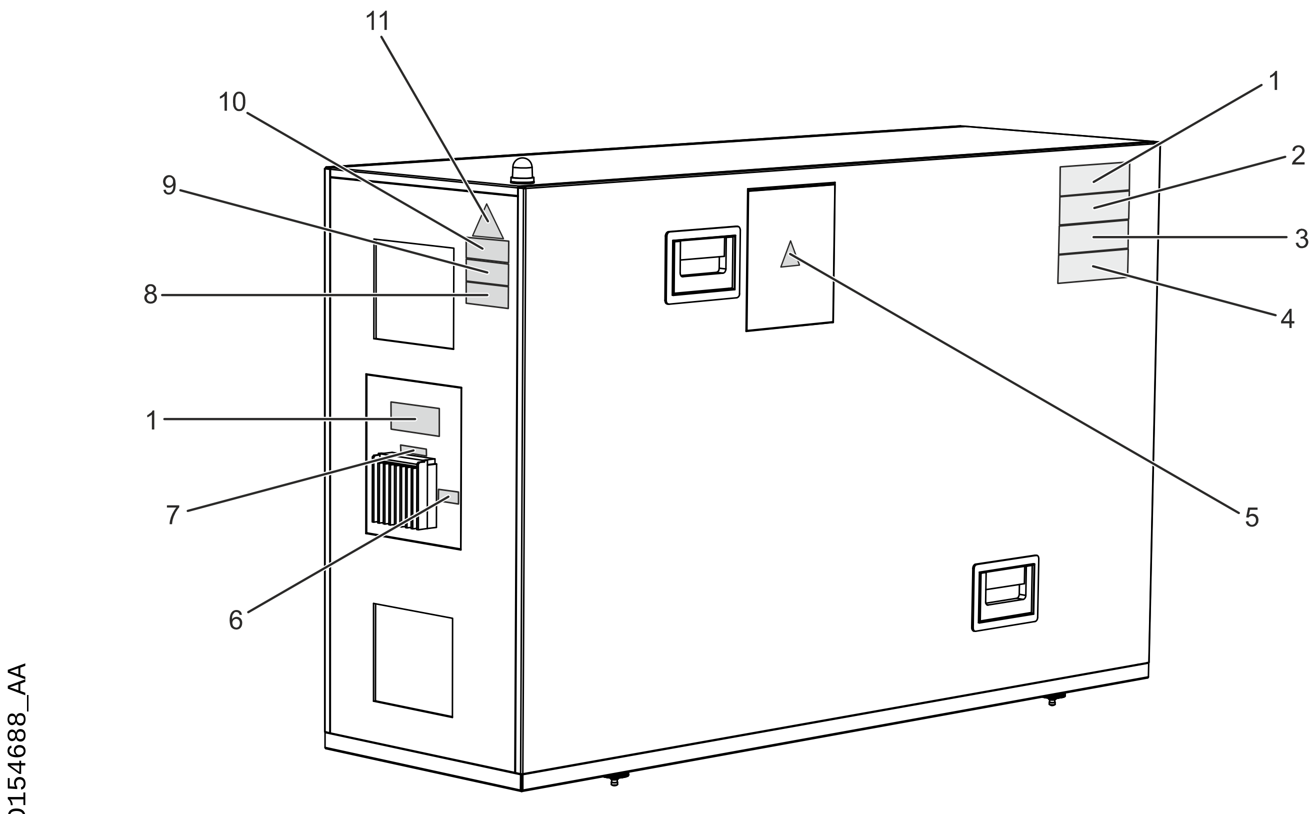


Figure 9: *Labels on beam exit and service side*

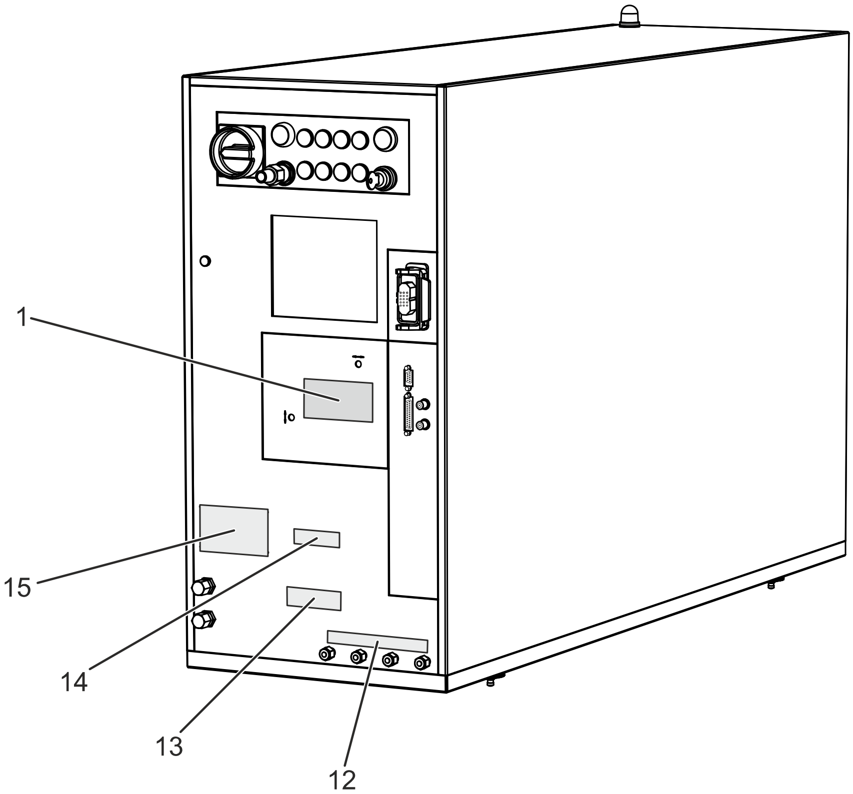
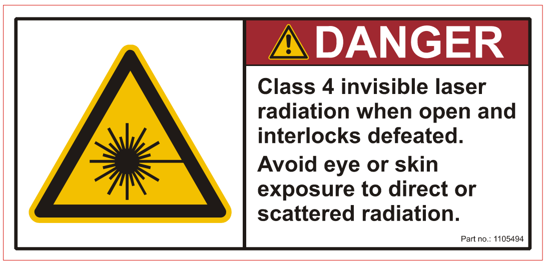


Figure 10: *Labels on connection side*

Pos. 1 (# 1105494):
Label warning of possible exposure to hazardous class 4 invisible laser radiation when the panel to which it is attached is removed and the interlock is defeated.



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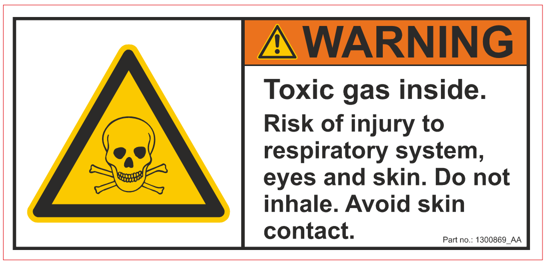
Pos. 2 (# 1300869 or # 1264371):
Label warning that a toxic or harmful halogen gas mixture is contained within the enclosure to which the label is attached. Further information about the gas mixture, inherent hazards, safety precautions and procedures required in the case of an accident are contained in the gas supplier's material data safety sheet (MSDS).

1300869: COMPex*Pro* F-version.
For laser operation at 193 nm, 248 nm or 351 nm, the label warns of a toxic halogen gas mixture.



1264371: COMPex*Pro* XeCl-version.
For laser operation at 308 nm, the label warns of a harmful halogen gas mixture.

Pos. 3 (# 1105490):
Label warning that there are hazardous voltages within the enclosure to which the label is attached. Only authorized and correspondingly trained persons are permitted to remove the cover to which the label is attached.

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Pos. 4 (# 1264375):
Safety notice instructing all persons that intend to work on or with the laser device to read the relevant section of the instruction manual and understand the consequences of their actions before starting work.

Pos. 5 (# 1158150):
Label warning of the risk of an electrical shock if a component behind the cover on which the label is affixed is touched or treated improperly. Only correspondingly qualified and authorized personnel may open the cover or work on the component situated behind.

Pos. 6 (# 1105489):
Label according to IEC 60825-1 indicating that laser radiation is emitted from the aperture next to the label.

Pos. 7 (# 1105907):
Label warning that the surfaces in the area where the label is affixed may be hotter than 60 °C.

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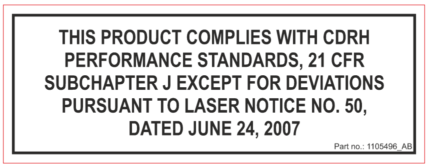
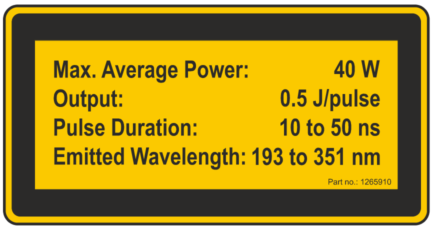
Pos. 8 (# 1105496):
Label to certify that the laser complies with FDA/CDRH performance standards.

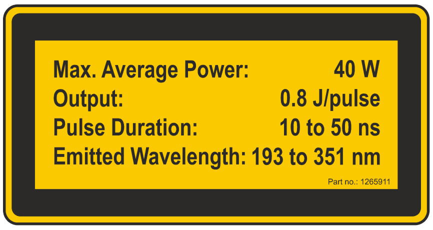


Pos. 9 (# 1265910 or 1265911)
Warning label according to IEC 60825-1 specifying the emitted laser radiation. The information indicated on this label is important for the choice of laser protective eyewear.

1265910: COMPex*Pro* 50, COMPex*Pro* 102 and COMPex*Pro* 110.



1265911: COMPex*Pro* 201 and COMPex*Pro* 205.



Pos. 10 (# 1105499)
Class 4 laser radiation explanatory warning label according to IEC 60825-1.

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Pos. 11 (# 1105500)
Laser radiation warning label according to IEC 60825-1.

Pos. 12 (# 1105481):
Advisory notice indicating that any gas inlets that are not in use should be sealed off with the appropriate sealing plug.

Always seal off gas inlets
and supply outlets after
disconnection or if not in use

Part no.: 1105481_AB

Pos. 13 (# 1304122 or # 1304123):
Label indicating the gas connections and permitted pressure range at each gas connection.

1304122: COMPex*Pro* F-version.
For lasers that operate at 193 nm, 248 nm or 351 nm, the label also contains a notice that stipulates that only fluorine gas mixtures shall be used.

Device only suitable for fluorine gas mixtures

INERT	HALOGEN	RARE	BUFFER (PREMIX)
4.4 to 5.2 bar (abs.)	4.4 to 5.2 bar (abs.)	4.4 to 5.2 bar (abs.)	4.4 to 5.2 bar (abs.)

PartNo.: 1304122_AA

1304123: COMPex*Pro* XeCl-version..
For laser operation at 308 nm, the label also contains a notice that stipulates that only hydrogen chloride gas mixtures shall be used.

Device only suitable for hydrogen chloride gas mixtures

INERT	HALOGEN	RARE	BUFFER (PREMIX)
4.4 to 5.2 bar (abs.)	4.4 to 5.2 bar (abs.)	4.4 to 5.2 bar (abs.)	4.4 to 5.2 bar (abs.)

PartNo.: 1304123_AA

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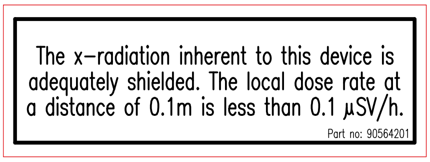
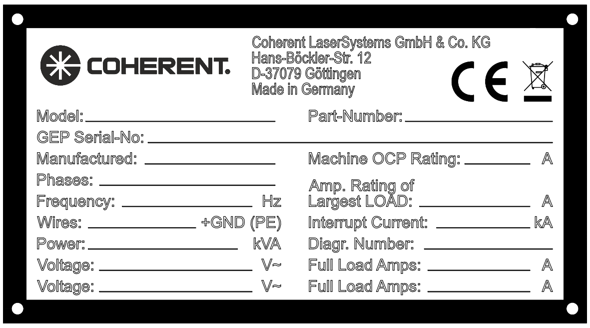
Pos. 14 (# 90564201):
Advisory notice indicating the X-radiation levels contained within the laser device.



Pos. 15 (# 90574302):
Identification plate for the laser device indicating the model, serial number, year of manufacture and electrical connection data.



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2.3.2 Labels Inside Laser Device

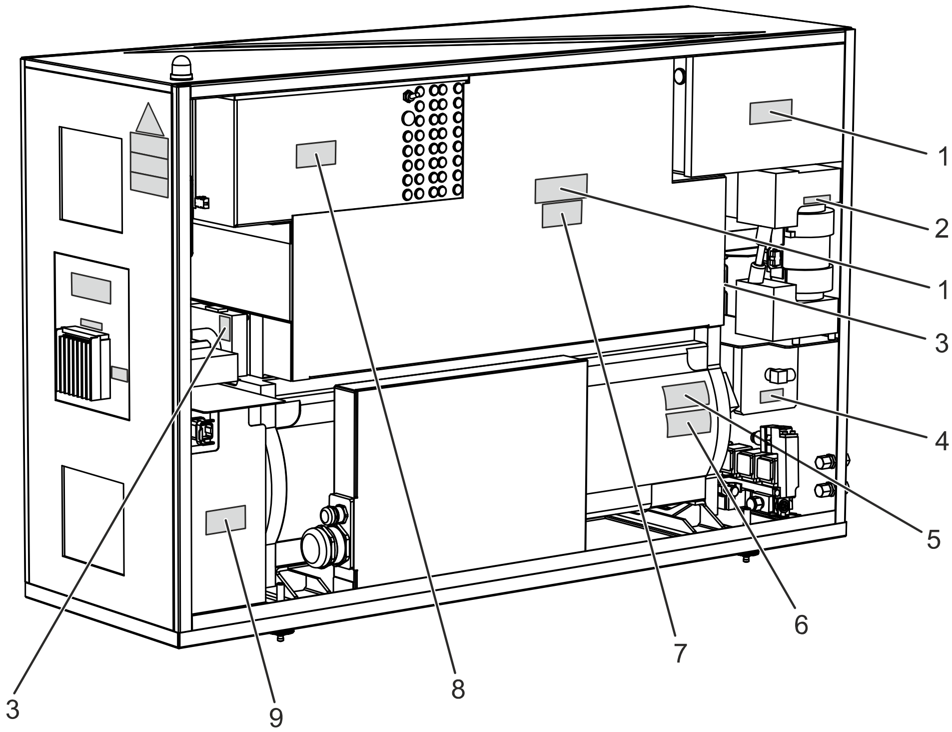
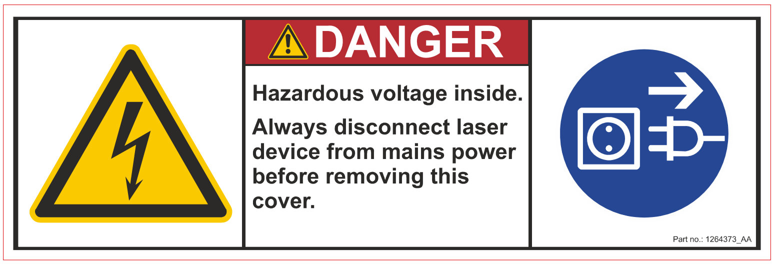
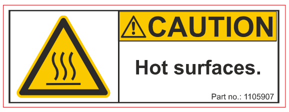


Figure 11: Labels inside

Pos 1: (# 1264373)
Label indicating that mains voltages can be directly accessed when the cover to which it is attached is removed. Always disconnect the mains power cord from the wall socket before removing the cover.



Pos. 2 (# 1105907):
Label warning that the surfaces in the area where the label is affixed may be hotter than 60 °C.



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Pos. 3 (# 1264372)
Label warning of the risk of exposure to the harmful halogen gas mixture inside the laser tube if the optics exchange procedure described in Section 7.6.1 of this manual is not strictly followed.

Pos. 4 (# 1105478):
Label warning that corrosive chemicals are contained in the filter which is located within the enclosure to which the label is attached. Always strictly follow the corresponding instructions in the instruction manual when working on or exchanging the filter.

Pos. 5 (# 1105475):
Label warning that the module to which the label is attached is too heavy to be lifted or transported without mechanical assistance (e.g. hoist, crane or cart). Manual lifting can cause serious back strain. There is also a high risk of serious injury through crushing if the object is dropped.

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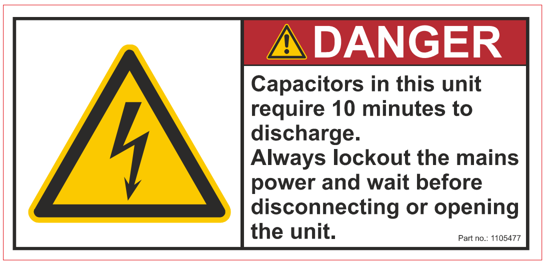
Pos. 6 (# 1264371):
Label warning that a harmful halogen gas mixture is contained within the enclosure to which the label is attached. Further information about the gas mixture, inherent hazards, safety precautions and procedures required in the case of an accident are contained in the gas supplier’s material data safety sheet (MSDS).

Pos. 7 (# 1105477):
Label warning that there are capacitors within the enclosure to which the label is attached. Only authorized and correspondingly trained persons are permitted to remove the cover to which the label is attached. The safety measures indicated on the label shall always be followed.



Pos. 8 (# 1105490):
Label warning that there are hazardous voltages within the enclosure to which the label is attached. Only authorized and correspondingly trained persons are permitted to remove the cover to which the label is attached.

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Pos. 9 (# 1105906):
Label warning that a rotating part is located behind the cover to which the label is attached. Always switch off the laser device before removing the cover. Ensure that the cover is refitted before restarting the laser device.

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3 SYSTEM DESCRIPTION

This chapter briefly describes the most important features, functions, and subassemblies of the COMPex*Pro* excimer laser device. This background information is provided to ease your understanding of the information contained in the subsequent chapters.

This chapter does not extensively cover topics such as laser physics, optics required for the operation of lasers or the principle of excimer lasers. These subjects are described in detail in the Lambda Physik publication “Excimer Laser Technology: laser sources, optics, systems and applications”.

The information in this chapter does not enable you to operate or service the COMPex*Pro* excimer laser.

Never switch on or attempt to operate or service the laser device before reading, understanding and fully familiarizing yourself with Chapter 2 of this manual (Safety)!

3.1 COMPex*Pro* Excimer Laser Device

The COMPex*Pro* is an excimer laser device. Excimer lasers belong to the category of gas lasers. The term “excimer” is an abbreviation for “*exci*ted di*mer*”, which is a reminder of the excited diatomic molecules that were originally used as a laser gas in the first systems.

Depending on the required laser output wavelength, the active laser medium used by the COMPex*Pro* is either Xenon Fluoride (XeF), Xenon Chloride (XeCl), Krypton Fluoride (KrF) or Argon Fluoride (ArF). All of these types of lasers operate in the pulsed mode and emit ultra-violet laser radiation.

– XeF lasers operate at a wavelength of 351 nm,

– XeCl lasers operate at a wavelength of 308 nm,

– KrF lasers operate at a wavelength of 248 nm,

– ArF lasers operate at a wavelength of 193 mm,

The required wavelength has to be specified when the laser device is ordered.

The repetition rate, i.e. the frequency at which the laser pulses are fired, is variable up to a predetermined version-dependent maximum.

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3.2 Laser Device Overview

This section provides an overview of the laser device and its components as well as their respective nomenclature.

3.2.1 Designation of Sides

To prevent confusion or ambiguity, the sides of the COMPex*Pro* are designated according to their purpose or function. These designations, as used throughout this manual, are indicated in Figure 12.

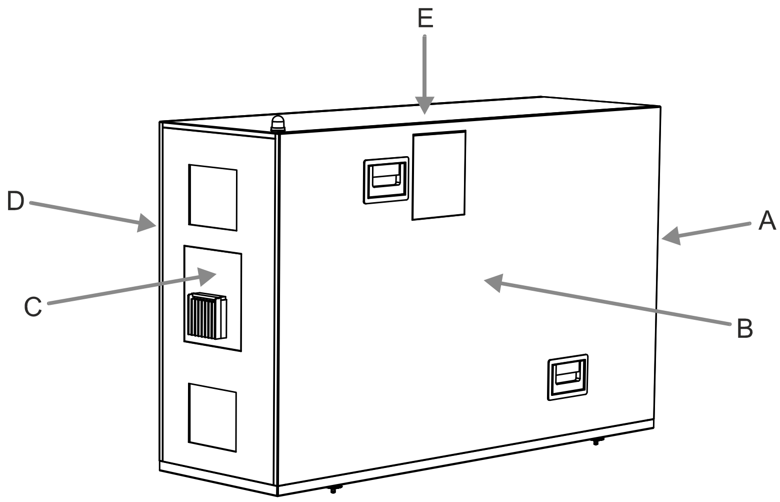

Figure 12: *Designation of the sides of the COMPexPro*

Key to Figure 12:

A Connection side
B Service side
C Beam exit side
D Rear side
E Top

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3.2.2 Exterior Views

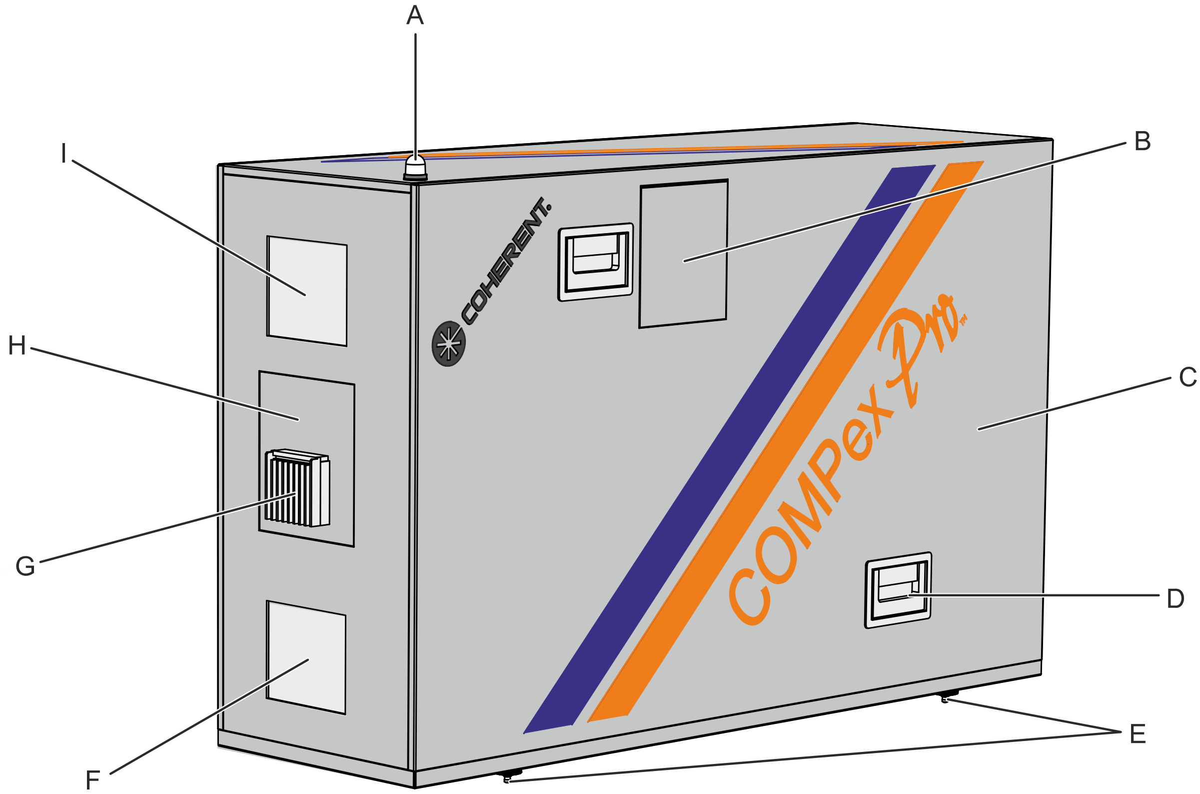

Figure 13: *Beam exit side and service side*

Key to Figure 13:

A	Laser radiation warning lamp
B	Thyratron adjustment panel cover
C	Service panel
D	Collapsible handle for service panel
E	Feet
F	Lower air intake
G	Beam shutter with beam dump
H	Front mirror access panel
I	Upper air intake

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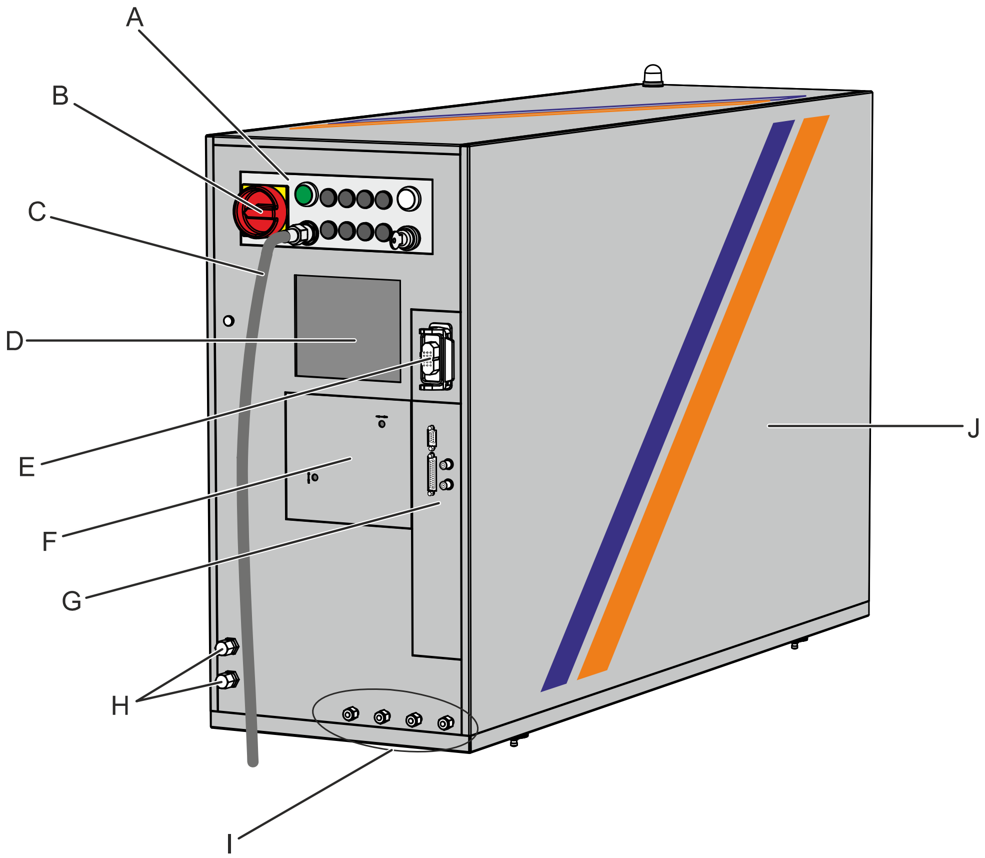

Figure 14: *Connection side and rear side*

Key to Figure 14:

A	Operating panel
B	Main switch
C	Mains power cord
D	Exhaust fan outlet
E	Remote interlock connector
F	Rear mirror access panel
G	Interface connection panel (RS232 serial interfaces, Trigger In and Sync. Out BNC connectors)
H	Water connections
I	Laser gas connections
J	Rear side panel

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3.2.3 Inside View

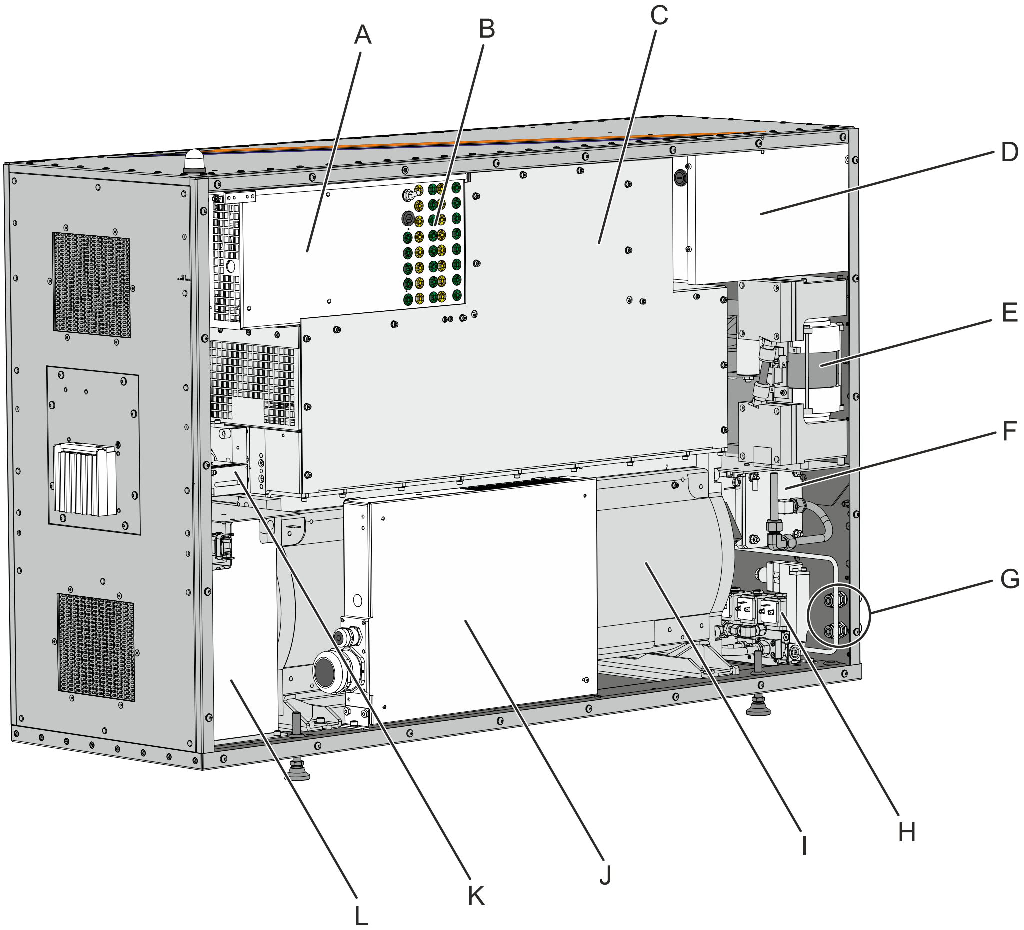

Figure 15: *Inside view*

Key to Figure 15[a]:

A	Thyratron supply unit (front) and HV power supply (behind)
B	Thyratron adjustment panel
C	HV discharge unit cover (EMI shielding)
D	Electrical module
E	Vacuum pump
F	Halogen filter
G	Water connections
H	Gas valve block
I	Laser tube
J	Central control module
K	Energy monitor unit
L	Gas circulation fan motor cover

a. For clarity, connecting cables are not shown

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3.3 Primary System Components

3.3.1 Laser Tube

The laser tube (NovaTube®) can be considered as the motor of the laser. Figure 16 shows a cutaway drawing of the longitudinally symmetrical laser tube.

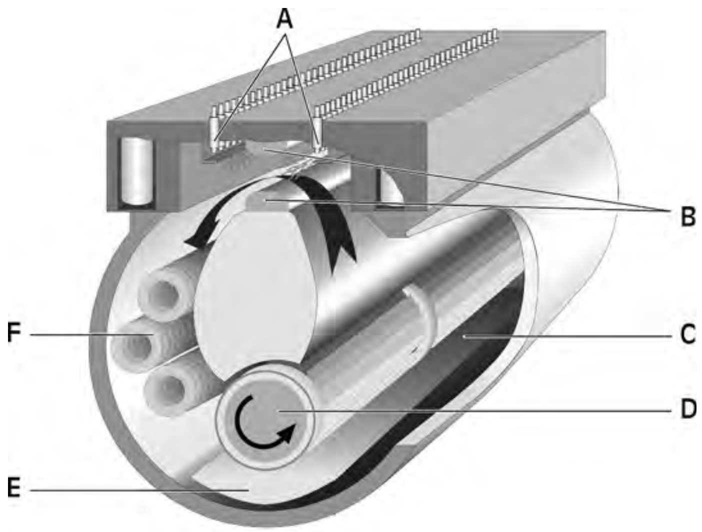

Figure 16: *Cutaway drawing of the laser tube*

Key to Figure 16:

A Preionization pins
B Electrodes
C Laser tube
D Gas circulation fan
E Dust filter
F Heat exchanger

The laser tube (C) is the reservoir for the laser gas. The materials chosen allow the problem-free use of excimer gas mixtures. The material surfaces become coated with a layer of halogen metal complex. This process, resulting from a reaction between halogen (laser gas) and metal (material within tube), is called passivation. Passivation renders the material surfaces within the tube chemically inert to halogen.

A repetition of this process, known as re-passivation, is always required if the surface passivation has been damaged as a result of air entering the laser tube or when the laser device or laser tube has been transported or stored for longer periods.

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A high voltage discharge between the electrodes (B) transfers the energy to the excimer gas mixture (e.g. fluorine or krypton premix). In order to obtain a controlled, spark-free discharge, the laser gas has to be preionized, i.e. a sufficiently high density of free charged molecules has to be created between the electrodes. This is achieved with preionization pins (A) arranged along the main electrodes. The result is a homogeneous preionization of the laser gas. The switching of preionization and main discharge in series ensures a perfect synchronization between preionization and main discharge.

After the high-voltage discharge, thermal inhomogenities in the laser gas arise in the discharge area. Therefore, the gas volume in the discharge area has to be completely exchanged between two laser pulses. A transverse circulation fan (D) positioned within the laser tube causes the gas volume between the main electrodes to be completely replaced between two successive laser pulses. The circulation fan is driven externally via a magnetic coupling by a single-phase motor.

The energy efficiency of the excimer laser is to the order of 2%, i.e. the main part of the energy supplied has to be carried away in the form of heat. The gas, heated up by the discharge, reaches the heat exchangers (F) as a result of the flow in the laser tube and is cooled down to the correct operating temperature (approx. 30 °C or 86 °F).

Each discharge pulse of the laser results in a load on the preionization pins and main electrodes and causes a slightly erosion of material. Precipitation of the created particles on the laser tube optics would result in diminishing beam intensity by scattering and absorption. Therefore these particles must permanently be removed from the laser gas which is done by an electrostatic filter (E) integrated in the gas circulation. Due to the pressure conditions generated by the circulation fan, the laser gas continuously flows through this electrostatic filter.

To maintain optimum performance, various energy management modes are available (see Section 3.5 on page 75).

Periodically, the gas fill in the laser tube has to be completely exchanged. This action, which is known as a new fill, is carried out through a dedicated software routine. The other necessary maintenance during the lifetime of the laser tube is the cleaning or exchange of the laser tube optics (resonator optics, see Section 3.3.2).

3.3.2 Resonator Optics

The optical feedback system that amplifies the laser light is normally provided by a plane-parallel resonator (see Section 3.3.2.1).

As an option, the resonator can be equipped with unstable resonator optics (see Section 3.3.2.2).

3.3.2.1 Plane-Parallel Resonator

Figure 17 shows the plane-parallel resonator optics configuration that is used in most versions of the COMPex*Pro* laser device.

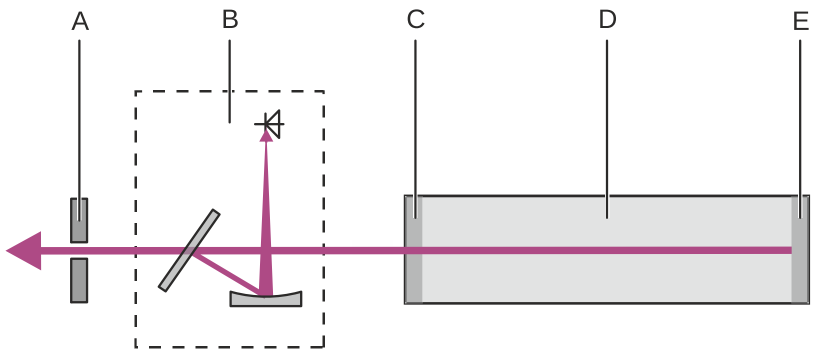

Figure 17: *Plane-parallel laser resonator*

Key to Figure 17

A Manually operated beam shutter
B Energy monitor
C Partly reflective (PR) output coupler (OC)
D Laser tube (gas reservoir)
E Highly reflective (HR) rear mirror

At the rear of the resonator is a highly reflective mirror (E). The other resonator mirror (C) is known as the output coupler. This is a partially reflective mirror that allows part of the laser light to escape from the resonator, thereby forming the laser beam.

The gas volume of the laser tube (D) is sealed by the mirrors (C, E) which are attached on each side of the laser tube. There are no external resonator optics.

As indicated in Section 3.3.1, the laser gas and resonator optics (mirrors) are subject to routine maintenance. The removal of the resonator optics for cleaning or exchange is controlled through a dedicated software routine. To minimize downtimes, the resonator optics are available as premounted units.

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3.3.2.2 Unstable Resonator

Figure 18 shows a resonator with unstable resonator optics.

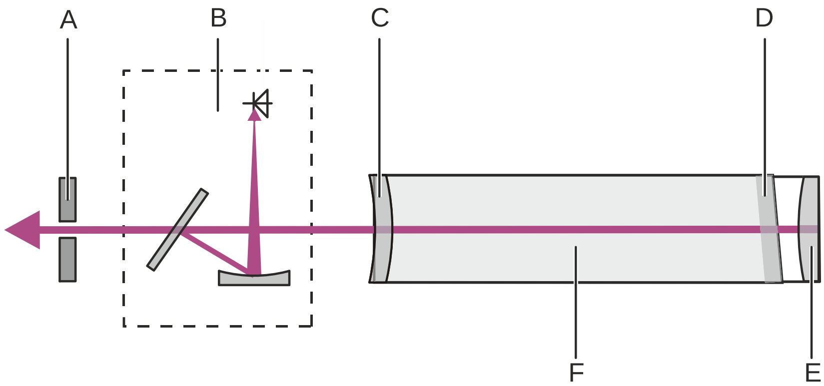

Figure 18: *Unstable laser resonator (plano-convex rear mirror)*

Key to Figure 18

A Manually operated beam shutter
B Energy monitor
C Miniscus as output coupler
D Cavity window
E Plano-concave rear mirror
F Laser tube (gas reservoir)

An unstable laser resonator produces a laser beam with significantly lower divergence and higher spatial coherence than a plane-parallel resonator (see Figure 19). It has optical characteristics similar to those of a point light source. The trade-off is that an unstable resonator is inherently less efficient than a plane-parallel resonator.

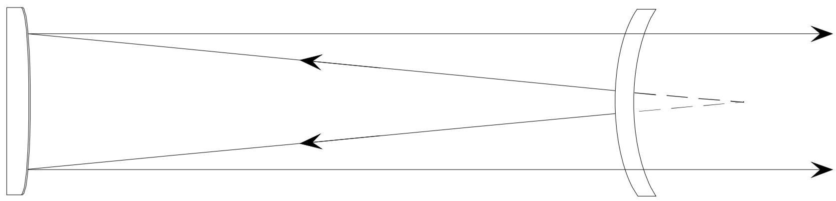

Figure 19: *Principle of unstable resonator with plano-convex rear mirror*

In general an unstable resonator has the following components:

– Concave HR mirror or plano-convex lens with HR coating on the plane side. The optic is coated according to the wavelength that the laser is to be operated at.

– Uncoated convex-concave meniscus lens as the output coupler.

– Tube sealing window.

An unstable resonator can either be factory fitted or field retrofitted.

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3.3.3 Energy Monitor

The internal energy monitor (see Figure 20, B) is situated between the output coupler (D) and beam shutter (A).

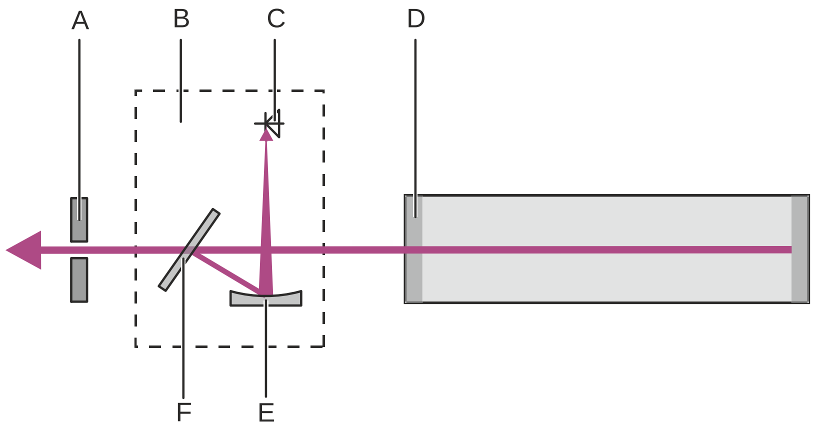

Figure 20: *Laser resonator with energy monitor*

A portion of the beam emitted through the output coupler is diverted by a beam splitter optic (F) onto a concave mirror (E). This reflects the diverted portion of the beam through a set of wire attenuators and focuses it onto a UV photodiode (C). The output from the UV photodiode is converted to a voltage signal, the peak value of which is digitally encoded and transmitted to the laser controller.

As the energy monitor does not supply absolute measured values, it has to be calibrated according to an externally measured energy reading. In addition to taking a reading with an external measuring device, no further measures are required. Calibration is performed using the laser control software's dedicated calibration procedure that can be accessed through the handheld keypad or external computer.

Under certain circumstances, the attenuation of the energy monitor has to be adjusted to ensure that the amount of laser light reflected onto the UV photodiode will provide a reliable reading. The attenuation is adjusted by changing the amount or density of the wire attenuators in front of the UV photodiode.

The beam splitter optic in the energy monitor is subject to wear and has to be periodically exchanged.

3.3.4 High Voltage Discharge Circuit

The high voltage (HV) circuit provides the rapid high-voltage discharge required to obtain efficient excitation of the laser gas. The primary components of the HV circuit are the HV power supply module (see Section 3.3.4.1 on page 67), thyratron (see Section 3.3.4.2 on page 67) and storage capacitors as well as the discharge electrodes and peaking capacitors of the NovaTube (see Section 3.3.1 on page 60).

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The duration of the high-voltage discharge is about 50 ns and the peak power can reach one gigawatt. The discharge is fed from peaking capacitors. These are a large number of discrete ceramic high-voltage capacitors coupled directly to the laser tube's discharge electrodes with minimum inductance.

The working principle of the high voltage circuit is shown in Figure 21.

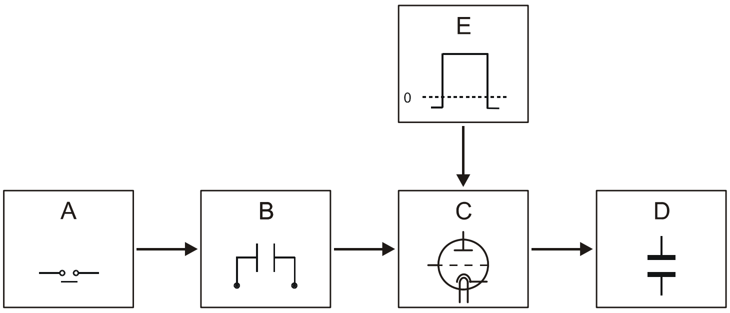

Figure 21: *Layout of the high voltage discharge circuit*

The peaking capacitors (D) are charged from a current pulse supplied from the storage capacitors (B). The storage capacitors are charged by the HV power supply module (A) between laser pulses. As soon as the storage capacitors are charged, the laser is ready to pulse. The laser pulse is triggered by the HV trigger generator (E) and thyratron (C), which switches the recharging of the storage capacitors.

Sync. Out Signal

To enable the laser to be coordinated with other operations (e.g. substrate or workpiece movement), a pre-defined signal is output synchronously with the emission of the laser pulse. This signal is referred to as the sync. out signal.

Charge On Demand (COD)

Normally, capacitor charging occurs automatically after the previous discharge. If, however, the capacitors have to remain charged for a long period before firing the next laser pulse, there is the risk of self-firing: in other words the laser might fire a laser pulse without receiving a trigger pulse. To prevent this and, at the same time, maximize the lifetime of the components in the HV circuit, the laser operates as standard in the so-called Charge On Demand (COD) mode.

With COD, capacitor charging is specifically triggered by the demand for a laser pulse rather than occurring automatically after the previous discharge. In other words, as long as there is no pulse trigger signal, the HV is switched off and the capacitors remain uncharged. When a laser pulse is needed, a trigger signal enables the HV power supply to charge the storage capacitors. When the storage capacitors have been charged, the thyratron is triggered, the laser emits a single pulse and the HV is switched off again.

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The jitter will remain the same, regardless of whether operation is with or without COD.

The fundamental difference between the two capacitor charging modes is the timing. This is illustrated in Figure 22 which shows the timing of the triggering of a laser pulse with and without COD.

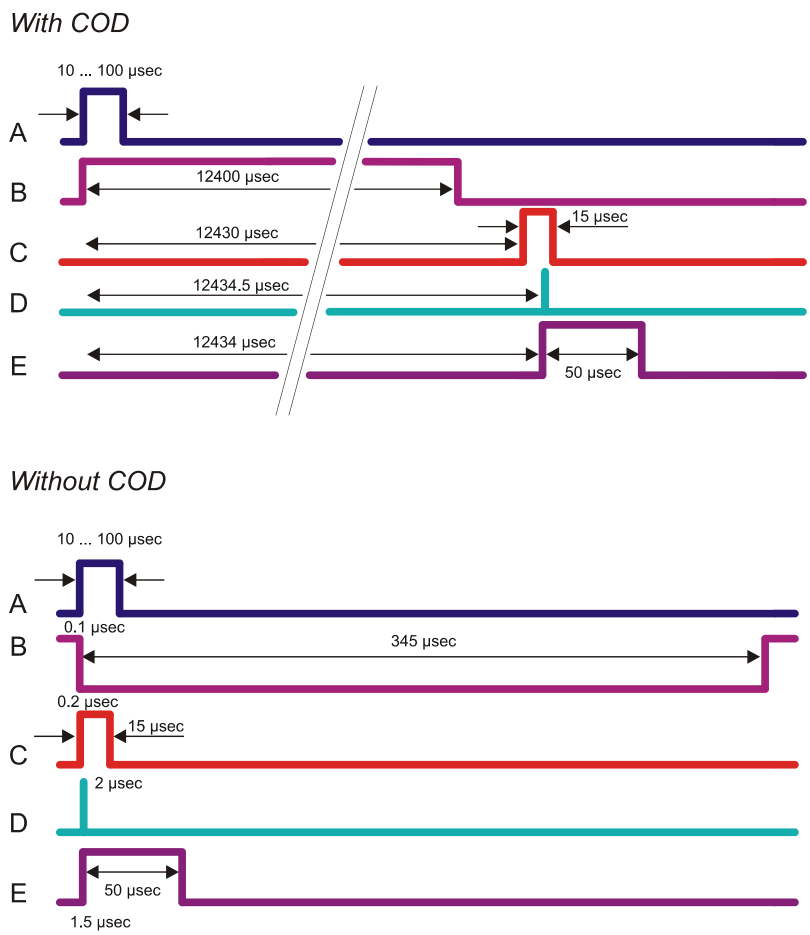

Figure 22: *Timing of laser pulse with / without COD*

Key to Figure 22

A Trigger In signal
B HV enable signal
C Thyratron trigger signal
D Laser pulse
E Sync. Out signal

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As can be seen in Figure 22, the trade-off of COD is a long delay between the trigger signal (A) and the laser pulse (D) and associated sync. out signal (E). This delay varies depending on the version of the laser device (see Section 4.6.7.4 on page 114). If the delay between trigger signal and laser pulse is unacceptable for the effective coordination of the laser with other operations, the COD mode can be switched off by the user through a dedicated software command.

3.3.4.1 HV Power Supply

The HV power supply module converts mains current into the high voltage DC required by the discharge circuit. It is a high voltage, switching power supply specifically designed for charging capacitors in laser systems.

The HV power supply is maintenance-free. It is classified as a spare part, i.e. exchange is only necessary in case of a failure.

3.3.4.2 Thyratron

The laser uses a simple 3-inch hydrogen thyratron, a thermionic tube. It is used as an active switch to discharge the storage capacitors. The anode of the thyratron is connected to the charging voltage. The cathode is connected to ground. Between these two main electrodes is the control grid, which initiates the discharge (switching) of the thyratron.

As is also the case with conventional thermionic tubes, the cathode structure has to be heated in order to ensure sufficient emission of starting electrons. If the electron emission after a longer operating period is no longer sufficient to initiate switching of the thyratron, this can be corrected during the thyratron lifetime by increasing the heating power of the cathode.

Hydrogen is necessary to provide a fast current increase and a high current intensity. However, as hydrogen is continually lost due to diffusion and metal erosion, the concentration of hydrogen has to be continually renewed. For this purpose, there is a reservoir structure (palladium) in the tube, in which a large quantity of hydrogen is stored. By heating the reservoir, hydrogen is released from the reservoir into the main thyratron. It should be noted, however, that too much hydrogen reduces the hold-off voltage between the electrodes of the thyratron to such a level that unwanted switching of the thyratron will take place even without the trigger pulse. On the other hand, if the partial hydrogen pressure in the thyratron is too low, the laser is unable to pulse. This is because there is no discharge in the thyratron due to a lack of charged particles.

The values for the two heating voltages, U_H for the cathode heating and U_R for the hydrogen reservoir voltage, are critical to the correct operation of the tube. The voltages are stabilized in a broad input voltage range in order to be unaffected by voltage fluctuations in the supply line (spikes). These values have to be altered during the total life of the thyratron to ensure proper switching of the tube. This can be done simply by using the jumpers provided for this purpose. You will find a description of the thyratron adjustment in Section 7.11 of this manual.

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3.3.5 Laser Control

The COMPex*Pro* (see Figure 23, A) is controlled through a central laser control board (C) that directly communicates with the system's various controllable modules and components (B) such as the HV power supply, energy monitor, trigger board, solenoid valves and ventilators. Depending on the address, communication occurs through 24 V control signals or optically through fiber optic lightwave guides.

The user interface to the central laser control module (C) is either the handheld keypad (F) supplied with the laser device or a remote computer control system (E) provided by the system integrator. Both devices use the same set of commands. As the laser device is equipped with two RS232 serial interface ports, two user interface devices can be connected at the same time. To prevent the input of conflicting commands, one of the ports (COM1) can be deactivated by the user. Alternatively, this port can be switched by the user to allow the connection of a diagnostics computer (D) or a control system designed for an earlier version of the laser device (backward compatibility).

In addition to the serial interfaces, the laser device is equipped with dedicated ports that allow trigger signals from an external trigger generator (H) to be input and synchronization pulses to be output to an external device (G) that synchronizes the laser pulses with other operating sequences.

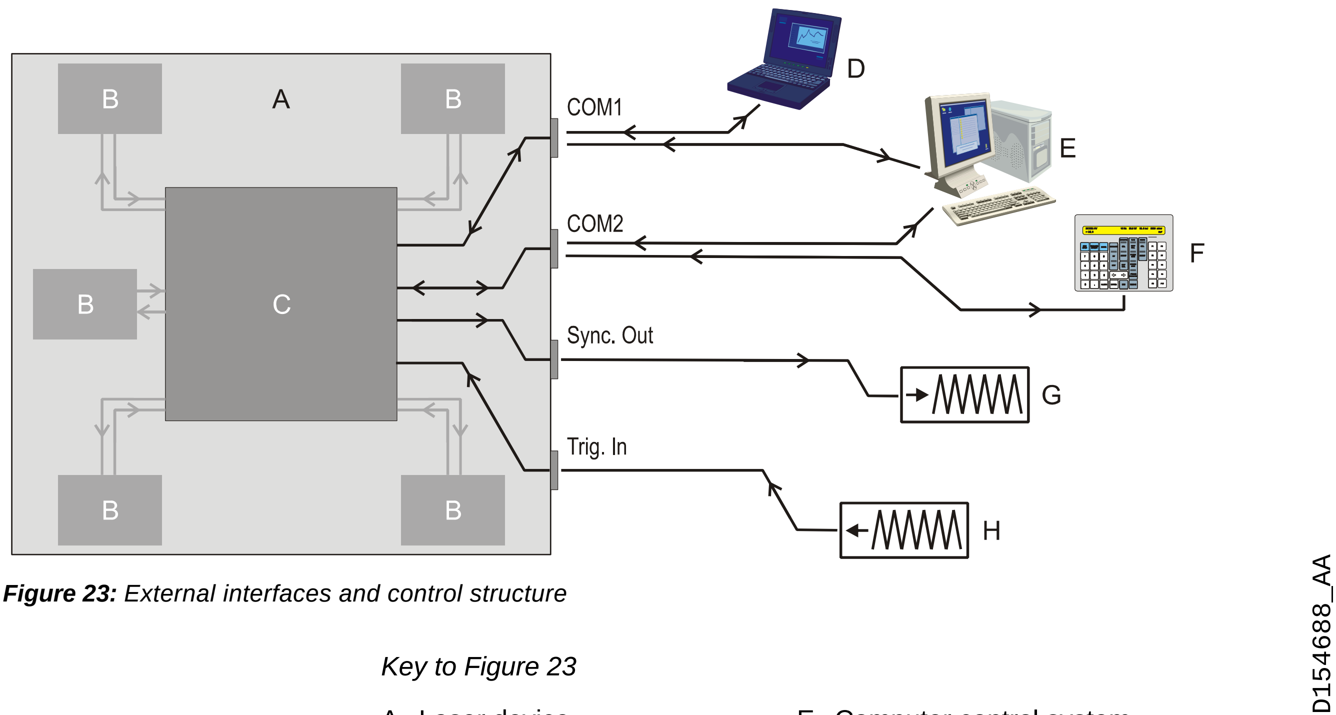

Figure 23: *External interfaces and control structure*

Key to Figure 23

A Laser device
B Controlled module/ component
C Laser control board (LCB)
D Diagnostics computer
E Computer control system
F Handheld keypad
G Synchronization device
H Trigger generator

3.3.6 Gas Supply / Exhaust System

The required excimer laser gases are supplied from an external source through dedicated supply lines (either a single premix gas or the constituent gases). When the constituent gases are used, the gases are mixed for laser operation in the laser tube. The gas evacuated from the laser tube is filtered, so that it is free of halogens, and then blown out through the exhaust. The inlet and evacuation of gases is controlled by solenoid valves actuated through signals received from the central control module.

The layout of the gas supply and exhaust system is shown in Figure 24.

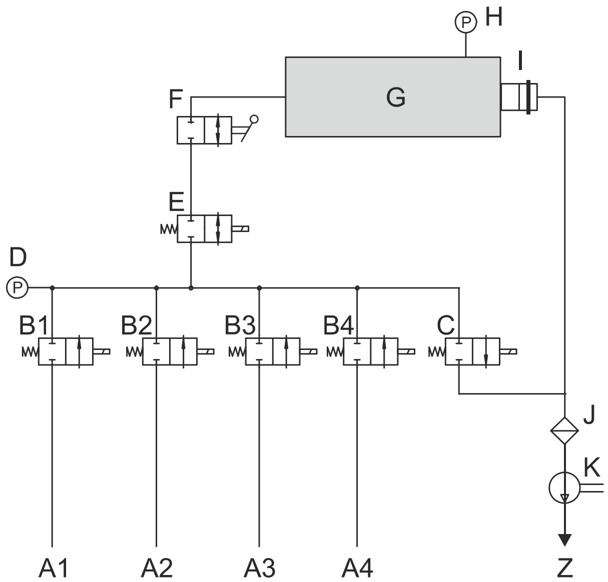

Figure 24: *Laser gas supply / exhaust*

Key to Figure 24:

A	Gas connection (1 = Buffer, 2 = Rare, 3 = Halogen, 4 = Inert)
B	Excimer laser gas valve (1 = Buffer, 2 = Rare, 3 = Halogen, 4 = Inert)
C	Vacuum valve
D	Gas manifold pressure sensor (F-version laser devices only)
E	Laser tube (head) valve
F	Ball valve
G	Laser tube (NovaTube®)
H	Laser tube pressure sensor
I	Rupture disk
J	Halogen filter
K	Vacuum pump
Z	Exhaust

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The individual gas supply lines are connected to the laser device at the corresponding connections (see Figure 24, A1 to A4) situated on the connection side of the laser head (see Figure 14 on page 58).

The gas solenoid valves (B) are normally closed. They are opened to allow the corresponding gas to flow into the gas manifold. The vacuum valve (C) is a solenoid valve that is normally closed. It is opened to allow the gas in the gas manifold and tube to be pumped out through the exhaust (Z) by the vacuum pump (J).

The gas manifold pressure sensor (D) provides a signal that can be compared with the signal from the laser tube pressure sensor (H). This enables the laser control software to detect irregularities in the gas supply system, such as insufficient or excess pressure in the external gas supply lines.

The head valve (E) is a solenoid valve that is normally closed. It is opened to allow fresh gases to flow from the gas manifold into the laser tube (G) or the spent gas mixture to be evacuated into the exhaust (Z). The hand-operated ball valve (F) is a shut-off valve that has to be closed for maintenance of the laser tube.

The laser tube pressure sensor (H) also provides a tube pressure reading that can be polled through a software command.

The rupture disk (I) bursts when the pressure in the laser tube is too high.

The vacuum pump (K) exhausts the gases from the NovaTube. It is started and stopped through signals received from the central control module. The halogen filter (J) removes molecular species of halogen gas from the laser gas mixtures exhausted from the NovaTube.

As the laser gas is evacuated and filtered through a separate connection, the exhausted air does not normally contain any toxic or harmful gases or by-products. Nevertheless, in certain failure scenarios, the exhaust gas may contain a small concentration of halogen gas or ozone. This means that, for safety reasons, an external exhaust system always has to be connected to the laser device during laser operation. This exhaust system should be designed to guide the exhaust gases out of the working area into a suitable industrial extraction system that will appropriately treat the exhaust gases.

Apart from turning on the externally supplied gases and regulating the pressure of the gases in the external gas circuits, the gas supply and exhaust requires no operation or routine maintenance.

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3.3.7 Electrical System

Depending on the configuration of the mains electrical power system, the laser device is connected to a single-phase or two-phase mains power source (see Section 4.6.3 on page 103). The individual consumers in the laser device are either connected to the mains voltage circuit or to a 24 V DC circuit.

The mains voltage consumers in the laser device include the HV power supply module, gas circulation fan and vacuum pump as well as the cooling and exhaust fans.

The 24 V DC circuit serves the low voltage consumers. These include the solenoid gas valves, gas purifier and various decentralized control modules.

The components in the electrical system are not subject to routine maintenance.

3.3.8 Cooling System

The efficiency of commercial excimer lasers is theoretically in the region of between 1 and 4%. The remaining energy is almost completely converted to heat and has to be eliminated by an effective cooling system.

COMPex*Pro* laser devices are primarily cooled by environmental air. Certain models, however, also require water cooling when they are operated at higher repetition rates (see Section 4.6.4 on page 106).

Air Cooling

The laser device has two air inlets on the beam exit side (see Figure 13 on page 57, G) and a central exhaust outlet on the connection side (see Figure 14 on page 58, H). As the laser gas is evacuated through a separate connection, the exhausted air does not contain any toxic or harmful gases or by-products. Nevertheless, in certain failure scenarios, the exhaust gas may contain a small concentration of halogen gas or ozone. The exhaust should, therefore, be connected to a suitable industrial extraction system which enables the gases to be appropriately treated.

Water Cooling

The cooling water circuit cools the laser tube through tap water. As standard, no flow sensors or regulating valves are provided.

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As an option, the cooling water circuit can be equipped or retrofitted with automatic temperature regulation (see Figure 25).

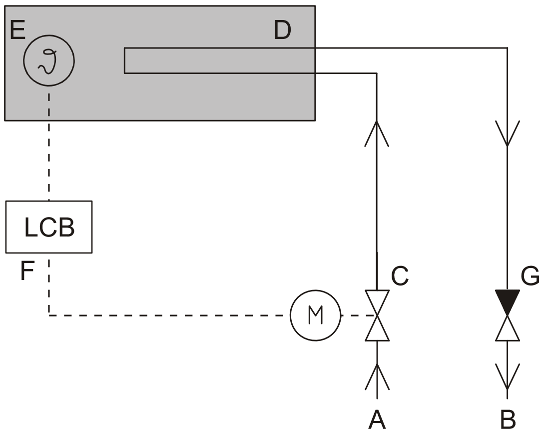

Figure 25: *Cooling water circuit with temperature regulation*

Key to Figure 25:

A Cooling water inlet
B Cooling water outlet
C Flow regulating valve
D Laser tube
E Laser tube temperature sensor
F Laser control board
G Check valve

The external cooling water supply and drain is connected to the laser device at the inlet (A) and outlet (B) connections situated on the connection side of the laser head (see Figure 14 on page 58). All COMPex*Pro* laser devices are fitted with water connections to enable water cooling of the laser tube (D), regardless of whether water cooling is required under normal operating conditions or not.

The Temperature sensor (E) monitors the temperature in the laser tube (D). If the temperature is too high or too low, a signal is sent through the laser control board (F) to the flow regulating valve (C). This automatically increases or decreases the water flow as required to ensure that the respective module operates at the correct temperature.

The check valve (G) ensures that cooling water does not re-enter the laser device at the cooling water outlet.

Apart from turning on the external water supply and ensuring that the outlet water flows into an appropriate drain, the cooling water circuit requires no operation or routine maintenance.

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3.3.9 Purge Gas System

UV light reacts with oxygen to create ozone. Apart from creating a health hazard (for more information, see Section 2.2.1.5), this oxidizes the surface of the optics and decreases laser performance.

To prevent ozone production, the beam path must be purged with nitrogen (purge gas) when operating the laser device at 193 nm. At other wavelengths, the use of purge gas minimizes contamination and increases optics lifetimes.

The external purge gas supply is connected to the corresponding connection on the laser head.

Apart from turning on and regulating the externally supplied purge gas, the purge gas supply requires no operation or routine maintenance.

3.3.10 Monitoring and Fail-Safety Systems

3.3.10.1 Error Handling

The laser control software prevents hazardous situations in all laser states. However, there may be malfunctions in some parts of the system. If a critical situation is detected, an appropriate reaction is initiated. According to the type of malfunction, there are two fundamental types of reaction:

- Interlocks

  An interlock occurs when there is a malfunction or critical interference in the functioning of the laser device.

  When the laser control software or a hardware sensor determines a malfunction, the laser will be switched to a safe state. In most cases, the high voltage circuit will be disabled so that emission of laser radiation is inhibited and the halogen valve will be switched to prevent halogen gas from entering the laser tube. The user will be informed about the interlock through an error message.

- Warnings

  Warnings inform the operator that there is a problem or potential malfunction, although laser operation is still possible. Some warnings will result in an interlock if the operator does not react to the warning within a given period of time.

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3.3.10.2 Watchdog

The COMPex*Pro* system controller uses a watchdog to perform functional checks. A watchdog is a switch that alters its logical level as soon as the reset pulses stop.

The laser control software sends reset pulses each second. If the watchdog no longer receives these pulses, as in the case of a breakdown, this is recognized by the watchdog and the system is switched to a safe, inactive state.

3.4 Pulse Triggering Modes

The COMPex*Pro* operates as a pulsed laser. The discharge and, consequently, emission of the individual laser light pulses can be triggered either internally or externally.

The following triggering modes are available:

- *Internal triggering:* laser light pulses are triggered by the laser device's internal trigger generator. Triggering occurs continuously at the parameters set by the user through the laser control software (input through handheld keypad or external computer).
- *External triggering:* laser light pulses are triggered from an external trigger generator that is connected to the external trigger socket on the laser device.
- *Internal gated triggering:* laser light pulses are triggered internally as long as there is a high signal at the external trigger socket on the laser device (low $\Rightarrow$ no triggering).
- *Internal single burst triggering:* a single burst of internally triggered laser light pulses is triggered by an external trigger signal.
- *Countdown mode:* laser light pulses are triggered until a preset number of pulses is reached (countdown function). The pulses can be triggered through either the internal trigger generator (*internal countdown mode*) or through an external trigger generator (*external countdown mode*).
- *Burst mode:* bursts are sequences of laser pulses separated by pauses during which the laser does not fire. These bursts can, in turn, be grouped together to become a sequence of bursts; the pause between the sequence of bursts being longer than the pause between each individual burst.

  Burst mode operation is frequently the mode of choice for production sequences. The laser control software provides an internal burst generator that allows internally triggered bursts and sequences of bursts to be set. Alternatively, the desired burst pattern can be defined through an external trigger generator, in which case the external triggering mode is to be selected.

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3.5 Energy Management

The pulse energy (output energy) of an excimer laser is dependent upon the charging voltage (high voltage) and condition (age) of the excimer laser gas.

When the pulse energy (E) is considered as a function of the charging voltage (U), the result is approximately the function shown in Figure 26

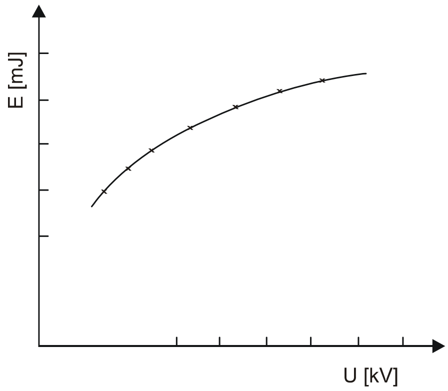

Figure 26: *Pulse energy as a function of charging voltage*

As excimer laser gases age, the pulse energy obtained from a given charging voltage will decrease.

To compensate for the decreasing pulse energy, the high voltage required for the electrical discharge can be modified and/or the quality of the excimer laser gas mixture can be improved through various gas actions. This means that the laser can be operated in one of two fundamental running modes, either with or without gas actions. These options are described in the Sections 3.5.1 to 3.5.3.

Regardless of the running mode and gas actions performed, the laser gas quality will reach a state where further adjustment of the high voltage and/or further gas actions will no longer provide the required output energy. In this case, the laser gas is to be exchanged completely using the New Fill procedure. The New Fill procedure is a dedicated software routine that is started as required by the system operator.

3.5.1 Fundamental Running Modes

The COMPex*Pro* can be operated in one of two fundamental running modes: the Energy Constant mode (EGY CONST) or the High Voltage Constant mode (HV CONST).

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When the *Energy Constant* mode is selected, the laser control continuously adjusts the high voltage to achieve laser operation at a preset energy level (see Figure 27).

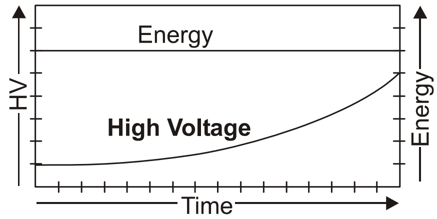

Figure 27: *Voltage increase in the Energy Constant mode*

When the *HV Constant* mode is selected, the pulse energy decreases with time as the excimer laser gas deteriorates (see Figure 28).

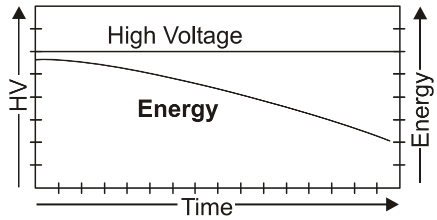

Figure 28: *Energy decrease in the HV Constant mode*

Most applications require the Energy Constant mode, whereas the HV Constant mode is primarily used for diagnostic purposes (e.g. to measure the gas lifetime).

Regardless of the selected running mode, the laser can be operated either with or without gas actions. Operation with gas actions is known as the Partial Gas Replacement (PGR) mode (see Section 3.5.2) and operation without gas actions as the No Gas Replacement (NGR) mode (see Section 3.5.3 on page 77).

3.5.2 Operation With Gas Actions (PGR Mode)

The *Partial Gas Replacement (PGR)* mode has no effect if the laser is supplied with a premix gas mixture (see Section 4.6.2 on page 97).

In the PGR mode, various gas actions are performed according to a predetermined algorithm to compensate for deviations between the preset energy (set point) and operating energy (actual value). The PGR mode algorithm is factory-defined for each type of laser.

The laser control software for COMPex*Pro* laser devices will only perform macro halogen injections (MHIs),

If commands for other gas actions are received by the laser control software, no action will occur.

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A macro halogen injection (MHI) is used to stabilize the halogen partial pressure in the laser tube. It replenishes halogen which is depleted during the idle time of the laser as well as during laser operation.

With each MHI, a small amount of halogen gas is filled into the laser tube. During this action, the properties of the laser beam might not be within the specified range.

The effect of MHIs on laser operation in the Energy Constant mode is shown in Figure 29.

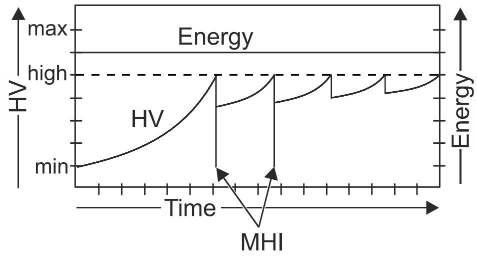

Figure 29: *Charging current with halogen injections*

The predetermined gas action algorithm is set to perform MHIs when the HV reaches the predetermined HV_{high} level. After a waiting period during which no gas actions are performed, a MHI is performed in an attempt to return the laser to range between HV_{min} and HV_{high}. If the gas action is unsuccessful, there is another waiting period and then another MHI is performed. If both MHIs do not return the laser to range between HV_{min} and HV_{high}, no further gas actions occur. Laser operation continues until HV_{max} is reached. When HV_{max} is reached, the laser is shut down with a “preset energy too high” interlock.

If the halogen proportion within the laser tube exceeds the permitted level, a “halogen concentration on upper limit” interlock occurs. In this case, no further gas actions will occur until a New Fill is performed to completely exchange the gas in the laser tube.

Each MHI after the last new fill will be counted by the COMPex*Pro* laser control software. This value is indicated by the PGR counter.

3.5.3 Operation Without Gas Actions (NGR Mode)

When the *No Gas Replacement (NGR)* mode is selected, no replenishment of the laser gas occurs. Depending on the selected running mode, the high voltage will continue to rise or the output energy will continue to drop until HV_{max} is reached.

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Figure 30 shows NGR laser operation in the Energy Constant mode.

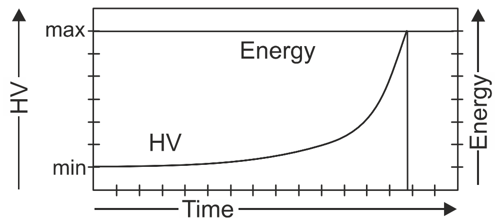

Figure 30: *Charging current with No Gas Replacement (NGR)*

When the high voltage reaches the HV_{max} level the laser is shut down automatically with a “Preset energy too high” interlock.

3.5.4 Energy Burst Mode

Energy Burst mode operation is only available if the laser device is fitted with the optional TIMELOK / POWERLOK package. This is indicated by a corresponding message during the boot sequence.

The Energy Burst mode is used to trigger a sequence of laser pulses with constant output energy throughout each burst. Consequently, Energy Burst mode operation is only possible in conjunction with constant energy operation.

As described in Section 3.4, the burst is either defined through the laser control software’s internal burst generator or through a correspondingly set external trigger generator. In each case, the amount of pulses in each burst, the pause between each burst, the amount of bursts in a sequence of bursts and the pause between each sequence have to be defined. The target energy of each pulse in the burst (in mJ) is defined by the user through the laser control software.

Due to the inherent physical characteristics of the excimer laser, power overshoots can occur at the beginning of each burst of laser pulses. When operating the laser in the burst mode, these overshoots would cause an unacceptable peak at the beginning of each burst of pulses. To compensate for this, the POWERLOK function is automatically activated when Energy Burst mode operation is selected. With POWERLOK, the energy management system is controlled in such a way that the overshoot at the beginning of each pulse is minimized. To enable the POWERLOK function to effectively operate, the laser control software automatically recognizes the burst pauses, regardless of whether the laser is externally or internally triggered.

Working in conjunction with POWERLOK is the TIMELOK function, this stabilizes the trigger-to-pulse delay of the laser device’s high voltage circuit.

Energy Burst mode operation (EGYBURST) is possible either with or without gas actions (EGYBURST PGR or EGYBURST NGR).

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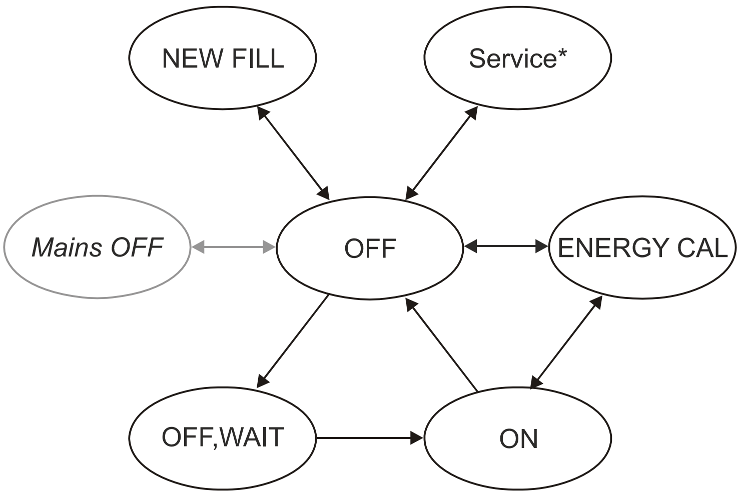
3.5.5 High Energy Mode

The High Energy mode is available for laser devices that are designed to operate at lower repetition rates (COMPex*Pro* 50,COMPex*Pro* 110, COMPex*Pro* 205). This mode increases the top end of the HV range when working at repetition rates below 11 Hz. This ensures that all laser pulses are emitted with the maximum pulse energy. The High Energy mode is automatically selected at lower repetition rates when the laser device is being internally triggered.

With external triggering, the High Energy mode has to be selected through a corresponding software command. When the High Energy mode has been selected, the repetition rate in the external trigger mode is limited to 11 Hz. The increased HV range becomes available when gas actions have been disabled by selecting the no gas replacement (NGR) mode (see Section 3.5.3).

3.6 Operating Modes

Figure 31 provides an overview of the available operating modes and the possible transitions between these modes. These operating modes are briefly described in the following subsections.



*PASSIVATION FILL, TRANSPORT FILL, PURGE <xy> LINE, FLUSH <xy> LINE, HI, PGR etc.

Figure 31: *Operating mode transition diagram*

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3.6.1 OFF Mode

The laser control software automatically selects the OFF mode after switching on the laser device. The OFF mode can also be selected by the user from the ON mode to stop laser operation.

In the OFF mode, all laser device system modules, except the high voltage (HV) power supply, are switched on. No laser operation occurs (no emission of laser radiation).

This mode should be selected if the laser device is not directly in use.

From the OFF mode, the user can select service actions, start the laser or switch off the laser. Before reaching the ON mode, the laser passes through the OFF, WAIT mode.

3.6.2 OFF, WAIT Mode

The temporary OFF, WAIT mode is automatically passed through when the laser is starting. In this mode, the laser controller waits for the HV power supply to enter standby and the gas circulation fan to start. This condition remains for approx. 8 seconds.

3.6.3 ON Mode

The ON mode can only be started from the OFF mode. In this mode, the HV power supply is switched on and laser operation starts with the currently active operating mode (energy management selection) and parameter settings.

When the laser is in the ON mode and the shutter is open, the workpiece will be irradiated with laser light pulses.

For short breaks in laser operation, the shutter can be closed. If a longer break is necessary, it is advisable to switch back to the OFF mode.

3.6.4 NEW FILL Mode

The NEW FILL mode is actuated by the user to execute a complete refill of the laser tube. The complete gas mixture is pumped out of the laser tube and replaced by fresh gas.

The NEW FILL mode is actuated from the OFF mode. At the end of the new fill, the OFF mode is automatically reactivated.

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3.6.5 ENERGY CAL Mode

The ENERGY CAL mode is a maintenance / service routine that enables the internal energy monitor to be calibrated according to an externally measured energy reading. Consequently, it should only be actuated by correspondingly authorized and trained maintenance or service personnel.

The ENERGY CAL mode can be actuated from either the OFF or ON mode. At the end of the energy calibration procedure, the mode that was active immediately before starting the energy calibration will be automatically reactivated.

3.6.6 Service / Maintenance Modes

Service or Maintenance modes are dedicated routines that enable specific service or maintenance actions to be carried out, e.g. flush or purge a gas line, fill the laser tube with the transportation fill etc.

These modes should only be actuated by correspondingly authorized and trained maintenance or service personnel.

3.7 Laser Operation

All operating modes and laser parameters can be set and the status requested from the laser control board through the handheld keypad or external PC connected to the laser device’s serial interface. The status of the laser device is indicated by a status code that is indicated on the handheld keypad display or output through the serial interface together with the currently active operating mode. The meaning of the individual status codes is described in Section 8 on page 245.

If a status code indicates an interlock or error that requires interaction with the user, solve the problem according to the information given in Section 8 on page 245.

The laser control software checks all data input for consistency. To prevent operating errors in case of corrupted or unreadable data output, the external computer controller should check all data for consistency that it receives from the laser control.

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4 SPECIFICATIONS

This section contains the specifications required to integrate the COMPex*Pro* into a laser assembly or laser unit.

Due to the COHERENT policy of continuous optimization of their laser devices, the data contained in this chapter is subject to variation.

Should information on separate sheets (e.g. laser data sheets) attached to or provided together with this Instruction Manual contradict the information in this chapter, the information on the separate data sheets has priority.

4.1 Laser Beam Parameters

4.1.1 COMPex*Pro* 50

Characteristic	ArF	KrF
Nominal wavelength	193 nm	248 nm
Max. repetition rate	50 Hz	50 Hz
Max. pulse energy	100 mJ	150 mJ
Max. average power	4 W	7 W
Energy stability, 1 Sigma	2%	1%
Pulse duration (FWHM), typical	15 ns	20 ns

4.1.2 COMPEx*Pro* 102

Characteristic	Version	ArF	KrF	XeCl	XeF
Nominal wavelength	F	193 nm	248 nm	-	351 nm
	XeCl	-	-	308 nm	-
Max. repetition rate	F	20 Hz	20 Hz	-	20 Hz
	XeCl	-	-	20 Hz	-
Max. pulse energy	F	200 mJ	400 mJ	-	200 mJ
	XeCl	-	-	250 mJ	-
Max. average power	F	4 W	7 W	-	4 W
	XeCl	-	-	5 W	-
Energy stability, 1 Sigma	F	2%	1%	-	2%
	XeCl	-	-	2%	-
Pulse duration (FWHM), typical	F	15 ns	20 ns	-	20 ns
	XeCl	-	-	20 ns	-

4.1.3 COMPEx*Pro* 110

Characteristic	Version	ArF	KrF	XeCl	XeF
Nominal wavelength	F	193 nm	248 nm	-	351 nm
	XeCl	-	-	308 nm	-
Max. repetition rate	F	100 Hz	100 Hz	-	100 Hz
	XeCl	-	-	100 Hz	-
Max. pulse energy	F	200 mJ	400 mJ	-	200 mJ
	XeCl	-	-	250 mJ	-
Max. average power	F	12 W	30 W	-	12 W
	XeCl	-	-	16 W	-
Energy stability, 1 Sigma	F	2%	1%	-	2%
	XeCl	-	-	2%	-
Pulse duration (FWHM), typical	F	15 ns	20 ns	-	20 ns
	XeCl	-	-	20 ns	-

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4.1.4 COMPex*Pro* 201

Characteristic	Version	ArF	KrF	XeCl	XeF
Nominal wavelength	F	193 nm	248 nm	-	351 nm
	XeCl	-	-	308 nm	-
Max. repetition rate	F	10 Hz	10 Hz	-	10 Hz
	XeCl	-	-	10 Hz	-
Max. pulse energy	F	400 mJ	700 mJ	-	300 mJ
	XeCl	-	-	500 mJ	-
Max. average power	F	4 W	5 W	-	3 W
	XeCl	-	-	3.5 W	-
Energy stability, 1 Sigma	F	2%	1%	-	2%
	XeCl	-	-	2%	-
Pulse duration (FWHM), typical	F	15 ns	20 ns	-	20 ns
	XeCl	-	-	20 ns	-

4.1.5 COMPex*Pro* 205

Characteristic	Version	ArF	KrF	XeCl	XeF
Nominal wavelength	F	193 nm	248 nm	-	351 nm
	XeCl	-	-	308 nm	-
Max. repetition rate	F	50 Hz	50 Hz	-	50 Hz
	XeCl	-	-	50 Hz	-
Max. pulse energy	F	400 mJ	700 mJ	-	300 mJ
	XeCl	-	-	500 mJ	-
Max. average power	F	15 W	30 W	-	15 W
	XeCl	-	-	20 W	-
Energy stability, 1 Sigma	F	2%	1%	-	2%
	XeCl	-	-	2%	-
Pulse duration (FWHM), typical	F	15 ns	20 ns	-	20 ns
	XeCl	-	-	20 ns	-

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4.2 Physical Dimensions and Weight

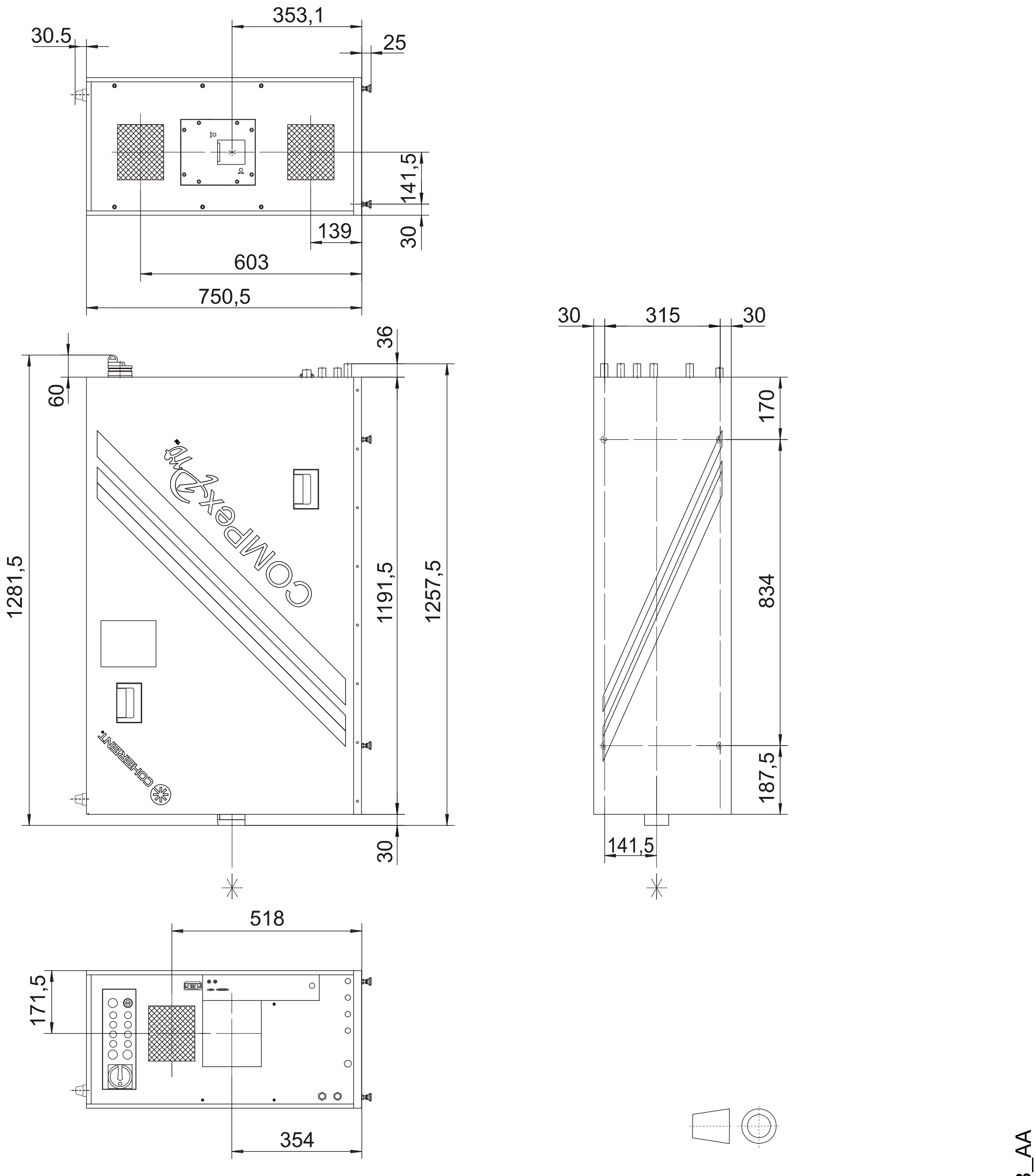

Figure 32: *Dimensions: COMPexPro 50 / COMPexPro 100*

Overall dimensions of laser device (l × w × h)	1282 mm × 375 mm × 793 mm (50.5 in × 14.8 in × 31.2 in)
Overall weight	270 kg (594 lbs)

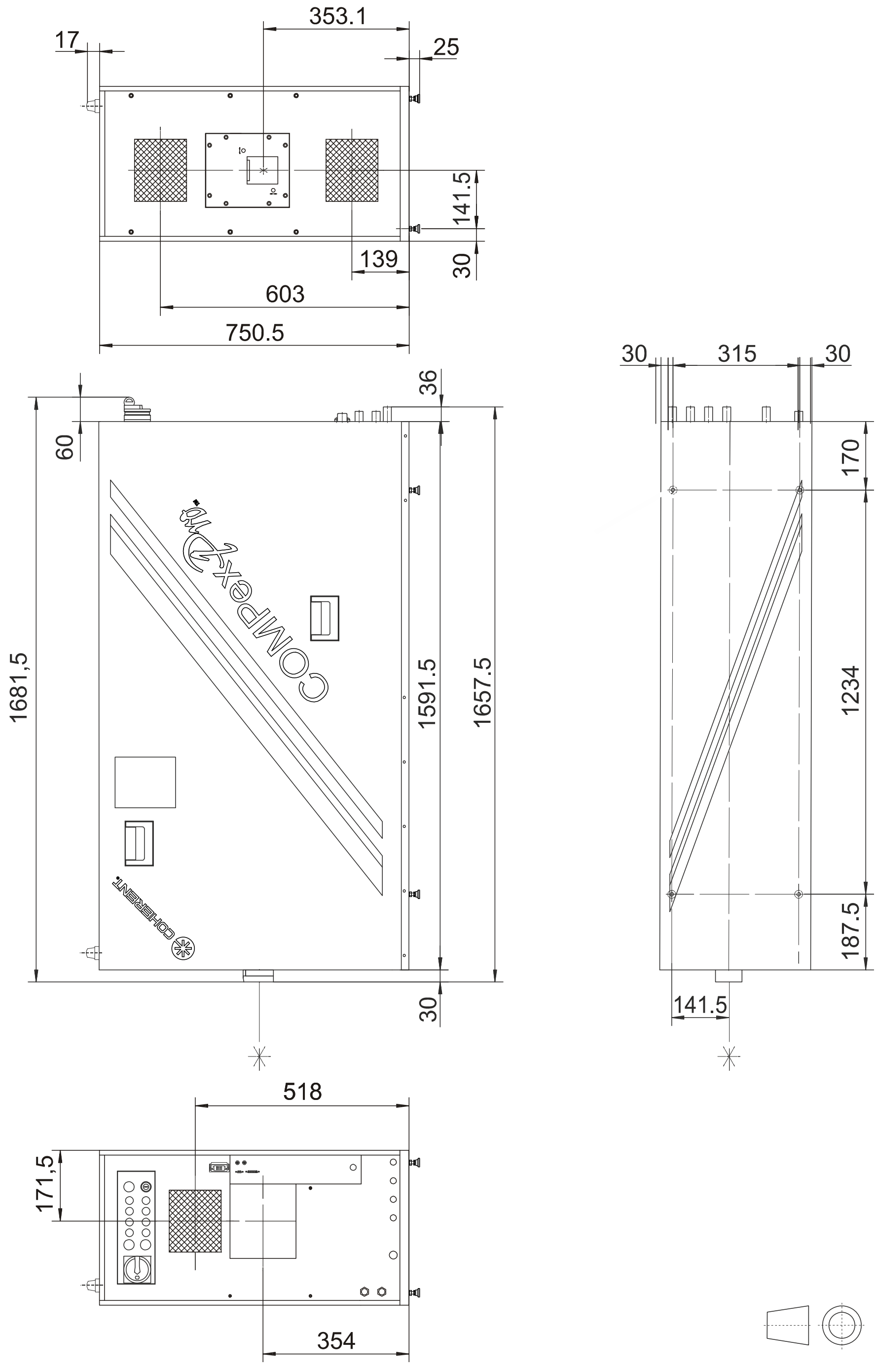

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Figure 33: *Dimensions: COMPexPro 200*

Overall dimensions of laser device (l × w × h)	1682 mm × 375 mm × 793 mm (66.2 in × 14.8 in × 31.2 in)
Overall weight	325 kg (715 lbs)

4.3 Space Requirements

The laser device must be located in sufficient space to allow the maintenance covers to be removed and installation and maintenance work to be performed.

Maintenance Area, 50 and 100 Series

The total floor area required for the installation of the COMPex*Pro* 50 or COMPex*Pro* 100 Series is 2500 mm × 1400 mm (98.5 in × 55.1 in). The plan of this area, which is designated the maintenance area, is indicated in detail in Figure 34.

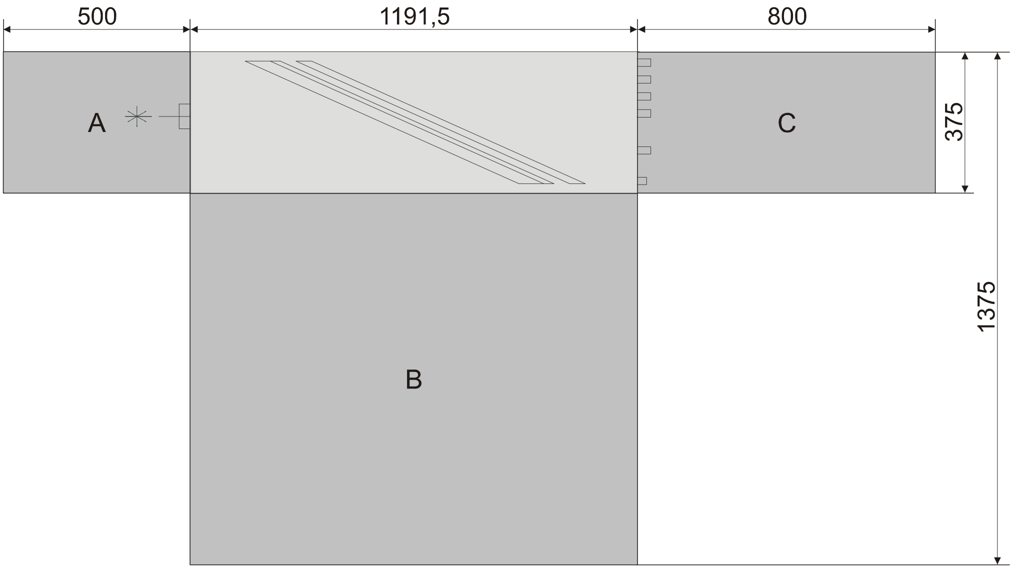

Figure 34: *Maintenance area: COMPexPro 50 / COMPexPro 100*

Position in Figure 34	Maintenance area	Dimensions B x T [mm]	Area [m^2]
	Device footprint	1191.5 x 375	0,45
A	Beam exit side	500 x 375	0,19
B	Service area	1191.5 x 1000	1,19
C	Connection side	800 x 375	0,30

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Maintenance Area, 200 Series

The total floor area required for the installation of the COMPex*Pro* 200 Series is 3000 mm × 1400 mm (118.1 in × 55.1 in). The plan of this area, which is designated the maintenance area, is indicated in detail in Figure 35.

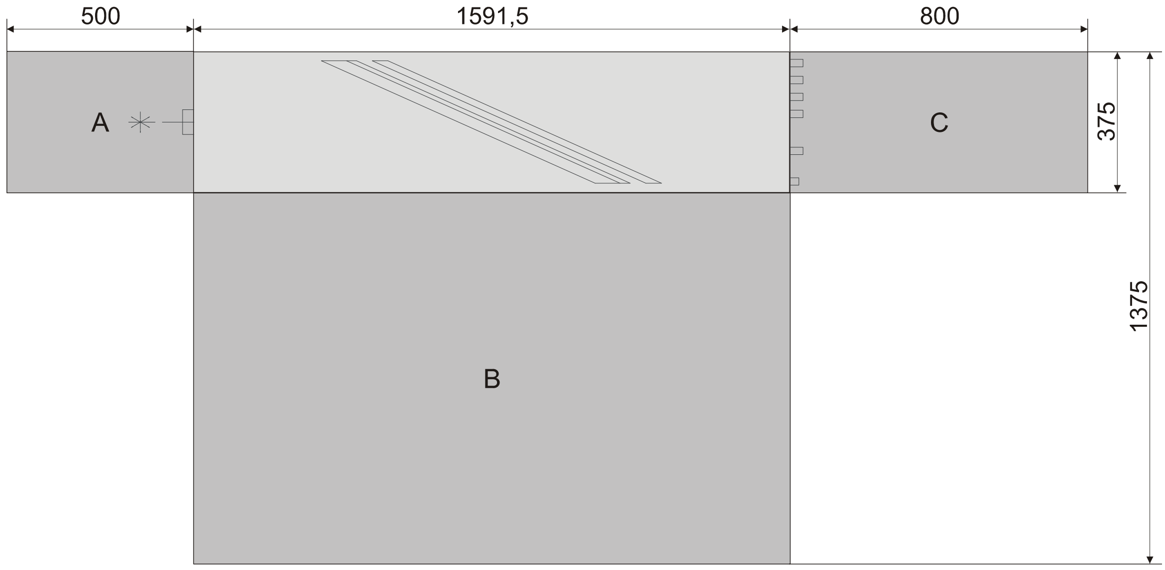

Figure 35: *Maintenance area: COMPexPro 200*

Position in Figure 34	Maintenance area	Dimensions B x T [mm]	Area [m^2]
	Device footprint	1591.5 x 375	0,60
A	Beam exit side	500 x 375	0,19
B	Service area	1591.5 x 1000	1,59
C	Connection side	800 x 375	0,30

Maintenance Height, All Models

All COMPex*Pro* laser devices require a maintenance height (height above base) of 1350 mm (53,2 in). When determining the necessary room height, take into account the required position of the main switch (see Section 4.5.3 on page 94).

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4.4 Center of Mass

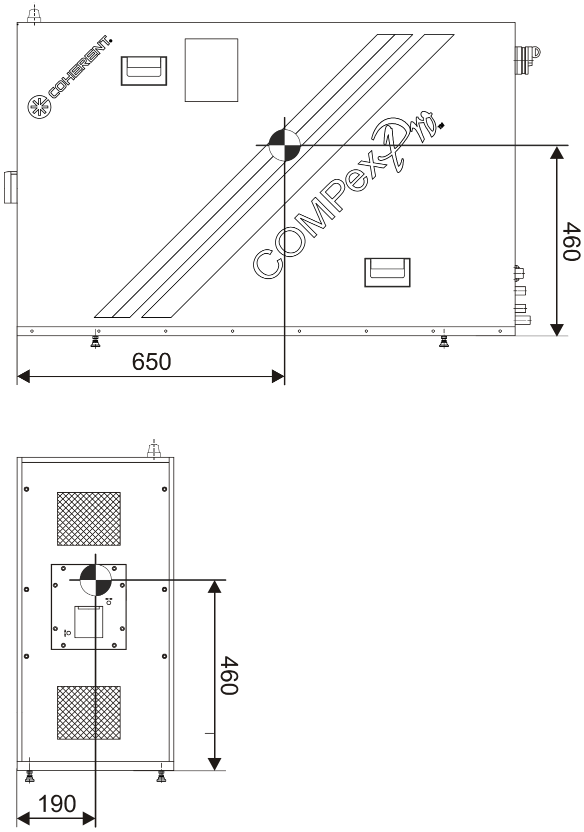

Figure 36: *Position of center of mass: COMPexPro 50 / COMPexPro 100*

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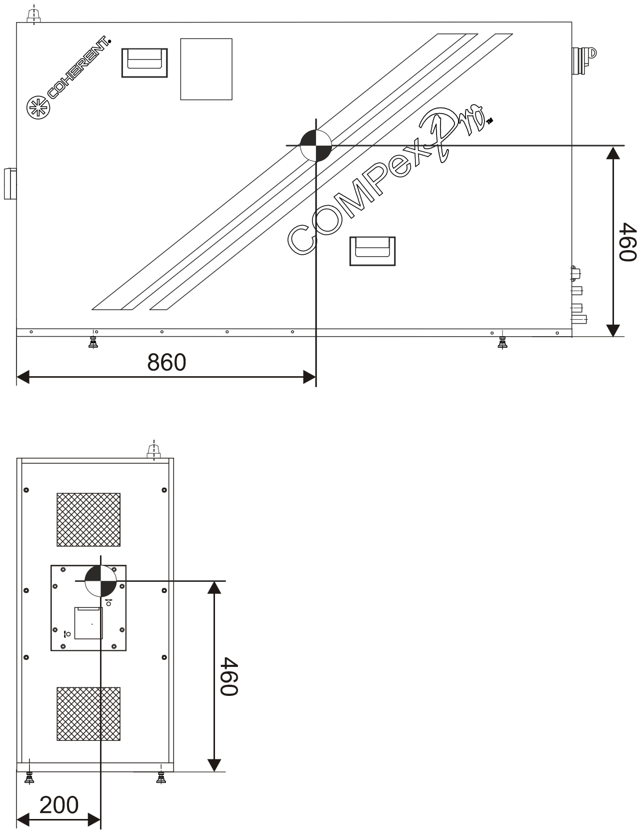

Figure 37: *Position of center of mass: COMPexPro 200*

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4.5 Mechanical Interface

4.5.1 Beam Exit Position

The COMPex*Pro* is equipped with four height-adjustable feet (see Section 4.5.2). These enable the beam exit position to be vertically adjusted from 378 mm to 418 mm (14.9 in to 16.4 in) above the base (locating surface) of the laser device.

The exact position of the beam exit aperture is shown in Figure 38 (A).

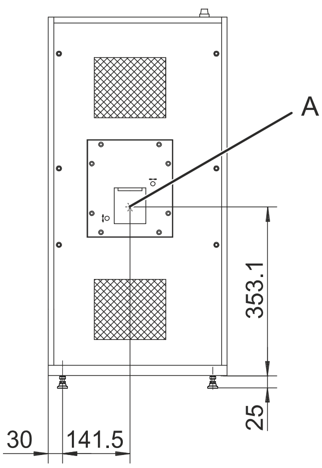

Figure 38: *Beam exit position*

The shutter plate at the beam exit position enables attachment of a beam delivery system (see Section 4.6.6 on page 109).

4.5.2 Foot Configuration

The laser device is equipped with four height-adjustable feet. The positions of the feet in relation to the footprint of the laser device and beam axis are shown in Figures 39 and 40.

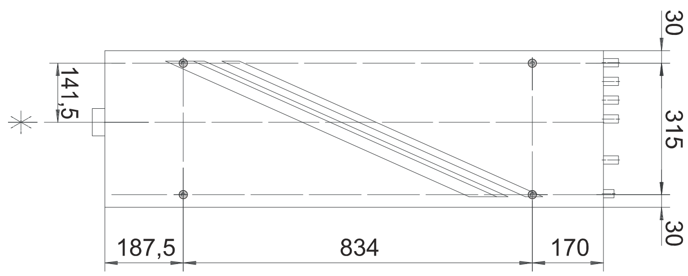

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Figure 39: *Positions of feet: COMPexPro 50 / COMPexPro 100*

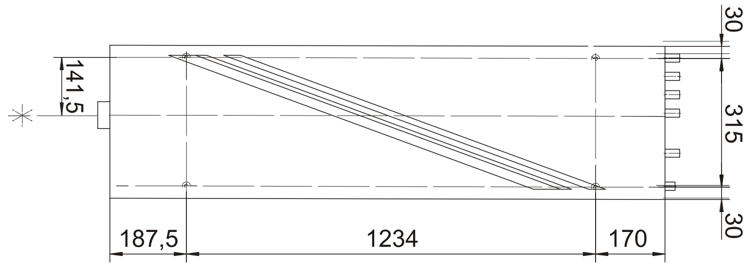

Figure 40: *Positions of feet: COMPexPro 200*

The configuration of each of the feet is shown in Figure 41.

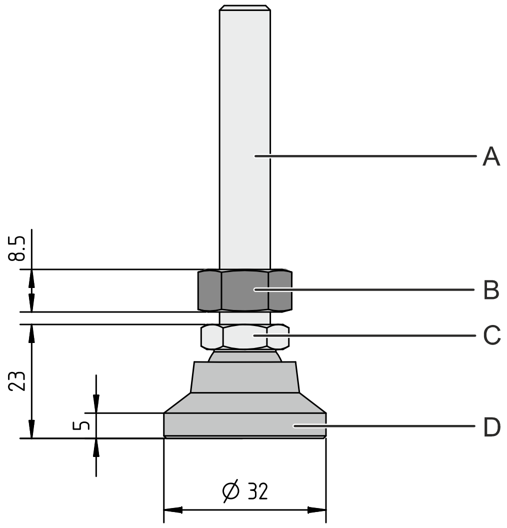

Figure 41: *Foot configuration*

Key to Figure 41:

A	Threaded rod	C	Adjustment nut
B	Counter nut	D	Foot

To compensate for permissible variations in the flatness of the floor, the four feet are height-adjustable within an adjustment range of 35 mm. Taking into account the minimum foot height of 31 mm, this means that the foot height adjustment range is from 31 mm to 66 mm (1.2 in to 2.6 in).

Each foot has a diameter of 32 mm. The shank of the foot has a size M10 thread.

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4.5.3 Main Switch Position

According to EN 60204-1, the main switch has to be positioned between 0.6 m and 1.9 m above the level of the floor on which the operator is to stand (see Figure 42). Where possible, this distance is not to exceed 1.7 m.

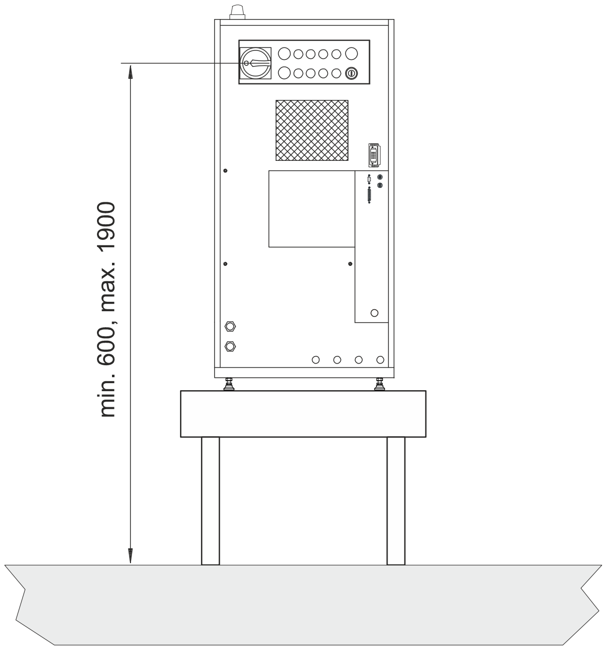

Figure 42: *Required main switch position*

The required position of the main switch is to be taken into account when choosing or configuring the supporting table or base for the COMPex*Pro*.

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4.5.4 Seismic Protection

For installations in areas that are susceptible to seismic activity, the end user is responsible for appropriately securing the laser device within their facility.

The end user is to make provision for:

– anchors that prevent movement or overturning of the laser device during a seismic event.

– suitable strain relief devices for all supply lines. These are to control the risks through leakage or escape of gases, liquids and electricity etc. during a seismic event.

For the exact configuration of the protective devices, always follow local regulatory requirements and take into account the center of mass of the laser device (see Section 4.4 on page 90) and site vulnerability of the facility or plant (e.g. soil conditions and total system design):

To allow seismic protection anchoring devices to be attached to the frame of the laser device, four through 20 mm holes with M10 internal threads are provided at the bottom of the laser device. The maximum length that the screws can be turned into the threads is 15 to 20 mm.

Figure 43 indicates the positions of the holes (A) in relation to the beam exit position, sides of the housing and laser device feet (B).
For further information about the location and configuration of the feet, please refer to Section 4.5.2.

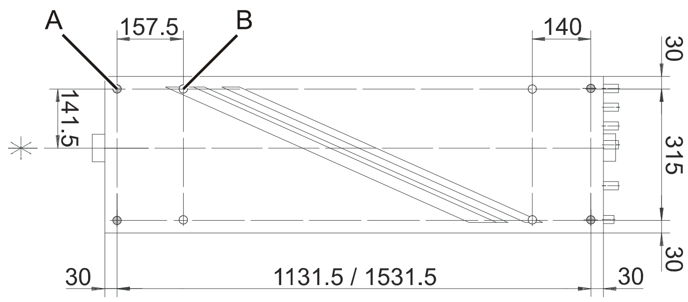

Figure 43: *Position of anchoring device location holes*

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4.6 Utilities / Connections

4.6.1 Overview

All external systems and devices are connected to one side of the COMPex*Pro*. This side is consequently referred to as the connection side (see Section 3.2.1 on page 56).

Regardless of the version, all COMPex*Pro* laser devices are equipped with the connections shown in Figure 44. Further information about these connections and the required utilities is contained in the indicated sections of this chapter.

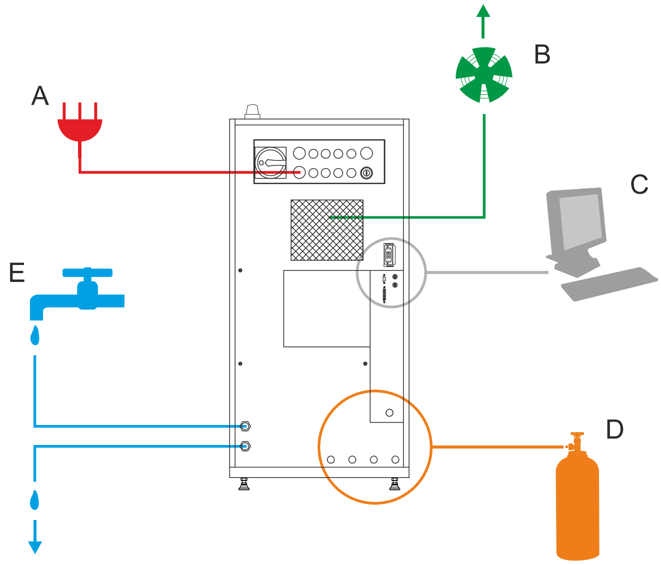

Figure 44: *Overview of connections*

Key to Figure 44:

A Electricity (see Section 4.6.3)
B Exhaust (see Section 4.6.5)
C Control and signal lines (see Section 4.6.7)
D Gases (see Section 4.6.2)
E Cooling water (see Section 4.6.4)

The exact connection and utility requirements depends on the version of the COMPex*Pro*, the wavelength it is to be operated at and the selected gas supply mode (separate gases or a premix gas, see Section 4.6.2 for further details).

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4.6.2 Gases

NOTICE
A) If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.
B) COHERENT recommends using premix / halogen gas cylinders for max. one year and all other gas cylinders for max. two years.

The active medium in an excimer laser is a mixture of a rare gas, a halogen gas and a buffer gas. The required gas mixture depends on the type of laser and wavelength at which the laser is to be operated.

Two fundamental versions of each laser type are available:

- The F-version operates with a fluorine gas mixture at a wavelength of 193 nm, 248 nm or 351 nm[a].
- The XeCl-version operates at a wavelength of 308 nm.

The required version has to be indicated when the laser device is ordered. Fluorine gas mixtures cannot be used with the XeCl-version and XeCl cannot be used with the fluorine version.

Both versions can either be supplied with a premix excimer laser gas mixture or with the constituent excimer laser gases from separate gas cylinders. Ensure that either the appropriate premix gas mixture or the constituent gases are available for the wavelength that the laser is to be operated at.

In addition to the excimer laser gas mixture, Helium (He) is required to purge and fill the laser tube and gas lines when certain maintenance actions are being carried out.

Nitrogen (N2) is required to purge the beam path and optics when operating the laser device at 193 nm. At other wavelengths, the use of purge gas is recommended as it minimizes contamination and increases optics lifetimes.

As the quality of the gas is critical to ensure correct performance of the laser, only use gases corresponding with the specifications indicated in this section.

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a. Except for COMPEx*Pro* 50 (see table in Section 4.6.1)

This section is subdivided as follows:

– Section 4.6.2.1 specifies the gas requirements when the laser device is to be supplied with a premix gas mixture.

– Section 4.6.2.2 (see page 99) specifies the gas requirements when the laser device is to be supplied with the constituent single gases.

– Section 4.6.2.3 (see page 101) specifies the purge gas required for laser operation at 193 nm and recommended for operation at other wavelengths.

– Section 4.6.2.4 (see page 102) indicates the responsibility for the provision of a suitable external gas supply system.

– Section 4.6.2.5 (see page 102) describes the gas connections and supply lines.

4.6.2.1 Premix Laser Gas

This section specifies the gas requirements when the laser device is to be supplied with a premix gas mixture. It provides an overview of the proportion of each of the constituent gases in the respective premix gas mixture. In each case, select the required premix gas according to the COMPex*Pro* version and wavelength that it is to be operated at.

Gas mixture	see corresponding table
Purity of constituent gases	- F_2: 99% (2.0) - HCl: 99.9995% (4.5) - Ar, Kr, Xe: 99.9995% (4.5) - Ne: 99.9995% (4.5) - He: 99.9995% (4.5)
Inlet pressure range	4.4 bar (abs) to 5.2 bar (abs)
Flow rate range	0.8 l/s to 3.0 l/s

COMPex*Pro* 50

193 nm (ArF)	248 nm (KrF)
0.13% F2 4.51% Ar 95.36% Ne	0.13% F2 3.42% Kr 96.45% Ne

COMPex*Pro* 102 / COMPex*Pro* 110

193 nm (ArF)	248 nm (KrF)	308 nm (XeCl)	351 nm (XeF)
0.17% F2 5.33% Ar 16.50% He 78.00% Ne	0.12% F2 3.03% Kr 96.85% Ne	0.13% HCl 0.03% H2 1.88% Xe 97.96% Ne	0.18% F2 0.46% Xe 99.36% Ne

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COMPEx*Pro* 201 / COMPEx*Pro* 205

193 nm (ArF)	248 nm (KrF)	308 nm (XeCl)	351 nm (XeF)
0.16% F2 6.25% Ar 93.59% Ne	0.09% F2 3.82% Kr 96.09% Ne	0.08% HCl 0.02% H2 2.78% Xe 97.12% Ne	0.19% F2 12.83% He 0.45% Xe 86.53% Ne

In addition to the premix gas line, an inert gas line also has to be connected. This is required to purge and fill the laser tube and gas lines when carrying out certain maintenance actions.

Type of gas	He
Purity	99.995%
Inlet pressure range	4.4 bar (abs) to 5.2 bar (abs)
Flow rate range	0.8 l/s to 3.0 l/s

4.6.2.2 Single Laser Gases

This section specifies the gas requirements when the laser device is to be supplied with the constituent single excimer laser gases. It provides the exact specifications and connection requirements of the individual gases.

In each case, select the required gases according to the COMPEx*Pro* version and wavelength that it is to be operated at. The required gases for the available types of laser and possible wavelengths are shown in the following table.

Type	Wavelength	Required Laser Gases			
		Halogen	Rare	Buffer	Inert
COMPEx*Pro* 50	248 nm	F2 in He[a]	Kr	Ne	He[b]
	193 nm	F2 in He[a]	Ar	Ne	He[b]
COMPEx*Pro* 100 series	351 nm	F2 in He[a]	Xe	Ne	He[b]
	308 nm	HCl, H2 in He	Xe	Ne	He[b]
	248 nm	F2 in He[a]	Kr	Ne	He[b]
	193 nm	F2 in He[a]	Ar	Ne	He
COMPEx*Pro* 200 series	351 nm	F2 in He[a]	Xe	Ne	He
	308 nm	HCl, H2 in He	Xe	Ne	He[b]
	248 nm	F2 in He[a]	Kr	Ne	He[b]
	193 nm	F2 in He[a]	Ar	Ne	He[b]

a. Ne can be used instead of He
b. Required for laser maintenance only

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Halogen

Fluorine (F2 in He)

Type of gas	5% F2 in He[a]
Purity	99.95%
Inlet pressure range	4.4 bar (abs) to 5.2 bar (abs)
Flow rate range	0.05 l/s to 0.5 l/s

a. Ne can be used instead of He

Hydrogen Chloride (HCl, H2 in He)

Type of gas	4.5% HCl and 0.9% H2 in He
Purity	99.995%
Inlet pressure range	4.4 bar (abs) to 5.2 bar (abs)
Flow rate range	0.05 l/s to 0.5 l/s

Rare

Argon (Ar)

Type of gas	Ar
Purity	99.995%
Inlet pressure range	4.4 bar (abs) to 5.2 bar (abs)
Flow rate range	0.05 l/s to 0.5 l/s

Krypton (Kr)

Type of gas	Kr
Purity	99.995%
Inlet pressure range	4.4 bar (abs) to 5.2 bar (abs)
Flow rate range	0.05 l/s to 0.5 l/s

Xenon (Xe)

Type of gas	Xe
Purity	99.995%
Inlet pressure range	4.4 bar (abs) to 5.2 bar (abs)
Flow rate range	0.05 l/s to 0.5 l/s

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Buffer

Neon (Ne)

Type of gas	Ne
Purity	99.995%
Inlet pressure range	4.4 bar (abs) to 5.2 bar (abs)
Flow rate range	0.8 l/s to 3.0 l/s

Inert

In addition to the constituent excimer laser gases, an inert gas line also has to be connected. This is required to purge and fill the laser tube and gas lines when carrying out certain maintenance actions.

Helium (He)

Type of gas	He
Purity	99.995%
Inlet pressure range	4.4 bar (abs) to 5.2 bar (abs)
Flow rate range	0.8 l/s to 3.0 l/s

4.6.2.3 Purge Gas

NOTICE
Risk of serious damage to the laser tube!
Nitrogen is only intended for purging the beam path and optics.
Never fill nitrogen into the laser tube or excimer laser gas supply lines.

Nitrogen (N2) is required to purge the beam path and optics when operating the laser device at 193 nm. This prevents the formation of ozone and ensures that the specified performance levels are attained. At other wavelengths, the use of purge gas minimizes contamination and increases optics lifetimes.

Type of gas	N2
Purity	99.999%
Flow rate range	8 l/min to 12 l/min

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4.6.2.4 External Gas Supply System

The final user is responsible for providing an external gas installation that fulfils local gas safety regulations and the requirements of the locally applicable risk management plan. For further information, consult the gas supplier and the institute responsible for occupational safety and health at the installation location (for example, NIOSH, National Institute for Occupational Safety and Health, in the USA).

4.6.2.5 Gas Connections

The positions of the individual gas connections on the laser device are shown in Figure 45.

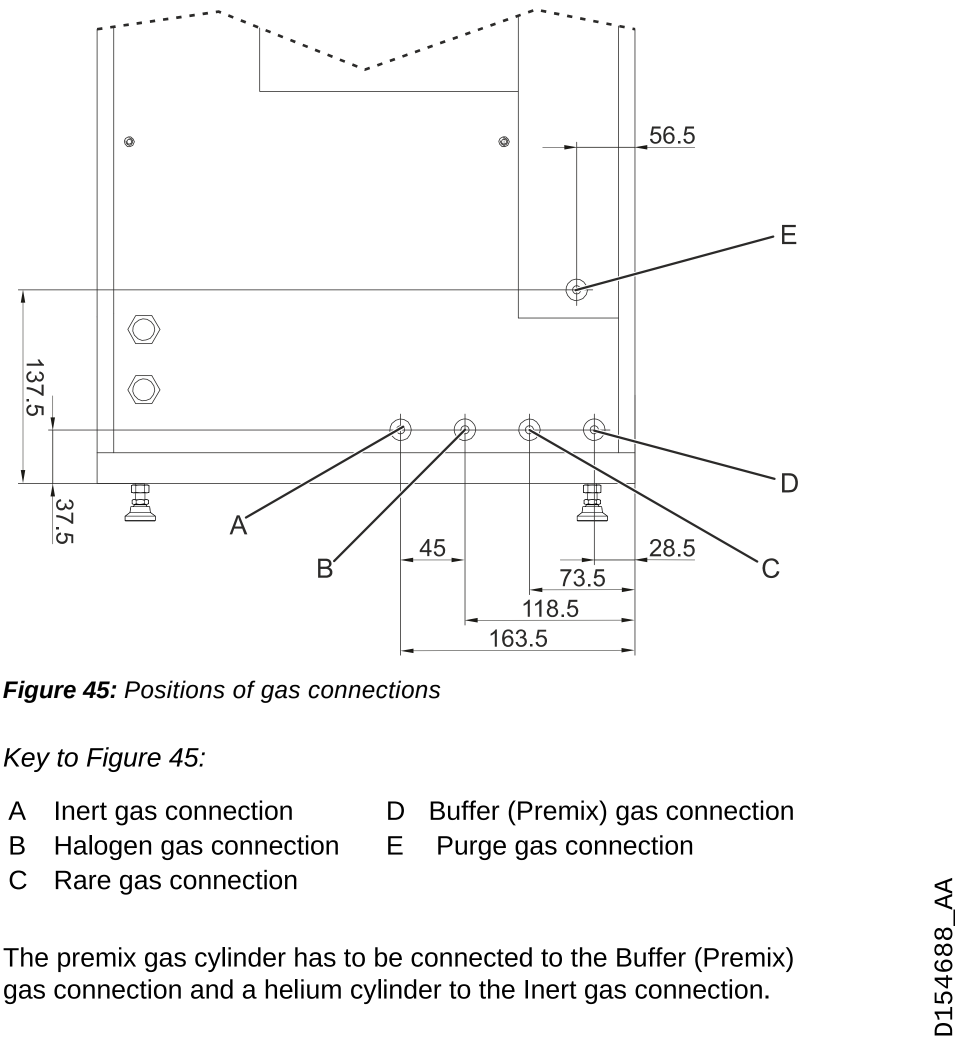

Figure 45: *Positions of gas connections*

Key to Figure 45:

A	Inert gas connection	D	Buffer (Premix) gas connection
B	Halogen gas connection	E	Purge gas connection
C	Rare gas connection		

The premix gas cylinder has to be connected to the Buffer (Premix) gas connection and a helium cylinder to the Inert gas connection.

For safety reasons, the halogen or premix gas supply line from an external gas cylinder should have a double wall tubing. A halogen protection cover is provided as an accessory with the laser device. This cover shall always be fitted to the gas connection that contains halogen, i.e. it has to be fitted to the Halogen connection with single gas supply and the or Buffer connection with premix gas supply.

Specifications:

Gas connections	6 mm Gyrolok (male thread on laser device)
Gas lines	316 L stainless steel, electropolished inside, 6 mm outer diameter, degreased

Each gas line requires an overpressure restriction device that limits the line pressure at the connection to the laser device to 7 bar (abs.) in case of failure.

It is the responsibility of the customer to provide suitable control devices and fail-safe means of pressure and flow limitation to ensure that there is no risk of excess pressure or flow at the respective gas inlet connections. In addition, each gas supply line shall contain a suitable dedicated mechanical shut-off valve.

Gas connections that are not used have to be sealed off with the stainless steel caps that are supplied with the laser device.

4.6.3 Electricity

NOTICE
A) To prevent serious mains supply line damage, the mains supply line must be installed with strain-relief in a cable channel.
B) In certain areas, local regulations require a breaking capacity larger than 1.5 kA for 208 V or 230 V operation. In this case, a 16 A, characteristic C circuit breaker with a minimum breaking capacity of 10 kA has to be inserted in the mains power supply for the laser device.
C) If operation with an external transformer is necessary, make sure that the transformer is correctly connected to the mains power source. Otherwise, there is the risk of serious damage to the laser device.

The COMPex*Pro* has an internal mains transformer that enables connection to a local mains electrical supply corresponding with the following specifications:

Nominal voltage	104 VAC / 120 VAC / 208 VAC / 230 VAC
Voltage range	Nominal voltage ± 10%
Frequency	50 Hz / 60 Hz
Wires	2 + PE

The internal mains transformer is factory set according to the required local voltage and frequency.

The other electrical specifications for the respective version and local voltage configuration are indicated in the following table:

Version	Voltage	Phases	Power	Full load amps	Machine OCP rating	Amp rating largest load	Short circuit current rating
50	104 VAC	1	1.5 kVA	15 A	12 A	12.5 A	10 kA
	120 VAC	1	1.5 kVA	13 A	12 A	12.5 A	10 kA
	208 VAC	2	1.5 kVA	7 A	16 A	12.5 A	1.5 kA
	230 VAC	1	1.5 kVA	6 A	16 A	12.5 A	1.5 kA
102	104 VAC	1	1.5 kVA	12 A	12 A	12.5 A	10 kA
	120 VAC	1	1.5 kVA	11 A	12 A	12.5 A	10 kA
	208 VAC	2	1.5 kVA	8 A	16 A	12.5 A	1.5 kA
	230 VAC	1	1.5 kVA	6 A	16 A	12.5 A	1.5 kA
110	104 VAC	1	3 kVA	24 A	12 A	12.5 A	10 kA
	120 VAC	1	3 kVA	22 A	12 A	12.5 A	10 kA
	208 VAC	2	3 kVA	15 A	16 A	12.5 A	1.5 kA
	230 VAC	1	3 kVA	13 A	16 A	12.5 A	1.5 kA
201	104 VAC	1	1.5 kVA	12 A	12 A	12.5 A	10 kA
	120 VAC	1	1.5 kVA	11 A	12 A	12.5 A	10 kA
	208 VAC	2	1.5 kVA	8 A	16 A	12.5 A	1.5 kA
	230 VAC	1	1.5 kVA	6 A	16 A	12.5 A	1.5 kA
205	104 VAC	1	3 kVA	24 A	12 A	12.5 A	10 kA
	120 VAC	1	3 kVA	22 A	12 A	12.5 A	10 kA
	208 VAC	2	3 kVA	15 A	16 A	12.5 A	1.5 kA
	230 VAC	1	3 kVA	13 A	16 A	12.5 A	1.5 kA

Connection to the mains power supply wall socket is provided through a 5 m long mains cable that is hard wired to the laser device. No mains plug is fitted.

The customer is responsible for obtaining and fitting a mains wall plug suitable for the applicable specifications indicated in this section. This plug shall be configured according to the locally applicable electrical standards (e.g. EN 61010-1) and be fitted by a qualified electrician.

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The exact positions of the electrical connections on the laser device are shown in Figure 46.

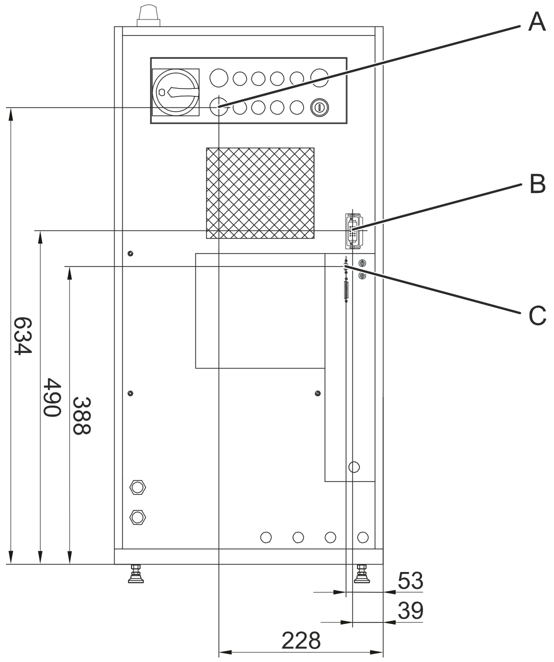

Figure 46: *Positions of electrical connections*

Key to Figure 46:

A Mains cable
B Remote connector (see Section 4.7 on page 115)
C COM1 connector (see Section 4.6.7.2 on page 113)

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4.6.4 Cooling Water

All COMPex*Pro* laser devices are fitted with cooling water connections which enable the laser tube to be cooled at higher repetition rates.

Under normal operating conditions:

– the COMPex*Pro* 102 and COMPex*Pro* 201 are fully air-cooled.

– the COMPex*Pro* 50 and COMPex*Pro* 110 require water cooling at repetition rates of 20 Hz and above.

– the COMPex*Pro* 205 requires water cooling at repetition rates of 10 Hz and above.

As an option, each COMPex*Pro* can be factory fitted with a built-in temperature stabilization facility that optimizes the gas temperature of the laser tube by regulation of the water flow.

As particles in the cooling water can clog the coolant circuit, the final user is to provide and maintain a fine line filter in the external cooling water supply line immediately in front of the shut-off valve for the laser device.

Do not use deionized water.

The cooling water specifications are listed below.

Water flow rate	1 l/min to 5 l/min
Water temperature at inlet	10° C to 20° C[a]
Static water pressure	2 bar to 4 bar
Dynamic water pressure drop (in/out)	2 bar to 4 bar
Heat transfer to water	< 1.5 kW
Electrical resistance	10 kΩ cm to 100 kΩ cm
Suspended particle size	< 200 µm
Hardness	< 100 ppm Ca
pH range	6.5 to 8

a. When setting the cooling water temperature, take into account the dew point. Set the inlet temperature of the cooling water in accordance with the ambient air temperature and relative humidity to prevent dew forming on the water lines in the laser device.

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Additives

When the laser device is cooled by a once-through cooling system, cooling water additives are not required.

If the laser device is to be operated in conjunction with a recirculating cooling water system, the following additives can be used:

Recommended additive:

- for corrosion protection and anti-freeze protection	Antifrogen N®
- for corrosion protection	10 ppm 1H-Benzotriazol

Water Connections

The locations of the cooling water connections on the laser device are indicated in Figure 47.

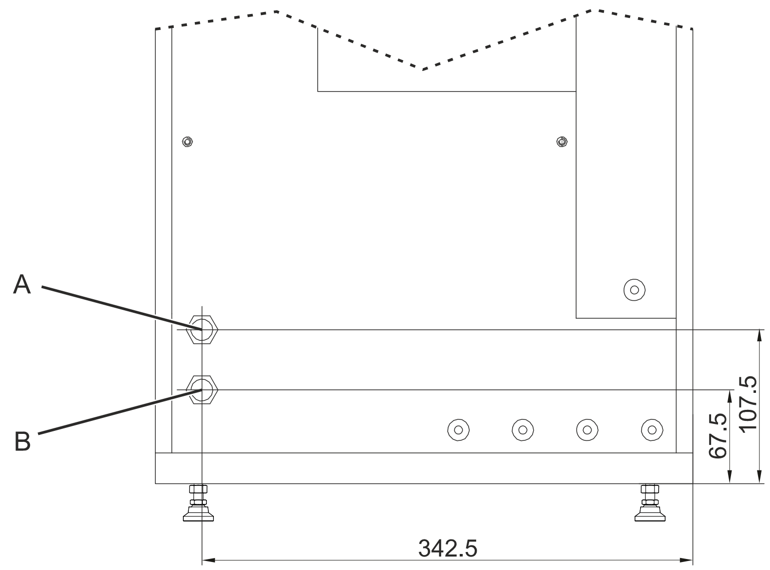

Figure 47: *Cooling water connections*

Key to Figure 47:

A Cooling water inlet

B Cooling water outlet

Specifications:

Water connector size	½” (outer diameter) pipe
Supplied water lines	two ½” (inner diameter) hoses, length: 3 m (118.1 in)

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4.6.5 Air Intake / Exhaust

Except for the laser tube at higher repetition rates (see Section 4.6.4), all components in the laser device are cooled by ambient air.

To ensure an adequate supply of cooling air, the laser device has to be situated in the specified maintenance area (see Section 4.3 on page 88). This area has to comply with the specified environmental conditions (see Section 4.7.2 on page 115).

The laser device has two air intakes on the beam exit side (see Figure 48, A) and a central exhaust outlet with moderate flow rate on the connection side (B).

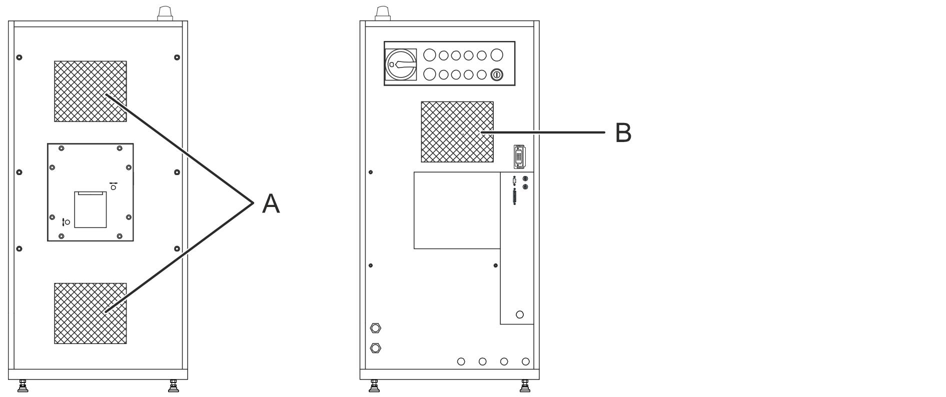

Figure 48: *Location of air intake and exhaust*

WARNING
Toxic gas hazard!
Permanently connect the laser device exhaust to an appropriate ventilation system. Make sure that the exhaust is not connected to the ducting of systems that are used to process breathing air (e.g. air conditioning systems).

Under normal operating conditions, the exhaust air does not contain toxic gases or by-products. With certain failure scenarios, however, the exhaust air may contain small concentrations of halogen gas or ozone. Consequently, the laser device has to be connected to an appropriate fume extraction or industrial ventilation system. A 3 m (118.1 in) long exhaust hose and the required attachment fittings are supplied with the laser device.

The exhaust specifications are indicated below.

Air flow rate	200 m³/hour to 300 m³/hour
Air intake temperature	15 °C to 25 °C
Heat transfer to air	< 1 kW
Max. exhaust length	4 m (157.5 in)[a]
Exhaust diameter	150 mm (5.9 in)

a. An additional blower is required if the max. length is exceeded

When planning the external exhaust system, always take into account the plant requirements indicated in Section 2.2.5.5 on page 40.

Make sure that the air flow in the area of the laser device is sufficient to continually replace the quantity of air that is extracted through the exhaust. Depending on the size and configuration of the room containing the laser device, it may be advisable for the user to provide forced ventilation and/or an air flow monitoring system.

4.6.6 Beam Delivery System

A guiding system is required to deliver the laser beam from the beam exit of the laser device to the processing station. The beam delivery system is to be configured in accordance with the layout of the final customers's fabrication facility. For laser devices purchased together with a beam delivery system, please refer to the beam delivery system documentation for further information.

The exact position of the beam exit from the laser device is indicated in Section 4.5.1 on page 92.

To connect the beam delivery system with the laser device's beam exit, the beam delivery tube is to be mounted on the beam shutter using the four 10 mm M4 threaded holes provided.

The dimensions and hole pattern of the shutter plate are shown in Figure 49. The shutter is manufactured from aluminum alloy (AlMg3).

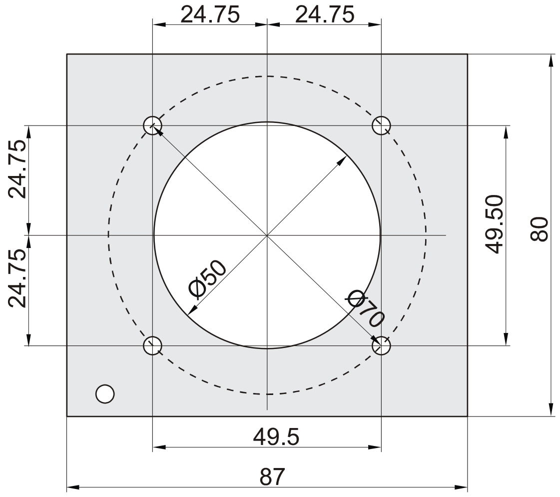

Figure 49: *Mechanical interface of the beam shutter*

The responsibility for the correct and sufficient connection of the laser beam exit to an appropriate beam delivery system lies entirely with the supplier of the final equipment assembly.

The entire beam path of Class 4 lasers, including the target area, should be hermetically sealed by an enclosure equipped with interlocks that prevents operation of the laser system unless the enclosure is properly secured. The beam path shall, insofar as possible, be free of specularly reflective surfaces and materials which would be combustible if irradiated by the beam.

The supplier of the final equipment assembly should ensure after installation of the beam delivery system that no laser radiation exceeding maximum permitted exposure (MPE) values arises at the connection between the laser device and the beam delivery system. Measurements in accordance with statutory requirements must be carried out by an authorized body to ensure that the MPE-values are not exceeded.

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4.6.7 Control and Signal Lines

Figure 50 shows the layout of the connections on the connector panel.

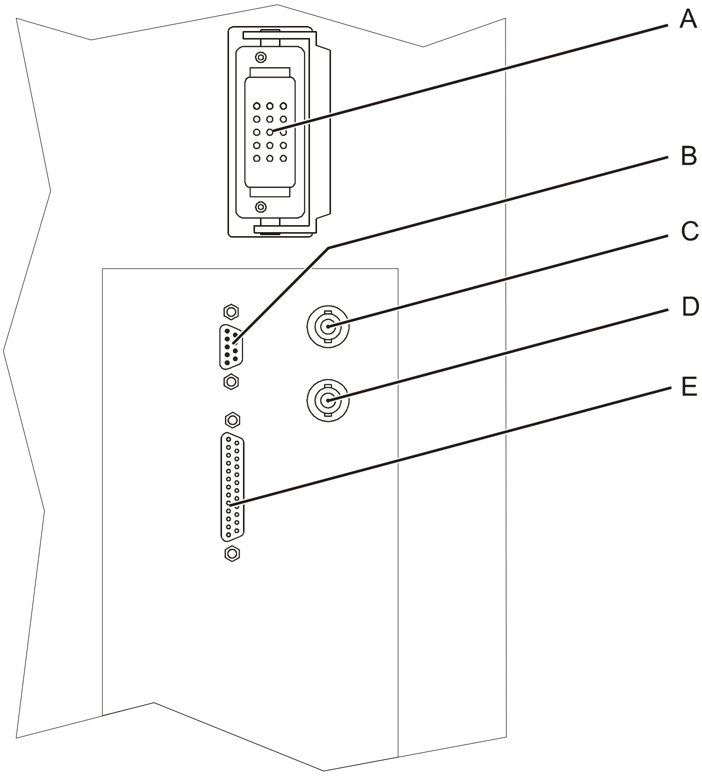

Figure 50: *Layout of connector panel*

The table below contains a key to Figure 50 and provides an overview of the configuration of the control and signal connections. The gender of the connector (where indicated) relates to the chassis part on the laser device and not the connector on the cable. The cables have to be provided with the corresponding plugs.

Pos.	Designation	Type	Purpose	Further information
A	Remote	15 pin Harting, female	Safety connections	Section 4.7
B	COM1	9 pin sub D, male	Serial interface for input/output of operating modes and parameters	Section 4.6.7.2
C	Sync Out	BNC	Output of synchronization signal	Section 4.6.7.5
D	Trigger In	BNC	Input of external trigger signal	Section 4.6.7.4
E	COM2 (TERMINAL)	25 pin sub D, female	Serial interface (handheld keypad configuration) for input/output of operating modes and parameters	Section 4.6.7.3

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As a positioning guide, Figure 46 on page 105 shows the exact locations of the Remote and COM1 connectors.

The following subsections provide an overview of the control and signal lines. For detailed information about pin configurations, signal definitions and commands/signals used please refer to the separate Interfacing Manual.

4.6.7.1 Remote Connector

The Remote connector is a 15 pin Harting HAN 15D female connector that enables the laser device to be connected to external emergency shutdown circuits (see Figure 51).

Pin Assignment and Connections

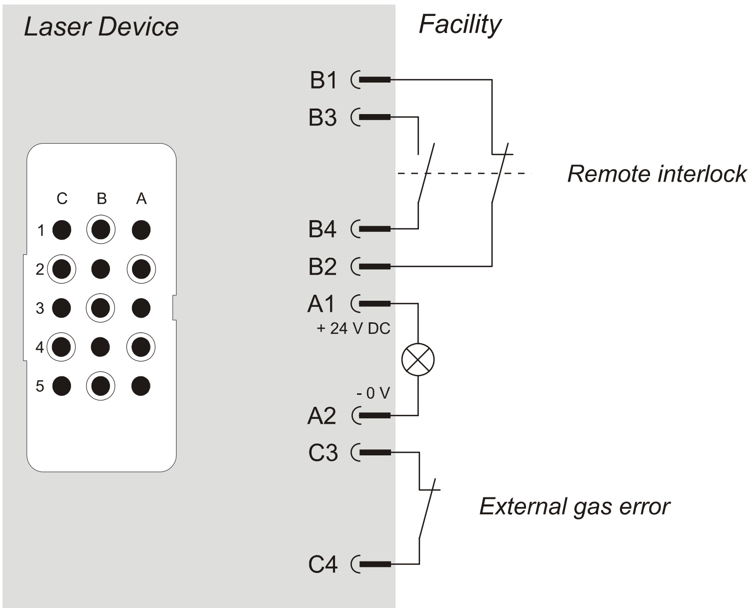

Figure 51: *Remote connector pin assignment and connections*

Signal	Pins	Type	Purpose	Specifications
Laser radiation warning lamp	A1 + A2	Output	External warning lamp that lights when laser radiation is being emitted	24 V DC 100 mA
Emergency Stop	B1 + B2	Input	ISO 13849-1 performance level d connection. B3 and B4 have to be open and B1 and B2 have to be closed to enable the emission of laser radiation	Potential-free contacts
	B3 + B4	Input		
External gas error	C3 + C4	Input	Contact has to be closed if the external gas supply system is correctly operating	

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4.6.7.2 Serial Interface (COM1)

COM1 is a 9 pin Sub-D, male serial interface (standard RS232C). It can be switched by the user through a pushbutton on the handheld keypad to enable the connection of one of the following:

– a diagnostics computer,

– an external computer control system (remote computer) that uses the current protocol (see separate Interfacing Manual),

– a control system designed for an earlier version of the COMPex, COMPex*Pro* or LPX series laser device (backward compatibility). With this setting, not all commands offered by the current laser control software will be supported. In addition, as the status code table has changed, status codes sent by the laser device may not be recognized or correctly interpreted by the external control system. A list of the currently applicable status codes is contained in Section 8.1 on page 246.

Alternatively, this port can be deactivated by the user to prevent the input of conflicting commands.

4.6.7.3 Serial Interface (COM2, Terminal)

COM2 (Terminal) is a 25 pin Sub-D, female serial interface (standard RS232C). It is configured for the connection of the handheld keypad supplied as standard with the laser device. If required, an external computer can be connected to this terminal instead of the handheld keypad. This computer has to use the same protocol as the handheld keypad (see separate Interfacing Manual).

4.6.7.4 Trigger In

NOTICE
Unexpected triggering may damage the laser tube.
To avoid unexpected triggering, never connect or disconnect the external trigger cable while the laser is running.

TRIG. IN is a BNC socket that enables the laser be triggered from an external source (trigger generator).

Signal level	3.3 VDC to 5 VDC, TTL
Pulse duration	10 µs to 100 µs
Trigger edge	positive slope
Delay ext. trigger to light pulse:[a]	
- without COD	2 µs
- 50 with COD	9500 µs
- 102 with COD	12500 µs
- 110 with COD ≤ 26 kV	9500 µs
- 110 with COD > 26.kV	12500 µs
- 201 / 205 with COD	18000 µs
Delay, drift	< 200 µs
Jitter ext. trigger to light pulse	< ± 25 ns (pulse-to-pulse)

a. For further information, see Section 3.3.4 on page 64

4.6.7.5 Sync. Out

SYNC. OUT is a BNC socket that enables the output of a signal that informs an external device that a trigger signal (either internal or external) has just been given.

Signal level	3.3 VDC to 5 VDC, TTL
Pulse duration	50 µs
Delay sync. out to light pulse[a]	0.5 µs

a. For further information, see Section 3.3.4 on page 64

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4.7 Environmental Conditions

4.7.1 Transport and Storage Conditions

The following climatic conditions must be maintained while transporting and during temporary storage of the laser device:

Air temperature	-20 °C to +50 °C (4 °F to 122 °F)[a]
Humidity	< 70% RH

a. Blow out all cooling water before transport and storage

The laser device can be transported by airfreight.

It is important that the units are not subjected to rapid changes in temperature or relative humidity.

4.7.2 Operating Environmental Conditions

It is essential that the site chosen for the installation of the laser device meets the specified environmental conditions.

Air temperature	15 °C to 25 °C
Temperature change	2 °C / hour
Humidity	30% RH to 70% RH
Pressure change	< 10 mbar / hour
Altitude above sea level	< 2000 m
Pollution	class 9 or better (according to ISO 14644-1)
Recommended illumination[a]	more than 500 lx
Housing IP classification[b]	IP20

a. for operation with optional handheld keypad; according to DIN 5035, part 2 for precise machining

b. If the housing IP classification is not sufficient for the selected operating environment, an additional housing or filter system may be provided. In this case, ensure that adherence to the other operating requirements indicated in this section will not be affected.

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5 OPERATING / DISPLAY ELEMENTS

This chapter describes the pushbuttons, switches and devices etc. for operating the laser device as well as the lamps and other display elements that indicate the status of the laser device.

5.1 Overview

Operation of the laser device is started and stopped through the switches and pushbuttons on the operating panel (see Figure 52, A). After being started, the laser device is operated through the laser control software (laser control program). As standard, the user interface to the laser control program is the handheld keypad that is supplied with the laser device.

The status of the laser device is indicated by lamps on the operating panel, the laser radiation warning lamp (see Figure 52, B) and the handheld keypad screen display.

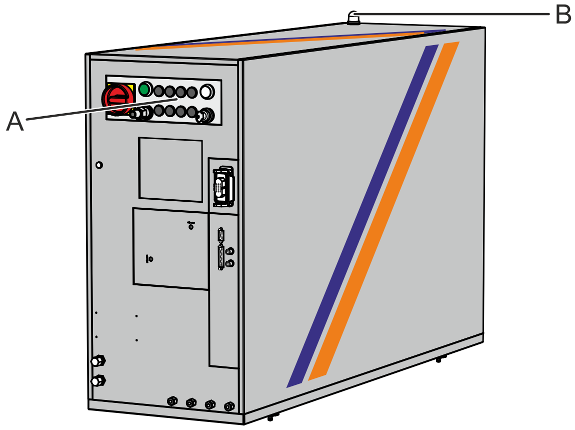

Figure 52: *Location of operating panel and laser radiation warning lamp*

The operating / display elements on the operating panel are described in Section 5.2 on page 118.

The location and purpose of the laser radiation warning lamp is described in Section 5.3 on page 120.

The fundamental design of the handheld keypad is described in Section 5.4 on page 120.

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5.2 Operating Panel

The operating elements that start up and shut down the COMPex*Pro* laser device are located on the operating panel at the rear of the laser head (see Figure 53). These operating elements are described in the following subsections.

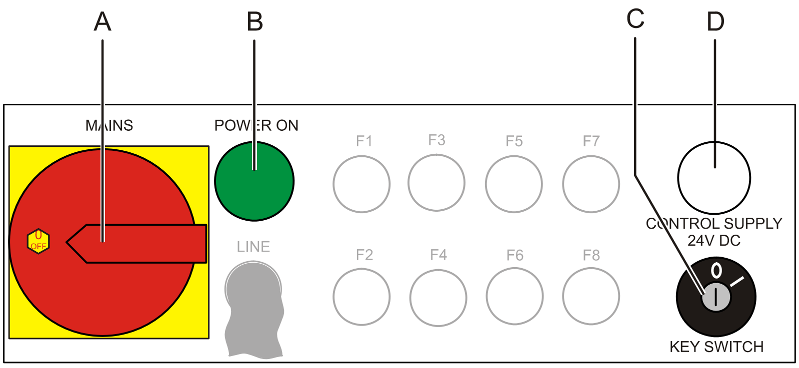

Figure 53: *Operating panel*

Key to Figure 53:

A Main switch
B Power ON lamp
C Key switch
D Control voltage lamp

5.2.1 Main Switch

Line Voltage On and Off Function

Set the main switch to “ON” to apply line voltage to the laser device. The mains voltage is the operating voltage of certain consumers in the laser device (e.g. thyratron). The laser cannot, however, be started until the control voltage is activated through the key switch.

Set the main switch to “OFF” to disconnect the laser device from the mains power. When shutting down the laser device under normal circumstances, do not switch off the main switch until the software has indicated that the software has been safely shut down.

When the main switch has been set to “OFF”, a lockout device corresponding with OSHA 29 CFR 1910.147(c)(5) can be inserted into the opening at the bottom of the switch.

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Emergency Off Function

The main switch is configured for use as an Emergency Off (EMO) device according to IEC/EN 60204-1. In case of an emergency, turn the main switch to the “OFF” position to immediately disconnect the laser device from the mains power.

NOTICE
Incorrect operation causes unnecessary downtime and spoilage!
Actuating Emergency OFF (EMO) immediately shuts down the system without finishing the current job.
Only use the EMO function in cases of emergency, i.e. to prevent injury or serious material damage.

5.2.2 Power ON Lamp

The POWER ON lamp indicates that line voltage is applied to the laser device. When this lamp is illuminated, the control voltage circuits in the laser device can be enabled by actuating the key switch.

5.2.3 Key Switch

Insert the key into the key switch and set to “I” to activate the control voltage. The control voltage is required for the control modules in the laser device (e.g. local control board).

Prior to enabling the control voltage, the main switch has to be set to “ON”.

Set the key switch to “O” to disable the control voltage power.

WARNING
Prevent injury or damage through unauthorized operation!
Always remove the key from the key switch and keep in a safe place when the laser device is not to be operated.

The key cannot be removed from the key switch in the I setting.

5.2.4 Control Voltage Lamp

The CONTROL SUPPLY 24V DC lamp indicates that the control voltage has been activated. When the lamp lights, the control modules in the laser device are ready to operate.

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5.3 Laser Radiation Warning Lamp

The laser radiation warning lamp (see Figure 54, A) is a white lamp that is situated in a clearly visible location on top of the laser device.

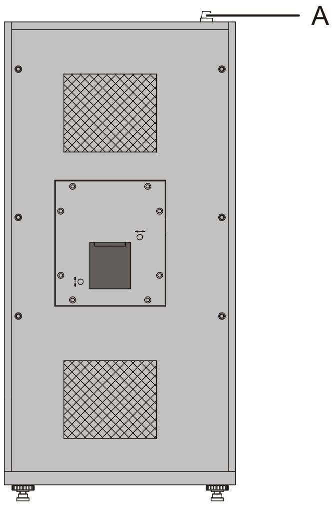

Figure 54: *Laser radiation warning lamp*

This lamp lights whenever the laser is operating; i.e. laser radiation is being emitted.

For safety reasons, the lamp is visible when wearing excimer laser eye protection. It will continue to light for five seconds after laser emission has ceased. This indicates that the discharge capacitors are charged and that there is the risk of self-firing.

5.4 Handheld Keypad

All descriptions in this section relate to CTERM hand-held keypad software version 4.71.

The handheld keypad (see Figure 55) controls the laser through the laser control module. It consists of a LCD display and membrane keyboard.

The operating elements on the handheld keypad are briefly described in the subsections indicated in the Key to Figure 55. For further information regarding the specific use of the keys within particular procedures, please refer to corresponding section in this manual.

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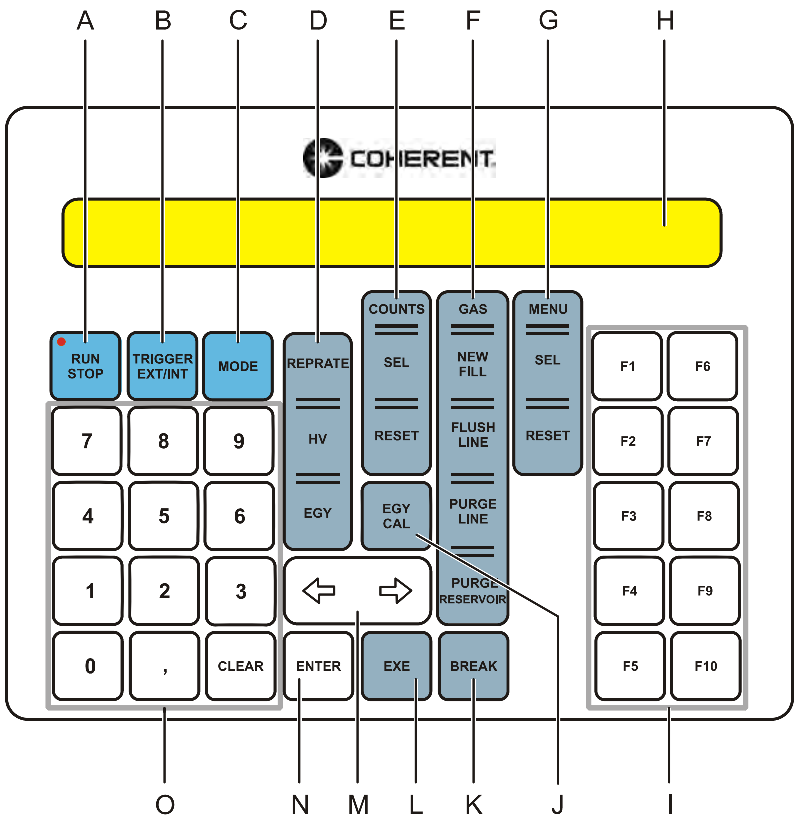

***Figure 55:** handheld keypad*

Key to Figure 55

A	RUN STOP key	(see Section 5.4.7 on page 124)
B	TRIGGER INT EXT key	(see Section 5.4.8 on page 125)
C	MODE key	(see Section 5.4.9 on page 126)
D	REPRATE / HV / EGY keys	(see Section 5.4.10 on page 127)
E	COUNTS keys	(see Section 5.4.12 on page 128)
F	GAS keys	(see Section 5.4.13 on page 129)
G	MENU keys	(see Section 5.4.14 on page 130)
H	Display	(see Section 5.4.1 on page 122)
I	Function keys	(see Section 5.4.15 on page 131)
J	EGY CAL key	(see Section 5.4.15 on page 131)
K	BREAK key	(see Section 5.4.6 on page 124)
L	EXE key	(see Section 5.4.5 on page 123)
M	Cursor keys	(see Section 5.4.3 on page 123)
N	ENTER key	(see Section 5.4.4 on page 123)
O	Numerical input keys	(see Section 5.4.2 on page 123)

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5.4.1 Display

LCD-display with 2 rows and 40 columns that indicates the current status and parameter settings of the laser as well as displaying prompts and error messages. Figure 56 shows a typical screen display that appears after powering up the laser device when the HV constant mode without gas actions (HV CONST NGR) and internal triggering are active.

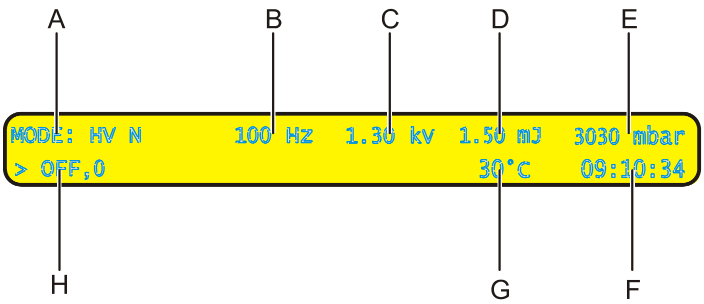

Figure 56: *Status and parameter settings display*

Key to Figure 56:

A	Running mode
B	Repetition rate (internally set)
C	Currently active charging voltage
D	Currently emitted beam output energy[a]
E	Laser tube pressure
F	Current time / date (alternating)
G	Currently active tube temperature / calculated output power
H	Currently active operating mode (laser status) and status code[b]

a. In the HV CONST mode and in the energy constant mode (EGY CONST) when the laser is running, the current value measured by the energy monitor is displayed. In the EGY CONST mode when the laser is off, the energy constant setpoint value is displayed.

b. For more information about the meaning of status codes for basic troubleshooting see Section 8 on page 245.

When the laser is running, the displays for time / date (F) and tube temperature / output power (G) will automatically change-over every few seconds.

After pressing one of the keys that enables a parameter setting to be changed (e.g. the MODE key), a prompt will appear in the bottom row of the display. Depending on the prompt, use the cursor buttons (right and left) to choose one of the items displayed in parentheses or use the numerical input keys to enter a numerical value. When additional input is required, this will be indicated by additional prompts in the bottom line of the display.

Unless otherwise indicated, confirm input by pressing ENTER and terminate a function by pressing BREAK.

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5.4.2 Numerical Input Keys

The numerical input keys (0 to 9 and decimal point) allow you to enter the numerical values that define parameters such as REPRATE (repetition rate), HV (charging voltage) and EGY (beam output power). The input is confirmed by pressing the ENTER key.

Incorrect entries can be terminated prior to pressing ENTER, by pressing the CLEAR key.

If the entered value is out of range, an audible warning occurs and the last accepted value is retained.

5.4.3 Cursor Keys

The cursor keys (cursor left, cursor right) allow you to select a menu item, i.e. one of the items displayed in parentheses in the bottom line of the display. Press the cursor key that moves the cursor in the direction of the required item and then press ENTER to confirm the selection.

When the last item in a list of available choices is reached, press the other cursor key to scroll back through the list in the opposite direction.

5.4.4 ENTER Key

The ENTER key is to be pressed to confirm numerical input or menu items selected with the cursor keys.

ENTER also has to be pressed to page through a menu.

5.4.5 EXE Key

The EXE (Execute) key is to be pressed to immediately start execution of the last selected function.

5.4.6 BREAK Key

The BREAK key is to be pressed to abort the currently active operation. Any unsaved changes will be lost.

If BREAK is pressed during laser operation, the laser immediately stops. Pressing BREAK during a gas action will immediately terminate the action.

BREAK can also be pressed during data input or menu item selection to terminate the action. In this case, the previously active setting is retained.

BREAK has to be pressed to clear an interlock after rectifying the reason for the interlock.

5.4.7 RUN STOP Key

The RUN STOP key starts and stops laser operation (emission of laser radiation).

When the laser is off (no radiation being emitted but laser device powered up), press RUN STOP to start laser operation. The prompt “RUN LASER” will appear. Press EXE to confirm that the laser is to start. After a short starting-up period, during which the mode OFF, WAIT is indicated, the laser automatically starts with the currently active operating parameters. Emission of laser pulses is indicated by a LED that lights in the corner of the RUN STOP key and the illuminated laser radiation warning lamp on top of the laser head.

When the laser is running, press RUN STOP to immediately stop laser emission. The laser radiation warning lamp and LED in the RUN STOP key will continue to light for a short period after the laser has stopped.

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5.4.8 TRIGGER INT EXT Key

The TRIGGER INT EXT key allows you to select the desired laser pulse triggering mode. After pressing TRIGGER INT EXT, the desired mode is selected with the cursor keys and confirmed by pressing the ENTER key. In all cases, laser operation is started by pressing the RUN STOP key (see Section 5.4.7).

- INT selects internal triggering. The laser pulses are triggered by the laser device’s internal trigger generator. The frequency (repetition rate) of the trigger pulses is set through the REPRATE key (see Section 5.4.10 on page 127).
- INTG selects internal gated triggering. The laser pulses are triggered according to the settings of the internal trigger generator when there is a low signal at the laser device’s external trigger socket.
- INT COUNTS selects the internal countdown triggering mode. A predetermined number of laser pulses will be fired according to the settings of the internal trigger generator.

  After pressing ENTER to confirm selection of the function, a prompt appears requesting the number of trigger pulses (COUNTS) that are to be fired. Enter the desired number of pulses and confirm with ENTER. The countdown of the preset number of trigger pulses starts each time that the laser is started. When the predetermined number of trigger pulses has been reached, laser emission will automatically stop.
- EXT selects external triggering. Laser pulses are triggered from an external trigger generator connected to the laser device’s external trigger socket. When the High Energy mode is available (see Section 3.5.5 on page 79), an additional request will appear after selecting external triggering.
- EXT COUNTS selects the external countdown triggering mode. A predetermined number of laser pulses will be fired according to the settings of the external trigger generator connected to the laser device’s external trigger socket.

  The counter in the EXT COUNTS mode is operated in the same way as the counter in the INT COUNTS mode.
- INTB selects operation with the internal burst generator. The laser is triggered by the internal trigger generator according to the current settings of the internal burst generator. The settings for the internal burst generator are defined through the function key F8 (see Section 5.4.15 on page 131).
- INTSB selects the internal single burst triggering mode. An external trigger signal starts a burst of internally triggered laser pulses. The burst length is defined through the function key F8.

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5.4.9 MODE Key

The MODE key allows you to select the desired running mode (see Section 3.5 on page 75).

- HV PGR selects the HV constant mode with gas actions. The high voltage remains constant and the output energy will gradually decrease. To compensate for this, the gas in the laser tube will be periodically replenished after a given number of pulses or a set time period. Depending on the PGR mode set through the function key F3 (see Section 5.4.15), the necessary gas action is either carried out automatically or the laser control software will issue a corresponding request.
- HV NGR selects the HV constant mode without gas actions. When the minimum output energy threshold is reached, the laser control software issues a low light interlock to indicate that the gas in the laser tube requires replacing.
- EGY PGR selects the energy constant mode with partial gas replacements. The high voltage (HV) is gradually increased to ensure that the output energy remains constant. When the HV reaches a preset value, the gas in the laser tube will be replenished and the HV value correspondingly reduced. With certain laser device configurations, gas actions can also be pulse-counter or timer controlled. Depending on the PGR mode set through the function key F3 (see Section 5.4.15), the necessary gas action is either carried out automatically or the laser control software will issue a corresponding request.
- EGY NGR selects the energy constant mode without partial gas replacements. When the maximum HV threshold is reached, the laser control software issues a warning to indicate that the gas in the laser tube requires replacing.
- EGYBURST PGR selects the energy burst mode with gas replenishment actions. This function is only available if the laser device is equipped with the optional POWERLOK/TIMELOK function (see Section 3.5.4 on page 78). Operation is similar to the constant energy mode with gas actions (see EGY PGR above). Additionally, the optional POWERLOK/TIMELOK function is activated to minimize power overshoots at the beginning of each burst of laser pulses.
- EGYBURST NGR selects the energy burst mode without gas replenishment actions. Operation is similar to the constant energy mode without gas actions (see EGY NGR above). Additionally, the optional POWERLOK/TIMELOK function is activated (see EGYBURST PGR above).

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5.4.10 REPRATE / HV / EGY Keys

The keys REPRATE, HV and EGY allow you to change the repetition rate, charging voltage and beam output energy value.

- REPRATE enables the repetition rate to be changed for internally triggered laser operations. The repetition rate determines the number of laser pulses per second, i.e. the value is specified in Hz.
- HV enables the charging voltage to be set for laser operation in the HV constant mode. Input is only possible when the HV NGR or HV PGR modes are selected.
- EGY enables the beam output energy value to be set for operations in the energy constant mode. The value is entered in mJ. Input is only possible when the EGY NGR or EGY PGR modes are selected.

In each case press the appropriate key to select the parameter to be changed (REPRATE, HV or EGY), enter the value through the numerical input keys and confirm the input by pressing ENTER.

5.4.11 EGY CAL Key

The EGY CAL key selects a routine that allows the internal energy monitor to be calibrated according to an externally measured energy reading.

NOTICE
The internal energy monitor is calibrated in the factory. Subsequent calibration is a maintenance procedure that is only to be carried by correspondingly authorized and trained maintenance or service personnel (see Section 7.10.1 on page 228).

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5.4.12 COUNTS Keys

The COUNTS keys enable you to display and, where applicable, reset the laser device’s counters. The available counters, their purpose and means of resetting are indicated in the following table:

Counter	Purpose	Counter Reset
Total	Indicates the number of laser pulses emitted since commissioning of the laser device	Non-resettable
User	Indicates the number of laser pulses emitted since the counter was last reset	By user
Maintenance	Indicates when certain maintenance actions (e.g. optics exchange) are next required	By user (after corresponding maintenance action)
New Fill	Indicates the number of laser pulses emitted since the last New Fill	Automatically after New Fill
HI	Indicates the number of mHIs performed since the last New Fill (see Section 3.5.2 on page 76)	Automatically after New Fill
PGR	Indicates the number of MHIs, PGRs and MPGRs performed since the last New Fill (see Section 3.5.2 on page 76)	Automatically after New Fill

- SEL indicates the current reading of the selected counter. After pressing COUNTS SEL, The desired counter is selected with the cursor keys and confirmed by pressing the ENTER key. If the suffix E3 is displayed, the counter reading is in thousands of pulses. All other readings are in individual pulses.
- RESET allows the User Counter and Maintenance Counter to be reset. After pressing COUNTS RESET, a menu appears enabling the counter to be reset. The desired counter is selected with the cursor keys and confirmed by pressing the ENTER key. The selected counter is reset to zero by pressing the EXE key.

NOTICE
The Maintenance Counter should only be reset by authorized personnel after the corresponding maintenance action has been performed.

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5.4.13 GAS Keys

The GAS keys allow various gas actions to be carried out. These gas actions are primarily required for maintenance operations and should, therefore, only be carried out by correspondingly authorized and trained personnel.

- NEW FILL enables one of the program routines to be started that fills the laser tube with fresh gas.

  The following selections are available:

  - NEW selects the new fill routine. This replaces the gas mixture in the laser tube with fresh excimer laser gases. The gases are filled according to the partial pressures defined in the currently active gas settings menu. The new fill procedure is described in detail in Section 7.5.1 on page 187.
  - TRANSP selects the transportation fill routine. This replaces the gas mixture in the laser tube with a gas fill that is suitable for the transport and storage of the laser device.
  - MAN. INERT selects the manual inert fill routine. This fills the laser tube with the gas connected to the INERT connection. This function is, for instance, required in case of a tube leakage to prevent ambient air from penetrating into the laser tube.

  In each case, select the desired option with the cursor keys, press ENTER to confirm the selection and EXE to start the procedure.

- FLUSH LINE enables the program routine to be started that evacuates a specific gas line for two seconds. After pressing FLUSH LINE, a prompt appears indicating the currently selected gas line and displaying the further choices in parenthesis. A different gas line is selected with the cursor keys and confirmed by pressing ENTER.

- PURGE LINE enables the program routine to be started that evacuates a specific gas line for five seconds before filling the line with the gas connected to the inert gas connection. After pressing PURGE LINE, a prompt appears indicating the currently selected gas line and displaying the further choices in parenthesis. A different gas line is selected with the cursor keys and confirmed by pressing ENTER.

- PURGE RESERVOIR enables one of the program routines to be started that purges the laser tube.

  The following selections are available:

  - PURGE TUBE evacuates the laser tube and fills it with the gas connected to the INERT connection to a pressure of 1050 mbar.
  - WIN EXCH starts the gas actions that are required for the tube optics exchange routine.

  Select the desired option with the cursor keys, press ENTER to confirm the selection and EXE to start the procedure.

5.4.14 MENU Keys

The MENU keys enable you to select or reset the laser device’s gas settings menus. These functions are only available in the OFF mode.

WARNING
Risk of exposure to halogen gas and serious equipment damage! Incorrect gas menu selection may result in excessive halogen concentrations in the laser tube. This results in sparking when the laser is switched on. Pumping this mixture out undiluted will overheat the halogen filter and exhaust, causing a gas leak.
The gas menu shall only be changed by authorized and correspondingly trained persons.
In case of an incorrect gas fill, immediately contact Coherent service before taking any further action!

- SEL allows different gas setting menus to be selected. To prevent injury or damage through unauthorized access to the gas menus, this function is password protected.

  Up to six gas menus are available. These are factory set according to the version of the laser device (F or XeCl) and, consequently, the gas mixtures that the laser can be operated with. The gas menu has to be changed when, for instance, the gas supply mode is changed from single gases to a premix gas (see Section 4.6.2.1 on page 98).

  Generally, the menus 1 to 3 are for single gases and the menus 4 to 6 are for premix gases. The F-version has single gas and premix gas menus for ArF, KrF and XeF. The XeCl-version has single gas and premix gas menus for XeCl. In each case, the gas mixture and gas supply mode relating to the gas menu are clearly displayed.

  After pressing ENTER to confirm the selection of the desired menu, the settings in the menu can be changed through numerical input.

- RESET allows you to reset the values in the currently active gas settings menu (gas partial pressures, gas mode and repetition rate) to their factory settings. After pressing MENU RESET, the gas settings are reset to their factory settings by pressing the EXE key.

  After using the MENU keys to change or reset the gas settings, a gas mismatch interlock will most likely be activated (status code 182). This can be rectified by performing a new fill according to the currently active gas menu settings.

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5.4.15 Function Keys

The function keys F1 to F10 allow various laser operating or display functions to be selected.

Function keys that are only intended for Maintenance or Service purposes are password protected.

- F1: help key that displays information about active interlocks and warnings. If no interlock or warning is active (status code 0), F1 will provide a list of all available interlocks and warnings.
- F2: switches off the low light function when the laser is off (not emitting radiation) or skips the warm-up period when the laser is in the warm-up phase.

  These password protected functions are provided for maintenance and troubleshooting purposes only and should, therefore, only be used by authorized and trained personnel.

  Never allow the laser to operate unattended when the low light function has been switched off.
- F3: enables a manual gas action or changes the PGR mode. After entering the required password, the desired function is selected through the cursor keys and confirmed with ENTER.

  GAS ACTION: enables a gas action to be performed at the request of the user (see Section 3.5.2 on page 76). The required gas action is selected through the cursor keys and ENTER and started by pressing EXE.

  PGR MODE: enables the PGR mode to be switched from Auto to Request and vice-versa.

  – In the Auto mode, PGRs will automatically be carried out.
  – In the Request mode, a warning (status code 104) will appear when a gas action is required.
- F4: shows the current filling level of the halogen filter. When 0 is pressed and the corresponding password is entered, the filling capacity indicator will be reset to 0. For safety reasons, only ever reset the halogen filter filling capacity indicator when the halogen filter has been exchanged.
- F5: switches the laser tube temperature regulation on or off. This password protected function is provided for maintenance and troubleshooting purposes only and should, therefore, only be used by authorized and trained personnel. The tube temperature regulation menu will remain active until BREAK is pressed.
- F6: a password protected function that starts a re-passivation fill if the laser device is supplied from separate gas cylinders. This evacuates the laser tube and fills it for re-passivation with a mixture of halogen and buffer gas.

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- F7: a password protected function that enables the energy regulation parameters to be checked and the parameter KP to be changed.
- F8: enables the pulse burst generator to be set.

  The required parameters are:

  – BST PULSES: number of pulses in a burst,
  – BST PAUSE: time period between bursts,
  – SEQ BURST: number of bursts in a sequence,
  – SEQ PAUSE: time period between burst sequences.
- F9: a multifunction key that changes the control terminal between Host and Terminal or deactivates the Charge On Demand (COD) function.

  The required function (CONTROL, COD) is selected with the cursor keys and confirmed with ENTER:

  – CONTROL switches control of the laser device between the device attached to COM1 (Host) or the handheld keypad attached to COM2 (Terminal). When the Host setting is active, operating parameters and messages are still indicated on the terminal. A corresponding message appears if there is any attempt to control the laser device through the handheld keypad when Host is active. The F9 Control function that switches control back to the handheld keypad remains active, however, at all times.
  – When COD is active (default choice), high voltage will only be available when a trigger signal is applied. Deactivation of COD reduces the delay between the trigger signal and laser pulse but increases the risk of self-firing (see Section 3.3.4 on page 64).
- F10: a multifunction key that selects the shutdown mode, the COM1 mode or time and date setting function.

  The required function (SHUTDOWN, COM1MODE, TIMEDATE) is selected with the cursor keys and confirmed with ENTER:

  – After selecting SHUTDOWN and pressing EXE, the control software and laser device will be shut down. The message “SWITCH MAINS OFF” appears on the handheld keypad display when the laser device is ready to be switched off.
  – COM1MODE enables the COM1 port to be deactivated or switched for the connection of a service computer, a computer using the latest control software commands or a computer with a control program written for an earlier laser device version.
  – TIMEDATE enables the laser device’s system clock to be set to the current locally-applicable time and date.

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6 OPERATION

This chapter describes the fundamental operation of the COMPex*Pro* excimer laser device. It is divided into the following sections:

– Section 6.1 describes the fundamental control modes of the laser device.

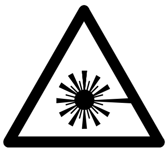
– Section 6.2 (see page 135) describes the routine to be performed to start-up the laser device.

– Section 6.3 (see page 141) describes laser operation through the handheld keypad.

– Section 6.4 (see page 162) describes the routine to be performed to shut-down the laser device.

– Section 6.5 (see page 164) describes the procedure to immediately shut down the laser device in case of an emergency (Emergency OFF, EMO).

The prerequisite for performing the procedures described in this chapter is the correct installation and regular maintenance of the laser device.



DANGER
Risk of eye and skin injury through laser radiation!
The COMPex*Pro* excimer laser device is a Class 4 laser product.
Avoid eye or skin exposure to direct or scattered laser radiation.

- Pay special attention to the general and specific laser safety aspects before starting operation (see Section 2 on page 11).
- If the laser device shows any defects, immediately switch off the laser device and solve the problem before starting the laser device again.

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6.1 Fundamental Control Modes

The exact procedures required to operate the COMPex*Pro* laser device depend on the currently active user interface to the laser control program (see Figure 57).

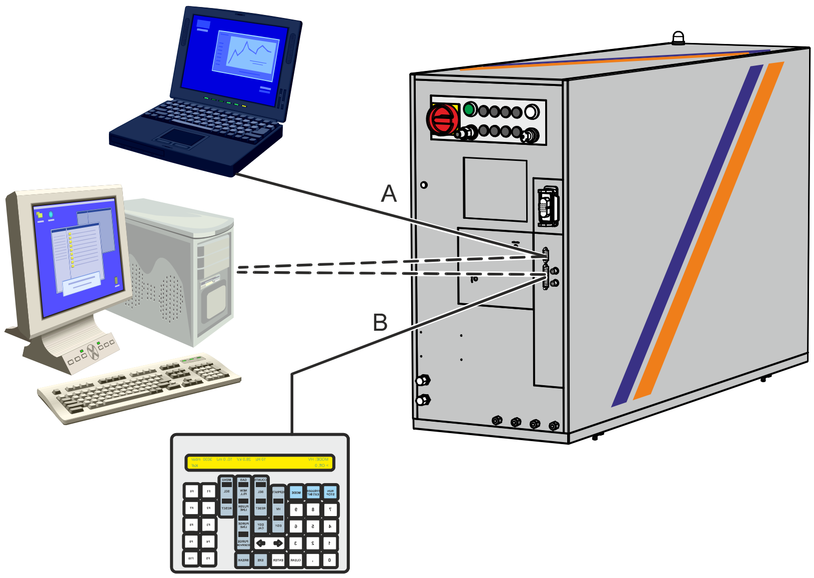

Figure 57: *User interfaces to laser control program*

The COMPex*Pro* is equipped with two serial interface ports: COM1 (A) and COM2 (B). Both ports allow direct communication with the laser control program. This program has a single set of commands that can be accessed through either of the ports.

COM1 is a 9 pole male interface. It is intended for communication with a remote diagnostics computer or an external computer control system (e.g. the central controller for the complete laser processing system). The communication mode through COM1 is user variable. This, for instance, enables connection of a service computer (for a remote diagnostics) and backward compatibility with programs written for earlier laser devices (see Section 6.3.7.4 on page 159).

COM2 is designated as the “Terminal” port. It is a 25 pole female interface that is configured for connection of the handheld keypad that is supplied as standard with the laser device. The handheld keypad is primarily intended to operate the laser during set-up, testing, servicing or maintenance routines.

The optional LASCONTROL software package is a user interface to the laser control software that is installed on a PC and used instead of the handheld keypad to control the laser.

When the laser is being operated during production sequences it is usually controlled through an external computer control system. This can be connected to either to COM1, as mentioned above, or to COM2 instead of the handheld keypad.

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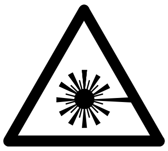
Unless otherwise indicated, this chapter describes laser operation through the handheld keypad. Operation of the laser through LASCONTROL is described in the separate LASCONTROL manual that is provided with the software package. For information about operating the laser through an external computer control system, please refer to the system integrator's (OEM) documentation. The set of commands that are to be used to control the laser device are described in the separate Interfacing Manual.

6.2 Start-Up Laser Device

6.2.1 Check Beam Path



DANGER
Uncontrolled direct or diffuse reflection of the laser beam can cause serious eye or skin injury!
Make sure that all housing covers are correctly fitted.
When working with an open beam, ensure that there are no reflective objects or particles in the path of the laser beam.

WARNING
Risk of fire or release of fumes!
Ensure that there are no materials in the path of the laser beam which may ignite or emit fumes when exposed to laser radiation.

Purpose

Ensure that the laser beam will be safely guided to the intended target.

Ideally, the COMPex*Pro* laser device is integrated in a Class 1 laser product. In this case, ensure that all housing covers, access panels and protective tubes are in place before starting-up the laser device.

When any part of the beam path is intentionally to remain open, thereby allowing human access to laser radiation exceeding Class 1 levels, strictly follow the procedures described in this section.

Tools and Materials

- None

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Preparation

1. Fully familiarize yourself with the safe working practices that minimize the hazards of ultraviolet laser light (see Section 2.2.3.1 on page 24).

Procedure

2. Ensure that all beam shields and beam stops in the area of the laser device and beam path are correctly installed, i.e. there is no risk of unwanted or uncontrolled beam emission.
3. Ensure that there are no unauthorized persons in the area of the laser device and beam path.
4. Ensure that there are no reflective objects or objects which can ignite and/or emit fumes in the beam path.
5. Secure the area of the laser device and beam path against the entry of unauthorized persons.
6. Ensure that appropriate warning notices are placed at all entrances to the area of the laser device and beam path.
7. Ensure that all persons that are to remain in the area of the laser device and beam path are issued with appropriate laser protective eyewear.

6.2.2 Turn On Cooling Water

Purpose

Turn on the water that cools the laser tube. This is necessary when operating the COMPex*Pro* 50 and 100 Series above 20 Hz and or when operating the COMPex*Pro* 200 Series above 10 Hz.

Tools and Materials

- None

Preconditions

- Cooling water supply as specified in Section 4.6.4 on page 106 connected to the cooling water inlet on the laser device.
- Cooling water outlet on the laser device connected to an appropriate drain.

Turning On the Cooling Water

1. Turn on the water supply at the source to the specified flow rate.
2. Where necessary, open the cooling water drain valve.

   If the laser device is not fitted with the automatic tube temperature regulation option, the water flow will have to be manually adjusted (see Section 6.2.5 on page 141).

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6.2.3 Turn On Gases

WARNING
Risk of toxic gas leakage!
To minimize the risk of gas leaks, keep the excimer laser gas cylinder valves closed except when the currently active operating mode or working action requires the external supply of gas.

This section describes gas handling for a straight-forward one gas source for one laser device system. The COMPex*Pro* may, however, be connected to an external gas handling system that serves a number of consumers. For exact information about operating the gas handling system, please refer to the system supplier’s instructions

Purpose

Turn on the externally supplied gases. We differentiate between excimer laser gases and the purge gas:

– The excimer laser gases are required for laser operation. The gases are to be turned on when running the laser in the energy constant mode (EGY CONST) or when performing a new gas fill, PGR or other gas action (e.g. purge laser tube prior to a window exchange).

– The purge gas purges the beam path within the laser device. This is necessary to prevent the formation of ozone when operating the laser at wavelengths shorter than approx. 240 nm (i.e. 193 nm). Nevertheless even when operating the laser at longer wavelengths (i.e. 248 nm), we strongly recommend that the beam path is purged, as this minimizes optic contamination.

NOTICE
A) If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.
B) The purge gas (nitrogen) has to be turned on at least 5 minutes before starting laser operation as this minimizes optics contamination and ensures that the specified performance levels are attained.

Tools and Materials

- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Gas cylinders connected to the appropriate connectors on the laser device.

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Turning On the Gases

NOTICE
Incorrect operation can damage the pressure regulator!
If pressure is applied to a pressure regulator with low secondary pressure, the pressure regulator membrane may become damaged. Always ensure that the pressure regulator is closed, before opening the gas cylinder valve.

1. Turn the valve on the pressure regulator (see Figure 58, A) of the first gas line counter-clockwise to its stop to ensure that the pressure regulator is closed.

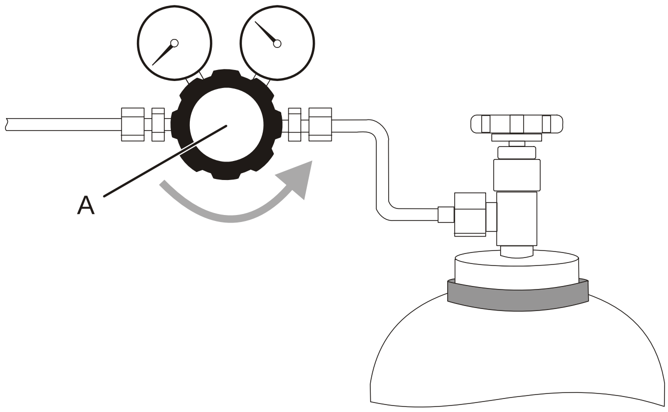

Figure 58: *Closing pressure regulator*

2. Open the valve on the gas cylinder (see Figure 59, A) by turning counter-clockwise.

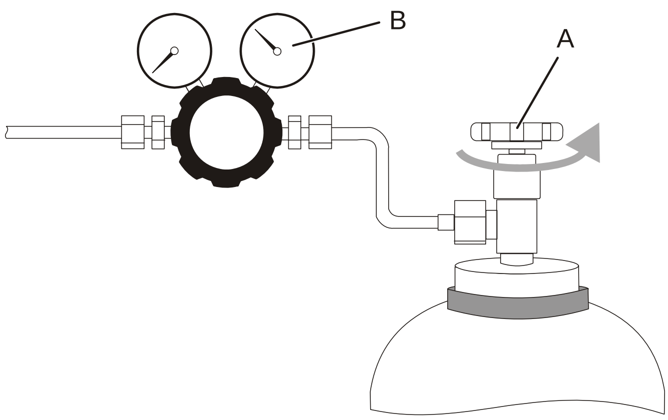

Figure 59: *Opening gas cylinder valve*

3. Check the pressure gauge (see Figure 59, B) indicating the pressure in the gas cylinder to ensure that there is sufficient remaining pressure.

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4. Turn the valve on the pressure regulator (see Figure 60, A) clockwise until the pressure gauge (B) indicates the required pressure.

   The required pressures for the individual gases are indicated in Section 4.6.2 on page 97.

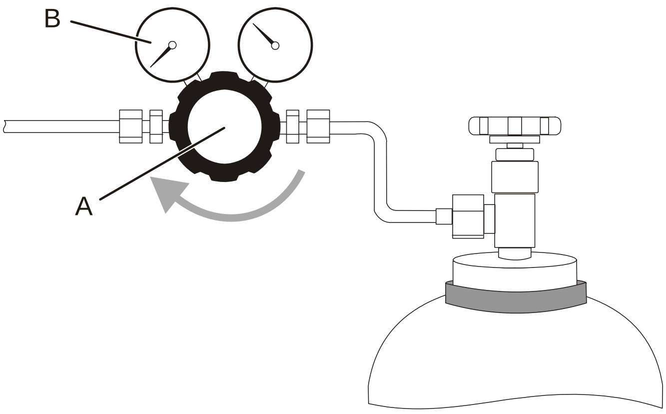

Figure 60: *Setting pressure regulator to required pressure*

5. Repeat steps 1 to 4 to turn on each of the other gases connected to the laser device.

6.2.4 Switch On Laser Device

WARNING
Misuse or improper operation can cause serious injury!
Only authorized and properly instructed personnel are to operate the laser device.
All persons operating the laser device must have read and fully understood the safety information in Chapter 2.

Purpose

Power-up the laser device to enable laser operation.

Tools and Materials

- Key to key switch

Preconditions

- Laser device ready to operate, i.e. cooling water, purge gas and laser gases (if applicable) turned on and beam path checked

  All housing covers are to be closed. No tags indicating potential hazards (e.g. uncompleted maintenance work) are to be affixed to the laser device.

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Turning-On the Laser Device

1. Turn the main switch (see Figure 61, A) clockwise to the ON setting. The POWER ON lamp (B) lights and various consumers in the laser device will start.

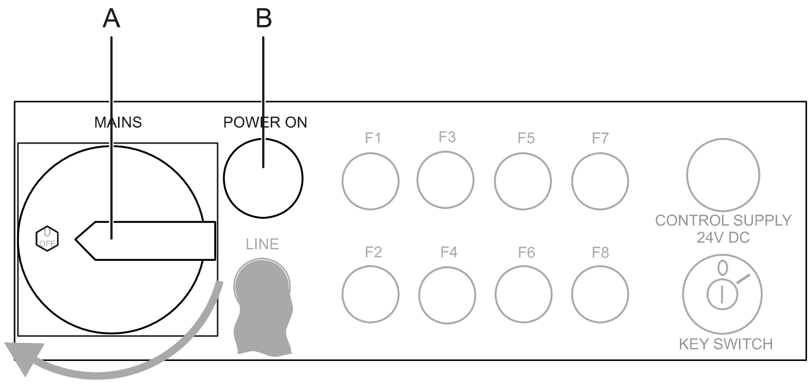

Figure 61: *Switching on the laser device*

2. Insert the key into the key switch (see Figure 62, A) and turn clockwise to the I setting to activate the laser controller.

   The CONTROL SUPPLY lamp (B) lights and the controller software boots. During this period the laser device performs a self-test which is indicated by the “self test....” message on the hand-held keypad display. At the end of the self-test, a corresponding message appears if the optional Powerlok and Timelok functions are available.

   After a successful self-test, the laser device will start to warm up the thyratron, during which OFF,21 and the remaining warm up period in seconds appears. As standard, the thyratron warm up period is set to 480 seconds (8 minutes.).

   During the warm-up period, the laser cannot emit laser radiation. Commands that do not require laser emission (e.g. parameter checks) can, however, be performed during this period.

   As soon as OFF,0 appears, the laser is ready to operate (see Section 6.3.1).

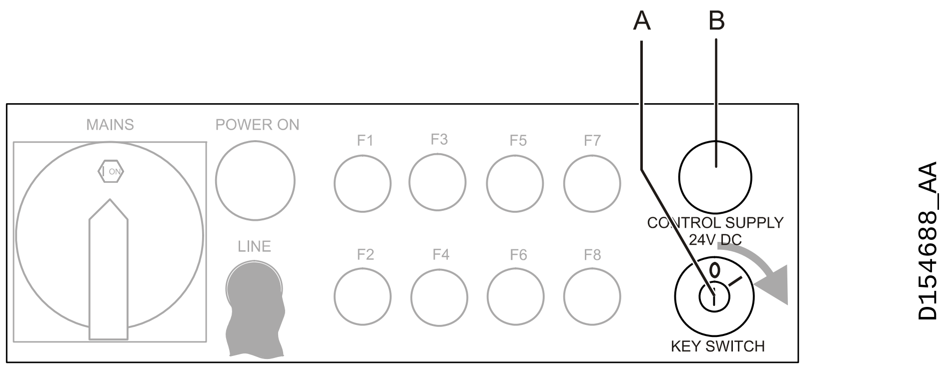

Figure 62: *Activating the control voltage*

6.2.5 Adjust Cooling Water Flow Rate

Purpose

Adjust the flow rate of the cooling water in the cooling water circuit.

This procedure only applies for COMPex*Pro* 50, COMPex*Pro* 110 and COMPex*Pro* 205 laser devices without the optional automatic tube temperature regulation facility.

Tools and Materials

- Thermometer, scaled from 0 °C to 50 °C (32 °F to 122 °F)

Preconditions

- Laser device switched on and ready to operate (OFF, 0 active)
- External cooling water turned on (see Section 6.2.2 on page 136)

Adjusting the Cooling Water Flow Rate

1. Start laser operation for about 1000 shots to warm up the laser tube.
2. Measure the water temperature at the cooling water outlet.

   The temperature of the cooling water at the outlet must be within 25 °C to 30 °C (77 °F to 86 °F). This corresponds with a laser tube temperature of 30 °C to 38 °C (86 °F to 100 °F).
3. When the water temperature is found to be below or above the temperature range indicated in step 2, correspondingly adjust the water flow:
   – If the water is too hot, the flow will need to be increased.
   – If the water is too cold, the flow will need to be decreased.

6.3 Laser Operation With Handheld Keypad

This section describes how to operate the laser using the handheld keypad supplied with the laser device.

The fundamental design of the handheld terminal is described in Section 5.4 on page 120.

Operation of the laser through LASCONTROL is described in the separate LASCONTROL manual that is provided with the software package. For information about operating the laser through an external computer control system, please refer to the system integrator’s (OEM) documentation. The set of commands that are to be used to control the laser device are described in the separate Interfacing Manual.

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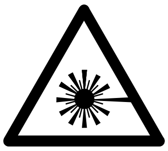
6.3.1 Start Laser Operation



DANGER
Risk of injury through laser radiation!
When working on or with an open (i.e. unprotected) excimer laser beam, always wear appropriate laser protective eyewear. Do not wear reflective jewelry such as rings or watches. Read the safety instructions in Section 2 before starting the laser.

CAUTION
Hot surface of beam shutter plate may cause burns!
If the laser is operated at high power for a long period with the beam shutter closed, the beam shutter will become hot.
Take into account that surface of the shutter plate may be hot when the beam shutter is used as a beam dump to stop laser emission.

Purpose

Switch on the laser beam to commence lasing using the currently set operating parameters. To enable generation of the laser beam, the high voltage circuit is activated.

Tools and Materials

- Appropriately rated laser protective eyewear

  Protective eyewear is not necessary when the COMPex*Pro* is part of a laser unit with a completely sealed beam path (for further information, please refer to the laser unit supplier documentation).

Preconditions

- Beam path correctly shielded or secured to ensure that the laser beam will be safely guided to the intended target (see Section 6.2.1 on page 135).
- Laser device started-up and ready to emit laser radiation (see Section 6.2.4 on page 139).
- Handheld keypad connected to COM2 on the laser device.

Starting the Laser

1. Ensure that the operating parameters displayed in the top line of the handheld keypad display are correct for the laser operating sequence that is to be started.
2. If necessary, correspondingly amend the operating parameters (see Section 6.3.5 on page 147).

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3. Open the beam shutter (see Figure 63).

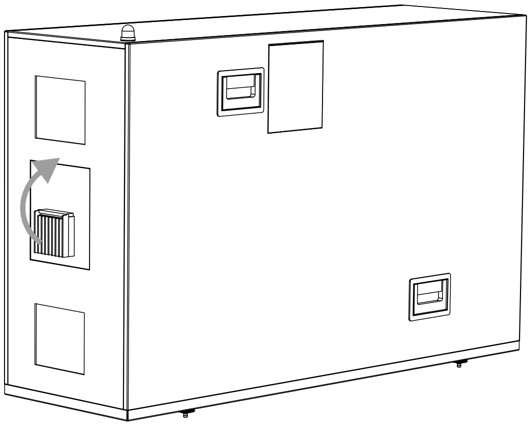

Figure 63: *Opening the beam shutter*

4. Press <RUN/STOP> (see Figure 64, A).

   "RUN LASER" appears when the laser is ready to start.

   If a maintenance action is due, a corresponding message will appear. In this case, press <ENTER> to acknowledge the message. Perform the required maintenance action as soon as possible.

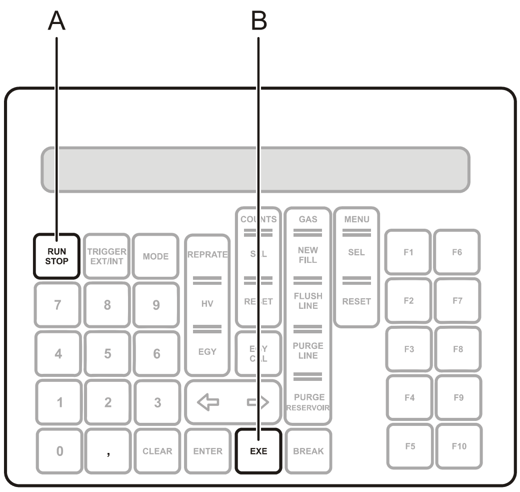

Figure 64: *Starting the laser through the handheld keypad*

5. Press <EXE> (B).

   "OFF, WAIT" appears on the display for a short period while the power supply is being initialized. Briefly before and during emission of laser radiation, the LED in the RUN/STOP key and the laser radiation warning lamp on the laser device will light. Laser light pulses are emitted at the given repetition rate. This can be recognized by an audible clicking. When no pulses are emitted, check the trigger settings (see Section 6.3.5.1 on page 147).

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6.3.2 Stop Laser Operation

Purpose

Stop the laser for longer processing interruptions and prior to shutting-down the laser device.

For short interruptions in the processing sequence, the manual shutter can be closed. To maximize the lifetime of the modules in the laser device, the laser should be switched off during longer processing interruptions.

Tools and Materials

- None

Preconditions

- Laser switched on (laser radiation being emitted)
- Handheld keypad connected to COM2 on the laser device.

Stopping the Laser

1. Press <RUN/STOP> (see Figure 65, A).

   “OFF, 0” appears on the display. The laser emission warning lamp continues to light for five seconds to indicate the risk of the laser self-firing.

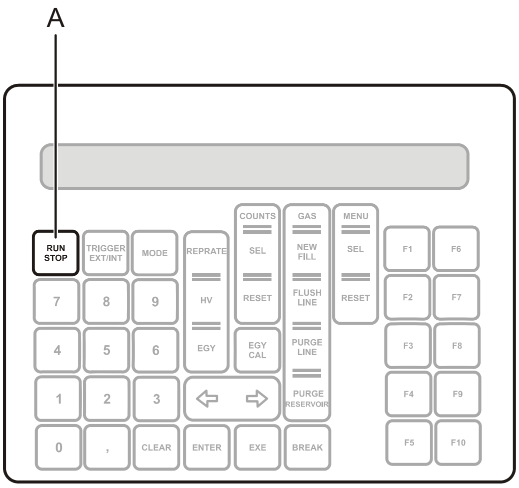

__Figure 65:__ Stopping the laser through the handheld keypad

2. Close the beam shutter.

6.3.3 Prepare Laser Device for Shut Down

Purpose

Shut down the laser device control software and prepare the laser device ready for it to be switched off at the mains.

Tools and Materials

- None

Preconditions

- Laser switched off (no laser radiation being emitted)

Preparing the Laser Device for Shut Down

1. Press <F10> (see Figure 66, A)
   “SHUTDOWN, COM1MODE, TIMEDATE” appears on the display.

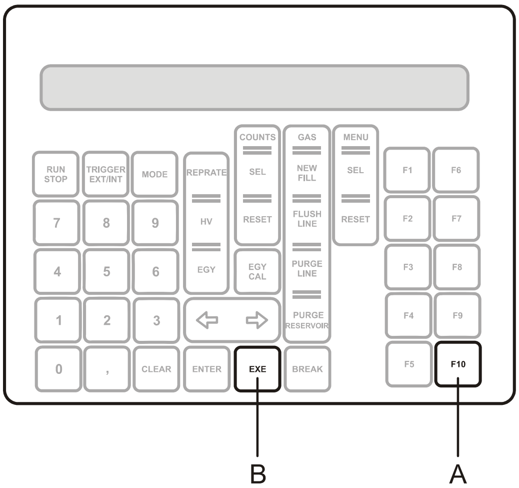

Figure 66: *Preparing the laser device for shut down*

2. Press either <Cursor Right> or <Cursor Left> until “SHUTDOWN” appears on the left of the display.
3. Press <ENTER> to confirm the selection.
4. Press <EXE> (B).
   “> SHUTDOWN ....” appears on the display while the laser device and laser control software are being shutdown.
5. When “SWITCH MAINS OFF” appears on the handheld keypad display, shut down the laser device (see Section 6.4 on page 162).

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6.3.4 Restart After “Safety Control Module Off” Interlock

Purpose

Restart the laser after interruption of the two channel safety control circuit (status code 122 active). This interlock can be caused by:

– Interruption of the external emergency shutdown circuit connected to the “Remote” connector (see Section 4.7 on page 115).

– Triggering of a cover interlock.

– Triggering of the laser tube over-temperature interlock.

Interruption of the safety control circuit will switch off the HV power supply and close the halogen valve (see Section 2.2.4.6 on page 33).

Tools and Materials

- None

Preconditions

- Laser ready to operate but safety control interlock triggered

Tracing the Root Cause of the Interlock

1. Check the handheld keypad display to see which other interlock status codes are active.
2. Depending on the indicated status code, proceed according to the rectification procedure described in Section 8.1.2 on page 246.

Restarting Laser Operation

3. When the interlock has been cleared and the safety control circuit is closed, press <BREAK> to reset the safety control interlock.

   If a *remote interlock* or *cover interlock* has occurred, never reboot the laser device in an attempt to clear the interlock. The laser control software remembers that the interlock was not correctly cleared and will issue a warning (status code 69) after each restart of the laser device until the interlock is correctly reset.

   If an *over-temperature interlock* has occurred, the laser device has to be rebooted after clearing the interlock.
4. If after pressing <BREAK> the interlock is not cleared, re-check the remote circuit and switches as this indicates that only one channel of the safety control circuit has been closed.
5. After ensuring that both channels are closed, correctly open and then close the safety control circuit (e.g. activate an external switch) before pressing <BREAK> to confirm that the interlock has been cleared.
6. Restart laser operation.

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6.3.5 Operating Modes and Parameters

This section describes the selection and setting of operating modes and parameters with the handheld keypad.

NOTICE
When the laser device is switched off, the last settings are stored and reactivated when the laser device is restarted. In certain operating modes, these settings will be overridden by default settings. Therefore, before starting the laser, always check the settings of the operating parameters.

6.3.5.1 Change Trigger Mode

Purpose

Set the trigger mode for the following laser operation.

The following trigger modes are available:

– Internal (INT)
– Internal Gated (INTG)
– Internal Counts (INT COUNTS)
– External (EXT)
– External Counts (EXT COUNTS)
– Internal Burst (INTB)
– Internal single burst (INTSB)

For further information, see Section 5.4.8 on page 125.

Tools and Materials

- INTG / EXT / EXT COUNTS / INTSB:
  External trigger generator connected to the laser device's EXT TRIG. socket (see Section 4.6.7 on page 111)
- INT / INT COUNTS / INTB:
  None

Preconditions

- INT / INTG / INT COUNTS / INTB / INTSB:
  Repetition rate correctly set (see Section 6.3.5.2)
- INTG / EXT / EXT COUNTS:
  External trigger generator correctly set and connected to the EXT. TRIG (external trigger) socket.

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Selecting the Trigger Mode

1. Press <TRIGGER INT EXT>.

   The bottom line of the handheld keypad display reads:
   "TRIGGER *current selection* (INT ,..., EXT, INTB, INTSB).
2. Press either <Cursor Right> or <Cursor Left> to scroll through the available choices until the desired trigger mode appears on the left of the display.
3. Press <ENTER> to confirm the selection.

   When TRIGGER EXT is selected and the High Energy mode is available, the bottom line of the handheld keypad display reads:
   "HIGH EGY OFF (OFF, ON)"
4. Press <Cursor Right> or <Cursor Left> as required to select or deselect the High Energy mode and Press <ENTER> to confirm the selection.

6.3.5.2 Set Repetition Rate

Purpose

Set the repetition rate (rep. rate) for internal triggering of the laser.

- When the laser is operating in the internal trigger mode, the changed repetition rate will become active immediately.
- The repetition rate can also be changed when the laser is operating in the external trigger mode. In this case, the next internally triggered laser operation will start with the changed repetition rate.

The repetition rate is always indicated in Hz (1/s). Only integers are accepted. The repetition rate range is between 1 Hz and the maximum repetition rate for the specific version of the laser device (see Section 4.1 on page 83).

Tools and Materials

- None

Preconditions

- None

Entering the Repetition Rate

1. Press <REPRATE>.

   The bottom line of the handheld keypad display reads:
   "REPRATE= *current setting* Hz".
2. Use the numerical input keys to enter the desired value in Hz.

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3. Press <ENTER> to confirm the selection.
   The new value will be indicated in the top line of the display.

   A beep tone will indicate an out of range value. In this case, the previously set value remains active.

6.3.5.3 Set Internal Burst Generator

Purpose

Set the internal burst generator for operations in the internal burst mode.

The parameters that are to be set for each burst pattern are shown in Figure 67.

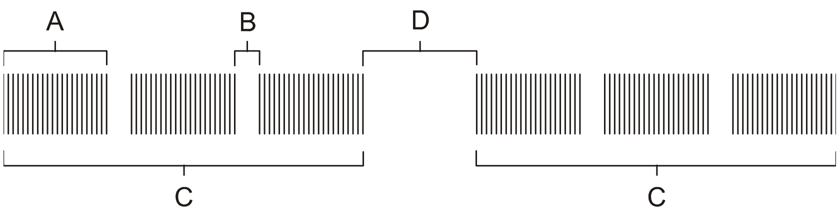

Figure 67: *Burst pattern*

Key to Figure 67:

A	Burst length in pulses	B	Burst pause in milliseconds
C	Sequence length in bursts	D	Sequence pause in milliseconds

Tools and Materials

- None

Preconditions

- None

Preparation

1. Select the INTB mode (see Section 6.3.5.1).
2. Set the required repetition rate for the burst (see Section 6.3.5.2).

Setting the Burst Generator

3. Press <F8>.

   The bottom line of the handheld keypad display reads:
   "BST PULSES= *current setting*".
4. Use the numerical input keys to enter the desired number of pulses for each burst (see Figure 67, A).

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5. Press <ENTER> to confirm the input.

   The bottom line of the handheld keypad display reads:
   "BST PAUSE= *current setting* msec".
6. Use the numerical input keys to enter the pause between each burst of pulses in milliseconds (B).
7. Press <ENTER> to confirm the input.

   The bottom line of the handheld keypad display reads:
   "SEQ BST= *current setting*".
8. Use the numerical input keys to enter the desired number of bursts for each sequence of bursts (C).
9. Press <ENTER> to confirm the input.

   The bottom line of the handheld keypad display reads:
   "SEQ PAUSE= *current setting* msec".
10. Use the numerical input keys to enter the pause between each sequence of bursts in milliseconds (D).
11. Press <ENTER> to confirm the input.

    The previously active hand-held keypad display re-appears. The burst is started by pressing <RUN/STOP> and <EXE> (see Section 6.2.4 on page 139).

6.3.5.4 Change Running Mode

Purpose

Select the desired laser running (energy management) mode.
The available choices are:

– HV constant mode with gas actions (HV PGR)

– HV constant mode without gas actions (HV NGR)

– Energy constant mode with gas actions (EGY PGR)

– Energy constant mode without gas actions (EGY NGR)

– Energy constant burst mode with gas actions (EGYBURST P)[a]

– Energy constant burst mode without gas actions (EGYBURST N)[a]

The selected running mode will become immediately active and is indicated in the top left corner of the handheld keypad display.

– When the energy constant mode is selected, the currently set output energy value becomes active.

– When the HV constant mode is selected, the currently set charging voltage becomes active.

For further information about the available energy management modes see Section 3.5 on page 75.

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a. Only available if the optional TIMELOK / POWERLOK package is active

Tools and Materials

- None

Preconditions

- HV constant mode:
  - HV charging voltage correctly set (see Section 6.3.5.6 on page 152).
- Energy constant mode:
  - Beam output energy value correctly set (see Section 6.3.5.5 on page 151).
- Operation with gas actions
  - Gas cylinder valves open and pressure regulators correctly set (see Section 6.2.3 on page 137).
  - PGR mode correctly set to either AUTO or REQUEST (see Section 5.4.15 on page 131).

Selecting the Running Mode

1. Press <MODE>.

   The bottom line of the handheld keypad display indicates the currently active running mode and the available choices.
2. Press either <Cursor Right> or <Cursor Left> to scroll through the available choices until the desired running mode appears on the left of the display.
3. Press <ENTER> to confirm the selection.

   The selected running mode is indicated in the top left corner of the display

   The message “PRESET ENERGY TOO HIGH” appears when a new gas fill is required (see Section 7.5.1 on page 187).

6.3.5.5 Set Output Energy Value

Purpose

Set the beam output energy value for laser operations in one of the energy constant modes.

The beam output energy value cannot be changed when the HV constant mode is selected. The range of possible energy values is indicated in the gas menu (see Section 6.3.7.1 on page 156).

D154688_AA

Preconditions

- Energy constant mode (EGY PGR or EGY NGR) selected (see Section 6.3.5.4)

Entering the Output Energy Value

1. Press <EGY>.

   The bottom line of the handheld keypad display reads:
   "EGY= *current setting* mJ".

   If <EGY> is pressed when the HV constant mode is active, a beep tone indicates that the selection has been denied.
2. Use the numerical input keys to enter the desired value in mJ.
3. Press <ENTER> to confirm the input.
   The new value appears in the top line of the handheld keypad display.

   A beep tone will indicate an out of range value. In this case, the previously set value remains active.

6.3.5.6 Set Charging Voltage

Purpose

Set the charging voltage for laser operations in the HV constant mode. The largest and smallest permissible high voltage values are determined in the gas menu (see Section 6.3.7.1 on page 156).

Preconditions

- HV constant mode selected (see Section 6.3.5.4)

Entering the Charging Voltage

1. Press <HV>.

   The bottom line of the handheld keypad display reads:
   "HV= *current setting* kV".

   If <HV> is pressed when one of the energy constant modes is active, a beep tone indicates that the selection has been denied.
2. Use the numerical input keys to enter the desired value in kV.

   Input with one digit after the decimal point is permitted.
3. Press <ENTER> to confirm the input.
   The new value appears on the handheld keypad display.

   A beep tone will indicate an out of range value. In this case, the previously set value remains active.

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6.3.5.7 Toggle Charge On Demand (COD)

Purpose

Deselect and reselect the COD mode (see Section 3.3.4 on page 64).

COD minimizes the risk of the laser self-firing and maximizes the lifetime of the components in the HV circuit. COD is set to on as the default choice.

COD should be deselected when the delay inherent to the COD mode is too long for the effective coordination of the laser with other processing sequences.

Preconditions

- Laser radiation not being emitted (laser device in the OFF mode)

  If one of the commands to change the COD mode status is sent when the laser is running (ON mode active), the command will not be accepted.

Toggling between COD On and COD Off

1. Press <F9>.

   The bottom line of the handheld keypad display reads: “*current selection* (CONTROL, COD)”.
2. Press either <Cursor Right> or <Cursor Left> until COD appears on the left of the display.
3. Press <Cursor Right> or <Cursor Left> as required to select OFF or ON.
4. Press <ENTER> to confirm the selection.

   The COD status is implemented. When COD is active, “COD” is displayed on the handheld keypad.

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6.3.6 Gas Actions

This section describes the functions that are available to manually start gas actions.

6.3.6.1 Manually Start Requested HI/PGR

Purpose

Manually start a macro halogen injection (MHI) according to the automated gas action algorithm when requested by the laser control software. MHI requests will not occur if the laser device is connected to a premix gas supply (see Section 4.6.2 on page 97).

The laser control software will request a gas action when the laser is running in the HV PGR or EGY PGR mode and the PGR mode is set to REQUEST (see Section 5.4.15 on page 131).

Preconditions

- Laser radiation being emitted and the following message flashing on the handheld keypad

  “> ON, HI/PGR REQUEST, <ENTER> TO CONFIRM”

  This message corresponds with status code 104.
- Gas cylinder valves open and pressure regulators correctly set (see Section 6.2.3 on page 137).

Manually Starting the Gas Action

1. Check the currently active processing sequence to determine when it can be safely interrupted.
2. When the processing sequence can be safely interrupted, press <ENTER>.

   Laser operation will be interrupted and the scheduled gas action started (see Section 3.5.2 on page 76). Laser operation will automatically be resumed when the gas action has been completed.

   When the gas action is not started within a predetermined period (factory default value 3600 sec), a HI/PGR request timeout interlock will occur (status code 63). In this case, restart the laser and press <ENTER> to perform the required gas action.

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6.3.6.2 Emergency Fill with Inert Gas

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

Purpose

Start an emergency gas fill (“manual fill with inert gas“) that fills the laser tube with inert gas for 10 seconds. This is required to fill the laser tube to a pressure higher than atmospheric pressure to protect it (e.g. after a malfunction) from the penetration of ambient air. This function is required when (e.g. due to the interruption of a procedure) the tube pressure has dropped below 1050 mbar,

Tools and Materials

- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Laser radiation not being emitted
- Inert gas cylinder valve open and pressure regulator correctly set (see Section 6.2.3 on page 137)

Emergency Fill Procedure

1. Press <NEW FILL>.

   The bottom line of the handheld keypad display shows the available options.
2. Use the cursor keys to select MAN INERT.
3. Press <ENTER> to confirm the selection.
4. Press <EXE> to start the manual fill with inert gas.

   The laser head valve and the inert gas valve open for 10 seconds and then automatically close. “INERT VALVE: CLOSED” appears when the inert valve has closed. The new pressure will be displayed. If a higher pressure is necessary, repeat step 4.
5. Press <BREAK> to terminate the Emergency Fill function.

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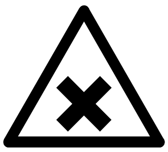
6.3.7 Set-Up and Service Functions

This section describes handheld keypad functions that can be used to change the operational set-up of the laser device or assist with servicing activities.

6.3.7.1 Select and Change Gas Menu



WARNING
Risk of exposure to halogen gas!
Incorrect gas menu selection can cause excessive halogen concentrations in the laser tube. If this mixture is pumped out undiluted, the halogen filter and exhaust can overheat. This significantly increases the risk of gas leaks.
Only authorized and correspondingly trained persons shall change gas menus. In case of an incorrect gas fill, immediately contact Coherent service before taking any further action!

Purpose

Select the gas menu for the gas mixture appropriate to the gas supply mode as well as the wavelength at which the laser is to be operated.

The factory gas menu settings for F-version lasers are as follows:

– Menu 1: ArF Single Gases
– Menu 2: KrF Single Gases
– Menu 3: XeF Single Gases
– Menu 4: ArF Premix
– Menu 5: KrF Premix
– Menu 6: XeF Premix

The factory gas menu settings for XeCl-version lasers are as follows:

– Menu 1: XeCl Single Gases
– Menu 4: XeCl Premix
– Menus 2, 3, 5 and 6: not used

Each gas menu displays the following parameters:

– Menu number,
– Gas mixture,
– Gas supply mode
– Partial pressures (sequentially).

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Requirements

- Laser in OFF mode (no laser radiation being emitted)

Selecting and Changing the Gas Menu

1. Press the <MENU SEL> key.

   The bottom line of the handheld keypad display reads: “Password= (read Manual!)”.
2. Type the password 778 and press <ENTER>

   The number of the current menu together with the gas mixture and supply mode appears in the bottom line of the display.
3. Press <Cursor Right> and/or <Cursor Left> to select the number of the desired gas menu.
4. Press <ENTER> to confirm the selection.

   The currently set partial pressure of the gas connected to the halogen line appears in the bottom line of the display.

   The factory settings for the partial pressures are optimized and should only be changed when the gas specifications change. If necessary, the gas menu can be reset to the factory settings (see Section 6.3.7.2 on page 157).
5. Where necessary, use the numerical keys to enter a new partial pressure.

   The limits for the partial pressures are ± 20 % of the partial pressures defined through the factory settings. If an invalid value is entered “out of range” appears.
6. Press <ENTER> to choose the next partial pressure.
7. Repeat steps 5 and 6 for the next gas components.

   After pressing <ENTER> to confirm the settings of the last partial pressure in the gas menu, the gas menu selection function is automatically terminated. The laser device will carry out the next new fill on the basis of the revised gas menu data.

6.3.7.2 Reset Gas Menu to Factory Settings

Purpose

Reset the data in the gas menus to the factory settings. The following values will be changed:

– Partial pressures,

– Gas mode,

– Repetition rate,

– Energy filter.

D154688_AA

Requirements

- Laser in OFF mode (no laser radiation being emitted)

Resetting the Gas Menu

1. Press the <MENU RESET> key.
2. Press <EXE> to reset the gas menus to the factory settings.

   The messages “accepted” and “Executed” briefly appear in the display.

6.3.7.3 Change Control Device

Purpose

Switch control of the laser device between the device attached to COM1 and the handheld keypad attached to COM2.

The following choices are available:

– HOST selects the device attached to COM1. After selecting HOST, make sure that the terminal mode is correctly set for the device attached to the COM1 (see Section 6.3.7.4)

– TERMINAL selects the handheld keypad attached to COM2.

If HOST is selected and there is an attempt to carry out a function through the handheld keypad, the message “not accepted, Laser controlled by host. Press F9 to set control to terminal” appears.

Requirements

- None.

Changing the Control Device

1. Press <F9>

   The bottom line of the handheld keypad display reads: “*current selection* (CONTROL, COD)”.
2. Press either <Cursor Right> or <Cursor Left> until “CONTROL” appears on the left of the display.
3. Press <ENTER> to confirm the selection.

   “CONTROL=*current selection* (HOST, TERMINAL)” appears.
4. Press either <Cursor Right> or <Cursor Left> until the desired mode appears on the left of the display.
5. Press <ENTER> to confirm the input.
6. Press <EXE> to change the control device.

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6.3.7.4 Change COM1 Terminal Mode

Purpose

Change the mode of the COM1 terminal on the laser device according to the device that is to be attached.

The following modes are available:

– INACT inhibits communication through COM1. When this mode is selected, communication can only occur through COM2.

– TERM selects the standard terminal data communication mode using the same set of commands as those available through COM2. These commands are described in the separate Interfacing Manual.

– SER selects the service mode.

– OLD selects communication using commands that are compatible with earlier versions of the COMPex, COMPex*Pro* or LPX laser devices. With this setting, not all commands offered by the current laser control software will be supported. In addition, status codes sent by the laser device may not be recognized or correctly interpreted by the system communicating with the laser device. For further information about status codes, see Section 8.1 on page 246.

– TERM.HBR increases the baud rate of the COM1 terminal from 9600 to 115200.

Do not select INDY CMD as this selects a communication protocol that does not apply to the COMPex*Pro* laser device.

Requirements

● Laser in OFF mode (no laser radiation being emitted).

Changing the COM1 Terminal Mode

1. Press <F10> (see Figure 66, A)

   The bottom line of the handheld keypad display reads: “SHUTDOWN, COM1MODE, TIMEDATE”.
2. Press either <Cursor Right> or <Cursor Left> until “COM1MODE” appears on the left of the display.
3. Press <ENTER> to confirm the selection.

   The available COM1 terminal mode options appear.
4. Press either <Cursor Right> or <Cursor Left> until the desired mode appears on the left of the display.
5. Press <ENTER> to confirm the input.
6. Press <EXE> to change the mode of COM1.

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6.3.7.5 Change Time and Date Settings

Purpose

Change the time and date displayed on the hand-held terminal.

The indicated time and date settings can also be called through the remote polling commands SYSTIME? and SYSDATE?.

Requirements

- Laser device switched on

Changing the Time and Date Settings

1. Press <F10> (see Figure 66, A)

   The bottom line of the handheld keypad display reads: “SHUTDOWN, COM1MODE, TIMEDATE”.
2. Press either <Cursor Right> or <Cursor Left> until “TIME/DATE” appears on the left of the display.
3. Press <ENTER> to confirm the selection.

   “SYSTIME hh:mm” appears.
4. Enter the hours and minutes, separated by a decimal point, through the numerical input keys.
5. Press <ENTER> to confirm the input.

   “SYSDATE dd.mm.yy” appears.
6. Enter the day, month and last two digits of the year, separated by a decimal point, through the numerical input keys.
7. Press <ENTER> to confirm the input.

   The previously active screen display re-appears.

6.3.7.6 Activate Temperature Control (Optional)

Purpose

Activate the temperature control to enable a given tube temperature to be maintained.

Tools and Materials

- None

Requirements

- Laser device switched on and laser ready to operate (laser radiation not being emitted)

D154688_AA

Activating the Temperature Control

1. Ensure that the cooling water valve is open.
2. Press <F5>.
   The current status of the temperature regulation appears in the bottom line of the handheld keypad display.
3. Press <Cursor Right> and/or <Cursor Left> to select ON or OFF.
4. Press <ENTER> to confirm the selection.

6.3.8 Counters

This section describes the functions that are available to read or reset the counters.

6.3.8.1 Read Counters

Purpose

Obtain the current reading of the required counter.

The following counters are available:

– Total Counter
– User Counter
– Maintenance Counter
– New Fill Counter
– HI Counter
– PGR Counter

All counter readings with the suffix E3 are displayed in 10^3 pulses. All other readings are displayed in single pulses or individual events (see Section 5.4.12 on page 128).

Preconditions

- None

Reading the Desired Counter

1. Press <COUNTS SEL>.

   The bottom line of the handheld keypad display indicates the currently active counter and the corresponding reading.
2. Use <Cursor Right> and/or <Cursor Left> to select the desired counter reading.
3. Note the counter reading.
4. Press ENTER to cancel the counter reading function.
   The previously active screen display re-appears.

D154688_AA

6.3.8.2 Reset Counter

Purpose

Reset the user or maintenance counter reading to zero.

Preconditions

- None

Resetting the Counter

1. Press <COUNTS RESET>.

   The bottom line of the handheld keypad display reads:
   “USER COUNTER=RESET (USER, MAINT.)”.
2. Use the cursor keys to select the desired counter.
3. Press <ENTER> to confirm the selection.
4. Press <ENTER> to confirm that the selected counter is to be reset.
5. Press <EXE> to reset the selected counter to zero.

   “EXECUTED” briefly appears to confirm that the user counter has been reset.

6.4 Shut-Down Laser Device

6.4.1 Switch Off Laser Device

Purpose

Shut down the laser device prior to maintenance or if it is to be not used for a longer period of time.

Tools and Materials

- None

Preconditions

- No laser radiation being emitted (see Section 6.3.2) or other routines (e.g. window exchange) active.
- Handheld keypad connected to the communication interface socket on the laser device.
- Laser device and control software ready for shut down (see Section 6.3.3 on page 145)

D154688_AA

Switching off the Laser Device

1. Turn the key in the key switch (see Figure 68, C) counter-clockwise to the “O” setting.

   The CONTROL SUPPLY lamp (D) goes out.

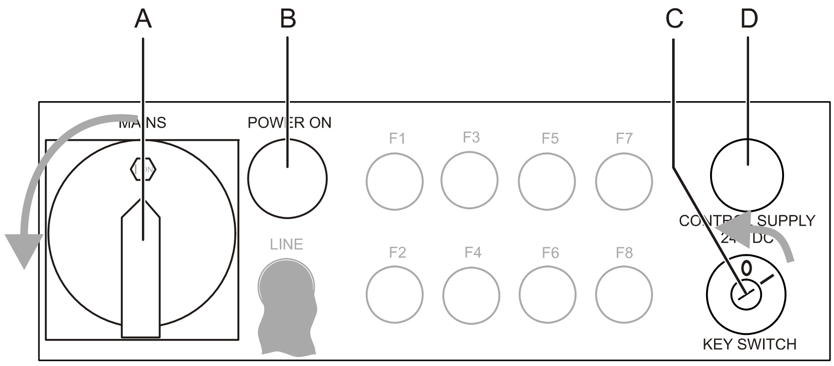

Figure 68: *Switching off the laser device*

WARNING
Prevent accidents through unauthorized operation!
To prevent unauthorized operation of the COMPex*Pro*, always remove the key from the key switch after shutting down the laser device. Keep the key in a safe place.

2. Remove the key from the key switch and keep in a safe place.
3. Turn the main switch (see Figure 68, A) counter-clockwise to the “OFF” setting.

   The LINE ON lamp (B) goes out.
4. Where applicable, turn off the cooling water supply at the source.
5. Turn off the gases (see Section 6.4.2).

6.4.2 Turn Off Gases

This section describes gas handling for a straight-forward gas system with one gas source for one laser device. The COMPex*Pro* may, however, be connected to an external gas handling system that serves a number of laser devices. Therefore, for exact operating information, please refer to the gas handling system supplier’s instructions.

Purpose

Turn off the excimer laser gases and/or purge gas at the source.

All gases should be turned off when the laser device is to be shut down for longer periods (e.g. overnight).
The excimer laser gases should be turned off when no operations requiring gas activities are to be performed.

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Tools and Materials

- None

Preconditions

- None

Turning Off Gases

1. Close the valve on the gas cylinder (see Figure 69, A) by turning it clockwise to its stop.

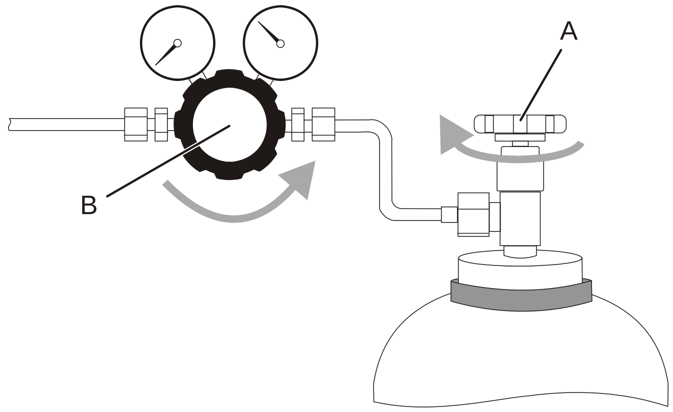

Figure 69: *Shutting down the gas supply*

2. Turn the valve on the gas pressure regulator (see Figure 69, B) counter-clockwise to its stop. This ensures that the pressure regulator is closed.
3. Repeat steps 1 and 2 to turn off the other gases.

6.5 Emergency OFF

Purpose

Immediately shut down the laser device in case of an emergency.

The procedure in this section describes the Emergency Off procedure to be followed when the laser device is not interlinked with external safety circuits. When the laser device is connected to an external Emergency Off and/or Emergency Stop circuit, always follow the emergency shut-down procedure described in the system integrator's (OEM) documentation.

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Tools and Materials

- None

Preconditions

- Laser operating in ON mode (laser radiation being emitted)

Activating Emergency OFF

NOTICE
Activating the Emergency OFF (EMO) function immediately shuts down the system without finishing the current job. This can cause unnecessary downtime and spoilage
Only use the EMO function in case of an emergency, i.e. to prevent injury or serious material damage

1. Turn the main switch (see Figure 70, A) counter-clockwise to the “OFF” setting.

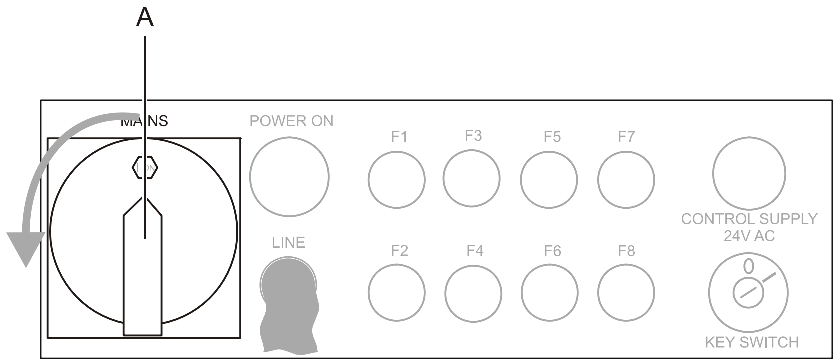

Figure 70: *Laser device Emergency Off (EMO) function*

WARNING
Injury hazard through incorrect reactivation!
After activating Emergency OFF (EMO), always contact authorized maintenance / safety personnel to ensure that the system is safely put back into operation.

2. Notify the appropriate authorized person that Emergency OFF has been activated, indicating the reason for activation.

Restarting the Laser Device

3. Ensure that the laser device and all other components in the system can be safely put back into operation.
4. Turn the key switch counter-clockwise to the “0” setting.
5. Restart the laser device (see Section 6.2.4 on page 139).

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7 MAINTENANCE

WARNING
Risk of serious injury or equipment damage!
Incorrect maintenance can cause exposure to or contact with hazards such as laser radiation, lethal voltages and toxic, harmful or corrosive substances.
Only authorized and correspondingly trained maintenance personnel shall perform maintenance work on the laser device.
Strictly follow the instructions contained in this manual.

For detailed safety information, see Section 2 on page 11.

This chapter describes the routine maintenance procedures that are necessary for the upkeep of the laser device as well as simple maintenance actions that are to be performed as required to optimize the performance of the laser.

7.1 Laser Logbook

Prepare a laser logbook to keep a continuous record of data relating to laser operations. This simplifies routine maintenance scheduling as well as troubleshooting.

The data recorded in the logbook should provide information about relevant changes in the operating behavior of the device. The logbook should include the following entries:

- Date and time
- Running mode (HV, EGY PGR, EGY NGR)
- Charging voltage and output energy
- Operating mode (OPMODE)
- Trigger mode
- Repetition rate
- Status (Gas actions, warnings, interlocks etc.)
- Counter reading (total counter).

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7.2 Maintenance Schedule

This section contains the periodic maintenance schedule for the COMPex*Pro* laser device.

The lifetimes are indicated in column 1 of the respective table. A lifetime can be indicated in pulses or actions (dynamic lifetime), as a time interval (static lifetime) or be determined by other factors or a combination of factors. Column 4 contains a cross reference to the section in this manual that describes the procedure in detail.

Maintenance Interval	Action	Time Required	Comments
- Every 5 to 25 million pulses[a] - Every 1 to 2 weeks[b]	New gas fill	0.5 h	see Section 7.5.1 on page 187
- Before a new gas fill - After a week of non-operation	Flush gas lines	0.1 h	see Section 7.4.1 on page 178
- Every 10 to 30 million pulses - Every 3 to 5 new gas fills	Clean resonator optics	1.5 h	See Section 7.6 on page 192
- After cleaning the tube optics five times	Renew resonator optics	1.0 h	
- Whenever the tube optics have been cleaned / exchanged	Align laser beam	1.0 h	See Section 7.7 on page 212
	Calibrate energy monitor	0.75 h[c]	See Section 7.10.1 on page 228
- With every energy monitor calibration	Clean beam splitter	0.5 h	See Section 7.10.4 on page 237
- Every 4 weeks - Before a new gas fill	Check halogen filter level	0.05 h	See Section 7.9.1 on page 223
- When indicated by the laser control software - When lifetime of five years has expired	Replace halogen filter	0.5 h	See Section 7.9.2 on page 224
- Every 300 million pulses	Check / adjust thyratron voltages	0.25 h	See Section 7.11 on page 240
- When remaining pressure is equal to or less than 20% of initial value - When gas cylinder has passed the expiry date	Change halogen gas cylinder	0.75 h	See Section 7.4.3 on page 180
	Change rare, inert or buffer gas cylinder	0.5 h	See Section 7.4.4 on page 183
- Before transportation - Before storage	Perform transportation fill	0.25 h	See Section 7.5.3 on page 191

a. Typical values for dynamic gas lifetime. XeCl lifetime tends to be greater than the other gases
b. Typical values for static gas lifetime. XeCl lifetime tends to be greater than the other gases
c. Including new gas fill

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7.3 Preparatory Procedures

7.3.1 Lockout / Tagout

Purpose

This procedure establishes the minimum requirements for the lockout of energy isolating devices whenever maintenance or servicing is performed on the COMPex*Pro* laser device. It shall be used to ensure that the laser device is stopped, isolated from all potentially hazardous energy sources and locked out before employees perform any servicing or maintenance where the unexpected energization or start-up of the laser device or release of stored energy could cause injury.

WARNING
Risk of serious injury!
All employees are required to comply with the restrictions and limitations imposed upon them during the use of lockout.
Authorized employees are required to perform the lockout in accordance with the procedures described in this section.
No employee shall attempt to start, energize or use the laser device when it has been locked out.

The potentially hazardous energy sources of the COMPex*Pro* are:

– High voltage / electric energy

– Laser light

– Compressed gases

To perform maintenance or servicing within the laser device, these hazardous energy sources are isolated by setting the laser device's main switch to the OFF position. When working with an open gas system, e.g. when disconnecting the laser device from the gas supply or working on the gas supply lines (up to and including the solenoid valves), the external gas supply also has to be shut off and locked out / tagged out.

Tools and Materials

- Assigned individual lockout and/or tagout devices suitable for use with the respective energy isolating device.

  The assigned lockout / tagout device shall correspond with OSHA 29 CFR 1910.147(c)(5), i.e. it is to be durable, of a standardized type within the facility, substantial enough to prevent removal without the use of excessive force or unusual techniques and shall indicate the identity of the person applying the device.

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Securing the Main Switch

1. Notify all responsible persons that the laser device requires servicing or maintenance and that it must be shut down and locked out to perform the servicing or maintenance.
2. If the laser device is operating, shut it down by following the usual shut down sequence (see Section 6.4 on page 162).
3. Ensure that the main switch is set to "OFF" (see Figure 71) so that the laser device is isolated from the potentially hazardous energy sources.

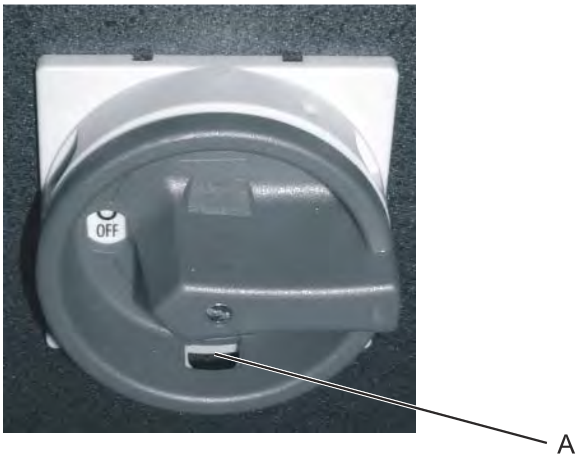

Figure 71: *Main switch lockout*

4. Lockout the main switch by inserting the assigned lockout device into the opening in the bottom of the main switch (see Figure 71, A).

   The lockout device can only be inserted when the main switch is in the "OFF" position.
5. Dissipate any stored or residual energy by following the specific instructions in the respective service or maintenance procedure; e.g. when working on the HV system, always allow the capacitors sufficient time to discharge before starting work.
6. Physically disconnect the laser device from the mains power source whenever specifically instructed.
7. Ensure that the laser device is disconnected from the energy source and isolated by turning the key switch and making certain that the laser device will not operate.
8. Depending on local regulations, attach appropriate tags to warn that maintenance or servicing is being performed and indicate the identity of the person who applied the lockout device.

   The main switch of the laser device is now locked out. Necessary maintenance or servicing can now be performed. If, however, work is to be carried out on an open gas system, always perform steps 9 to 12 prior to starting the maintenance or servicing work.

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Securing the Gas Supply Lines

Steps 9 to 12 are generally applicable when the external gas supply lines are to be isolated to perform work on the COMPex*Pro* excimer laser device. The exact procedure to de-energize and secure the gas supply lines depends on the configuration of the facility's gas supply system and design of the shut off valves. Always first contact the person authorized to perform the gas system lockout/tagout procedure when work an open gas system is necessary.

9. Notify the responsible persons that servicing or maintenance is required on the COMPex*Pro* laser device and that the gas supply lines leading to the laser device must be shut down and locked out to perform the servicing or maintenance.
10. Turn off the shut off valve (e.g. ball or gate valve) and secure the valve by installing the appropriate valve cover, lock and/or tag.

    Halogen gas lines require double valve isolation for maintenance on the gas system.
11. Evacuate the gas lines between the shut off valve and gas manifold in the laser device.
12. Ensure that the appropriate gas pressure gauges indicate a reading of zero before starting the maintenance or servicing.

Restoring the Laser Device to Service

When the servicing or maintenance action is completed and the COMPex*Pro* excimer laser device is ready to return to the normal operating condition, follow steps 13 to 16.

13. Check the laser device and the immediate area around the laser device to ensure that nonessential items have been removed and that the laser device is operationally intact.
14. Check the work area to ensure that all employees have been safely positioned or removed from the area.
15. Remove the lockout device.

    The lockout device shall be removed from the energy isolating device by the person who applied the device. If the authorized person who applied the device is not available, contact the supervisor of the person who applied the device.
16. Notify the responsible persons that the servicing or maintenance is completed and that the laser device can be switched on and restored to service.

7.3.2 Handling Housing Covers

This section describes the handling of covers that are intended to be removed from the laser device housing (enclosure) to gain access to the working areas inside the laser device. The removable covers are the service panel (see Section 7.3.2.1) front mirror access panel (see Section 7.3.2.2) and rear mirror access panel (see Section 7.3.2.3).

Each of the removable housing covers is protected by an interlock switch. This will disable the high voltage circuit, thereby inhibiting laser emission, and close the halogen valve when the cover is removed. Software-controlled routines that do not require the activation of the high voltage circuit or halogen valve can, however, still be performed.

Securing the Working Area

WARNING
Risk of exposure to toxic halogen gas mixture!
When any housing cover panel is removed, the exhaust no longer effectively extracts air from inside the laser housing. In case of an excimer laser gas leak, toxic gas may be released into the area of the laser device.
Before removing any housing cover, always secure the working area against the potential hazards of a gas leak incident.

To secure the working area before removing a housing cover:

- Turn off the halogen gas supply at the source.
- Ensure that there is no indication of a halogen gas leak inside the laser device. A possible sign of a leak is an interlock or warning indicating that the tube pressure is outside of the permitted range (see Section 8.1 on page 246).

  Whenever a leak is suspected, always purge the gas lines and laser tube before removing the housing cover.

When the housing cover is removed, make sure that no unauthorized persons can access the working area.

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7.3.2.1 Service Panel

CAUTION
Risk of injury through dropping panel!
Depending on version, the service panel is up to approx. 1.7 m (67 in) long and weighs up to approx. 16 kg (35 lb).
Always use the handles to remove and fit the service panel.

Purpose

Remove the service panel from the laser device (see Figure 72).

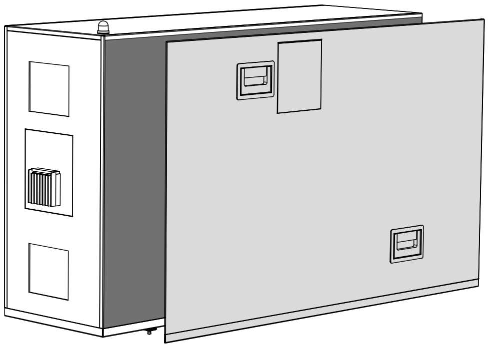

Figure 72: *Service panel*

Tools and Materials

- 3 mm allen key
- 7 mm wrench

Preconditions

- Laser switched off (no laser radiation being emitted)
- Working area secured (see Section 7.3.2).

Preparation

1. Make sure that the laser tube is filled with inert gas.
2. Turn off the halogen gas supply at the source.

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Removing the Service Panel

3. Use the 3 mm allen key to loosen and remove the screws, on all four sides, that secure the service panel, except for two screws on opposite sides (see Figure 73).

Figure 73: *Unscrewing the service panel*

4. While holding the service panel to prevent it from falling away from the laser device, use the 3 mm allen key to remove the last two screws.
5. Using the two collapsible handles (see Figure 74, B), tilt the service panel away from the top of the laser device. Take into account that a grounding cable is attached to the inside of the service panel.

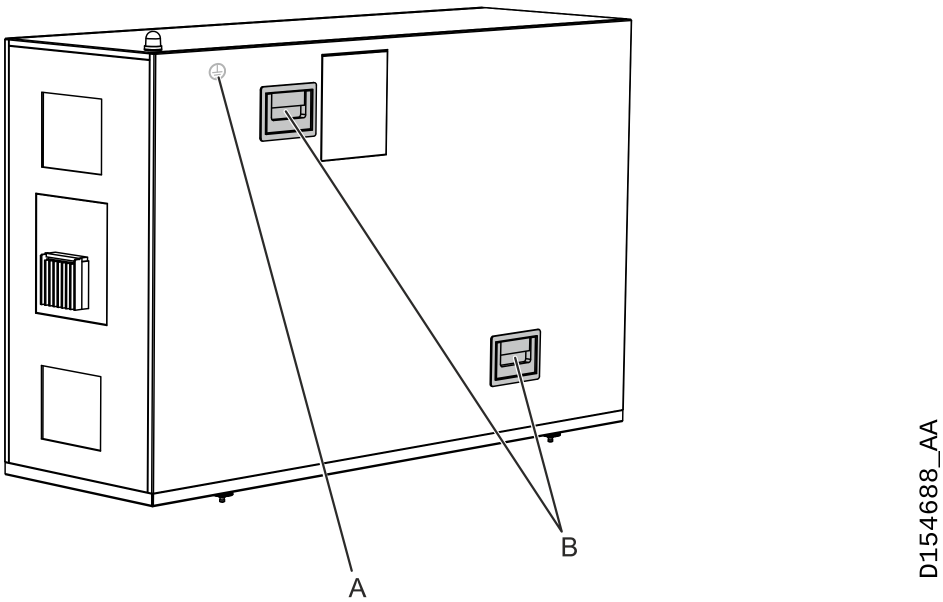

Figure 74: *Service panel grounding cable connection and handles*

6. If necessary, use the 7 mm wrench to unscrew the service panel grounding cable. The approximate location of the grounding cable connection is indicated in Figure 74, A.
7. Lift the service panel away from the laser device.

Fitting the Service Panel

8. Use the 7 mm wrench to connect and tighten the service panel grounding cable.
9. Using the two collapsible handles to hold the service panel at an angle, carefully guide the panel into the recess at the bottom of the laser device housing.
10. Press the service panel at the top so that it is correctly located onto the laser device.
11. While holding the panel in position, use the 3 mm allen key to insert and tighten the securing screws.

7.3.2.2 Front Mirror Access Panel

Purpose

Remove the front mirror access panel (see Figure 75) to gain access to the laser device’s output coupler and energy monitor. The internal beam delivery tube is attached to the inside of the front mirror access panel and will be removed together with the front mirror access panel.

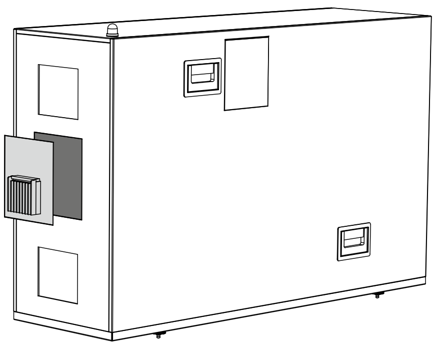

Figure 75: *Front mirror access panels*

Tools and Materials

- 3 mm allen key

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Preconditions

- Laser switched off (no laser radiation being emitted)
- Working area secured (see Section 7.3.2).
- No protective tubes or other fittings attached to the mirror access panel.

Removing the Front Mirror Access Panel

1. Use the 3 mm allen key to loosen and remove the screws securing the front mirror access panel.
2. Lift and pull the front mirror access panel away from the laser device (see Figure 76).

   Take into account that the access panel is held in position by the interlock switch. The internal beam delivery tube is attached to the access panel and will be removed together with the access panel.

Figure 76: *Removing the front mirror access panel*

Fitting the Front Mirror Access Panel

3. Making sure that the internal beam delivery tube fits into the energy monitor and actuator tongue enters the interlock switch, fit the front mirror access panel onto the laser device.
4. Use the 3 mm allen key to insert and tighten the securing screws.

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7.3.2.3 Rear Mirror Access Panel

Purpose

Remove the rear mirror access panel (see Figure 77) to gain access to the laser device's rear mirror.

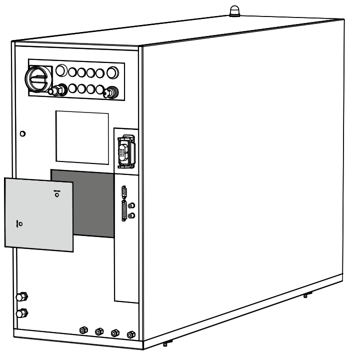

Figure 77: *Rear mirror access panels*

Tools and Materials

- 3 mm allen key

Preconditions

- Laser switched off (no laser radiation being emitted)
- Working area secured (see Section 7.3.2).

Removing the Rear Mirror Access Panel

1. Use the 3 mm allen key to loosen and remove the securing screws.
2. Lift and pull the mirror access panel away from the laser device.

   Take into account that the access panel is held in position by the interlock switch.

Fitting the Rear Mirror Access Panel

3. Making sure that the actuator tongue enters the interlock switch, fit the mirror access panel onto the laser device.
4. Use the 3 mm allen key to insert and tighten the securing screws.

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7.4 Gas System Maintenance

This section describes the procedures that are to be followed to maintain the external gas system. The condition of the external gas system and the gases has a direct influence on the operating performance of the excimer laser.

The instructions in this section apply for a straight-forward gas system with one gas source for one laser device. In industrial environments, the COMPex*Pro* may be connected to an external gas handling system that serves a number of consumers. Therefore, always consult the gas handling system supplier's instructions before performing any of the actions described in this section.

7.4.1 Flush Gas Line

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

Purpose

Evacuate a gas line and fill the line with fresh gas. This is, for example, necessary to remove helium from the gas line after a leak test or to remove impurities from the gas line after a period of non-operation or exchanging a gas cylinder.

Maintenance Interval

- Before a new gas fill
- After a week of non-operation

Time Required

- 0.1 h

Tools and Materials

- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures see Section 4.6.2 on page 97)

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Evacuating the Gas Line

1. Close the corresponding gas cylinder valve.
2. Ensure that the pressure regulator in the gas line is open.
3. Press <FLUSH LINE> on the handheld keypad.
   “FLUSH: *current selection* (INERT, BUFFER, RARE, HAL.)” appears in the bottom line of the display
4. Press <Cursor Right> and/or <Cursor Left> to select the desired gas line.
5. Press <ENTER> to confirm the selection.
6. Press <EXE> to evacuate the selected gas line between the laser head valve and the gas cylinder valve.
   The message ”FLUSH: *current selection...*“ appears in the bottom line of the display.

   The vacuum pump runs for two seconds to evacuate the gas line.

   Depending on the length of the gas line, this procedure has to be repeated until the gas line is completely evacuated.

Filling the Gas Line with Fresh Gas

7. Open the gas cylinder valve that was closed in step 1.
8. Repeat the procedure at least once with the gas supply open (i.e. from step 2) to completely fill the line.

7.4.2 Purge Gas Line

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

Purpose

Evacuate the gas line for five seconds and then fill the line with the gas connected to the INERT connection (helium). This is, for example, necessary to perform a leak test with a helium leak tester or to remove impurities from the system when the laser is not used for a number of days.

Tools and Materials

- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures see Section 4.6.2 on page 97)

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Purging the Gas Line

1. Close the pressure regulator in the gas line that is to be purged.
2. Ensure that the inert gas cylinder valve is open and the pressure regulator is correspondingly set (see Section 4.6.2 on page 97).
3. Press <PURGE LINE> on the handheld keypad.
   “PURGE: current selection (*available gas lines*)”. appears in the bottom line of the display.
4. Press <Cursor Right> and/or <Cursor Left> to select the desired gas line.
5. Press <ENTER> to confirm the selection.
6. Press <EXE> to start the purging procedure.
   The message “PURGE: *current selection...*“ appears in the bottom line of the display. “OFF” appears in the display when the line purging has been completed.

   Depending on the length of the gas line, steps 3 to 6 have to be repeated until the gas line is completely purged.

   Before restarting laser operation, the gas line has to be completely filled with the appropriate gas for the line (see Section 7.4.1 on page 178).

7.4.3 Exchange Halogen Gas Cylinder

WARNING
Toxic or harmful gas hazard!
The halogen gas line to an excimer laser contains a mixture of up to 5% fluorine or 4.5% hydrogen chloride.
Always purge the halogen gas line before separating it. Avoid breathing in or skin contact with halogen gases.

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

Purpose

Replace exhausted or expired halogen (premix) gas cylinders with fresh gas cylinders.

After exchanging the gas cylinder, use inert gas to check the corresponding line for leaks.

Maintenance Interval

- When remaining pressure is equal to or less than 20% of initial value
- When gas cylinder has passed the expiry date

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Time Required

- 0.75 h

Tools and Materials

- Appropriate wrench to disconnect/re-connect gas cylinders
- Stainless steel cap (e.g. laser device’s gas line blanking plug removed during the installation) for sealing the halogen line
- Helium leak tester or liquid leak tester (e.g. SNOOP)

  Make sure that the chosen leak tester is suitable for use in the environment in which the laser is installed. Liquid leak testers are, for instance, not permitted in cleanrooms.
- Ethanol and cleaning paper (when SNOOP was used)
- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Pressure regulators and cylinder valves in each gas line closed.

Evacuating the Halogen Line

NOTICE
If pressure is applied to a pressure regulator with low secondary pressure, the pressure regulator membrane may become damaged. Always ensure that the pressure regulator is closed, before opening the gas cylinder valve.

1. Open the halogen gas cylinder valve.
2. Set the pressure regulator in the halogen line to the required pressure (see Section 4.6.2 on page 97).
3. Close the halogen gas cylinder valve.
4. Evacuate the halogen gas line without refilling it (see Section 7.4.1 on page 178).

Purging the Halogen Gas Line

5. Open the inert gas cylinder valve.
6. Set the pressure regulator in the inert line to the required pressure (see Section 4.6.2 on page 97).
7. Purge the halogen gas line at least six times (see Section 7.4.2 on page 179). The halogen gas line is now free of halogen so that the gas cylinder can now be changed.
8. Close the pressure regulator in the halogen line.

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Exchanging the Halogen Gas Cylinder

NOTICE
The halogen gas line is not to be left open for more than two minutes. Always seal the halogen line with a stainless steel cap when the line is to be separated for a longer period.

9. Exchange the gas cylinder according to the gas supply system's instructions.

Checking the Gas Line for Overpressure Leak Tightness

10. Completely open the pressure regulator in the halogen line.
11. Purge the halogen gas line (see Section 7.4.2 on page 179) to fill it with inert gas (He).

    Depending on the configuration of the gas system, the line purging routine has to be repeated at least six times until the line is completely purged.
12. Use a leak tester to check the gas line connections for leaks.
13. If there is a leak, tighten the connections and, where necessary, exchange the sealing ring. Following this, repeat the leak test.
14. When SNOOP was used, clean the gas line connections with ethanol and wipe dry with cleaning paper!

Checking the Gas Line for Vacuum Leak Tightness

15. Evacuate the halogen gas line between the laser head valve and the gas cylinder valve (see Section 7.4.1, steps 1 to 6 on page 179).
16. Repeat step 15 until the pressure regulator gauge indicates a relatively constant vacuum.

    If a vacuum is not reached there is a relatively large leak in the gas line. Check all connections in the line. If necessary, tighten the connections and repeat the evacuation of the gas line.
17. After approximately 10 minutes, check the pressure regulator gauge again. A significant increase in pressure indicates a leak.
18. If there is a leak, tighten the connections and, where necessary, exchange the sealing ring. Following this, repeat the leak test.

Cleaning, Refilling and Passivating the Gas Line

19. Close the pressure regulator in the halogen line.
20. Open the halogen gas cylinder valve.
21. Set the pressure regulator in the halogen gas line to the specified value (see Section 4.6.2.2 on page 99).
22. Flush the halogen gas line to fill it with fresh halogen gas (see Section 7.4.1 on page 178).

    Depending on the configuration of the gas system, the flushing procedure has to be repeated until the gas line is completely filled.
23. Leave the halogen gas in the gas line for approx. 15 minutes.

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24. Repeat step 22 as often as required to completely fill the halogen line with fresh gas.

Finalization

25. Ensure that the gas cylinder valves and pressure regulators are correctly set (see Section 4.6.2 on page 97).

7.4.4 Exchange Inert Gas Cylinder

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

Purpose

Replace exhausted inert gas cylinders with fresh gas cylinders.

Maintenance Interval

- When remaining pressure is equal to or less than 20% of initial value
- When gas cylinder has passed the expiry date

Time Required

- 0.5 h

Tools and Materials

- Appropriate wrench to disconnect/reconnect gas cylinders
- Stainless steel cap (e.g. laser device’s gas line blanking plug removed during the installation) for sealing the halogen line
- Helium leak tester or liquid leak tester (e.g. SNOOP)

  Make sure that the chosen leak tester is suitable for use in the environment in which the laser is installed. Liquid leak testers are, for instance, not permitted in cleanrooms.
- Ethanol and cleaning paper (when SNOOP was used)
- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Pressure regulators and cylinder valves in each gas line closed.

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Exchanging the Gas Cylinder

NOTICE
If pressure is applied to a pressure regulator with low secondary pressure, the pressure regulator membrane may become damaged. Always ensure that the pressure regulator is closed, before opening the gas cylinder valve.

1. Close the inert gas cylinder valve.
2. Exchange the gas cylinder according to the gas supply system's instructions.

Checking the Gas Line for Overpressure Leak Tightness

3. Open the inert gas cylinder valve.
4. Set the pressure regulator in the inert line to the required pressure (see Section 4.6.2 on page 97).
5. Use a leak tester to check the gas line connections for leaks.
6. If there is a leak, tighten the connections and, where necessary, exchange the sealing ring. Following this, repeat the leak test.
7. When SNOOP was used, clean the gas line connections with ethanol and wipe dry with cleaning paper!

Checking the Gas Line for Vacuum Leak Tightness

8. Close the inert gas cylinder valve and evacuate it between the laser head valve and the gas cylinder valve (see Section 7.4.1, steps 1 to 6 on page 179).
9. Repeat step 8 until the pressure regulator gauge indicates a relatively constant vacuum.

   If a vacuum is not reached there is a relatively large leak in the gas line. Check all connections in the line. If necessary, tighten the connections and repeat the evacuation of the gas line.
10. After approximately 10 minutes, check the pressure regulator gauge again. A significant increase in pressure indicates a leak.
11. If there is a leak, tighten the connections and, where necessary, exchange the sealing ring. Following this, repeat the leak test.

Cleaning and Refilling the Gas Line

12. Close the pressure regulator in the inert line.
13. Open the inert gas cylinder valve.
14. Set the pressure regulator in the inert gas line to the specified value (see Section 4.6.2 on page 97).
15. Flush the inert gas line to fill it with the fresh inert gas (see Section 7.4.1 on page 178).

    Depending on the configuration of the gas system, the flushing procedure has to be repeated until the gas line is completely filled.

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Finalization

16. Set the inert gas cylinder valve and pressure regulators to the corresponding pressure settings (see Section 4.6.2 on page 97).

7.4.5 Exchange Rare or Buffer Gas Cylinder

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

Purpose

Replace exhausted or expired rare or buffer gas cylinders with fresh gas cylinders.

After exchanging the gas cylinder, use inert gas to check the line for leaks instead of expensive rare or buffer gases.

Maintenance Interval

- When remaining pressure is equal to or less than 20% of initial value
- When gas cylinder has passed the expiry date

Time Required

- 0.5 h

Tools and Materials

- Appropriate wrench to disconnect/reconnect gas cylinders
- Stainless steel cap (e.g. laser device's gas line blanking plug removed during the installation) for sealing the gas line
- Helium leak tester or liquid leak tester (e.g. SNOOP)

  Make sure that the chosen leak tester is suitable for use in the environment in which the laser is installed. Liquid leak testers are, for instance, not permitted in cleanrooms.
- Ethanol and cleaning paper (when SNOOP was used)
- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Pressure regulators and cylinder valves in each gas line closed.

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Purging the Gas Line

NOTICE
If pressure is applied to a pressure regulator with low secondary pressure, the pressure regulator membrane may become damaged. Always ensure that the pressure regulator is closed, before opening the gas cylinder valve.

1. Close the corresponding gas cylinder valve.
2. Open the inert gas cylinder valve.
3. Set the pressure regulator in the inert line to the required pressure (see Section 4.6.2 on page 97).
4. Purge the corresponding gas line (see Section 7.4.2 on page 179).

   Depending on the configuration of the gas system, the line purging routine has to be repeated at least six times until the line is completely purged.
5. Close the pressure regulator in the corresponding gas line.

Exchanging the Gas Cylinder

6. Exchange the gas cylinder according to the gas supply system's instructions.

Checking the Gas Line for Overpressure Leak Tightness

7. Completely open the pressure regulator in the corresponding gas line.
8. Purge the corresponding gas line (see Section 7.4.2 on page 179) to evacuate it and fill it with inert gas (He).
9. Use a leak tester to check the gas line connections for leaks.
10. If there is a leak, tighten the connections and, where necessary, exchange the sealing ring. Following this, repeat the leak test.
11. When SNOOP was used, clean the gas line connections with ethanol and wipe dry with cleaning paper!

Checking the Gas Line for Vacuum Leak Tightness

12. Evacuate the corresponding gas line between the laser head valve and the gas cylinder valve (see Section 7.4.1, steps 1 to 6 on page 179).
13. Repeat step 12 until the pressure regulator gauge indicates a relatively constant vacuum.

    If a vacuum is not reached there is a relatively large leak in the gas line. Check all connections in the line. If necessary, tighten the connections and repeat the evacuation of the gas line.
14. After approximately 10 minutes, check the pressure regulator gauge again. A significant increase in pressure indicates a leak.
15. If there is a leak, tighten the connections and, where necessary, exchange the sealing ring. Following this, repeat the leak test.

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Cleaning and Refilling the Gas Line

16. Close the pressure regulator in the corresponding line.
17. Open the corresponding gas cylinder valve.
18. Set the pressure regulator in the corresponding gas line to the specified value (see Section 4.6.2 on page 97).
19. Flush the corresponding gas line to fill it with the respective fresh gas (see Section 7.4.1 on page 178).

    Depending on the configuration of the gas system, the flushing procedure has to be repeated until the gas line is completely filled.

Finalization

20. Ensure that the gas cylinder valves and pressure regulators are correctly set (see Section 4.6.2 on page 97).

7.5 Laser Tube Maintenance

7.5.1 New Fill

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

Purpose

Evacuate spent excimer laser gases from the laser tube and fill the laser tube with the appropriate fresh excimer laser gases. The laser tube is automatically evacuated and filled to the required pressure through the dedicated software routine “NEW FILL”. The exact gas mixture is determined through the currently active gas menu.

The gas lifetime is largely dependent on the operating conditions. The frequency with new fills are required should be recorded so that you can prepare a maintenance schedule specific to your individual requirements. Note the date and total counter reading at which each new fill is made in your laser logbook.

The following situations will reduce the laser gas lifetime:

– the laser tube has just been passivated,

– the first fill after a period of weeks without laser operation,

– the laser resonator optics are contaminated,

– high energy values in the EGY CONST mode.

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Maintenance Interval

- Every 5 to 25 million pulses
- Every 1 to 2 weeks
- A new gas fill is also recommended:
  - if the output energy is too low for your application,
  - after a warning or error message ”PRESET ENERGY TOO HIGH“, “NEW GAS FILL NEEDED“ or “LOW LIGHT“,
  - before calibrating the energy monitor,
  - after re-passivating the laser tube.

Time Required

- 0.5 h

Tools and Materials

- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Laser device housing closed
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures see Section 4.6.2 on page 97)
- No impurities in the laser tube or gas lines

  When the laser has not been run for more than a month, flush the gas lines to remove any impurities (see Section 7.4.1 on page 178).

Evacuating and Filling the Laser Tube

1. Turn on the excimer laser gases and set the pressure regulator in each line to the required pressure (see Section 6.2.3 on page 137).
2. Press <NEW FILL> on the handheld keypad.

   “> NEW FILL” appears in the bottom line of the display.
3. Press <ENTER> to confirm that a new fill is to be started.

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4. Press <EXE> to start the NEW FILL procedure.

NOTICE
Only interrupt the procedure with <BREAK> in case of an emergency. As the procedure is immediately interrupted and the fill is incomplete, there may be insufficient pressure in the laser tube. In this case, manually fill the laser tube to 1050 mbar with inert gas (see Section 6.3.6.2 on page 155) or restart the new fill procedure.

Before the new fill is started a gas system check is executed. This ensures that the time-delay relay is correctly working, verifies that there is no overpressure or underpressure in the external gas lines, checks the correct operation of the halogen gas solenoid valve and compares the pressure sensor values. After successfully completing the check, the new fill will be started.

At the start of each new fill, the halogen filter ratio is checked. If it exceeds 100%, the message “RENEW HALOGEN FILTER” is displayed and an interlock occurs after the next halogen gas action. Replace the halogen filter at the latest before the next new fill procedure.

The vacuum pump starts to evacuate the tube, the current pressure is displayed. After reaching 60 mbar the individual gases are then filled into the laser tube at the partial pressures indicated in the gas menu. When the new fill has been successfully completed, “OFF” appears in the display.

NOTICE
If evacuation fails (vacuum setpoint value not reached), warning status code 32 appears and a safety fill is performed. This automatically fills the laser tube to 1050 mbar with inert or buffer gas (depending on external gas supply configuration). Always determine the reason for the evacuation failure before continuing the new fill procedure (for further information, please refer to the troubleshooting information on page 253).

7.5.2 Purge Laser Tube

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

Purpose

Replace the laser gas in the laser tube with inert gas. The “purge reservoir” procedure evacuates the laser tube and fills it to 1050 mbar with the gas that is connected to the inert gas line.

The <PURGE RESERVOIR> key enables two different procedures to be chosen: reservoir purging and resonator optics exchange. The optics exchange procedure is described in Section 7.6.1 on page 193.

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Maintenance Interval

Purging the laser tube is recommended:

- When the laser was not in use for more than one month
- If a gas leak is suspected
- After repairing a leak in the laser tube.

Tools and Materials

- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).

Purging the Tube with Inert Gas

1. Close all pressure regulators and gas cylinder valves.
2. Open the valve on the inert gas cylinder.
3. Set the pressure regulator in the inert gas line to the required pressure.
   The gas pressures are indicated in Section 4.6.2 on page 97.
4. Press <PURGE RESERVOIR>.
5. Where necessary, press cursor left or cursor right to select “PURGE TUBE”.
6. Press <ENTER> to confirm the choice.
7. Press <EXE> to proceed. The message ”FLUSHING...“ appears.

   The vacuum pump starts to evacuate the laser tube. After reaching the vacuum setpoint, the laser tube is filled to 1050 mbar with inert or buffer gas (depending on external gas supply configuration).

NOTICE
Only interrupt the procedure with <BREAK> in case of an emergency. As the procedure is immediately interrupted and the fill is incomplete, there may be insufficient pressure in the laser tube. In this case, manually fill the laser tube to 1050 mbar with inert gas (see Section 6.3.6.2 on page 155) or restart the purging procedure.

Finalization

8. Carry out a new fill before restarting laser operation.

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7.5.3 Transportation Fill

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

Purpose

Fill the laser tube with inert gas prior to transportation of the device or long periods of storage.

Tools and Materials

- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Laser radiation not being emitted
- Inert gas cylinder valve open and pressure regulator correctly set (see Section 4.6.2 on page 97)

Transportation Fill Procedure

1. Press <NEW FILL>.
   The bottom line of the handheld keypad display shows the available options.
2. Use the cursor keys to select <TRANSP>.
3. Press <ENTER> to confirm the selection.
4. Press <EXE> to start the transport fill.

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7.6 Resonator Optics Maintenance

Maintenance of the laser optics consists of cleaning and exchange.

Cleaning the optics is necessary

– after a specific number of pulses (dependent on gas mixture / wavelength),
– if the pulse energy is too low,
– if the beam profile is poor.

Exchange of the optics is necessary

– if the optics are degraded (e.g. damaged coating),
– if the optics are unable to be cleaned (e.g. burned-in deposits),
– after a specific number of optics cleaning operations (dependent on gas mixture / wavelength).

Each of the optics is contained in a dedicated optics mount that first has to be removed from the laser device and disassembled before the optic can be cleaned or exchanged.

To maximize uptime, sets of ready-to-use laser optics can be prepared and stored in spare mounts. This enables contaminated or degraded laser optics to be maintained at your convenience while the laser is running.

In accordance with the maintenance concept described above, this section consists of the following subsections:

– Section 7.6.1 describes the procedure to remove optics mounts containing the contaminated or degraded optics from the laser device and insert optics mounts containing the new or cleaned optics. This includes the procedure to adjust the laser resonator after exchanging the optics.
– Section 7.6.2 on page 205 describes the procedure to disassemble and reassemble the optics mount removed in Section 7.6.1. This enables the contaminated or degraded optics to be cleaned or exchanged.
– Section 7.6.3 on page 209 describes the procedure to clean contaminated optics.

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7.6.1 Exchange Resonator Optics

DANGER
Harmful gas exposure hazard!
Incorrect maintenance will cause the harmful halogen gas mixture to escape from the laser tube into the environment. Resonator optics shall only be exchanged by correspondingly trained personnel that are fully aware of the inherent hazards.

DANGER
Risk of exposure to Class 4 radiation!
During this procedure, adjustment work on an open laser may be required. This work shall only to be performed by authorized and correspondingly trained personnel.
Always wear suitable eye and skin protection when there is the risk of exposure to Class 4 excimer laser radiation.

CAUTION
The laser device is to remain powered up during this procedure! Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device. All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

NOTICE
Contamination can cause serious damage to optical components. Always wear disposable plastic gloves when working with and on optical components

Purpose

Remove worn or damaged resonator optics (output coupler and rear mirror) and insert new premounted optics into the laser device.

Prior to removing the optics, the halogen gas mixture has to be pumped out of the laser tube and the tube refilled with the gas connected to the inert valve. Following replacement of the optics, a leak test has to be performed. These procedures are controlled through a dedicated software routine.

After inserting the replacement optics, re-adjustment of the laser resonator will be necessary. Therefore, always exchange the output coupler and the rear mirror in two separate procedures. This enables the replaced optics to be aligned using correctly adjusted optics as a reference. The dedicated optics exchange software routine will, however, have to be executed for the exchange of each of the optics mounts (i.e. twice in total).

When both resonator optics mounts are replaced in a single procedure (i.e. the software routine is only executed once), resonator adjustment can only be performed by specially trained service personnel.

Maintenance Interval

- Remove optics for cleaning:
  - Every 10 to 30 million pulses
  - Every 3 to 5 new gas fills
- Exchange optics:
  - After cleaning the tube optics five times
    With ArF versions, always exchange the optics after cleaning every third time.
  - If the optics are degraded or unable to be cleaned

Time Required

- 1.5 h

Tools and Materials

- 4 mm allen key
- Long 3 mm allen key
- Short 3 mm allen key
- 2.5 mm allen key
- Set of premounted optics (HR rear mirror and output coupler) or sealing plates

  Coherent recommends using two sets of pre-mounted optics. If only one set of optics is available, always use the corresponding sealing plates.
- External energy measuring device (e.g. energy meter)

  Whenever practical, choose an energy meter head (sensor) that can be placed against the beam exit aperture so that no Class 4 laser emission enters the working area. Make sure that the energy meter head does not restrict access to the alignment screws. If necessary, use an extension tube to provide the necessary clearance.

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

- Gases as specified (see Section 4.6.2 on page 97).
- Laser safety glasses
- Disposable skin-tight plastic gloves

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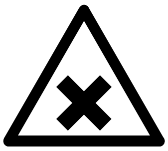
Preconditions

- Laser device switched on.
- No laser radiation being emitted (laser off mode).
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures see Section 4.6.2 on page 97)

Flushing the Laser Tube



DANGER
Risk of exposure to harmful halogen gas mixture!
If the predetermined optics exchange procedure is not strictly followed, harmful gas will escape from the laser tube.
Never open the laser device housing or start to remove the optics unless the laser tube has been flushed and filled with inert gas
Always use the dedicated optics exchange software routine and strictly follow all instructions.

NOTICE
A) When the dedicated software routine has been started, the laser device cannot be opened until the laser tube is filled with inert gas ready for the resonator optics exchange procedure. This condition is indicated by a corresponding message on the hand-held keypad. If the laser device is opened prematurely, the automatic flushing routine will be immediately aborted[a].
B) If pressure is applied to a pressure regulator with low secondary pressure, the pressure regulator membrane may become damaged. Always ensure that the pressure regulator is closed, before opening the gas cylinder valve.

1. Ensure that the cylinder valve and pressure regulator in the inert gas line are closed.
2. Open the valve on the inert gas cylinder.
3. Set the pressure regulator in the inert gas line to the specified value (see Section 4.6.2 on page 97).
4. Press <PURGE RESERVOIR>.
   A list of selections appears in the bottom line of the display.
5. Press <Cursor Right> and/or <Cursor Left> to select ”WIN.EXCHANGE“.
6. Press <ENTER> to confirm.

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a. In case of unintentional abortion of the automatic flushing routine, the dedicated software routine will have to be repeated from the beginning

7. Press <EXE> to start the laser tube flushing routine.

   The routine shown in Figure 78 starts. The timing of the routine as well as the exact pressure values are subject to change depending on the version and operating conditions of the laser device.

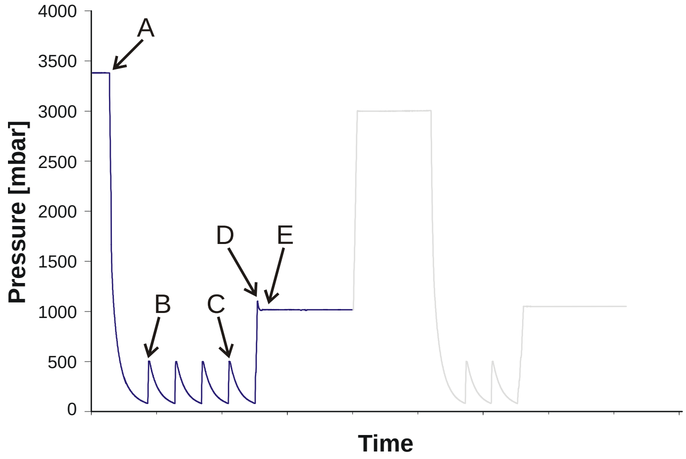

Figure 78: *Flushing routine (cycles prior to optics exchange)*

Each cycle within the flushing routine is indicated by a corresponding message on the hand-held keypad:

- FLUSHING 1 OF 5 - KEEP COVER CLOSED (see Figure 78, A): The excimer gas is released from the laser tube. At 1500 mbar the vacuum pump cuts in and evacuates the laser tube to 80 mbar.
- FLUSHING 2 OF 5 - KEEP COVER CLOSED (B): The first of three cycles starts that fill the laser tube to 500 bar with inert gas and then evacuate it to 80 mbar.
- FLUSHING 5 OF 5 - KEEP COVER CLOSED (C): The laser tube is filled to 500 mbar with inert gas, evacuated to 80 mbar and then filled to 1100 mbar with inert gas.
- PRESSURIZATION - KEEP COVER CLOSED (D): Pressure is released from the laser tube and inert gas is slowly added to the laser tube until the pressure inside the laser tube is slightly above the ambient air pressure.
- EXCHANGE WINDOWS THEN PRESS <ENTER> (E): The laser tube is ready for the tube optics exchange procedure. At the this point the appropriate laser device housing covers can be safely removed to enable the optics to be exchanged.

NOTICE
Never press <ENTER> when the tube optics are removed as this may damage the laser tube by causing a large amount of ambient air to enter.

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Exchanging the Output Coupler

8. Use the 3 mm allen key to remove the front mirror access panel and internal beam delivery tube from the laser device (see Section 7.3.2.2 on page 175).

   Removal of the front mirror access panel (shutter panel) provides sufficient access to enable removal of the output coupler. If access is nevertheless restricted, also remove the service panel to gain access to the output coupler.
9. Disconnect the purge gas line from the top of the energy monitor (see Figure 79, B).

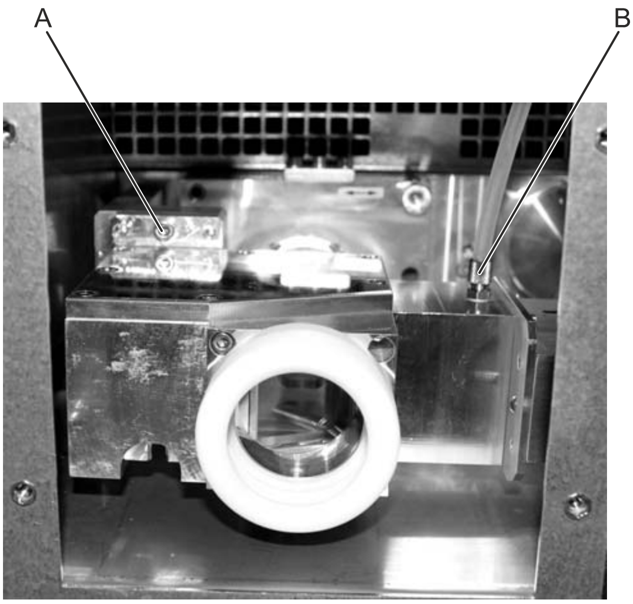

Figure 79: *Disconnecting and unscrewing the energy monitor*

10. Use the 4 mm allen key to remove the screw that secures the energy monitor (see Figure 79, A).
11. Carefully pull the energy monitor away from the locating pins.
12. Turn aside the energy monitor. Where necessary, disconnect the electrical line and FOLs from the energy monitor. The output coupler is now accessible.

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NOTICE
Take into account that there is overpressure in the laser tube. Always hold the optic mount with the other hand while loosening it. Loosen the screws crosswise and in stages. After approx. three turns of each screw, wait for the overpressure to escape before continuing to remove the screws.

13. Use the 3 mm allen key to loosen the six M4 screws securing the output coupler mount (see Figure 80).

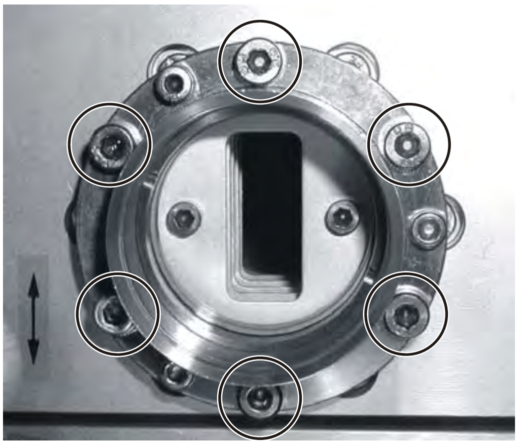

Figure 80: *Screws securing the output coupler mount*

14. Wearing plastic gloves, remove the optics mount (see Figure 81).

    A short hissing sound indicates that the tube is now open. The inert gas valve opens every two seconds to compensate for the pressure drop and prevent air from entering the tube. When the tube is open for longer than a minute, a warning message appears. In this case, immediately insert the optics or a dedicated sealing plate.

Figure 81: *Removing the output coupler mount*

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15. Immediately insert the premounted optics (see Figure 82) or sealing plate.

Figure 82: *Inserting the output coupler mount*

16. Tighten the six screws securing the optics mount crosswise and in stages with the 3 mm allen key (see Figure 83).

Figure 83: *Tightening the output coupler mount*

17. Use the 4 mm allen key to re-mount the energy monitor (see Section 7.10.2 on page 231).
18. Where necessary, reconnect the disconnected supply lines to the energy monitor.
19. Use the 3 mm allen key to re-insert the front mirror access cover (see Section 7.3.2.2 on page 175).

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Leak Testing the Laser Tube

20. Press <ENTER> to confirm that the optics have been exchanged and the housing covers are closed.
    The automatic flushing routine is continued (see Figure 84).

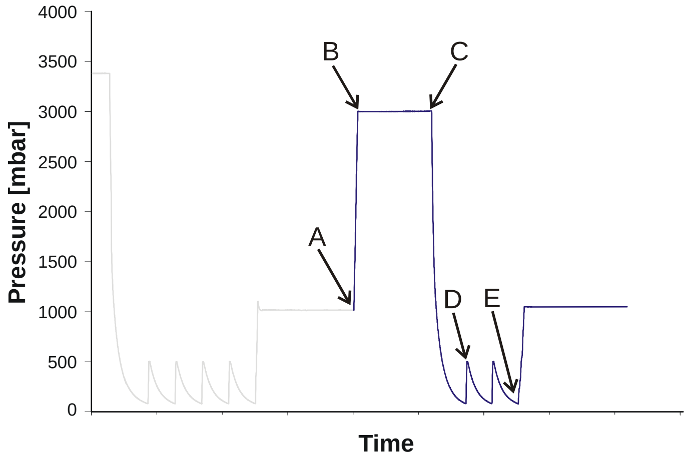

Figure 84: *Flushing routine (cycles after optics exchange)*

Each cycle is, once again, indicated by a corresponding message on the hand-held keypad:

- PREPARING LEAK TEST - PLEASE WAIT (see Figure 84, A):
  The laser tube is filled to 3000 mbar with inert gas.
- LEAK TEST xxx s - KEEP COVER CLOSED (B):
  The laser tube remains filled with 3000 mbar of inert gas and the pressure is monitored to test for leaks. The remaining time is indicated on the hand-held keypad display.
  Initially there is a coarse leak test that monitors the pressure for approx. 5 minutes and indicates a leak if the pressure drops more than 100 mbar. If there is no significant pressure drop, a fine leak test commences for a further period of approx. 10 minutes. This indicates a leak if the pressure drops more than 3 mbar.
  The routine that is started if a leak occurs is shown in Figure 85.
- FINAL FLUSH 1 OF 3 - KEEP COVER CLOSED (C):
  The inert gas is released from the laser tube. At 1500 mbar the vacuum pump cuts in and evacuates the laser tube to 80 mbar.
- FINAL FLUSH 2 OF 3 - KEEP COVER CLOSED (D):
  The first of two cycles starts that fill the laser tube to 500 bar with inert gas and then evacuate it to 80 mbar.
- FINAL FILL - KEEP COVER CLOSED (E):
  The laser tube is filled to 1050 bar with inert gas.

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In case of a leak, additional cycles are necessary in the flushing routine to enable the leak to be detected.

Figure 85 shows the additional leak detection cycles in the flushing routine. Each of these cycles is indicated by a corresponding message on the hand-held keypad:

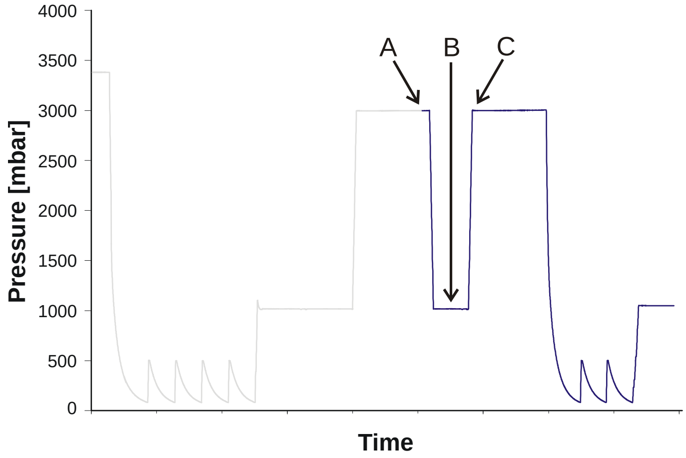

Figure 85: *Flushing routine (cycles if leak detected)*

- LEAK DETECTED - PLEASE WAIT (see Figure 85,A):
  Due to a detected drop in the laser tube pressure during the leak test, the laser tube is evacuated to a pressure slightly above ambient pressure.
- LEAK CHECK WINDOWS THEN PRESS <ENTER> (B):
  The laser device is ready for the source of the leak to be determined. At this point the appropriate housing covers can be removed. Nevertheless, before taking further action in case leaks between 4 mbar and 15 mbar, it is advisable to repeat the leak test at least once by pressing <ENTER>. This is because a drop in the ambient temperature during the leak test may erroneously indicate a leak.
  If, after repeating the leak test, the warning message appears again, locate the exact source of the leak and rectify. The most likely reason for a leak is either damage to the optic mounts, the two O-ring seals and O-ring grooves or incorrect positioning of the optic in the mount. In this case, repeat steps 13 to 16 to remove and check the optic mounts.
  After locating and rectifying the leak, press <ENTER> to continue the flushing cycle.
- The laser device repeats the leak test (C) shown in Figure 84.
  At the end of the flushing routine, the laser tube is filled to 1050 mbar with inert gas.

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Adjusting the Output Coupler

NOTICE
Always adjust the newly installed optic before exchanging the other optic.

21. Perform a new fill (see Section 7.5.1 on page 187) to fill fresh excimer laser gas into the laser tube.
22. Place the external energy measuring device in the beam path and set-up the display unit (for further information, please refer to the energy measuring device’s operating instructions).

    A configuration similar to that shown in Figure 86 enables adjustment of the optics without Class 4 laser emission entering the working area. Always strictly comply with local safety regulations. Contact the responsible laser safety officer for further information and guidance.

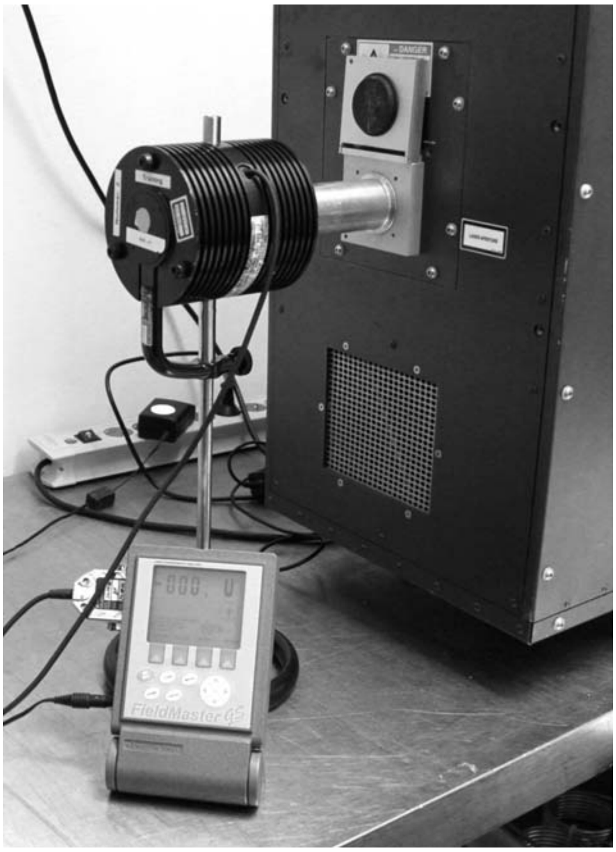

Figure 86: *Set-up for output coupler adjustment*

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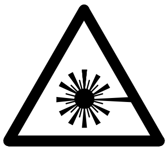

DANGER
Class 4 laser radiation can cause serious eye injury and burns!
Always familiarize yourself with the necessary safety precautions before starting the laser.
Whenever there is a risk of exposure to Class 4 laser radiation, wear suitable eye and skin protection at all times.
Avoid contact with the laser beam.
Never stare into the laser beam or its reflection.

23. Start the laser and allow it to run for a few minutes to warm up the excimer laser gas mixture.
24. Set the laser to the HV CONST mode, select the maximum high voltage indicated on the data sheet as well as the repetition rate specified on the data sheet for the required output energy (see Section 6.3.5 on page 147).
25. Turn the horizontal adjustment screw (see Figure 87, A), from right to left until the output energy is at its highest.

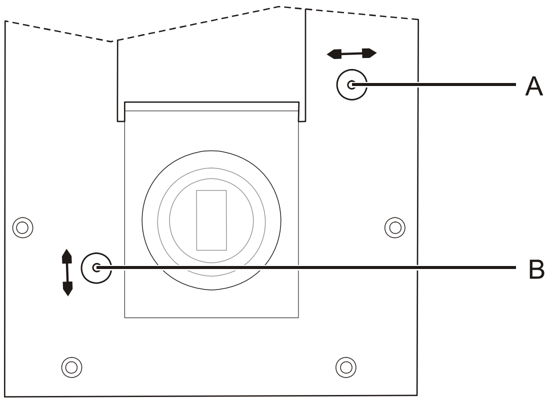

Figure 87: *Horizontal and vertical optics adjustment*

26. Repeat step 25 with the vertical optic adjustment screw (B).
27. If there is insufficient energy (see laser data sheet for the required energy output), repeat steps 25 and 26.
28. When the output coupler has been correctly adjusted (maximum energy output), stop the laser.

Exchanging and Adjusting the HR Rear Mirror

29. Repeat the “Flushing the Laser Tube” procedure (see page 195) to fill the laser tube with inert gas.
30. When “REPLACE WINDOWS (enter)” appears, use the 3 mm allen key to remove the rear mirror access panel (see Section 7.3.2.3 on page 177).

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31. Pull, with a slight turning and to-and-fro motion, the cap off of the rear mirror (see Figure 88).

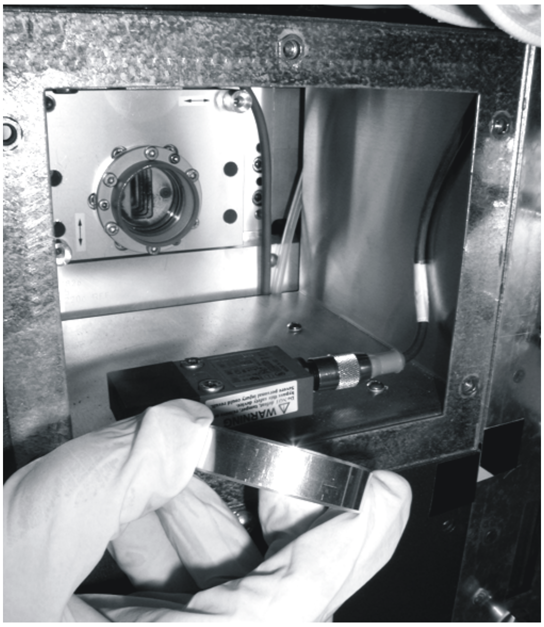

Figure 88: *Removing rear mirror cap*

32. Repeat steps 13 to 16 (see page 198) to exchange the rear mirror.
33. Push the cap back onto the rear mirror (see Figure 89).

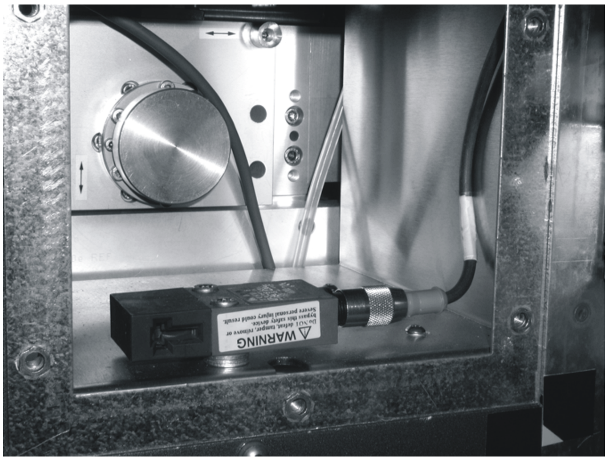

Figure 89: *Rear mirror cap in working position*

34. Use the 3 mm allen key to re-insert the rear mirror cover.
35. Repeat step 20 to perform a leak test.
36. Repeat steps 21 to 27 (see page 202) to adjust the rear mirror.

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Finalization

37. Calibrate the energy monitor (see Section 7.10.1 on page 228).

7.6.2 Disassemble / Assemble Resonator Optics Mounts

NOTICE
Contamination can cause serious damage to optical components. Always wear disposable plastic gloves when working with and on optical components.

Purpose

Disassemble the resonator optics mounts to remove the resonator optics (mirrors) for cleaning (see Section 7.6.3) or exchange. Reassemble the optics mounts for installation into the laser device.

To minimize downtime, Coherent recommends the use of an additional set of resonator optics and mounts. This enables the procedure described in this section to be performed at your convenience while the laser is running.

Tools and Materials

The tools and materials that are required to exchange the resonator optics in the optics mounts are shown in Figure 90.

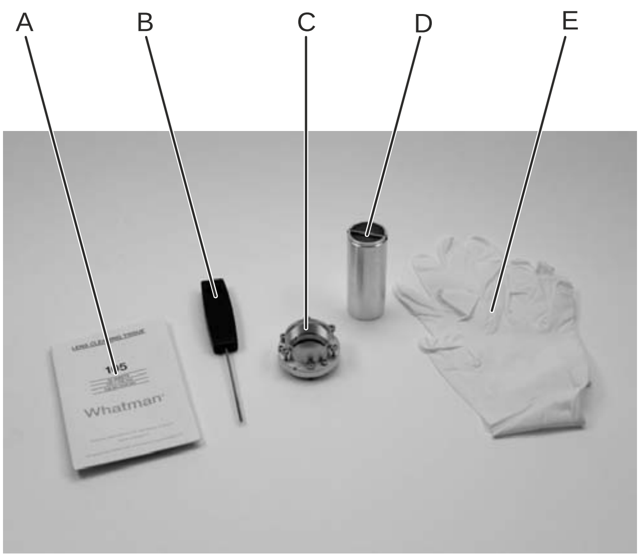

Figure 90: *Preparing resonator optics mount disassembly*

- Optics mount with contaminated or worn mirror (C)
- Optics wrench (D, special tool in service case)
- 2.5 mm allen key (B)
- Disposable skin-tight plastic gloves (E)
- Lens cleaning tissue (A)

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Maintenance Interval

- See Section 7.6.1 on page 193

Preconditions

- Mount with contaminated or degraded optic removed from the laser device (see Section 7.6.1 on page 193).

Disassembling the Optics Mount

1. Use the optics wrench to turn (approx. 5 times) and loosen the threaded pressure ring (see Figure 91).

Figure 91: *Loosening the optics pressure ring*

2. Use the 2.5 mm allen key to loosen the three screws (do not lose the washers!) and remove optics mount from counter optics mount (see Figure 92).

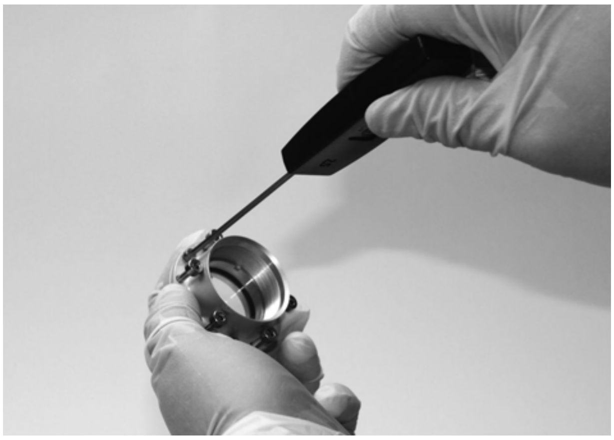

Figure 92: *Unscrewing the optics mount*

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3. Remove the mirror (see Figure 93, B) and spacer (E) from the collar (F). If the mirror and spacer are stuck in the collar, gently apply pressure with a piece of lens cleaning tissue to separate them.

   The mirror is now ready for cleaning or exchange. To minimize contamination and damage, lay the mirror onto a piece of fresh lens cleaning tissue.

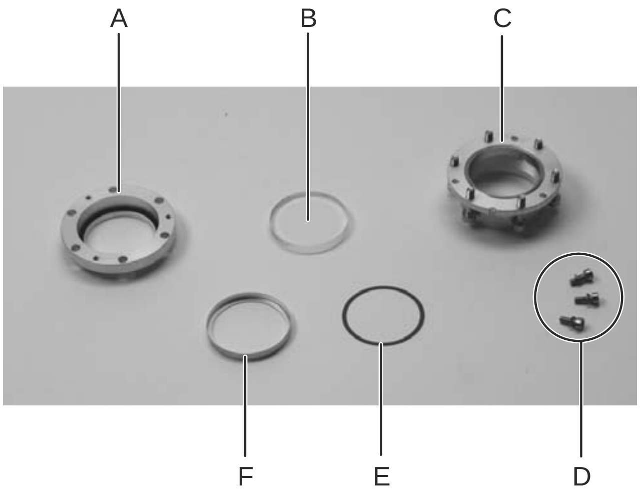

Figure 93: *Disassembled resonator optics mount*

Key to Figure 95:

A	Counter optics mount	D	Fastening screws
B	Mirror (optical element)	E	Spacer
C	Optics mount	F	Collar

Reassembling the Optics Mount

4. Visually check all parts of the optics mount to ensure that there are no signs of damage.
5. Note the pencil marking that indicates the coated side of the mirror (see Figure 94).

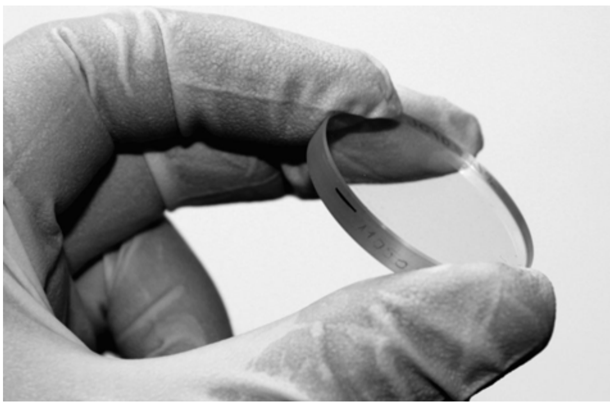

Figure 94: *Marking indicating the coated side of the mirror*

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6. Insert the spacer (see Figure 95 D) and mirror (B) into the collar (E). The coated side (C) of the mirror has to point towards the spacer and collar.

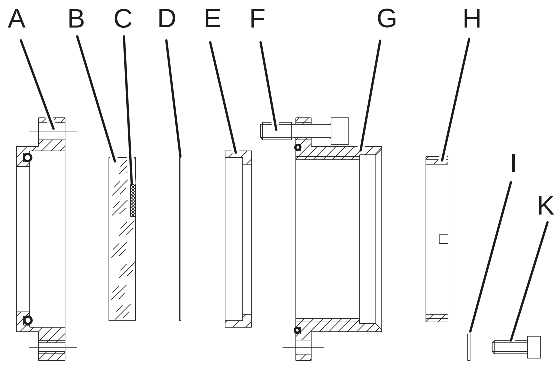

Figure 95: *Assembling the optics mount*

Key to Figure 95:

A	Counter optics mount	F	Captive screws
B	Mirror	G	Optics mount
C	Coating mark	H	Pressure ring
D	Spacer	I	Washer
E	Collar	K	Fastening screw

7. Place the collar onto the optics wrench so that the non-coated side of the mirror points upwards.
8. Place the counter optics mount over the collar (see Figure 96).

Figure 96: *Assembling the counter optics mount*

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9. Taking into account the position of the screw holes, place the optics mount onto the counter optics mount (see Figure 97) and use the 2.5 mm allen key to evenly tighten the three fastening screws.

Figure 97: *Assembling the optics mount*

10. Use the optics wrench to tighten the threaded pressure ring until it is hand tight.

7.6.3 Clean Resonator Optics

NOTICE
Contamination can cause serious damage to optical components. Always wear disposable plastic gloves when working with and on optical components.

Purpose

Clean contaminated resonator optics.

Tools and Materials

- Glass plate or similar clean, flat and smooth working surface
- Lens cleaning tissue
- Pressurized air or inert gas that is particulate and oil-free
- Polishing powder (e.g. vienna chalk from service case)
- Distilled water
- Optics grade Ethanol or Methanol
- Lead pencil
- Disposable skin-tight plastic gloves

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Maintenance Interval

- Every 10 to 30 million pulses
- Every 3 to 5 new gas fills

Preconditions

- Contaminated optic removed from the optics mount (see Section 7.6.2 on page 205).

Preparation

1. Place three layers of lens tissue on a clean, dry and smooth surface (glass plate).
2. Use pressurized air or inert gas to blow off any loose particles from both sides of the optic.
3. Check that the optic has a mark indicating the coated surface.

   The coated side of the mirror only requires cleaning when contaminated (e.g. through fingerprints or dust).

   The coated side of the optic is usually marked with a horizontal line along the edge that has the coating or an arrow or upside down V pointing towards the coating.

   To verify for yourself which side of the optic has the coating, hold the optic at an angle while looking at reflected light from a fluorescent bulb. The reflected light will have a greenish to pink tint across the entire surface whereas the backside has no tint.
4. Use a pencil to make or enhance the mark indicating the coated surface.
5. Lay the optic with the coated side downwards onto the prepared lens tissue.

Cleaning the Optic

NOTICE
A) Any action performed on an optic can potentially scratch it. Always begin with the simplest cleaning approach and the one least likely to scratch the optic.
B) Risk of damaging coated optics!
Never use cleaning powders (e.g. vienna chalk) to clean the coated side of the optic. Only use ethanol for polishing. Polish carefully with gentle pressure.

6. Place a single sheet of lens cleaning paper over the optic.
7. Put a few drops of ethanol onto the lens tissue close to one edge of the optic.
8. While holding the optic in place, drag the lens tissue across the surface of the optic.
9. Turn over the optic and repeat the above procedure to clean the coated side of the optic.

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10. If the first cleaning approach did not result in a clean optic, place three fresh sheets of lens cleaning tissue onto a clean, dry and smooth surface (glass plate).
11. Mix two teaspoons of distilled water or ethanol with one teaspoon of vienna chalk on the uppermost tissue.
12. Holding the optic between your index finger and thumb, place the uncoated side of the optic onto the vienna chalk slurry.

NOTICE
The surface of the optic is easily scratched!
Excessive downward pressure can scratch the optical surface. Let the weight of the optic apply the downward force.

13. While applying a sideways pressure, move the optic in a circular or figure-eight fashion for approx. three minutes (see Figure 98).

Figure 98: *Cleaning the uncoated side of the mirror*

14. Rinse the optic, e.g. under flowing distilled water.
15. Place three layers of fresh lens tissue on a clean, dry and smooth surface (glass plate).
16. Lay the optic with the coated side downwards onto the prepared lens tissue.
17. Place a single sheet of lens cleaning paper over the optic.
18. Put a few drops of ethanol onto the lens tissue close to one edge of the optic.
19. While holding the optic in place, drag the lens tissue across the surface of the optic.
20. Repeat steps 17 to 19 until the optic is clean and dry.
21. Visually inspect the optic (in a well-lit area) to ensure that it is clean and dry.

Finalization

22. Insert the cleaned optic into the optics mount (see Section 7.6.2) ready for re-installation into the laser device.

7.7 Laser Resonator Alignment

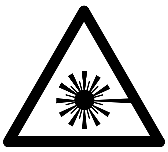
Purpose

Use a visible HeNe or diode alignment laser to align the rear mirror and output coupler of a plane-parallel resonator so that they are parallel to each other and at right-angles to the laser beam. This is necessary to ensure even energy distribution and a good beam profile.

Prior to aligning the optics, the visible alignment laser has to be adjusted to pass through the exact center of the laser resonator.

This procedure only applies when a dielectric coated HR rear mirror is inserted. Aluminum coated mirrors will not transmit the visible light of the alignment laser.

Alternative Methods



DANGER
Risk of injury through class 4 laser radiation!
Laser resonator alignment procedures that require working with an open class 4 laser beam shall only be performed by authorized persons that have received specific instruction at a Coherent training course. Always strictly follow the required laser safety precautions.

In addition to resonator alignment using a visible alignment laser as described in this section, there are other methods of aligning the resonator and optimizing energy distribution and beam profile, e.g. aligning the resonator by optimizing the power output of the laser.

Some alternative methods of laser alignment require working with an open class 4 laser beam. These methods shall only be performed by persons that are authorized and have received specific training at a dedicated Coherent training course. Please contact Coherent for further information.

Tools and Materials

- Class 2 diode or HeNe (visible) alignment laser

  Class 2 lasers have a maximum power output of 1 mW. HeNe lasers operate at a wavelength of 632.8 nm (visible red). The wavelength of a diode laser is version dependent. For further information, please refer to the manufacturer’s instructions.
- Alignment apertures (from service case)
- Piece of card, on which points of light can easily be seen, with 2 mm pin hole
- 4 mm allen key
- Long 3 mm allen key

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Maintenance Interval

- Whenever the tube optics have been cleaned / exchanged

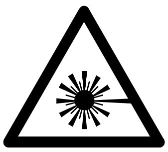
Time Required

- 1.0 h

Preconditions

- Laser device switched off and locked out (see Section 7.3.1 on page 169).
- Front and rear mirror access covers removed and accessed gained to the front and rear optics.

Setting Up the Visible Alignment Laser



CAUTION
Risk of eye injury!
Do not stare into the beam of a class 2 laser.
Remove all jewelry while performing the alignment procedure.
Never look directly at reflected beams.

1. Direct the visible alignment laser from the rear through the center of the laser cavity (see Figure 99).

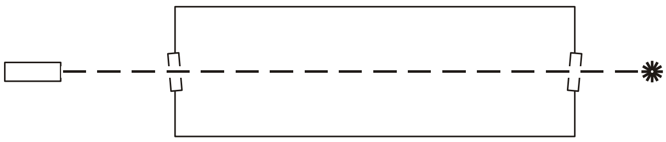


Figure 99: *Direct alignment laser through laser cavity*

   The electrodes in an excimer laser are very smooth and can easily reflect the light of the alignment laser. It is, therefore, possible to align the laser such that it appears to be on axis when, in fact, it is being reflected off an electrode. This is easily determined by observing the direction in which the alignment laser light moves as you adjust the alignment laser mirror:
   - If you adjust the mirror to move the light upwards, the light at the output side should move upwards.
   - If you make an adjustment upwards and the beam moves downwards, this indicates that the alignment laser beam is being reflected off an electrode.
2. When the alignment laser is roughly on axis with the laser resonator, screw the two plastic alignment apertures into the opening of each optics mount.

   The optics can remain installed during this procedure.

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3. Adjust the alignment laser until the beam exactly passes through both holes in the alignment apertures (see Figure 100).

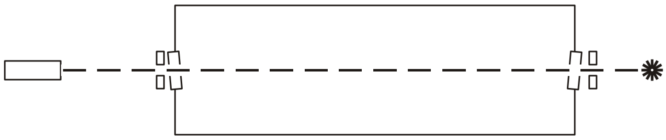

Figure 100: *Direct alignment laser through alignment apertures*

4. Remove the alignment apertures.

Aligning the Laser Resonator

5. Place the piece of card as close as possible to alignment laser.
6. Position the card so that the beam cleanly passes through the pin hole.

   Each resonator optic will reflect a small percentage of the alignment laser beam back towards the alignment laser. Depending on the size of the card and initial adjustment of the optics, these two light spots may already be visible on the card (see Figure 101).

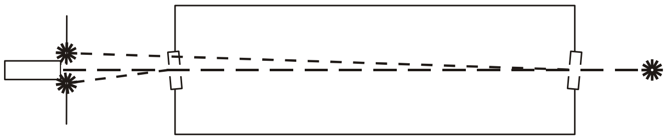

Figure 101: *Reflection of alignment laser on card (alignment necessary)*

7. Use the long 3 mm allen key to adjust the horizontal and vertical adjustment at the output coupler until the reflected light is concentric with the alignment laser beam at the pin hole.
8. Using the long 3 mm allen key, adjust the horizontal and vertical adjustment at the HR rear mirror until the reflected light is concentric with the alignment laser beam and reflected light from the output coupler at the pin hole (see Figure 102).

   The reflection from the output coupler is dimmer and larger in diameter.

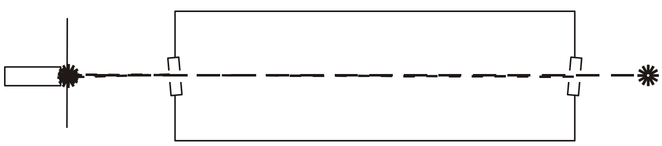

Figure 102: *Reflection of alignment laser on card (optics aligned)*

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Finalization

9. Re-install the components removed to gain access to the tube optics.

   The exact procedure depends on the version of the COMPex*Pro*. For further information please refer to the appropriate optics exchange procedure (see Section 7.6 on page 192).

7.8 Unstable Resonator Set-Up / Alignment

This section describes the set-up and maintenance of an unstable resonator.

- Section 7.8.1 describes the procedure to install an unstable resonator instead of a standard plane-parallel resonator.
- Section 7.8.2 describes the procedure to align an unstable resonator.

7.8.1 Retrofit Unstable Resonator

CAUTION
The laser device is to remain powered up during this procedure! Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device. All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

NOTICE
Contamination can cause serious damage to optical components. Always wear disposable plastic gloves when working with and on optical components

Purpose

Install a set of unstable optics in the external resonator instead of the standard plane-parallel resonator optics.

The unstable resonator optics set consists of:

– a meniscus lens that serves as the output coupler (OC) and seals the laser tube. This optic is installed instead of the standard stable resonator OC.

– a MGF2 cavity window that seals the laser tube. This optic is installed instead of the standard stable resonator HR rear mirror.

– a plano-convex rear mirror. This optic is installed in an optics mount that, in turn, is installed in an extension to the laser resonator.

Tools and Materials

- Set of unstable resonator optics
- MGF2 cavity window
- Unstable resonator adapter kit
- Sealing plates or an additional set of optics mounts
- 4 mm allen key
- Long 3 mm allen key
- Short 3 mm allen key
- 2.5 mm allen key
- Disposable skin-tight plastic gloves

NOTICE
If the remaining gas cylinder pressure drops below a critical value, the humidity in the gas may significantly increase. Only use gas cylinders with a remaining pressure of more than 20% of the initial value.

- Gases as specified (see Section 4.6.2 on page 97).

Preconditions

- Laser device switched on.
- No laser radiation being emitted (laser off mode).
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures, refer to the Specifications section of the User Manual)

Preparation

NOTICE
For safety reasons, the laser device cannot be opened until the laser tube is filled with inert gas ready for the resonator optics exchange procedure. This condition is indicated by a corresponding message on the hand-held keypad. If the laser device is opened prematurely, the automatic flushing routine will be immediately aborted.

1. Use the dedicated ”WIN.EXCHANGE“ software routine to flush the laser tube (see Section 7.6.1, steps 1 to 7 on page 195).

Exchanging the Output Coupler

2. Remove the front mirror access panel and energy monitor (see Section 7.6.1, steps 8 to 12 on page 197)
3. Wearing skin-tight plastic gloves, remove the output coupler mount from the laser device and insert a sealing plate.
4. Disassemble the output coupler mount (see Section 7.6.2, steps 1 to 3 on page 206).

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5. Taking into account the direction of the beam (see Figure 103, N), insert the meniscus lens (E), spacer (L), collar (D), and one of the sealing rings (K) into the counter optics mount (F).

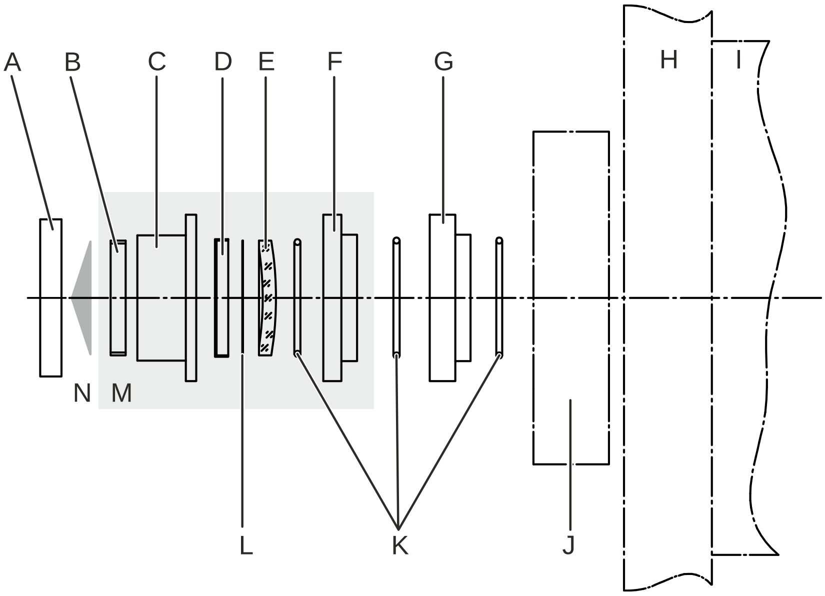

Figure 103: *Unstable resonator output coupler assembly (top view)*

Key to Figure 103:

A	Adapter	H	Baseplate
B	Pressure ring	I	Laser tube
C	Optics mount	J	Alignment plate
D	Collar	K	Sealing rings (O-rings)
E	Meniscus lens (OC)	L	Spacer
F	Counter optics mount	M	Output coupler mount assembly
G	Extension piece	N	Beam direction indicator

6. Using the longer captured screws provided with the upgrade kit, screw the counter optics mount (F) onto the optics mount (C), and tighten the pressure ring (B). The output coupler mount assembly (M) is now ready for installation into laser device.
7. Remove the sealing plate (installed in step 3) and attach the extension (G), sealing ring (K) and output coupler mount assembly (M) to the alignment plate (J).
8. Exchange the adapter (A) on the energy monitor.

The energy monitor, front mirror access panel, bellows and internal beam delivery tube have to remain removed to enable resonator alignment.

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Installing the Cavity Window

9. Remove the rear mirror access panel (see Section 7.3.2.3 on page 177).

10. Remove the cap from the rear mirror (see Section 7.6.1, step 31 on page 204).
11. Repeat step 3 to remove the HR rear mirror mount and insert a sealing plate.
12. Follow the procedure in Section 7.6.2 on page 205 to remove the HR rear mirror from the optics mount assembly (see Figure 104, O) and insert the uncoated MgF2 cavity window (E).

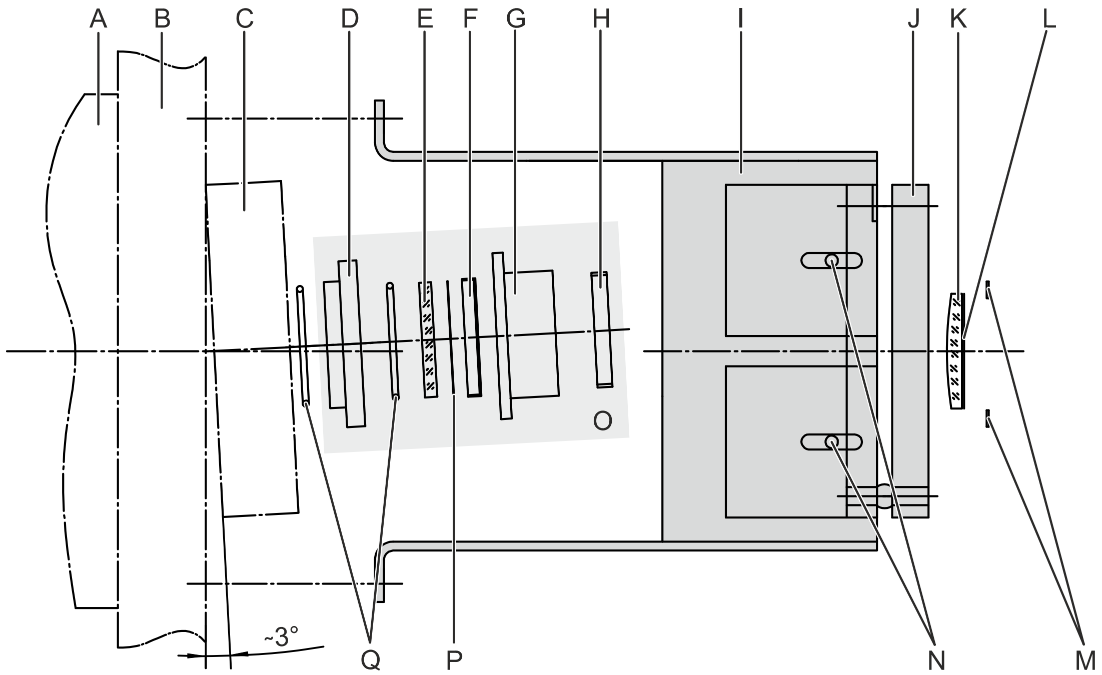

Figure 104: *Unstable resonator cavity window and HR mirror installation (top view)*

Key to Figure 104:

A	Laser tube	J	Mirror alignment plate
B	Base plate	K	Plano-convex rear mirror
C	Window alignment plate	L	HR coating
D	Counter optics mount	M	Mirror clamp
E	MgF2 cavity window	N	Adjustable extension piece
F	Collar	O	Cavity window mount assembly
G	Optics mount	P	Spacer
H	Pressure ring	Q	Sealing rings (O-rings)
I	Resonator extension assembly		

13. Remove the sealing plate (installed in step 11) and insert the mounted tube window (O). Make sure that the window alignment plate (C) is not tilted at this stage.

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Installing the HR Rear Mirror and Resonator Extension

14. Fit the HR rear mirror (K) to the mirror alignment plate (J) on the adjustable resonator extension (I) so that the HR coating (L) points towards the back of the resonator.
15. Use the corresponding screws and the mirror clamp (M) to attach the HR rear mirror (K) to the mirror alignment plate (J).
16. Attach the adjustable resonator extension assembly (I) to the rear base plate (B) in the orientation shown in Figure 105.

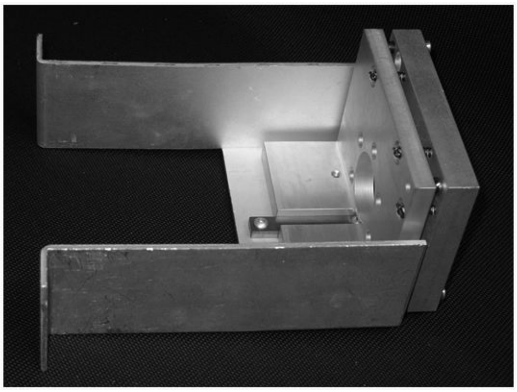

Figure 105: *Adjustable resonator extension assembly*

Finalization

17. Press <ENTER> to confirm that the optics have been exchanged and the housing covers are closed.
    The automatic flushing routine is continued
18. Align the unstable resonator (see Section 7.8.2).

    The alignment procedure should be performed with the required excimer laser gas at the nominal operating pressure. Consequently after initially installing the resonator optics, the housing covers have to be re-installed and a new fill performed. Following this, the front/rear mirror access panels have to be removed again to enable resonator alignment.

7.8.2 Align Unstable Resonator

Purpose

Align the unstable resonator after retrofitting the unstable resonator adapter kit and optics.

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Tools and Materials

- Class 2 diode or HeNe (visible) alignment laser

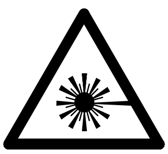
  Class 2 lasers have a maximum power output of 1 mW. HeNe lasers operate at a wavelength of 632.8 nm (visible red). The wavelength of a diode laser is version dependent. For further information, please refer to the manufacturer's instructions.
- Piece of card, on which the reflexes of the alignment laser can easily be seen, with 2 mm pin hole
- Piece of white paper
- Power meter or energy meter (e. g. Coherent LM 100 E)
- Set of allen keys
- 8 mm wrench
- Set of unstable resonator alignment apertures

Preconditions

- Laser tube filled with excimer laser gas at the nominal operating pressure
- Front and rear mirror access panels removed
- Energy monitor removed
- Set of unstable resonator optics installed
- Adjustable base plate of rear optic mount not tilted (approx. 90° to beam axis)

Setting-Up the Alignment Laser

1. Set-up the alignment laser on the beam exit side of the laser device at a distance of approx. 1.5 m from the laser device.



CAUTION
Risk of eye injury!
Do not stare into the beam of a visible alignment laser.
Remove all jewelry while performing the alignment procedure.
Never look directly at reflected beams.

2. Direct the output of the alignment laser through the center of the laser tube (see Figure 106). The alignment apertures are not installed at this stage.

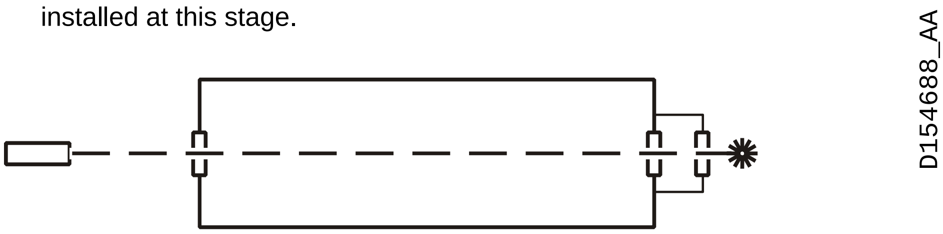


Figure 106: *Direct alignment of alignment laser through the laser tube*

3. Verify that the laser beam passes through the laser tube without clipping or reflecting off of the electrodes.

   The electrodes of an excimer laser are very smooth and can easily reflect the light of the alignment laser. It is, therefore, possible to align the laser such that it appears to be on axis when, in fact, it is being reflected off an electrode. This is easily determined by observing the direction of the alignment laser light while adjusting the alignment laser mirror.

   If you adjust the mirror to move the light upwards, the light at the output side should move upwards. If you make an adjustment upwards and the beam moves downwards, this indicates that the alignment laser beam is being reflected off an electrode.

Angular Alignment of the Laser Resonator

4. Insert the front alignment aperture into the opening directly in front of the output coupler and rotate until the appropriate position points upwards:
   - COMPex*Pro* 102, 110, 201 and 205: Position 2,
   - COMPex*Pro* 50: Position 1.
5. Insert the rear alignment aperture into the opening directly at the rear of the rear mirror and rotate until the appropriate position points upwards:
   - COMPex*Pro* 102, 110, 201 and 205: Position 2,
   - COMPex*Pro* 50: Position 1.
6. Using the hole in the horizontal center of each alignment aperture (see Figure 107, A), thread the alignment laser through the output coupler and optical axis of the laser tube towards the HR rear mirror.

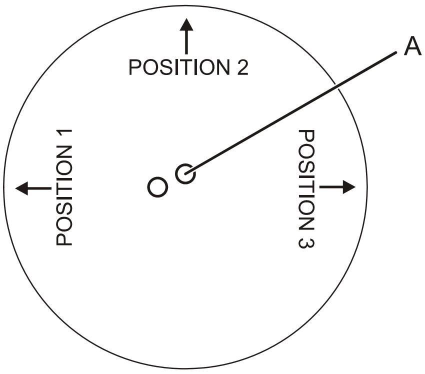


Figure 107: *Using the alignment aperture in Position 2*

7. Place the card with pinhole directly in front of the alignment laser so that the alignment laser centrically emerges through the pinhole. Make sure that the laser beam still passes through the alignment apertures.
8. Remove the alignment apertures.

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9. Adjust the HR rear mirror and output coupler perpendicular to the optical axis. The back reflex has to be colinear with the alignment laser beam as shown in Figure 109.

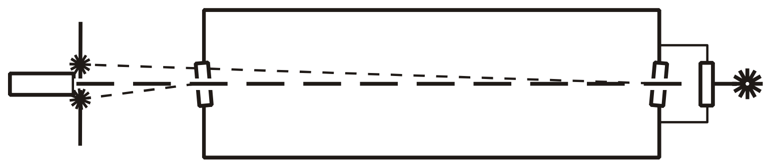

Figure 108: *Alignment laser reflections on card (alignment necessary)*

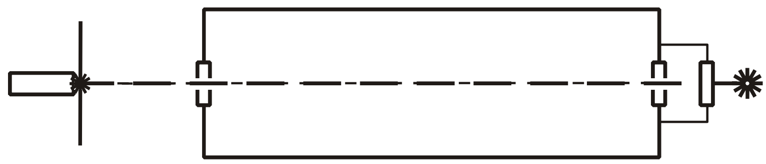

Figure 109: *Alignment laser reflections on card (optics aligned)*

10. Tilt the window alignment plate horizontally to the stop. This corresponds to a tilting angle of approx 3° (see Figure 104, C on page 218).
11. Check the back reflex of the HR rear mirror has not moved. If necessary adjust the HR rear mirror.

Length Adjustment of the Laser Resonator

12. Remove the copper tubes from the rear mirror access panel.
13. Re-install the rear mirror access panel.
14. Re-connect and re-install the energy monitor.
15. Re-install the front mirror access panel and internal beam delivery tube.
16. Recalibrate the energy monitor.
17. Check the beam size close to the output coupler (0.1 m) and at a distance of between 2 m and 5 m. Due to tolerances in the radius of the rear mirror, the laser beam cross section might increase or decrease in the far field by 1 mm to 2 mm.
    - If the beam converges in the far field, decrease the length of the resonator.
    - If the beam is divergent, increase the length of the resonator (adjustment range ±7.5 mm).

    In each case, switch off the laser and remove the rear access panel to enable length adjustment. The length is adjusted by using the 8 mm wrench to loosen the hex head screws of the adjustable extension piece (see Figure 104, N on page 218), setting the resonator extension to the desired length and tightening the hex head screws.
18. Repeat steps 4 to 10 to angularly align the laser resonator.

After completing the resonator alignment procedure described in this section, no additional fine tuning is required.

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7.9 Halogen Filter Maintenance

7.9.1 Check Halogen Filter Filling Ratio

Purpose

Check the filling level of the halogen filter. At a filling level of 100% the halogen filter has to be exchanged.

Maintenance Interval

- Every 4 weeks
- Before a new gas fill

Time Required

- 0.05 h

Tools and Materials

- None

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).

Checking the Halogen Filter Filling Ratio

1. Press <F4> on the handheld keypad.
2. Read off the filling ratio.
3. Press <BREAK> to terminate the function.
4. Where necessary, make sure that a replacement halogen filter is available in good time.

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7.9.2 Exchange Halogen Filter

WARNING
Harmful and corrosive substances hazard!
The halogen filter consists of activated carbon impregnated with potassium carbonate. The used filter will also contain halogen gas components.
Avoid eye or skin contact. Do not inhale released dusts.
Keep the filter in a well ventilated place.
Always wear gloves and safety glasses when handling the filter.

Purpose

Exchange the halogen filter cartridge when the filling capacity has been reached.

Maintenance Interval

- When indicated by the laser control software
- When lifetime of five years has expired

Time Required

- 0.5 h

Tools and Materials

- 3 mm Allen key
- Two 19 mm open wrenches
- 10 mm socket driver
- Pliers
- Replacement halogen filter
- Sealable plastic bag
- Plastic gloves
- Safety glasses

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).

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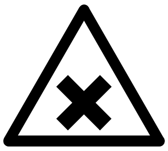
Preparation



WARNING
Harmful gas hazard!
The vacuum line may contain halogen. To ensure that there is no halogen in the line, always purge the line with inert gas (as described below) before removing the halogen filter.

1. Use the ”FLUSH INERT LINE“ procedure to flush the inert gas line and vacuum line (see Section 7.4.1 on page 178).

   The vacuum pump will extract the inert gas through the vacuum line and halogen filter.
2. Switch off and secure the laser device (see Section 6.4.1 on page 162).
3. Use the 3 mm allen key to remove the service panel (see Section 7.3.2.1 on page 173).

Removing the Halogen Filter Cartridge

4. Use the two 19 mm open wrenches to loosen the exhaust line from the connection on the vacuum pump (see Figure 110, A). Use one wrench to hold the nut directly below the vacuum pump while turning the nut on the exhaust line with the other wrench.

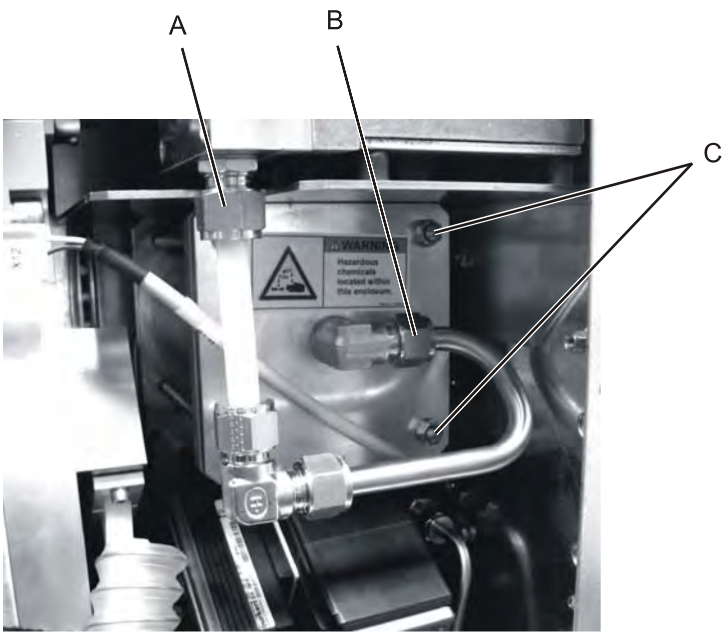


Figure 110: *Gaining access to the halogen filter*

5. Use a 19 mm open wrench to loosen the exhaust line from the connection on the halogen filter housing (see Figure 110, B).
6. Remove the exhaust line and lay it aside.
7. Use the 10 mm socket driver to remove the four nuts and washers from the top of the halogen filter housing (see Figure 110, C).

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8. Take the top cover off of the filter housing.
9. Remove the top O-ring.
10. Pull the used halogen filter cartridge out of the filter housing.

    The filter cartridge may be tightly held by the vacuum in the filter housing. To release the vacuum, gently push the filter cartridge sidewards with a suitable tool (e.g. slotted screwdriver).

11. Remove the bottom O-ring.

NOTICE
The O-rings removed from the filter cartridge are not to be re-used.

Inserting the New Halogen Filter Cartridge

12. Insert the replacement bottom O-ring
13. Insert the new filter cartridge into the filter housing.

    Ensure that the arrow on the filter cartridge points towards the front of the filter housing (see Figure 111).

Figure 111: *Inserting the halogen filter*

14. Insert the replacement top O-ring.
15. Refit the top of the filter housing.
16. Place the washers on each of the threaded rods
17. Use the 10 mm socket driver to fit and tighten the four securing nuts.
18. Use a 19 mm open wrench to reconnect and tighten the exhaust line to the halogen filter housing.
19. Use the two 19 mm open wrenches to reconnect and tighten the exhaust line to the vacuum pump.
20. Refit the service panel.

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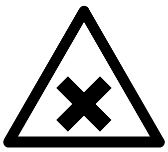
Finalization

21. Switch on the laser device (see Section 6.2.4 on page 139).
22. Repeat step 1 to flush the inert gas line.
23. Perform a new fill (see Section 7.5.1 on page 187).

    Compare the time required to evacuate the laser tube with the time that was typically required for with the old halogen filter. If this time is now significantly longer, there is most likely a leak at the halogen filter connection. Alternatively, warning 32 (No vacuum. Vacuum detection time-out) also indicates a leak in the halogen filter. In case of a suspected leak, check the connections to the halogen filter (see steps 18 and 19).
24. Press <F4> on the handheld keypad.
25. Press the numerical button <0> to reset the filter filling ratio and press <ENTER> to confirm.

    The message “Enter password” appears.
26. Enter the password “778” through the handheld keypad and press <ENTER> to confirm.

Filter Cartridge Disposal



WARNING
Harmful gas hazard!
The halogen filter may contain halogen gas that has not reacted. Therefore, for safety reasons, a storage period prior to disposal is necessary. Observe the storage period and pre-disposal procedure indicated in this section and the information in the filter packaging

27. Store the filter cartridge for 6 hours in a well-ventilated location.
28. Place the filter cartridge inside the plastic bag removed from the new filter and seal the bag by means of the supplied twist-tie.
29. Dispose of the filter cartridge in accordance with local regulations.

7.10 Energy Monitor Maintenance

7.10.1 Calibrate Energy Monitor

DANGER
Risk of exposure to Class 4 radiation!
This procedure may require working with an open laser.
Such work shall only to be performed by authorized and correspondingly trained personnel.
Always wear suitable eye and skin protection when there is the risk of exposure to Class 4 excimer laser radiation.

CAUTION
The laser device is to remain powered up during this procedure! Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device. All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

Purpose

Calibrate the internal energy monitor in accordance with an external power or energy meter. This is performed with the help of a dedicated software option which starts the laser and enables input of a reference power value.

Maintenance Interval

- Whenever the tube optics have been cleaned / exchanged
- After energy monitor exchange
- Discrepancy between internal and external power reading

Time Required

- 0.75 h

Tools and Materials

- 3 mm Allen key
- 4 mm Allen key
- Protective eyewear suitable for the currently active laser wavelength
- Suitable energy meter or power meter (contact Coherent for more information)

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Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).

Preparation

1. Perform a New Fill to ensure optimum calibration conditions (see Section 7.5.1 on page 187). This takes about 20 minutes.

Calibrating the Energy Monitor

2. Place the external energy measuring device in the beam path and set-up the display unit (for further information, please refer to the energy measuring device’s operating instructions).

   A configuration similar to that shown in Figure 86 on page 202 enables energy measurement without Class 4 laser emission entering the working area. Always strictly comply with local safety regulations. Contact the responsible laser safety officer for further information and guidance.
3. Press <REPRATE>.
4. Set the repetition rate so that it is suitable for the energy or power meter that you are using and press <ENTER> to confirm input.

   To obtain the best results, set the repetition rate to the rate that you normally work with.
5. Press <HV>.
6. Set the high voltage to the level that is required to obtain the nominal energy of the laser that you are working with and press <ENTER> to confirm the input.
7. Open the beam shutter.
8. Press <EGY CAL>.
9. Press <EXE> to confirm that the procedure is to be started.

   “WAIT...“ is displayed in the second line for a short period. The laser starts firing with the chosen repetition rate and HV.

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10. Check that the displayed values are within a range of 25000 and 45000.

    Under certain circumstances the reading may not be within the required range. In this case, take note of whether it is too high or too low.

    When the reading is too high or too low, the number of attenuators in the energy monitor has to be varied (see Section 7.10.3).

    - If the reading is below 25000, the attenuation has to be reduced (i.e. attenuators have to be removed).
    - If the reading is above 45000, the attenuation has to be increased.

    When the adjustment has succeeded, the display changes to "READING=".

    If the attenuation has to be changed, press <BREAK> to abort the energy calibration, follow the instructions in Section 7.10.3 and repeat the energy calibration from step 8.

    Take into account that the laser controller expects values to be input in mJ (1/1000 Joule). If you are using an external power meter, use the following equation to obtain the required value:

$$E_{input} = \frac{P_{ext}}{1000 \cdot f}$$

    E_{input} is the input value $[E_{input}]$ = mJ
    P_{ext} is the reading from the external power meter $[P_{ext}]$ = W
    f is the repetition rate [f] = Hz.

11. Enter the external energy measurement data in mJ.
12. Press <ENTER> to confirm input.

    The laser device sets the external energy measuring data equal to the internally calculated value. The energy monitor is now calibrated.

Checking the Calibration

13. Start the laser with the currently active settings.
14. Measure a few laser pulses with the external energy meter and compare these values with those displayed by the energy monitor. They should differ no more than 2 to 3%. If there is a larger deviation, repeat the calibration procedure from step 3.

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7.10.2 Remove / Insert Energy Monitor

Purpose

Remove and re-insert the internal energy monitor (see Figure 112). This is, for example, necessary to insert or remove attenuators or clean or replace the beam splitter.

Figure 112: *Internal energy monitor in the working position*

Key to Figure 112:

A	Beam splitter box	E	Electronics box
B	Attenuation box	F	FOLs
C	Purge gas connection	G	Electrical connection
D	Bellows		

Tools and Materials

- 4 mm allen key
- 3 mm allen key

Preconditions

- Laser device switched off.

Removing the Energy Monitor

1. Use the 3 mm allen key to remove the front mirror access panel and internal beam delivery tube (see Section 7.3.2.2 on page 175).

   Removal of the front mirror access panel (shutter panel) provides sufficient access to enable exchange of the energy monitor. If access is nevertheless restricted, also remove the service panel.
2. Disconnect the purge gas line from the energy monitor.

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3. Use the 4 mm allen key to remove the screw that secures the energy monitor (see Figure 113).

Figure 113: *Unscrewing the energy monitor*

4. Carefully pull the energy monitor away from the locating pins.
5. Turn the energy monitor and remove it from the laser device sufficiently to allow disconnection of the remaining supply and signal lines (see Figure 114).

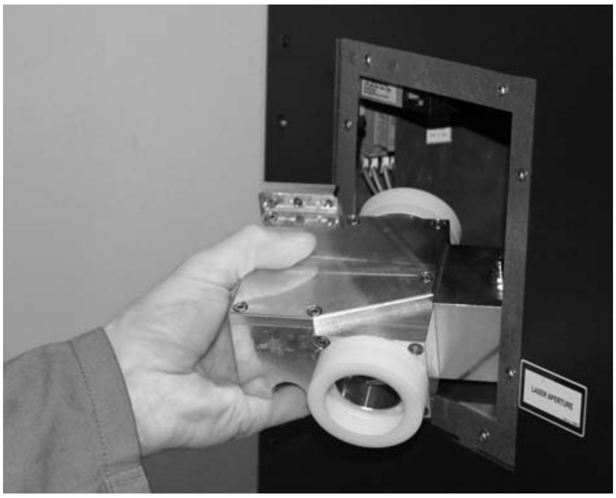

Figure 114: *Removing the energy monitor*

6. Disconnect the electrical connection from the energy monitor.
7. Disconnect the FOLs from the energy monitor.
8. Place aside the removed energy monitor.

Inserting the Energy Monitor

9. Connect the FOLs to the replacement energy monitor.
10. Connect the electrical connection to the energy monitor.

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11. Insert the energy monitor into the laser device and carefully attach it onto the two locating pins (see Figure 115, A).

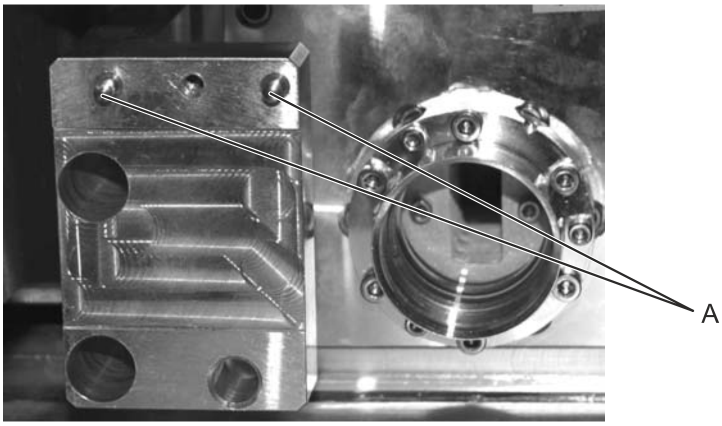

Figure 115: *Attaching the energy monitor*

12. Use the 4 mm allen key to reinsert and tighten the securing screw.
13. Connect the purge gas line to the energy monitor.

Finalization

14. Reinsert the front mirror access panel and internal beam delivery tube (see Section 7.3.2.2 on page 175).
15. Switch on the laser device.
16. Calibrate the energy monitor (see Section 7.10.1).

7.10.3 Insert / Remove Attenuators

NOTICE
Contamination can cause serious damage to optical components. Always wear disposable plastic gloves when working with and on optical components.

Purpose

Change the number of wire attenuators in the energy monitor to ensure that the correct amount of light that reaches the UV photodiode to provide a reliable reading. This is, for example, necessary if the energy monitor calibration routine was unable to automatically set the gain (see Section 7.10.1) or after changing the output wavelength of the laser.

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Tools and Materials

- 3 mm allen key
- 1.5 mm allen key
- Disposable plastic gloves
- Additional wire attenuators

Preconditions

- Laser device switched off.

Preparation

1. Remove the energy monitor from the laser device (see Section 7.10.2).

Insert or Remove Attenuators

2. Use the 3 mm allen key to unscrew the four screws and remove the energy monitor electronics box from the attenuator box (see Figure 116).

Figure 116: *Removing the energy monitor electronics box*

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3. Pull the attenuation tube out of the attenuator box (see Figure 117). Where necessary, use suitable tool (e.g. the straight shaft of an allen key) to initially lift the attenuation tube.

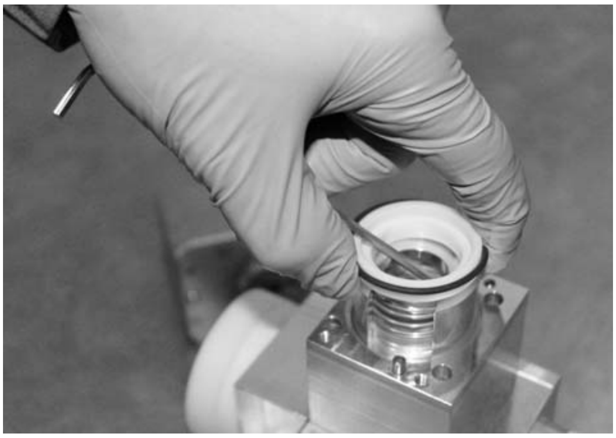

Figure 117: *Removing the attenuator tube*

4. Use the 1.5 mm allen key to carefully unscrew the two screws and remove the plastic cap from the attenuation tube (see Figure 118). Take into account that the attenuators in the tube are clamped in position by a spring.

   After removing the cap, the clamping spring and attenuators are loose in the attenuator tube.

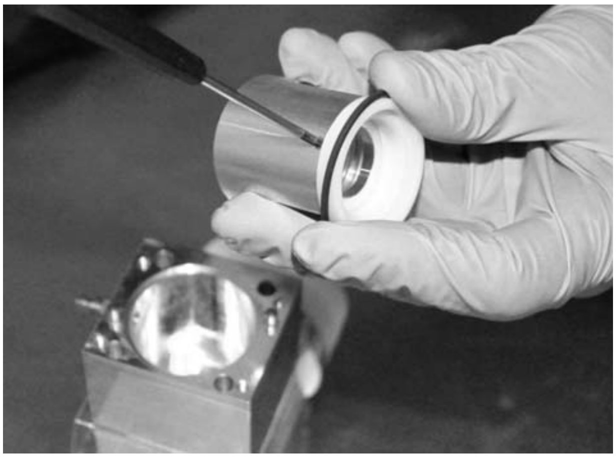

Figure 118: *Removing the attenuator tube cap*

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5. Carefully remove the clamping spring and attenuators as required (see Figure 119).

Figure 119: *Removing the clamping spring and attenuators*

6. Check the removed attenuators for any signs of damage and, if necessary, exchange.
7. Carefully insert the required number of attenuators into the attenuation tube.
8. Insert the clamping spring.
9. Use the 1.5 mm allen key to fit the cap onto the attenuation tube.
10. Insert the attenuation tube into the attenuator box.
11. Noting the respective positions of the locating pins and screws, attach the energy monitor electronics box onto the attenuator box (see Figure 120).

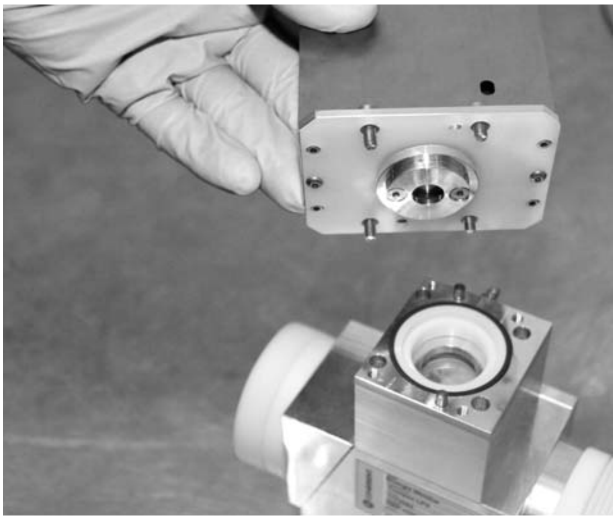

Figure 120: *Refitting the energy monitor electronics box*

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12. Use the 3 mm allen key to tighten the four screws securing the electronics box.

Finalization

13. Insert the energy monitor into the laser device (see Section 7.10.2).
14. Switch on the laser device.
15. Calibrate the energy monitor (see Section 7.10.1).

7.10.4 Clean Beam Splitter

NOTICE
Contamination can cause serious damage to optical components. Always wear disposable plastic gloves when working with and on optical components.

Purpose

Check and clean the beam splitter in the energy monitor.

Maintenance Interval

- With every energy monitor calibration

Time Required

- 0.5 h

Tools and Materials

- 3 mm allen key
- Disposable plastic gloves
- Glass plate or similar clean, flat and smooth working surface
- Lens cleaning tissue
- Pressurized air or inert gas that is particulate and oil-free
- Polishing powder (e.g. vienna chalk from service case)
- Distilled water
- Optics grade Ethanol or Methanol

Preconditions

- Laser device switched off.

Preparation

1. Remove the energy monitor from the laser device (see Section 7.10.2).

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Removing the Beam Splitter

2. Place the energy monitor beam exit side up (see Figure 121).

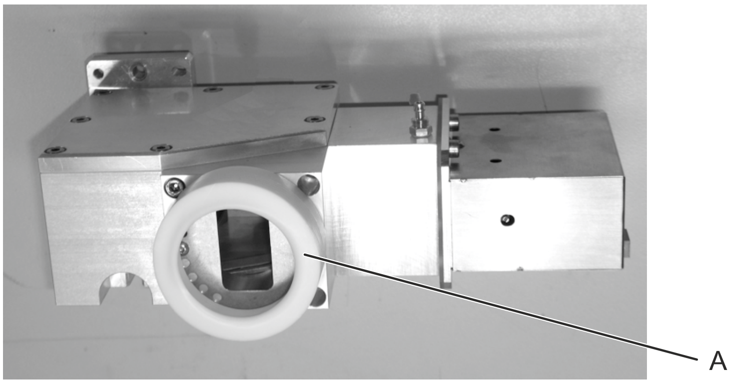

Figure 121: *Energy monitor with beam exit bellows*

3. Remove the beam exit bellows (see Figure 121, A).
4. Use the 3 mm allen key to remove the four screws and their washers (see Figure 122, A) and lift off the aperture plate (B).

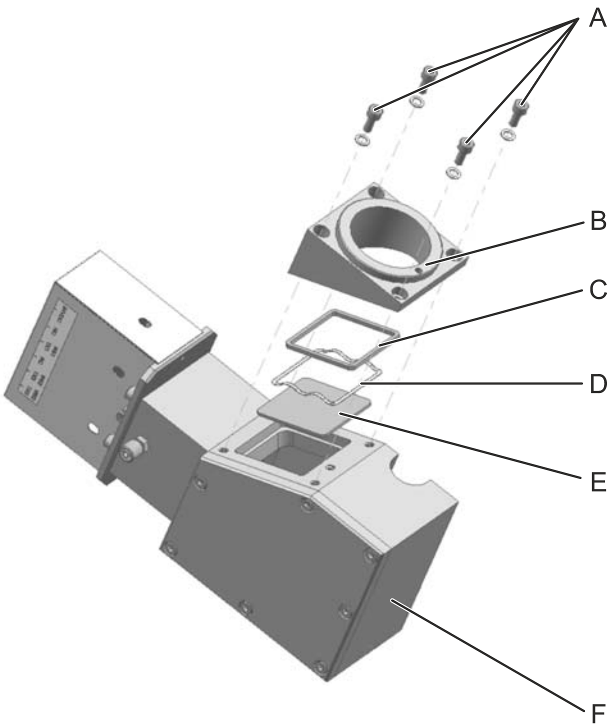

Figure 122: *Removing the beam splitter*

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Key to Figure 122:

A	Screws and washers	D	Wave spring washer
B	Aperture plate	E	Beam splitter
C	Spacer	F	Energy monitor

5. Remove the spacer (C).
6. Remove the wave spring washer (D).
7. Carefully remove the beam splitter (E).

Cleaning the Beam Splitter

8. Clean beam splitter in the same way as an uncoated optical element (see Section 7.6.3 on page 209).

Installing the Beam Splitter

9. Carefully re-insert the beam splitter (see Figure 123).

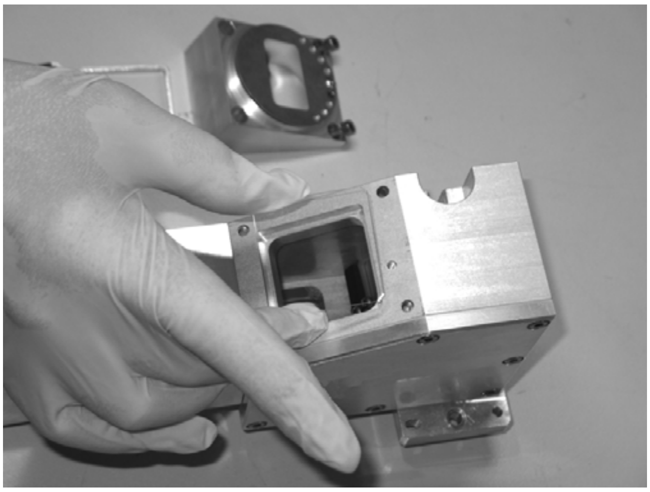

Figure 123: *Inserting the beam splitter*

10. Re-insert the wave spring washer (see Figure 124).

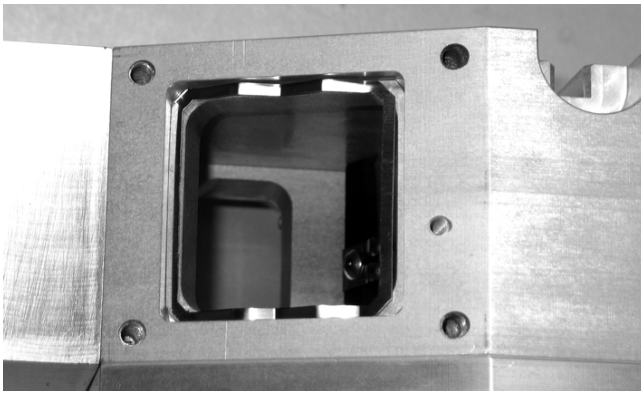

Figure 124: *Inserting the wave spring washer*

11. Insert the spacer (see Figure 122, C).

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NOTICE
The beam splitter will be irreparably damaged if the allen key slips!

12. Use the 3 mm allen key to carefully refit and tighten the aperture plate (see Figure 122, B).
13. Refit the plastic bellows (see Figure 121, A).
14. Insert the energy monitor into the laser device (see Section 7.10.2).
15. Switch on the laser device.
16. Calibrate the energy monitor (see Section 7.10.1).

7.11 Thyratron Maintenance

WARNING
Risk of electric shock!
Work on the electrical system shall only be carried out by skilled electricians working in accordance with electrical engineering rules and regulations. Ensure that the maintenance area is adequately secured at all times.

Purpose

Check and, if necessary, increase the thyratron supply voltage to compensate for ageing of the thyratron.

The procedure described in this section primarily applies to a routine maintenance action. The same procedure can be followed to rectify faults such as missing pulses or no trigger. Take into account the deviations in the procedure when rectifying faults such as additional pulses and overload.

Maintenance Interval

- Every 300 million pulses

Time Required

- 0.25 h

Tools and Materials

- 3 mm allen key
- TRMS Voltmeter (TRMS=True Root Mean Square)
- Laser logbook

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Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).

Preparation

1. Use the 3 mm allen key to remove the thyratron adjustment panel cover (see Figure 125).

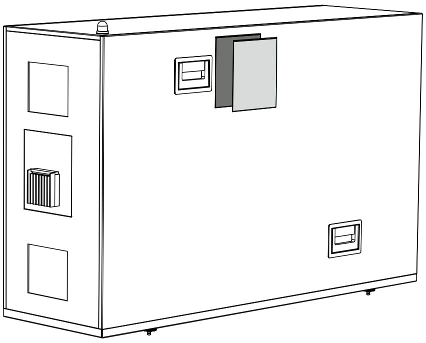

Figure 125: *Removing the thyratron adjustment panel cover*

2. Check the settings of the jumpers.

   If one of the jumpers is already at the maximum setting on the thyratron adjustment plate, the thyratron or hydrogen reservoir is exhausted. In this case, contact Coherent service.

Measure the Heating Voltages (U_H and U_R)

The specified range for the heating voltage is 6.3 to 6.7 V. If the voltage is considerably outside of this range, the supply voltage will need to be increased or decreased. Ageing of the thyratron causes a decrease in the heating voltage which is compensated for by increasing the supply voltage.

3. Use the TRMS voltmeter to measure the heating voltage of the thyratron (U_H) between the jacks GND and HEAT (see Figure 126).

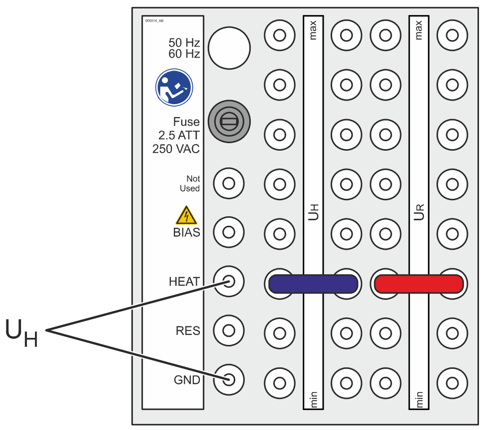

Figure 126: *Measuring thyratron heating voltage*

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4. Note the measured value.
5. Measure the heating voltage of the hydrogen reservoir (U_R) between the jacks GND and RES (see Figure 127).

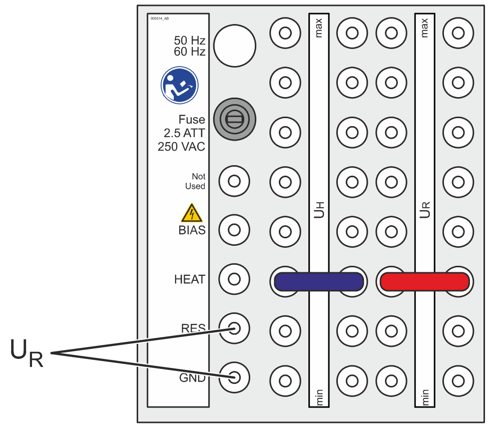

Figure 127: *Measuring reservoir heating voltage*

6. Note the measured value.

Measure the Bias (U_{BIAS})

WARNING
Risk of electric shock!
A voltage of at least 150 V is applied to the BIAS jack.
Take particular care when performing the BIAS voltage measurement.

Note that U_{BIAS} is a DC value. The voltage has to be between -150 V and -160 V. If this is not the case, the varistor is exhausted. In this case, contact Coherent service.

7. Measure U_{BIAS} between the jacks GND and BIAS (see Figure 128).

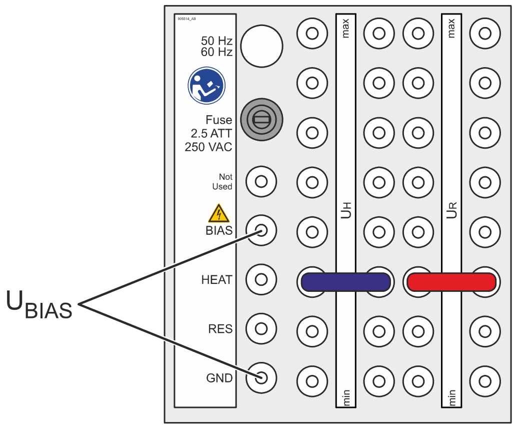

Figure 128: *Measuring the bias voltage*

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8. Note the measured value.

Increase the Supply Voltage

Steps 10 to 14 only apply to routine maintenance or the rectification of faults such as missing pulses, no trigger or low output energy. To rectify additional pulses or if the error message OVERLOAD occurs, perform steps 15 to 22.

9. Remove the U_H and/or U_R jumpers and insert at the next highest setting (see Figure 129).

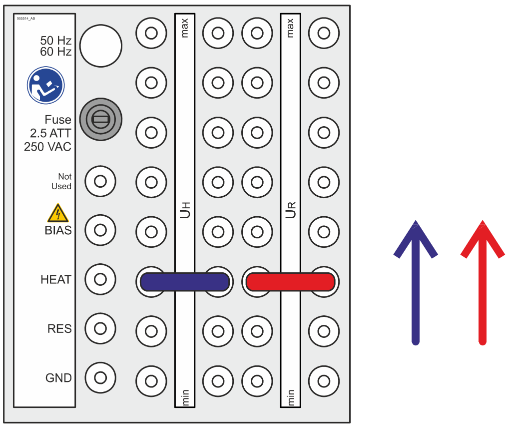

Figure 129: *Thyratron supply voltage increase*

10. Start the laser.
11. Wait at least three minutes for the thyratron to reach a thermally stable state. If additional pulses should occur, decrease UR one step.
12. Measure U_H between GND and HEAT again.
13. Measure U_R between GND and RES again.
14. Note the new values and compare them with the previously recorded values.

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Decrease the Supply Voltage

Steps 15 to 22 only apply if faults such as additional pulses or the error message OVERLOAD occurs.

15. Remove the U_R jumper and insert at the next lowest setting (see Figure 130).

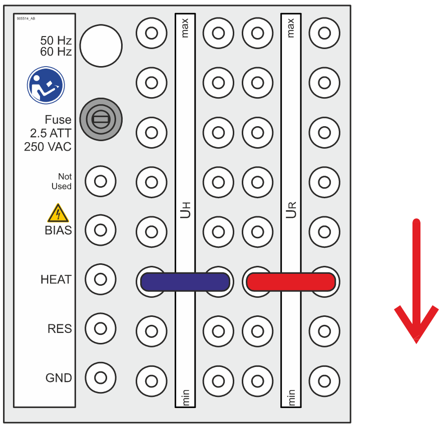

Figure 130: *Thyratron supply voltage decrease*

16. Start the laser.
17. Wait at least three minutes for the thyratron to reach a thermally stable state.
18. Measure U_R between GROUND and RES again.
19. Note the new value.
20. Start laser operation at the lowest possible HV value for stable energy output.
21. Operate the laser for five minutes at max. repetition rate.
22. Increase the HV value in steps of 1 kV every five minutes until the max. HV value is reached and operate the laser at max. HV for 15 minutes.

    If no additional pulses occur, the thyratron is adjusted. Otherwise, return to step 15 and repeat the procedure.

Finalization

23. Use the 3 mm allen key to refit the thyratron adjustment plate cover.

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8 BASIC TROUBLESHOOTING

WARNING
Risk of serious injury or equipment damage!
Incorrectly performed troubleshooting can cause exposure to or contact with hazards such as laser radiation, lethal voltages and harmful or corrosive substances.
Only authorized and correspondingly trained maintenance personnel shall perform troubleshooting on the laser device.
Strictly follow the instructions contained in this manual.

This section provides information that will assist with searching for and solving malfunctions and errors that can occur during laser operation.

If rectification is not possible with the proposals made in this section, call authorized service:

EUROPE
Coherent LaserSystems GmbH & Co. KG
Hans-Böckler-Strasse 12
D - 37079 Göttingen, Germany

Tel.: +49 (551) 6938-345 / 306
Fax: +49 (551) 6869-358
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Fax:+82 (2) 460-7901

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8.1 Interlocks and Warnings

If a malfunction or error occurs during laser operation, an interlock or warning is triggered (see Section 3.3.10.1 on page 73).

The following sections give an overview of important interlock messages and warnings and provide basic information to solve problems. If the problems cannot be solved with the proposals made in this section, call authorized service.

8.1.1 Status Code Display

Interlocks and warnings are indicated by a status code that appears after the currently active operating mode in the bottom line of the hand-held keypad display (see Section 5.4.1 on page 122). If more than one interlock or warning is active, the corresponding status codes are separated by a comma.

When a status code other than “0” (laser OK) appears, press <F1> to display a help text. This text indicates the error status (warning or interlock) and provides a plain-language description of the malfunction. If more than one status code is active, press the appropriate cursor key to page through the help texts. To terminate the help text display, press <ENTER> or <BREAK>.

8.1.2 Interlocks

An interlock indicates a malfunction or critical interference in the functioning of the laser. The interlock can be triggered by a hardware device such as a switch or sensor (hardware interlock) or be triggered by a software monitoring function (software interlock).

When an interlock occurs, the operating mode is automatically switched to OPMODE=OFF (see Section 3.6.1 on page 80). The extent to which the laser device is shut down and laser operation is inhibited as a response to an interlock varies depending on the circumstances and potential hazard. This case-related differentiation allows the laser to be safely restarted as quickly as possible after rectifying the malfunction. Communication with the laser device’s controller remains possible at all times.

The following table provides an overview of the interlock status codes and provides fundamental information regarding error rectification. If rectification is not possible with the proposals made below, call authorized service.

D154688_AA

No.	Interlock	Reason	Solution	Comments
0	Laser ok	- No interlock or warning active	- No action required	
2	Preset energy too high	- Energy set-point value too high - High voltage reaches HV_{max} (i.e. insufficient laser gas quality)	- Set energy to a valid value - Perform a new gas fill - Check optics lifetime and exchange if necessary - Check that the gas mixture and gas quality is as specified	This software interlock will be triggered after the “Preset energy too high” warning (status code 89).
6	Tube pressure out of range	- The laser tube pressure is either too high or too low - New gas fill required - Gas leak	**WARNING** **Harmful gas hazard! Removing a housing cover will interrupt the exhaust flow and allow leaking gases to escape. Always purge the gas lines and laser tube before opening the housing.** - Check the sum of the gas partial pressures (gas menu) - Check pressure sensor signal line connections - Check for gas leaks - Perform a new gas fill	Software interlock. For devices without automatic pressure regulation, the pressure is to be between 0.8 p_N and 1.2 p_N (“p_N” is the total pressure given in the menu). For devices with automatic pressure regulation, the pressure is to be between 0.97 p_N and 1.05 p_N (“p_N” is the total pressure given in the menu with temp. compensation).
10	Tube temperature too high	- No or insufficient flow of cooling water through the laser tube heat exchanger	- Check the cooling water supply (source, valves, flow, inlet pressure) - After fault rectification, press <BREAK> to clear the interlock and then reboot the laser device	Hardware interlock triggered by a thermal switch located on the laser tube. When the temperature returns to within the permitted range, the switch automatically closes itself The interlocks “safety control module off” (status code 122) and “reboot required” (status code 31) will also be triggered.

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No.	Interlock	Reason	Solution	Comments
11	Ventilation motor failed	- Gas circulation fan motor damaged - Internal motor temperature switch has triggered as the motor has become too hot - Gas circulation fan does not turn properly or has seized up	- Try to reboot the laser device. If unsuccessful, call authorized service.	Hardware interlock.
16	Remote interlock switch is open	- The external (remote) safety circuit has been interrupted (e.g. an external interlock switch has been activated)	- Check the external safety circuit connected to the Remote socket on the laser device (look for activated switch or loose connection etc.)	Hardware interlock A “safety control module off” interlock (status code 122) will also be triggered.
18	HV power supply load fault	- Power supply HV charging circuit does not reach set HV level - Short circuit in HV charging circuit	- Call authorized service	Hardware interlock
26	Low Light. > 30% of light pulses missing in 10 s	- At least 30% of all pulses in an interval of 10 seconds are below the energy detection threshold and more than 20 pulses have been triggered within this interval - High Voltage setting is too low	- Check gas fill (correct gas mixture, lifetime) - Check laser tube lifetime - Check optics - Check energy monitor connections - Increase the HV or energy set point	Software interlock
27	No gas flow. Check gas bottle pressure	- “No gas flow. Check gas bottle pressure” warning (status code 23) ignored - Gas cylinder is empty - Gas cylinder valve is closed - Pressure regulator closed or setting incorrect - Defective solenoid valve	- Ensure that the gas cylinders are not empty - Ensure that the gas cylinder valves are open - Ensure that the pressure regulators are correctly set	Software interlock. A “No gas flow. Check gas bottle pressure” warning (status code 23) always occurs before this interlock is triggered.
30	Configuration error detected	- No valid set of parameters can be loaded from the FRAM	- Call authorized service	Software interlock
31	Reboot required	- The tube temperature interlock (status code 10) has been activated. The laser control software has to be rebooted to reset the safety control relay	- Follow the instructions to rectify the fault that caused the temperature interlock. Following this, switch the laser device off and then on again to reboot the laser control software	Software interlock

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No.	Interlock	Reason	Solution	Comments
42	Cover 1 open. Service panel open	- Cover interlock triggered as the service panel (cover 1) is open	- Close the service panel and press <BREAK> before restarting laser operation	Hardware interlock that inhibits laser operation and gas actions. A “safety control module off” interlock (status code 122) will also be triggered.
46	Liquid leak detected	- The liquid sensor detects liquid at the bottom of the laser device housing	- Check cooling water temperature (if cooling water is too cold, condensation my occur) - Check cooling water connections inside the laser device housing	Hardware interlock
49	HV power supply temperature too high	- The HV power supply is running too hot - HV power supply fuse (F6) has blown. This also disables the thyratron supply voltage	- Check for excessive ambient temperature - Check fuse and, if necessary, replace	Hardware interlock
62	Halogen filter exchange required	- The halogen filter filling capacity has been exceeded - The corresponding maintenance counter and warning code 103 have been ignored	- Exchange the halogen filter and reset the halogen filter filling capacity indicator	Software interlock. No further gas actions are permitted
63	HI/PGR request time out	- The predefined period to perform the requested gas action (3600 sec) has elapsed	- Restart the laser and send the necessary command to start the required gas action (see status code 104 in Section 8.1.3). - Manually perform the required gas action	Software interlock
95	Max. power	- Calculated power exceeds the max. power parameter - The energy monitor calibration is completely incorrect	- Reduce the energy setting, HV setting or repetition rate - Recalibrate the energy monitor	Software interlock
120	Cover 2 open. Front mirror access panel open	- Cover interlock triggered as front mirror access panel (cover 2) is open	- Close the respective access panel and press <BREAK> before restarting laser operation	Hardware interlock that inhibits laser operation and gas actions. A “safety control module off” interlock (status code 122) will also be triggered.
121	Cover 3 open. Rear mirror access panel open	- Cover interlock triggered as rear mirror access panel (cover 3) is open		

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No.	Interlock	Reason	Solution	Comments
122	Safety control module off	- The interlock circuit has been interrupted by activation of a cover interlock (status codes 42, 120 or 121), an external interlock switch (status code 16) or an over-temperature switch (status code 10)	- Follow the instructions relating to the other hardware interlock status code that is displayed - Press <BREAK> to clear the interlock after physical rectification - If the interlock is not cleared by pressing <BREAK>, there is a fault in the safety circuit (e.g. defective switch). After repair, check the operation of the safety circuit before restarting the laser (see Section 6.3.4 on page 146).	Hardware interlock Never reboot the laser device in an attempt to clear a cover or remote interlock. The laser control software remembers that the interlock has been triggered and not correctly cleared and will issue a warning (status code 69) after each restart of the laser device. Always reboot the laser device after an over-temperature interlock
125	Tube temperature too high	- Indicated temperature exceeds the max. tube temperature parameter	- Check the cooling water supply (source, valves, flow, inlet pressure)	Software interlock. Only applicable with automatic temperature regulation option
127	Communication time out	- No communication through the serial interface within set time period or communication corrupted	- Check that the handheld keypad or control computer is correctly connected to the serial interface	Software interlock
128	Tube pressure sensor failed	- The tube pressure sensor reading is outside of the parameter range	- Call authorized service	Software interlock
130	Tube temperature sensor failed	- The tube temperature sensor reading is outside of the parameter range	- Call authorized service	Software interlock
157	Gas action time out	- A gas action could not be completed within the max. permitted time period	- Check the external gas supply (cylinder pressure and valves, pressure regulator settings) - Check the vacuum pump	Software interlock
182	Gas mismatch. Gas mixture in tube <> selected gas menu	- Gas mixture does not correspond with the currently active gas menu - Tube flushing, transport fill, passivation fill or safety fill has been carried out (no excimer laser gas in laser tube)	- Check the currently active gas menu - Perform a new gas fill (see Section 7.5.1 on page 187)	Software interlock The interlock is reset by a new fill

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No.	Interlock	Reason	Solution	Comments
202	Deviation between pressure sensors too high	- Gas system check error. Excessive deviation between the tube and manifold pressure sensors. - Pressure sensor defective - Gas leak - Vacuum pump defective	- Call authorized service	Software interlock
203	Gas check block pressure	- The valve block is unable to be evacuated	- Call authorized service	Software interlock
204	Halogen line pressure too low	- The halogen gas supply line pressure is too low	- Ensure that the gas cylinder is not empty - Ensure that the gas cylinder valve is open - Ensure that the pressure regulator is correctly set	Software interlock
205	Halogen line pressure too high	- The halogen gas supply line pressure is too high		
206	Rare line pressure too low	- The rare gas supply line pressure is too low		
207	Rare line pressure too high	- The rare gas supply line pressure is too high		
208	Buffer line pressure too low	- The buffer gas supply line pressure is too low		
209	Buffer line pressure too high	- The buffer gas supply line pressure is too high		
210	Inert line pressure too low	- The inert gas supply line pressure is too low		
211	Inert line pressure too high	- The inert gas supply line pressure is too high		
220	Watchdog error. Fatal error, call service	- Fatal internal software error. Watchdog will no longer be automatically reset	- Call authorized service	Software interlock
221	External gas failure	- A failure has been detected in the external gas circuit - The corresponding contacts in the Remote connector are open (see Section 4.7 on page 115)	- Check the external gas supply circuit - Check the Remote connector	Software interlock
224	Tube pressure too high	- The gas pressure in the laser tube has reached the predetermined upper limit. Any further increase will cause the rupture disk to burst. Do not try to fill additional gas into the tube!	- Perform a new gas fill (see Section 7.5.1 on page 187)	Software interlock

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No.	Interlock	Reason	Solution	Comments
227	Halogen time relay failed	- The time-delay relay for the halogen valve is not correctly working. It does not close within the permitted time period.	- Call authorized service	Software interlock
228	Halogen valve closed by time relay	- The halogen time-delay relay has closed the halogen valve	- Call authorized service	Hardware interlock
229	Halogen valve probably not closed	- The plausibility check after closing the halogen valve has detected an increase in pressure in the valve block.	- Flush all gas lines a number of times. - If this is a once-only error, perform a new gas fill	Software interlock
230	Halogen concentration on upper limit	- The proportion of halogen in the laser tube is too high.	- Perform a new gas fill (see Section 7.5.1 on page 187)	Software interlock

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8.1.3 Warnings

Warnings will automatically be cleared if the corresponding parameter becomes within it's limits, if the corresponding missing signal is detected or if the corresponding error state has been rectified. In some cases, an interlock may be triggered after a pre-defined warning period.

The table below provides an overview of the warning status codes and contains fundamental information regarding error rectification. If rectification is not possible with the proposals made below, call authorized service.

No.	Warning	Reason	Solution	Comments
0	Laser ok	- No interlock or warning active	- No action required	
21	Warm-up	- Laser device has just been switched on. The thyratron is warming up	- Wait until the thyratron has warmed up before starting laser operation	The default value for the warm-up period is 8 minutes
23	No gas flow. Check gas bottle pressure	Gas flow too low during a gas action - Gas cylinder is empty - Gas cylinder valve is closed - Pressure regulator closed or setting incorrect - Defective solenoid valve	- Ensure that the gas cylinders are not empty - Ensure that the gas cylinder valves are open - Ensure that the pressure regulators are correctly set	If the warning is ignored, a “No gas flow. Check gas bottle pressure” interlock will occur (status code 27)

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No.	Warning	Reason	Solution	Comments
25	Preset energy too low, check energy setpoint	- High voltage has reached HV_{min} but the energy output is still higher than preset value (entered value is out of range)	- Enter a new value within the permitted range - Check gas partial pressures	
32	No vacuum. Vacuum detection time-out	Set time period (1200 sec) to evacuate the laser tube to the set point pressure has been exceeded - Halogen filter leak or gas leak - Vacuum pump failure	- Check halogen filter for leak - Audibly check if the vacuum pump starts correctly - Check vacuum pump fuse - Check internal gas system for leak	A safety fill will automatically be carried out *NOTICE* Risk of seriously damaging laser tube! Each attempt to evacuate a leaking laser tube allows atmospheric oxygen to penetrate the laser tube.
51	Internal gas purifier error	- Short circuit at internal gas purifier	- Call authorized service	If operation is continued in this state, optic lifetime may be reduced
64	Tube temperature too high	- No or insufficient flow of cooling water through the laser tube heat exchanger	- Check water supply (flow, pressure, temperature) - Check environmental conditions	If no action is taken, the "Tube temperature too high" interlock will be triggered (status code 125) Only applicable with automatic temperature regulation option
69	Check safety relay	- Only one channel of the remote interlock circuit was opened - The laser device was switched off with a remote interlock active (status code 16)	- Rectify the reason for the activation of the Remote interlock (status code 16) as described in Section 8.1.2, - After rectifying the interlock, interrupt and then close both channels of the safety circuit, e.g. by physically triggering and rectifying a cover interlock. Press <BREAK> to confirm that the interlock has been cleared	

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No.	Warning	Reason	Solution	Comments
89	Preset energy too high	- High voltage reaches the HV Warning Range (i.e. insufficient laser gas quality)	- Check energy setpoint - Perform a new gas fill (see Section 7.5.1 on page 187) - Check optics lifetime - Check gas mixture and quality of gases	If no action is taken, the “Preset energy too high” interlock will be triggered (status code 2).
103	Halogen filter exchange required soon	- The filling capacity of the halogen filter calculated by the software on the basis of the executed gas actions has been reached	- Exchange the halogen filter and reset the halogen filter filling capacity indicator (see Section 7.9 on page 223)	No further gas actions can be carried out until the halogen filter has been exchanged. The next attempt to carry out a gas action triggers the “Halogen filter exchange required” interlock (status code 62)
104	Laser request: HI/PGR	- The automated gas action algorithm indicates that a PGR or macro PGR is required	- Manually activate the required gas action by pressing <ENTER> on the handheld keypad or sending the command OPMODE=HI/PGR	This warning only occurs in the PGR “Request” mode (see Section 3.3.3 on page 64) If no action is taken, the “HI/PGR request time out“ interlock will be triggered (status code 63)
123	Tube pressure too high	- The gas pressure in the laser tube is too high	- Perform a new gas fill (see Section 7.5.1 on page 187)	
124	Tube temperature too low	- The laser has just been started and the gas has not reached the required operating temperature - Malfunction in the laser cooling circuit	- If the warning occurs when the laser is initially started, allow the laser to run for a few minutes. The warning should disappear when the gas reaches the required operating temperature - If the warning occurs during laser operation, call authorized service	Only applicable with automatic temperature regulation option. When the laser is operated when this warning is active, the required performance specifications may not be attained.
126	Leak test failed	- Excessive temperature change during the leak test - The pressure drop during the leak test after exchanging the tube optics exceeded the permitted threshold	- Press <ENTER> to repeat the leak test - Check the newly installed tube optics for leaks	

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No.	Warning	Reason	Solution	Comments
192	Halogen line pressure too low	- The halogen gas supply line pressure is too low	- Ensure that the gas cylinders are not empty - Ensure that the gas cylinder valves are open - Ensure that the pressure regulator is correctly set	If the indicated pressure irregularity continues to increase, an interlock will occur
193	Halogen line pressure too high	- The halogen gas supply line pressure is too high		
194	Rare line pressure too low	- The rare gas supply line pressure is too low		
195	Rare line pressure too high	- The rare gas supply line pressure is too high		
196	Buffer line pressure too low	- The buffer gas supply line pressure is too low		
197	Buffer line pressure too high	- The buffer gas supply line pressure is too high		
198	Inert line pressure too low	- The inert gas supply line pressure is too low		
199	Inert line pressure too high	- The inert gas supply line pressure is too high		
223	Tube pressure high	- The gas pressure in the laser tube has almost reached the predetermined upper limit.	- Perform a new gas fill (see Section 7.5.1 on page 187)	If the pressure continues to rise, the “Tube pressure too high” interlock will be triggered (status code 224)

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8.2 Fuses

WARNING
Risk of electric shock!
Fuses shall only be exchanged by a skilled electrician working in accordance with electrical engineering rules and regulations. Always shut down and lockout/tagout the laser device before starting work.

NOTICE
Use of incorrect fuses can cause serious damage to the laser device or unnecessary downtime. Therefore, always replace blown fuses with fuses of exactly the same type and rating. If a fuse repeatedly blows, contact COHERENT authorized service as this indicates a malfunction in the protected circuit.

The user-serviceable fuses of the COMPex*Pro* are either located externally on the operating panel (see Figure 131, A) or internally on the electrical module (B), 24 V power supply fuse block (C) or distribution box (D). A marking or label close to or on each individual fuse cover clearly indicates the fuse number and rating of the respective fuse.

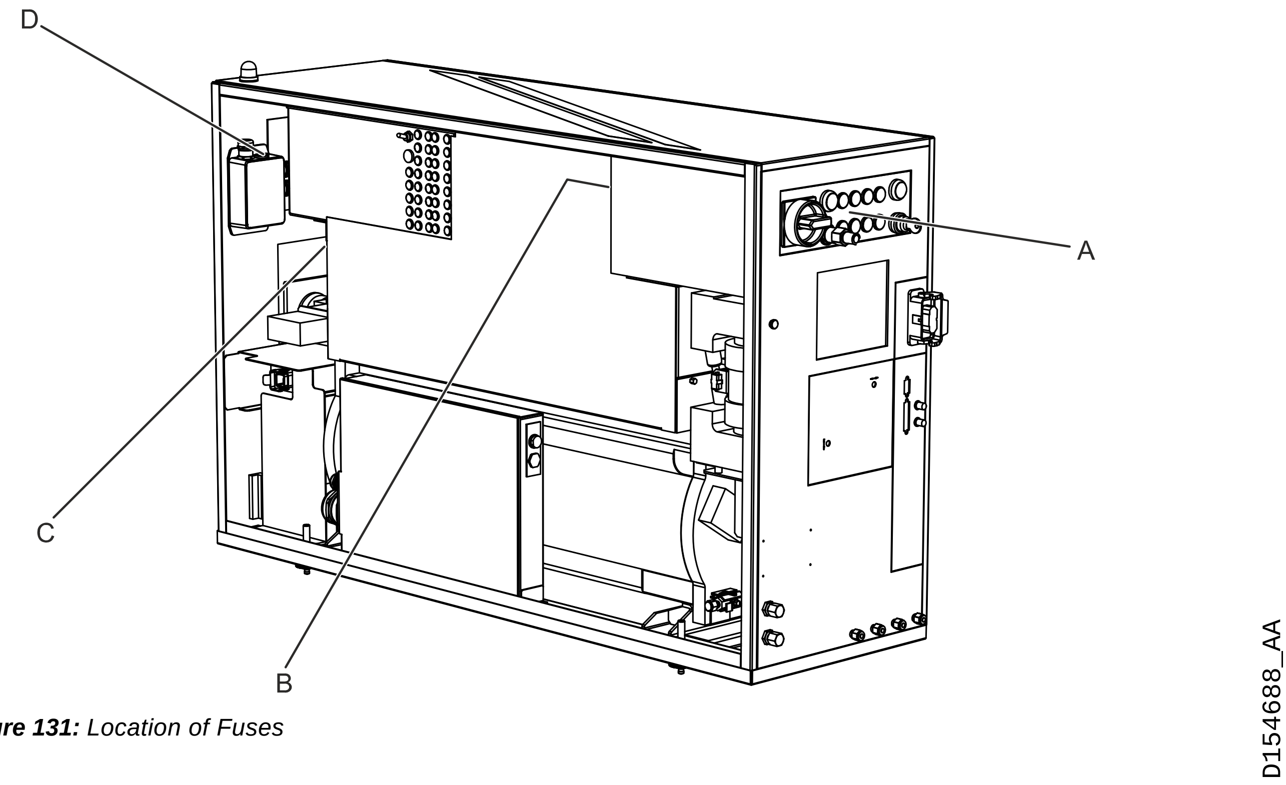

Figure 131: *Location of Fuses*

No.	Rating	Protected circuit	Location
F1	T16A	Main fuse 230 V mains inlet	Operating panel
	T12A	Main fuse 120 V / 104 V mains inlet	
F2	T16A	Main fuse 230 V mains inlet	Operating panel
	T12A	Main fuse 120 V / 104 V mains inlet	
F3	T16A	Main fuse 230 V mains inlet	Operating panel
	T12A	Main fuse 120 V / 104 V mains inlet	
F4	T16A	Main fuse 230 V mains inlet	Operating panel
	T12A	Main fuse 120 V / 104 V mains inlet	
F5	T10 A	All 230 V AC consumers	Operating panel
F6	T12.5A	HV power supply	Operating panel
F7	T1.25A	24 V DC power supply	Operating panel
F8	T5A	Gas circulation fan	Operating panel
F9	T1.6A	Exhaust fan and vacuum pump 230 V supply	Electrical module
F10	T3.15A	Thyratron supply	Distribution box
F11	T0.63A	Exhaust fan	24 V power supply fuse block
F12	T0.8A	Laser control board	24 V power supply fuse block
F13	T0.5A	Remote connector and relay on laser control board	24 V power supply fuse block
F14	T1A	Gas valves, relay for gas circulation fan and vacuum pump	24 V power supply fuse block
F15	T1.6A	Gas purifier switching circuit	24 V power supply fuse block
F16	T2A	Water valve, halogen sensor, safety relay for HV power supply and time-delay relay for halogen valve	24 V power supply fuse block
F17	T0.8A	Pulser ventilator, energy monitor and interface board	24 V power supply fuse block
F18	T3.15A	Gas purifier power supply	24 V power supply fuse block

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