

GSI

TM

IPEX™-800

Industrial Excimer Laser

User's Guide





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User's Guide

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INTRODUCTION

GSI Group is a worldwide technology company specialising in the development, production and support of Lasers, Laser-based systems and Precision Motion products. The Company organisation includes manufacturing operations located in North America and Europe along with a network of support centres.

GSI Group, Laser Division offers a complete range of lasers that cover applications in sectors including electronics, aerospace, automotive, advanced manufacturing, packaging and advanced research. In the manufacturing sector, they are used to cut, drill, engrave, etch, mark and weld a large variety of materials and items. In the field of research, our products are employed for spectroscopy, holography, photochemistry, and many other specialised applications.

GSI Group collaborates with customers to develop laser systems that increase productivity, solve manufacturing problems and meet the requirements of leading-edge research.

Thank-you for purchasing this product. You can now benefit from the superior and reliable performance of an advanced laser system.

Please find the necessary time to read this manual thoroughly. It begins with safety measures that must be observed by all personnel authorised to use this system, and includes relevant installation, operation and maintenance details.

It is vital that we draw your attention to the following:

WARNING: Certain precautions essential for the safe operation and maintenance of this high power laser are included within the manual and must be fully understood prior to the application of any electrical power to the system!

WARNING: No modifications or adjustments to components and controls should be undertaken other than those specified herein. Failure to observe this condition may result in hazardous laser radiation exposure!

After Sales Support

GSI Group, Laser Division supports its installed base worldwide, through a network of Regional Offices, Distributors and Machine Integrators.

For after sales support, please contact the local GSI Group office, Distributor or Machine Integrator that you purchased the laser from. Full contact details of these offices can be found on our website at www.gsiglasers.com - Service and Support - Call for Service

Should you have any queries about this system, or experience any difficulties in its use, do not hesitate to contact us. Our engineers and technical staff are on hand to provide professional advice

GSI Group, Laser Division - Service and Technical Support Hotline

Telephone: +44 (0)1788 532612
Fax: +44 (0)1788 553564
Email: support.laserdivision@gsig.com

When contacting a Customer Centre, please have the following information at hand:

- The Laser model.
- The Laser serial number.
- Number of accumulated laser pulses
(from mechanical shot counter located in the power distribution module of the laser).
- Operating gas mixture of the laser.
- Typical pulse energy and repetition rate.

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1. GENERAL INFORMATION

1.1 Class of Laser

The IPEX Series Laser is a Class 4 (IV) Laser system. Refer to Section 2 for information on Laser radiation hazards and safety precautions in a Class 4 (IV) environment.

1.2 Intended Users

All operators using this Laser equipment must be officially trained and authorised. They must also be fully conversant with the following:

- Laser hazards, safety procedures and correct use of related safety equipment.
- Hazards related to the use of Lasers for materials processing, prescribed safety procedures and related equipment.
- The contents of this manual, and therefore the related safety provisions prescribed for the safe installation of the equipment.

Authorised Personnel are classified as Engineers who have attended official GSI Group, Laser Division Training Courses and have been certified as competent.

1.3 Documentation

1.3.1 Pre-installation Manual

The Pre-installation Manual provides information on Pre-installation requirements, Installation Procedures and De-Commissioning Procedures.

The Pre-installation section specifies site preparation and the interfaces that need to be in place prior to Laser delivery. The Installation section provides information and the procedures necessary for installation and commissioning.

1.3.2 User Manual

The User Manual provides information on the Operating Procedures, User Maintenance and some Fault Diagnosis. It mainly relates to operation when the remote control keyswitch is in the USER position.

1.3.3 Operation and Maintenance Manual

A third manual, the Operation and Maintenance Manual will be provided for the use of Authorised Personnel only. It describes how to operate, maintain, troubleshoot and service an IPEX800. It describes the laser and its component systems in more detail than the User's Guide.

1.3.4 Safety Paragraphs

Throughout the documentation '**WARNING**', '**Caution**' and '**Note**' paragraphs appear. It is the responsibility and duty of all personnel who operate and maintain this equipment to fully understand the **WARNING**, **Caution** and **Note** procedures in order to reduce or eliminate hazards.

WARNING: Warning text must be observed to prevent personal injury to yourself and others.

Caution: Caution text must be observed to prevent possible damage or destruction to equipment or loss of operational effectiveness.

Note: Note text must be observed for essential and effective operating procedures and conditions.

2. SAFETY AND STANDARDS

2.1 General

Only authorised personnel who have been instructed in, and fully understand, the necessary safety procedures must use this laser.

Access to the laser should be restricted to authorised personnel. Suitable warnings signs should be placed around the area where it is operating.

Any local safety requirements for the operation of this equipment must be complied with.

2.2 Optical Safety

IPEX800 lasers are high-power pulsed laser sources capable of producing radiation at wavelengths between 193 nm and 308 nm in the ultraviolet spectrum. This is a high power Class 4 (IEC 825-1:2001) / IV (CDRH) laser system.

The optional HeNe laser is used as a guide beam to indicate the location of the Class 4 laser beam. This is a Class 3b (IEC 825-1:2001) / IIIb (CDRH)

WARNING: Laser radiation can cause serious eye damage - including blindness. Never look directly into either the main or HeNe laser beam. Injury to the eyes and skin can result from direct exposure to high power laser radiation.

When the system is operational, all personnel must at all times wear approved laser goggles or glasses. It is vital that these are effective at the wavelength(s) emitted by this laser! The wavelength of the main beam is given on the Laser Radiation Warning and Classification Labels (see Section 3.3), while that of the optional aiming beam is 633nm. (The latter is visible red light.)

**Administrative procedures must be introduced to enforce the above requirement on use of protection.
In Europe, Laser safety goggles must comply with EN 207 and EN 208.**

Information to assist with the selection of suitable eye protection is provided on the Laser Radiation Warning and Classification Label.

Never look directly into the main beam or any reflected laser beams - even when wearing eye protection - or blindness may occur.

Ensure that the beam is never reflected - even partially - back along its path into the laser head, as this will result in optical damage to its components.

Ensure that the beam is not directed towards reflective objects. (Note that personal jewellery is a potential hazard.)

It is strongly recommended that the laser is positioned so that beams are not at eye level, and the beam is not pointed at a room entrance. Take care that laser light cannot escape through windows.

The expected laser beam path should always be well defined before the laser is turned on. The beam path should be enclosed by tubes or channels wherever possible.

If the beam is not enclosed, personnel working close to the beam path should protect their hands by using high UV protection sunblock and by wearing plastic gloves.

Interaction of the beam with certain materials can cause potentially harmful levels of visible radiation to be emitted. Appropriate protective measures must be taken in this case. For further information on this subject see subsection 2.6.

2.3 Electrical Safety

The high voltage power supply in the IPEX800 operates from an AC power line, and produces outputs of up to 40 kV. The main discharge capacitor in the laser holds tens of joules at up to 40 kV. These voltages and energies constitute a lethal shock hazard. Safety interlocks are incorporated into the equipment to afford maximum practical protection against high voltage hazards.

WARNING: This equipment contains lethal AC and DC voltages. These may still be present even when the power is disconnected.

A two minute period must be allowed after isolation of the power supply before opening the removing covers from the Laser.

This delay permits the high voltage capacitors in the equipment to fully discharge.

Only qualified technical personnel who are familiar with the equipment should ever remove the covers from the laser, disable the interlocks or perform tests on the high voltage supply, main discharge capacitor, or the thyatron. Always use extreme caution when operating the system with the head covers removed, as there is then a risk of exposure to HV electricity. Always assume that high voltage is present within the laser cabinet unless proper grounding procedures have been performed.

WARNING: Stimulating the discharge in the laser requires voltages as high as 40kV, which are present in the laser head, the PSU, and the HV connection between them.

2.3.1 Main disconnect switch

The main disconnect switch is large and easy to turn off in an emergency. You can also connect your own emergency stop switch to pins 1 and 2 of the Interlock/Status connector on the left panel.

2.3.2 Removing laser covers

Five cover switches have been installed on the IPEX800:

- top right panel
- top left panel
- vessel service panel
- electrical service panel
- right panel

When one of these covers is removed, a cover switch opens, the laser enters the Interlock state, and the COVER SWITCH OPEN error message is posted. The laser cannot be operated until the switch is closed and the error message is cleared.

Any maintenance procedure that requires removing laser covers should be initiated with caution to electrical shock hazards by trained personnel only.

The laser contains a high energy capacitor called the main discharge capacitor that can contain a residual charge for a significant length of time after the power to the laser has been turned off.

See the high voltage grounding procedure described in Chapter 2, Safety, in the *Operation and Maintenance Manual*.

DANGER: Only qualified personnel should operate the laser with a cover off.

2.3.3 High voltage components

Any procedure that involves handling any of the following parts requires that the high voltage grounding procedure (see next sub-section) be carried out:

- the high voltage power supply
- the pulsed power section
- the components inside the pulsed power section
- the high voltage feedthrough from the pulsed power section to the laser vessel
- dust precipitator.

The high voltage grounding procedure is contained in Chapter 2, Safety, in the *Operation and Maintenance Manual*.

DANGER: Never touch or make electrical contact with any high voltage component unless the high voltage grounding procedure has been performed.

Note that if the main discharge capacitor has been disconnected but a shorting lead has not been installed, the capacitor can build up a dangerous charge even though the laser is turned off and has been previously shorted.

2.4 Laser Beam Exposure Prevention

2.4.1 Safety Beam Stops

The IPEX Series of Lasers has a pneumatically operated safety shutter fitted in the laser beam path. When this is closed the laser beam path exiting from the laser is blocked, and internal circuits also prevent the laser excitation system from operating.

The shutter interlock contacts on the Interlock/Status connector control whether the shutter blocks the laser beam or allows it to pass. When the contacts are open, the shutter blocks the laser beam. When the shutter contacts are closed, the shutter opens and allows the beam to pass.

WARNING: Do not run the laser for extended periods with the beam shutter closed.

2.4.2 Remote Interlock Connector

The IPEX laser is equipped with an Interlock/Status connector to minimize the possibility of the laser being operated in an unsafe condition. The external interlock contacts on the Interlock/Status connector may be connected to a switch or piece of external equipment. The interlocks in this circuit are:

- main disconnect switch
- keyswitch
- Interlock/Status connector
- cover switches.

If any of these interlocks or cover switches is open, the laser goes into an interlock state and the high voltage power supply is disabled. The laser shuts off when the main disconnect switch is turned off; the main control is powered off when the keyswitch is turned off. The corresponding error message appears on the remote control display (EXTERNAL SWITCH OPEN or COVER SWITCH OPEN). The remote control is not powered when the main disconnect switch or keyswitch are off.

If all of the interlocks are closed, the control of the high voltage power supply is given to the main control, which can then enable the power supply. The Emission Indicators on the front and rear of the laser and on the remote control are lit to indicate this condition. The laser can now fire.

The Remote Interlock Connector (RIC) is a safety feature used to protect personnel from exposure to Laser radiation. It enables an external Remote Safety Interlock to be fitted to the interlock circuit of the Laser. The Remote Interlock Connector is a requirement of the two principal Laser radiation standards:

- Worldwide IEC 60825-1 (Europe EN 60825-1).
- North America FDA Regulation 21 CFR Chapter J 1040.10.

When the terminals of the RIC are open circuit, exposure to Laser radiation is prevented. This is caused by either the RIC plug being removed or the terminals of a Safety Interlock Switch connected to the plug being open circuit. In these circumstances, the interlock chain is broken, causing the laser power circuits to be de-energised and the Shutter closed.

Restoring electrical continuity at the RIC will not restart the Laser. This facility is equivalent to a remote emergency stop control. It must not be used for planned shutdown of the Laser.

WARNING: NO ONE must enter an area where exposure to harmful levels of radiation is possible.

If the Laser beam terminates in a Class 1 (I) work enclosure, the access doors must be protected by safety interlock Shutter switches connected to the Shutter interlock socket.

2.5 Environmental Hazards

Materials used in Laser processing applications can become hazardous if safe working practices are not followed. Hazards can result from the following:

2.5.1 Fire

Particular care is necessary when processing combustible materials. Combustible materials include plastics, waxes, and some metals. The use of oxygen as an assist gas on combustible materials can exacerbate a fire hazard. Compressed gases and solvents used for equipment maintenance also increase the risk of Laser-initiated fires.

2.5.2 Fume

Fume and fine particulate can be generated during processing. Fume can include metallic particles, dust, chemical and gaseous vapours. Such materials must always be regarded as a potential health and safety hazard. Ensure measures are taken to prevent inhalation.

Always consult the following regulations/recommended practices:

- Health and Safety Regulations.
- Local and Plant Regulations.
- Material Manufacturers' Safety Recommendations.

The following guidelines will reduce or eliminate fume hazards:

- Containment of processing by-products in a safety enclosure.
- Evacuation of the processing by-products and assist gases.

2.6 Compressed Gases

By their nature, Excimer lasers operate with high pressure gas mixtures containing corrosive halogens such as hydrogen chloride (HCl) or fluorine (F₂). Normally, the halogens are purchased in concentrations of 5% diluted in helium or neon, and are present in the laser mixture at concentrations well below 1%. All halogens must be purchased as a mixture in neon or helium with concentrations no greater than 10%.

WARNING: Despite the low concentrations of the halogens, the Excimer laser gas mixtures must be considered as hazardous, and standard safety precautions should be observed for such gases.

Statutory requirements relating to the storage, use and transport of compressed gases must be followed, in particular the handling of gas cylinders.

All high-pressure gas lines must be constructed to a high standard using high integrity components. Do not use grease on components that are exposed to oxygen. This increases risk of explosion. Flashback arrestors must be used in oxygen lines.

Strictly adhere to Manufacturers' Safety Recommendations and Procedures.

2.6.1 Exhausting laser gases

In conventional operation, a halogen-absorbing filter, called a scrubber, in the gas exhaust system scrubs the spent Excimer laser mixture as it is pumped from the laser vessel. The exhaust line exits the laser on the left panel of the laser, beside the gas inlets. The laser exhaust should be vented to a fume hood or chemical exhaust system, and the scrubber should be replaced every 50 gas fills (see Chapter 7, Maintenance in the *Operation and Maintenance Manual*).

The IPEX™-800 laser vessel can operate at pressures up to 6,000 mbar. The main control will prevent operation above this pressure, while a mechanical pressure relief valve in the laser head is set to release at 6,300 mbar. This valve vents to the inside of the laser cabinet, which is forced air ventilated through the cabinet exhaust port, on the left panel. A leak in the laser gas handling system is also exhausted in this fashion.

A large-diameter flexible duct should be connected to the cabinet exhaust port and vented to the plant air exhaust system. The length of duct and the number of bends in the duct should not restrict air flow. The exhaust duct should be protected from being crushed or otherwise blocked.

WARNING: Whenever the IPEX™-800 is in operation, that is, whenever the laser vessel is pressurised, it is essential that all gas cylinders be connected by leak-tight lines to the gas connections. If ANY gas inlets are not in use, even temporarily, they MUST be capped off with a VCR or Swagelock® blind nut. Failure to carry out this safety procedure may result in halogen leakage into the surrounding area.

DANGER: Never look down the optical axis of the laser when the vessel is under pressure.

2.7 Equipment Standards

2.7.1 CE Mark Information

This laser component is designed to comply with the following:

- BS EN 60825 - Radiation Safety of Laser Products - Equipment Classification, Requirements and User's Guide
- BS EN 60204 - Safety of Machinery - Electrical Equipment Machines
- BS EN55011 – Emitted RF radiation.
- BS EN61000 – EMC Requirements
- CDRH US Safety Requirements: Compliance with 21 CFR 1040.10 and 1040.11; except for deviations pursuant to Laser Notice No. 50, dated 26 July 2001.

2.7.2 Declaration of Incorporation

Use of the GSI Group Ltd, Laser Division product(s) referred to in this Manual, as part of a whole Machine may not ensure conformity of the whole Machine with the Machinery Directive. Machinery may not be put in to service until it has been declared in conformity with the relevant provisions of the Directive.

2.8 References

For further guidance on the safe use of laser equipment, the following is a list of suggested reading:

1) Laser Safety Guide

Laser Institute of America, 12424 Research Parkway, Orlando Florida 32826-3249, USA

2) American National Standard for the Safe Use of Lasers (ANSI Z136.1-1986)

Laser Institute of America, 12424 Research Parkway, Orlando Florida 32826-3249, USA

3) Radiation Safety of Laser Products - Equipment Classification, Requirements and User's Guide (BS EN 60825)

BSI, Linford Wood, Milton Keynes MK14 6LE, UK

3. SAFETY CONTROL SYSTEM

3.1 Safety Category

A Laser Safety Officer must be appointed to specify the level of safety precautions and control to be implemented during normal operating and maintenance work.

At all times a Laser must be operating in a controlled area, appropriate to the level of hazard it represents.

3.2 Safety Compliance

The following standards apply to Laser safety:

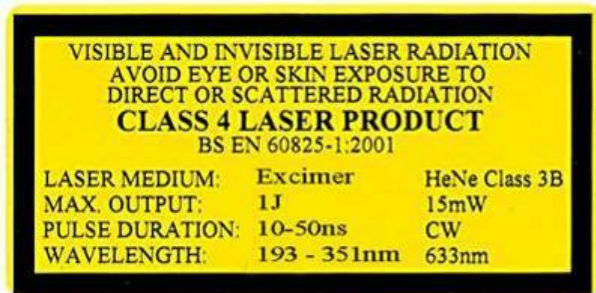
- **Worldwide:** IEC 60825-1: 2001
- **Europe:** EN 60825-1: 2001
- **North America:** FDA Regulation 21 CFR Chapter J 1040.10.

3.3 Safety Labelling

Safety labels are fitted to the equipment in compliance with IEC regulations. Before operating on any part of the Laser system, the hazard level must be checked by examining the Safety and Compliance labels - refer to Figures below.

The labels illustrated in this section are essential for the safe operation of the laser. They must not be removed under any circumstances, and any missing or defaced labels must be immediately replaced. Spares can be obtained from GSI Group. Customers must ensure any component fitted has the correct labelling (refer to GSI Group).

3.3.1 Laser Radiation Warning and Classification Labels



(Left - No HeNe fitted, Right – HeNe alignment laser fitted).

This information is supplied for safety purposes only and serves principally to assist in the selection of suitable protective eyewear and guarding, including integral viewing panels. These values reflect an appropriate safety margin; it is not an output specification.

3.3.2 Laser Aperture Labels

Labels are provide to clearly show where the laser beam will exit from the laser casing. Variations (as shown) depend on whether or not the HeNe alignment laser is fitted.



4. OPERATING CONTROLS

Under normal conditions, two items are used to operate the IPEX™-800:

- remote control
- left panel controls.

The IPEX™-800 can also be controlled by a computer connected to the RS232 connector. For details, see Chapter 9 in the *Operation and Maintenance Manual*.

4.1 Remote Control

The remote control is used to select operating parameters and control the operation of the laser. It indicates the current status of the laser, parameter settings, and error conditions.

The remote control is connected by a serial link to the microprocessor on the Main Control printed circuit board, located inside the laser. The serial link is made via the Remote connector on the right panel of the laser.

The remote control consists of the following parts (see Figure 4-1):

- remote control keyswitch
- display
- keypad.

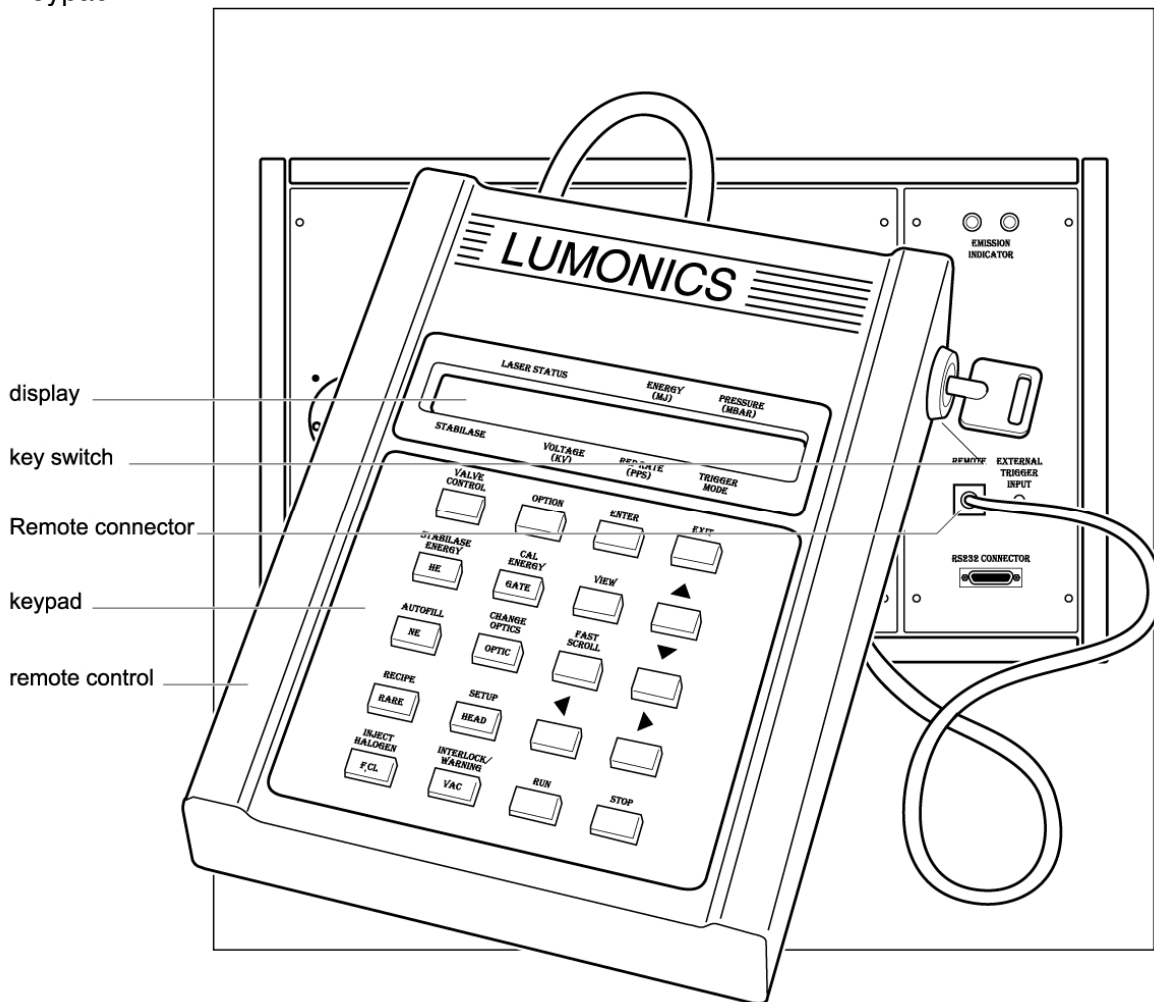


Figure 4-1: Remote control

4.1.1 Remote control keyswitch

The remote control keyswitch has two positions: USER and OPERATOR. When the keyswitch is in the USER position, the RUN, STOP, VIEW, Interlock/Warning, EXIT, ▲, ▼, ► and ◀ keys are

accessible. If any of the other keys are pressed, the message OPERATOR FUNCTION ONLY appears.

4.1.2 Display

The two-line liquid crystal display is used to indicate the value being selected for operating parameters, the value of certain measurements, and error conditions that have occurred.

During normal operation, the primary screen is displayed, as shown in Figure 4-2. The names of the information fields and parameters are written on the surface of the remote control. The primary screen can be displayed at any time by pressing EXIT.

		Energy (mJ)	Pressure (mbar)
Laser Status			
RUN		400	5000
OFF	32.0	20	INTERN
StabiLASE	Voltage (kV)	Rep Rate (pps)	Trigger Mode

Figure 4-2: Primary screen

The primary screen indicates:

- laser status
- output energy of the laser beam
- laser vessel pressure
- StabiLASE mode
- charge voltage
- repetition rate
- trigger mode.

Laser Status: This information field indicates the status of the laser as described in Table 4-1.

Laser Status	Description
WARM-UP	The thyatron heater is being warmed up (5 minutes). The top line displays the time remaining before the laser is ready to run (in the format minutes:seconds). The laser enters the Warm-up state each time the main disconnect switch and keyswitch are turned on. At the end of the warm-up period, the laser enters the Interlock state until RUN or STOP is pressed to start the head recirculation blower.
STANDBY	The laser is ready to operate. Press RUN to fire.
RUN	The laser is firing under internal or external trigger. Press STOP to end firing.
RUN-INJECT	The laser is firing under internal or external trigger, and a halogen injection is in progress.
RUN-OPTIM	The laser is firing and performing a gas optimization procedure.
RUN or STANDBY alternating with WARNING	An error condition has occurred, but the laser can still operate. Press Interlock/Warning to display the error message.

INTERLOCK	If the laser has just finished warming up, this status means that the head recirculation blower has not been turned on. Press RUN or STOP to start the head recirculation blower. The laser enters Run or Standby state respectively. In the Run or Standby state, this status means that an error condition has occurred, and that the laser can not operate. Press Interlock/Warning to display the error message.
SHUTDOWN	Power has been removed from the high voltage power supply and the thyatron power supply. Press Interlock/Warning to display the error message.

Table 4-1: Laser status

Energy (mJ): This information field displays the average pulse energy emitted by the laser, as measured by the internal energy detector at the bottom of the StabiLASE. The average is for all the pulses measured in a one-second interval.

Pressure (mbar): This information field displays the pressure inside the laser vessel. The resolution of the pressure reading is 1 mbar below 1,000 mbar, and 10 mbar above 1,000 mbar.

StabiLASE: This parameter determines if the StabiLASE is being used to maintain constant output energy from the laser. The settings are described in Table 4-2. The StabiLASE and related parameters are described in more detail in this chapter.

Setting	Description
OFF	The output energy is not being controlled by StabiLASE but is determined by the selected charge voltage of the high voltage power supply (set by the Charge Voltage parameter). The pulse energy may vary with time as the laser's conditions change.
ON	The output energy is being controlled by StabiLASE. The StabiLASE adjusts the charge voltage of the high voltage power supply so that the output energy remains at the set value (set using the StabiLASE Energy key). The output energy remains constant over time.
INJ (inject)	StabiLASE is on. The StabiLASE injects halogen into the laser vessel to maintain optimum halogen concentration and keep the output energy at the set value.
OUT	Indicates that the StabiLASE was on but is now off and the laser is still running. This occurs when the StabiLASE increases the charge voltage to the maximum allowed (as set by the StabiLASE HV Limit) then turns off. The laser continues to run with the charge voltage set at the maximum value. This field is not user-selectable.

Table 4-2: StabiLASE settings

Voltage (kV): If the laser is not running under StabiLASE control, this parameter displays the charge voltage selected for the high voltage power supply, which charges the main discharge capacitor. Increasing this parameter generally increases the laser output energy and power. See Chapter 6, Operation, in the *Operation and Maintenance Manual*.

If the laser is running under StabiLASE control (StabiLASE is set to ON or INJ), this parameter displays the current charge voltage of the high voltage power supply, which may be changed by the StabiLASE. The Charge Voltage parameter cannot be altered from the remote control while the laser is running under StabiLASE control.

Repetition Rate (pps): This field displays the selected repetition rate of the laser pulses as determined by the internal rate generator. See Chapter 6, Operation, in the *Operation and Maintenance Manual*.

Trigger Mode: This parameter indicates the triggering mode of the laser. The available modes are:

- internal (INTERN)
- external (EXTERN)
- gated (GATED)
- synchronized (SYNC)
- internal burst (IBURST)
- external burst (EBURST)

The trigger mode cannot be changed while the laser is running. The trigger modes are described in Chapter 6, Operation, in the *Operation and Maintenance Manual*.

4.1.3 Keypad

The keypad consists of 20 keys. Each key has a name written above the key on the face of the remote control.

Most keys have only one function. However, eight keys also allow the operator to manually control the valves of the laser's gas system. These eight keys are darker than the other keys and have the valve names written on the keys themselves. The valve functions are enabled by pressing Valve Control to display the Valve Control screen. Valve functions are described in Chapter 7, Maintenance, in the *Operation and Maintenance Manual*.

If the primary screen is displayed, the eight keys perform the function printed above the key. The function or functions of each key on the remote control keypad is summarized in Table 4-3 below. The use of the keys is described in more detail in various procedures throughout this guide and the *Operation and Maintenance Manual* (indicated in the column "See also").

Note: Not all functions are available when the remote control keyswitch is in the USER position.

Key	Function (nn = number or letter)	See also
ENTER	<p>Primary screen: scrolls through the parameters on the bottom line, allowing them to be changed (StabiLASE mode, charge voltage, repetition rate, and trigger mode).</p> <p>Secondary screens: allows changes to parameters and confirms parameter settings.</p>	
EXIT	Returns to the primary screen from any secondary screen.	
VIEW	<p>Displays the VIEW screen. The information shown under VIEW includes:</p> <p>REF.SHOTS: nnnnnn (the number of laser pulses since the counter was last reset)</p> <p>SHOTS: nnnnnn (the number of pulses since the laser was manufactured or the RAM on the Main Control PCB was replaced)</p> <p>OUTPUT POWER: nn.n W (the average output power in watts)</p> <p>MAIN SW REV.: 8xx.n (the revision level of the software on the Main Control PCB)</p>	<i>Operation and Maintenance, Ch. 7</i>

	REMOTE SW REV: 8xx.n (the revision level of the software in the remote control)	
Fast Scroll	Increases the rate of change of a numerical parameter (changes the second digit from the right). Holding it down, press ▲ or ▼. Used in conjunction with ENTER to reset the Reference Shots reading (under VIEW).	
▲	Scrolls through settings for a parameter; increases the value of a numerical parameter.	
▼	Scrolls through settings for a parameter; decreases the value of a numerical parameter.	
▶	Scrolls through parameters or information being displayed.	
◀	Scrolls through parameters or information being displayed.	
RUN	Starts the firing of the laser. It will not start firing while the laser vessel is being filled, if the optics are being changed, or if the laser is in the Interlock state. Resets errors.	<i>User's</i> Ch. 5
STOP	Stops the firing of the laser. Aborts procedures to fill the laser vessel and to change the optics. Resets errors.	<i>User's</i> Ch. 5
Valve Control	Displays the Valve Control screen. Allows manual control of the valves in the gas system (activates the eight dark valve keys).	<i>Operation and Maintenance,</i> Ch. 7
StabiLASE Energy He	Primary screen: displays the output energy level in millijoules that the StabiLASE is to maintain; can be changed using ▲ and ▼, then pressing ENTER. Valve Control screen: opens or closes the helium valve (buffer 2).	<i>Operation and Maintenance</i> Ch. 6 <i>Operation and Maintenance</i> Ch. 7
CAL Energy GATE	Primary screen: with laser in Run state, displays the output energy level in millijoules given the current calibration; can be recalibrated using ▲ and ▼, then pressing ENTER. Valve Control screen: opens or closes the gate valves.	<i>Operation and Maintenance</i> Ch. 8 <i>Operation and Maintenance</i> Ch. 7
Autofill Ne	Primary screen: displays the Autofill screen and starts the automatic filling of the laser vessel with gas. Valve Control screen: opens or closes the neon valve (buffer 1).	<i>Operation and Maintenance</i> Ch. 7
Recipe	Primary screen: displays the Recipe screen and allows eight parameters to be set: PRESSURE: nnnn mbar (the total fill pressure in millibar: 500 to 6000 mbar)	<i>Operation and Maintenance</i> Ch. 7

<p>RARE</p>	<p>TRANSITION: nnnn nnn (the combination of gases used to produce the laser beam: KrCl, F2, PASSIV., XeF, ArF, KrF, XeCl)</p> <p>HALOGEN FILL: n.nn% (the percentage of halogen in the laser gas mixture; 0.00 to 10.00%). "HALOGEN" is "HCl" or "F2" to match the selected transition.</p> <p>HALOGEN BOTTLE: nnn% (the concentration of halogen in the halogen cylinder; 0 to 100%, usually 5%) "HALOGEN" is "HCl" or "F2" to match the selected transition.</p> <p>RARE GAS FILL: n.nn% (the percentage of rare gas in the laser gas mixture; 0.00 to 10.00%). "RARE GAS" is "Kr", "Xe" or "Ar" to match the selected transition.</p> <p>RARE GAS CYLINDER: nnn% (the concentration of rare gas in the rare gas cylinder; 0 to 100%, usually 100% for argon or krypton, 10 or 20% for xenon). "RARE GAS" is "Kr", "Xe" or "Ar" to match the selected transition.</p> <p>Ne/PREMIX FILL: nn.n% (the percentage of neon in the laser gas mixture; 0.0 to 100.0%, BALANCE or PREMIX, usually BALANCE)</p> <p>He FILL: nn.n% (the percentage of helium in the laser gas mixture; 0.0 to 100.0% or BALANCE, usually 0.0%)</p> <p>Valve Control screen: opens then closes the rare gas valve.</p>	
<p>Setup</p>	<p>Primary screen: displays the Setup screen and allows the following parameters to be set:</p> <p>BURST SIZE: nnnnnn (the number of pulses in a burst; used for IBURST and EBURST triggering modes: 1 to 500,000)</p> <p>SYNC TRIGGER MODE: nnnnnn (The number of pulses, 1pulse or 2pulse, required to fire the laser in synchronized trigger mode.) For repetition rates over 10 pps, the high voltage power supply remains enabled and each pulse fires the laser. For repetition rates below 10 pps, two separate pulses are required to enable the high voltage power supply and fire the laser.</p> <p>LOW ENERGY CHECK: nn (controls the monitoring of the laser output energy: ON or OFF)</p>	<p><i>Operation and Maintenance</i> Ch. 6</p> <p><i>Operation and Maintenance</i> Ch. 6</p> <p><i>Operation and Maintenance</i> Ch. 7</p>

HEAD	HV ADJUST: nn (enables or disables the high voltage feedback loop that corrects for any variations in the high voltage power supply with repetition rate: ON or OFF). This parameter should always be set to ON, except as specified during service procedures.	<i>Operation and Maintenance</i> Ch. 8
	S'LASE END ACTION: nnnn (what the StabiLASE will do when the HV limit is reached: STOP or CONT.)	<i>Operation and Maintenance</i> Ch.6
	S'LASE HV LIMIT: nn.n kV (the maximum charge voltage to be applied by the high voltage power supply: 15.0 to 40.0 kV)	<i>Operation and Maintenance</i> Ch. 6
	HeNe LASER: nnn (controls the optional HeNe laser: ON or OFF) (<i>only appears for lasers with HeNe option</i>)	<i>Operation and Maintenance</i> Ch. 7
	Valve Control screen: opens or closes the head valve.	<i>Operation and Maintenance</i> Ch. 7
Inject Halogen	Primary screen: with laser in Run state, injects a calibrated quantity of halogen into the laser vessel. With laser in Standby state, starts gas optimization.	<i>Operation and Maintenance</i> Ch. 6
F,Cl	Valve Control screen: opens then closes the halogen valve.	Ch. 7
Interlock/W arning	Primary screen: displays Interlock/Warning screen, allows you to scroll through and clear error messages.	<i>Operation and Maintenance</i> Ch. 8
VAC	Valve Control screen: opens or closes the evacuate valve.	<i>Operation and Maintenance</i> Ch. 7

Table 4-3: Key functions

4.2 Left panel controls

Several controls on the left panel are used during normal operation (see Figure 4-3):

- main disconnect switch
- main control keyswitch
- Power On indicator
- Emission Indicators (left and right panels)
- Interlock/Status connector

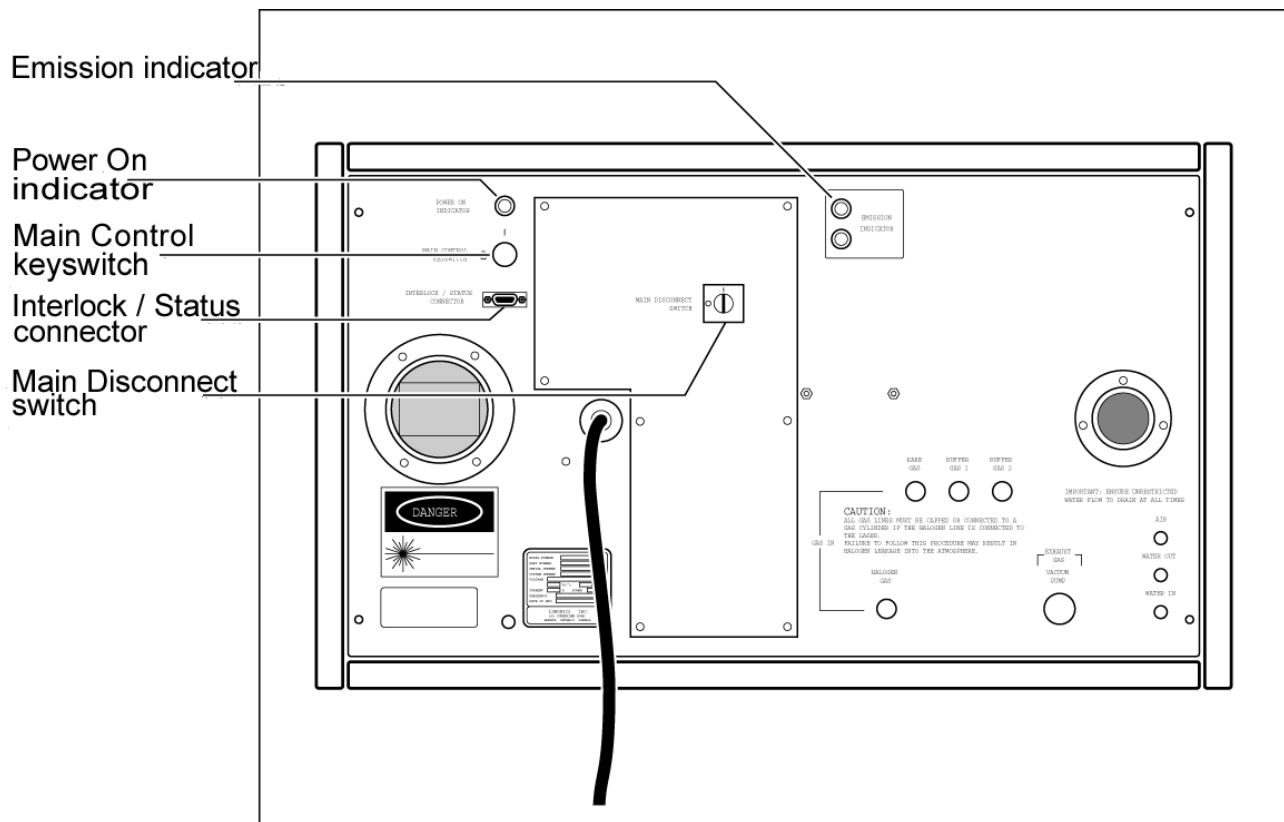


Figure 4-3: Left panel controls

4.2.2 Main disconnect switch

The main disconnect switch is the large red and yellow knob on the left panel of the laser.

When the main disconnect switch is off (pointing to the "O"), no power is supplied to any component in the laser.

When the main disconnect switch is on (pointing to the "|"), power is present within the power distribution assembly and various subassemblies.

The main disconnect switch should be turned off whenever you perform procedures involving power distribution or high voltage components. The switch is large and easy to turn in an emergency.

4.2.3 Main control keyswitch

The main control keyswitch enables and disables the main control if the main disconnect switch is on. The keyswitch has two positions: "O" (off) and "|" (on).

When the keyswitch is in the "O" position, the laser is not powered on.

When the keyswitch is turned to the "|" position, the laser's main control begins the initialization procedure and powers up other devices within the laser cabinet in the proper sequence. The laser can then perform any of the functions described in this documentation.

4.2.4 Power On indicator

The white Power On indicator lights when the main disconnect switch is on.

4.2.5 Emission Indicators

The yellow Emission Indicators light to indicate that the laser is in a potentially dangerous state: the high voltage power supply may be on. The Emission Indicators do not indicate that the laser is firing. The indicators are redundant for additional safety and are located on both end panels of the laser.

5. NORMAL OPERATION

Before operating the IPEX™-800, all personnel must be familiar with the safety precautions described in Chapter 2, Safety.

This chapter assumes that the laser has been correctly installed, filled with gases, and that no error conditions exist.

5.1 Powering the laser on and off

The main disconnect switch and keyswitch are shown in Figure 5-1.

5.1.1 To turn the laser on

1. Open the halogen cylinder (F2 or HCl).
2. Ensure the compressed air supply is on.
3. Turn on the cooling water supply.
4. Turn the main disconnect switch to "I".
The Power On indicator on the rear panel lights.

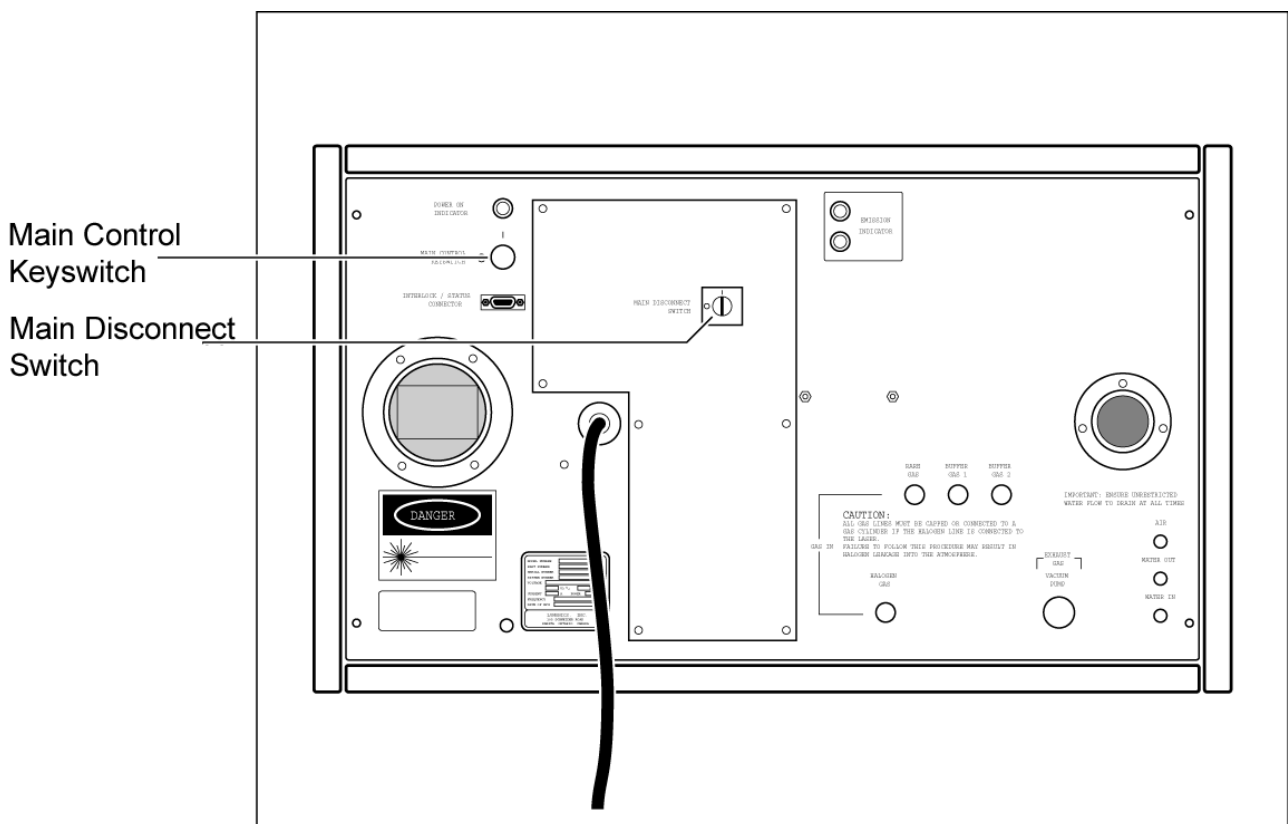


Figure 5-1: Main disconnect switch and keyswitch

5. Turn the keyswitch on the rear panel to "I".
If all the interlocks are closed, the Emission Indicators on the left and right panels of the laser.

After a few seconds, the remote control display looks similar to this:

```

WARMUP 4:38      0      5000
CHECK WATER, PRESS <EXIT>
    
```

The top line shows the time remaining until the thyatron reaches the correct operating temperature. The bottom line reminds the operator to check that the cooling water is flowing.

6. Press EXIT to return to the primary screen.
The laser enters the Interlock state and posts the error message BLOWER OFF to indicate that the head recirculation blower is off.
7. Press STOP to clear the BLOWER OFF error and start the blower.

The laser also posts the error message GATE VALVES CLOSED if the gate valves are closed.

8. Press EXIT to return to the primary screen.

The laser enters the Standby state.

If the laser vessel contains a good gas fill, the laser can be started after the warm-up period is complete.

5.1.2 To start the laser

1. Press RUN on the remote control.

The laser enters the Run state. Depending on the trigger mode selected, the laser will begin firing immediately or fire when a trigger pulse is received.

5.1.3 To stop the laser

1. Press STOP on the remote control.

The laser enters the Standby state.

Note: In an emergency, the laser can be stopped by turning the main disconnect switch on the rear panel to the "0" position.
--

5.1.4 To turn the laser off

1. Press STOP on the remote control.
2. Turn the keyswitch on the rear panel to "0".
The Emission Indicators on the left and right panels extinguish.
3. Remove the key.
4. Turn the main disconnect switch to "0".
The Power On indicator on the left panel extinguishes.
5. Turn off the cooling water supply.
6. Close all gas cylinder valves. Leave the gas fill in the vessel. If the vessel needs refilling, do it shortly before the laser is next operated.

If the laser is to be left idle for a few days, purge the halogen lines with helium before turning off the laser. **Regular purging of the halogen lines and regulator minimizes corrosion.** See Chapter 7, Maintenance, in the *Operation and Maintenance Manual*, for information on gas procedures.

6. ERROR MESSAGES

A variety of abnormal conditions can occur with IPEX™-800. The conditions can be divided into three groups: warnings, interlocks, and shutdowns. In each case, an error message is generated and can be displayed on the remote control display or read by the host computer.

Warnings: Warnings that occur while the laser is running do not prevent the laser from firing. If the laser is running, the words **RUN** and **WARNING** alternate in the Laser Status field on the top line of the remote control display. If the laser is not running, the words **STANDBY** and **WARNING** alternate in the same place. The error message may have to be cleared before the laser can run again.

Interlocks: Interlock conditions stop the laser from firing. The word **INTERLOCK** is displayed in the Laser Status field on the top line of the remote control display.

Shutdowns: Two conditions cause the laser to enter the Shutdown state. The laser must be turned off, then on, to resume normal operation.

The error messages that may appear when the remote control keyswitch is in the USER position are listed in Section 6.3, "Error messages". For a complete list of error messages see Chapter 8, Service, in the *Operation and Maintenance Manual*.

6.1 Displaying error messages

Error messages are displayed by pressing Interlock/Warning. If you press Interlock/Warning while the laser is running, it continues to operate.

If the laser isn't running, the remote control display looks like this when only one error has been detected:

```
interlock/warning
COVER SWITCH OPEN
```

When more than one error has been detected, the first error message is preceded by a number. Interlock messages are displayed first, followed by warning messages. The remote control display looks like this:

```
interlock/warning
1. COVER SWITCH OPEN
```

The error messages can be scrolled by pressing ▲ or ▼.

If you press Interlock/Warning and no errors are present, the remote control's display looks like this:

```
interlock/warning
OK
```

If you press Interlock/Warning while the laser is running and no errors are present, the remote control display looks like this:

```
RUN           400     5000
interlock/warning: OK
```

From any Interlock/Warning screen, press EXIT to return to the primary screen.

6.2 Clearing error messages

Once the cause of an error condition has been corrected, the message can be cleared by pressing STOP. If the laser is running, a warning message can be cleared by pressing RUN. A few messages will clear by themselves when the cause of the error is removed. These are indicated as "non-latched".

From any Interlock/Warning screen, press EXIT to return to the primary screen.

6.3 Error messages

This section lists the error messages that may appear when the remote control keyswitch is in the USER position, using the exact text that appears on the remote control display, and then provides the following information for each message.

LASER STATE	The state that the laser is put in when the message occurs, if any; errors that clear automatically when the cause of the error is removed are indicated as "non-latched".
MEANING	What the message means
CAUSE(S)	The possible causes of the message
ACTION	How to determine the cause of the error and the corrective action required. If the error is corrected, you need not carry out any more steps. Some errors can be cleared by the laser operator; others may require a call to your service representative.

The error messages are listed alphabetically in Table 6-1.

Message	Laser state
ALIGNMENT LASER ON	Warning
BLOWER OFF	Interlock
CANNOT REACH ENERGY	Warning
GAS OPTIM. REQUIRED	Warning
GATE VALVES CLOSED	Warning
HEAD OVER-PRESSURE	Interlock
LASER OVER TEMPERATURE	Shutdown
LOW OPERATING MARGIN	Warning
STABILASE ENDED	Interlock
STABILASE OUT	Warning

Table 6-1 Error messages

6.3.1 Alignment Laser On

LASER STATE	Warning, non-latched
MEANING	The HeNe alignment laser is on.
CAUSE(S)	The HeNe Laser parameter has been set to ON.
ACTION	

DANGER: Do not look directly into the HeNe laser beam.

1. If no red beam is exiting the HeNe laser, check fuse F10 in the power distribution compartment and replace it, if necessary. Press STOP to clear the error.
2. To turn the alignment laser off, set the HeNe Laser parameter to OFF (see Table 5.5 in the *Operation and Maintenance Manual*).

6.3.2 Blower Off

LASER STATE	Interlock
MEANING	The head recirculation blower is not on.
CAUSE(S)	<ol style="list-style-type: none"> a. The head recirculation blower has not been switched on after warmup. b. The head recirculation blower has switched off automatically after the laser has remained in Standby for 30 minutes. c. The laser vessel's pressure had dropped below 300 mbar during an automatic or manual gas fill procedure.
ACTION	<ol style="list-style-type: none"> 1. Press STOP to clear the error and start the blower. 2. You can also press RUN to clear the message, wait a few seconds while the blower reaches its operating speed, then press RUN to start the laser.

6.3.3 Cannot Reach Energy

LASER STATE Warning

MEANING Laser could not achieve the requested StabiLASE energy.

CAUSE(S)

- a. The requested energy is too high.
- b. StabiLASE high voltage limit set too low.
- c. Laser requires halogen injection.
- d. Laser requires new gas fill.
- e. The optics are dirty.
- f. The StabiLASE energy monitor requires calibration.

ACTION See Chapter 8, Service, in the *Operation and Maintenance Manual*.**6.3.4 Gas Optim. Required**

LASER STATE Warning

MEANING During a StabiLASE run, the microprocessor increases the current high voltage to within 1 kV of the HV Limit, warning the operator that little time remains for StabiLASE operation.

CAUSE(S)

- a. The laser requires an injection.
- b. The optics are dirty.
- c. The gas fill is severely degraded.

ACTION See Chapter 8, Service, in the *Operation and Maintenance Manual*.**6.3.5 Gate Valves Closed**

LASER STATE Warning, non-latched

MEANING The gate valves on the optic chambers are closed. No laser output can be obtained with the gate valves closed.

CAUSE(S)

- a. The gate valves were closed while the optics were being changed.
- b. The gate valves were closed by pressing Valve Control then GATE.

ACTION See Chapter 8, Service, in the *Operation and Maintenance Manual*.**6.3.6 Head Overpressure**

LASER STATE Interlock, non-latched

MEANING The pressure of gas inside the laser vessel has increased beyond the normal operating range (15% more than the laser fill pressure or manual valve value).

CAUSE(S)

- a. The cooling water is not turned on.
- b. The water flow is inadequate.
- c. The laser vessel was overfilled using manual valve control.
- d. A cylinder is leaking into the laser vessel.
- e. Too much halogen has been injected.

ACTION

1. Turn off the laser and allow the laser vessel to cool down.
2. Increase the flow of cooling water.
3. Press STOP to clear the error.
4. Reduce the pressure in the laser vessel by pressing HEAD and VAC to open the head and evacuate valves respectively.
5. Watch the Pressure field on the top line of the remote control's display.
6. When the pressure drops to the desired level, press HEAD and VAC to close the head and evacuate valves.

7. Check the cylinders to make sure they are not leaking (see Section 7.10, "Leak testing the laser" in the *Operations and Maintenance Manual*).

6.3.7 Laser Over Temperature

As discussed in Section 8.2 "Cooling water" in the *Operations and Maintenance Manual*, there are two related, but separate causes for this error message to be posted.

LASER STATE Shutdown

MEANING

1. The water flow through the pulse power section dropped below 3 litres per minute for more than 10 seconds.
2. The temperature of the laser vessel has risen to above 50 °C.

CAUSE(S)

- a. The cooling water is not turned on.
- b. The water flow is inadequate.
- c. The Danfoss valve is set incorrectly.

ACTION

1. Turn off the laser and allow the laser vessel to cool down.
2. Increase the flow of cooling water.
3. Press STOP to clear the error.
4. If the water flow is adequate and unrestricted, call your service representative to check that the Danfoss valve is set appropriately.

6.3.8 Low Operating Margin

LASER STATE Warning

MEANING StabiLASE reached the requested energy but after injections has less than 1.5 kV of operating voltage headroom to maintain this energy with.

CAUSE(S)

- a. The requested energy is too high.
- b. StabiLASE high voltage limit set too low.
- c. Laser requires halogen injection.
- d. An optic cleaning is required.
- e. The gas fill is severely degraded.

ACTION See Chapter 8, Service, in the *Operation and Maintenance Manual*.

6.3.9 Stabilase Ended

LASER STATE Interlock

MEANING The laser could not maintain the level of output energy requested under StabiLASE control and the StabiLASE End Point parameter was set to STOP. The laser has stopped.

CAUSE(S)

- a. The requested StabiLASE output energy is too high.
- b. The optics are dirty.
- c. The gas fill is severely degraded.

ACTION See Chapter 8, Service, in the *Operation and Maintenance Manual*.

6.3.10 Stabilase Out

LASER STATE Warning

MEANING The laser could not maintain the level of output energy requested under StabiLASE control and the StabiLASE End Point parameter was set to CONT. The laser is running without StabiLASE.

CAUSE(S)

- a. The requested StabiLASE output energy is too high.
- b. The optics are dirty.
- c. The gas fill is severely degraded.

ACTION See Chapter 8, Service, in the *Operation and Maintenance Manual*.

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