Preinstallation Manual

DIAMOND Cx-10 Series

OEM Laser
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Should you experience any difficulties with your laser or need any technical information, please go to our web site www.coherent.com. Should you need further assistance, please contact Coherent Technical Support by e-mail product.support@coherent.com or telephone, 1-800-367-7890 (1-408-764-4557 outside the U.S.). Please be prepared to supply the model and laser head serial number of your laser system also the description of the problem and any attempted corrective steps to the Product Support Engineer responding to your request.

Telephone coverage is available Monday through Friday (except U.S. holidays and company shutdowns). Inquiries received outside of normal office hours will be captured by our automatic answering system and will be quickly returned the next business day.

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Coherent provides telephone and web-based technical assistance as a service to its customers and assumes no liability thereby for any injury or damage that may occur contemporaneous with such services. Under no circumstances do these support services affect the terms of any warranty agreement between Coherent and the buyer. Operation of any Coherent laser with any of its interlocks defeated is always at the operator's own risk.
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Signal Words and Symbols in this Manual

This 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.

Signal Words

Four signal words are used in this 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 that, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

WARNING!
Indicates a hazardous situation that, if not avoided, could result in death or serious injury.

CAUTION!
Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.

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

NOTICE!
Indicates information considered important, but not hazard-related.

Messages relating to hazards that could result in both personal injury and property damage are considered safety messages and not property damage messages.
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 intended to alert the operator to the presence of important operating and maintenance instructions.

This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.

This symbol is intended to alert the operator to the presence of dangerous voltages within the product enclosure that may be of sufficient magnitude to constitute a risk of electric shock.

This symbol is intended to alert the operator to the danger of Electro-Static Discharge (ESD) susceptibility.

This symbol is intended to alert the operator to the danger of crushing injury.

This symbol is intended to alert the operator to the danger of a lifting hazard.
Preface

This is the Preinstallation Manual for the DIAMOND Cx-10 OEM/Industrial carbon dioxide (CO₂) laser manufactured by Coherent. These lasers are OEM systems; they are designed as components which are to be inserted by the original equipment manufacturer (OEM) prior to delivery to the end user. Coherent requires that the user read Section One: Laser Safety, before operating the laser.

NOTICE!
Read this Preinstallation Manual carefully before operating the laser for the first time. Special attention must be given to the material in Section One: Laser Safety.

WARNING!
Use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

NOTICE!
Use of the system in a manner other than that described within this manual may impair the protection provided by the system.
It is the policy of Coherent to comply strictly with U.S. export control laws.

Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification must be obtained from Coherent or an appropriate U.S. Government agency.

Products manufactured in the European Union, Singapore, Malaysia, Thailand: These commodities, technology, or software are subject to local export regulations and local laws. Diversion contrary to local law is prohibited. The use, sale, re-export, or re-transfer directly or indirectly in any prohibited activities are strictly prohibited.

This laser component does not include all safety features that are required by the United States Food and Drug Administration (FDA), Center for Devices and Radiological Health (CDRH) in laser systems sold to end users. It is sold solely to qualified manufacturers who in their end product, supply interlocks, indicators, and other required safety features, in full compliance with 21 CFR 1040, Subchapter J and/or other applicable national and local regulations.

Operation or handling of this laser component, inconsistent with this manual, may void the warranty.
SECTION ONE: LASER SAFETY

This user information is in compliance with the following standards for Light-Emitting Products IEC 60825-1 / EN 60825-1 “Safety of laser products - Part 1: Equipment classification and requirements” and CDRH 21 CFR Title 21 Chapter 1, Subchapter J, Part 1040 “Performance standards for light-emitting products”.

WARNING!
LASER RADIATION - AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT!

WARNING!
Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

This laser safety section must be reviewed thoroughly prior to operating the Cx-10 laser system. Safety instructions presented throughout this manual must be followed carefully.

Hazards

Hazards associated with lasers generally fall into the following categories:

• Biological hazards from exposure to laser radiation that may damage the eyes or skin
• Electrical hazards generated in the laser power supply or associated circuits
• Chemical hazards resulting from contact of the laser beam with volatile or flammable substances, or released as a result of laser material processing

The above list is not intended to be exhaustive. Anyone operating the laser must consider the interaction of the laser system with its specific working environment to identify potential hazards.

1 - 1
Optical Safety

Laser light, because of its optical qualities, poses safety hazards not associated with light from conventional light sources. The safe use of lasers requires all operators, and everyone near the laser system, to be aware of the dangers involved. Users must be familiar with the instrument and the properties of coherent, intense beams of light.

The safety precautions listed below are to be read and observed by anyone working with or near the laser. At all times, ensure that all personnel who operate, maintain or service the laser are protected from accidental or unnecessary exposure to laser radiation exceeding the accessible emission limits defined in the laser safety standards.

WARNING!
Direct eye contact with the output beam from the laser may cause serious eye injury and possible blindness.

The greatest concern when using a laser is eye safety. In addition to the main beam, there are often many smaller beams present at various angles near the laser system. These beams are formed by specular reflections of the main beam at polished surfaces such as lenses or beamsplitters. While weaker than the main beam, such beams may still be sufficiently intense to cause eye damage.

Laser beams are powerful enough to burn skin, clothing, or combustible materials, even at some distance. They can ignite volatile substances such as alcohol, gasoline, ether, and other solvents, and can damage light-sensitive elements in video cameras, photomultipliers, and photodiodes. The user is advised to follow the control measures below.

Recommended Precautions and Guidelines

1. Observe all safety precautions in this preinstallation manual.
2. Always wear appropriate eyewear for protection against the specific wavelengths and laser energy being generated. See “Laser Safety Eyewear” on page 1-3. for additional information.
3. Avoid wearing watches, jewelry, or other objects that may reflect or scatter the laser beam.
4. Stay aware of the laser beam path, particularly when external optics are used to steer the beam.
5. Provide enclosures for beam paths whenever possible.
6. Block the beam before applying tools such as Allen wrenches or ball drivers to external optics.
7. Limit access to the laser to trained and qualified users who are familiar with laser safety practices. When not in use, lasers should be shut down completely and made off-limits to unauthorized personnel.

8. Terminate the laser beam with a light-absorbing material. Laser light can remain collimated over long distances and therefore presents a potential hazard if not confined. It is good practice to operate the laser in an enclosed room.

9. Post laser warning signs in the area of the laser beam to alert those present.

10. Exercise extreme caution when using solvents in the area of the laser.

11. Never look directly into the laser light source or at scattered laser light from any reflective surface, even when wearing laser safety eyewear. Never sight down the beam.

12. Set up the laser so that the beam height is either well below or well above eye level.

13. Avoid direct exposure to the laser light. Laser beams can easily cause flesh burns or ignite clothing.

14. Advise all those working with or near the laser of these precautions.

**Laser Safety Eyewear**

Always wear appropriate laser safety eyewear for protection against the specific wavelengths and laser energy being generated. The appropriate eye protection can be calculated as defined in the “EN 207 Personal eye protection equipment - Filters and eye-protectors against laser radiation (laser eye-protectors)”, in other national or international standards (e.g. ANSI, ACGIH, or OSHA) or as defined in national safety requirements. Anyone working with or near the Cx-10 laser must wear laser safety eyewear with an OD (Optical Density) rating 5 eye protection.

**CAUTION!**

Laser safety eyewear protects the user from accidental exposure to laser radiation by blocking light at the laser wavelengths. However, laser safety eyewear may also prevent the operator from seeing the beam or the beam spot. Exercise extreme caution even while wearing safety glasses.
**Viewing Distance**

The Cx-10 lasers produce optical power levels that are dangerous to the eyes and skin if exposed directly or indirectly. These products must be operated only with proper eye and skin protection at all times. Never view directly emitted or scattered radiation with unprotected eyes. When viewing the laser during operation, the operator must maintain the Nominal Ocular Hazard Distance (NOHD) between the laser or scattered radiation and the operator's eyes. Figure 1-1 summarizes the NOHD for the power range of the Cx-10 for direct viewing of the collimated beam along with two other common configurations. The NOHD in this figure is based on the Maximum Permissible Exposure (MPE = 0.1 W/cm²) level for each power condition as specified in ANSI Z136.1 and IEC 60825-1.

![Nominal Ocular Hazard Distance](Image)

*Figure 1-1. Nominal Ocular Hazard Distance (NOHD) for indicated conditions calculated per ANSI Z136.1-2007*

**Electrical Safety**

**RF Power Module**

The Cx-10 RF power module requires 48 VDC input voltage. This voltage and other voltages derived within this laser can be lethal. Every portion of the electrical system should be treated as if it were at a dangerous voltage level.

All units are designed to be operated as assembled. Warranty will be voided if the laser head, the controller, or the cable is disassembled.
Laser Safety

DANGER!
Normal operation of the Cx-10 should not require access to the power supply circuitry. Removing the power supply cover will expose the user to potentially lethal electrical hazards. Contact an authorized service representative before attempting to correct any problem with the power supply.

Laser Head

High voltages are present in the laser head when the power is on. There are no serviceable parts or optics within the laser head. Do not remove any covers or make any adjustments to any screw.

DANGER!
To avoid potentially fatal electrical shock hazards from electrical equipment, follow all applicable electrical codes such as (in the U.S.) the National Electrical Code.

Recommended Precautions and Guidelines

The following precautions must be observed by everyone when working with potentially hazardous electrical circuitry:

DANGER!
When working with electrical power systems, the rules for electrical safety must be strictly followed. Failure to do so could result in the exposure to lethal levels of electricity.

1. Disconnect main power lines before working on any electrical equipment when it is not necessary for the equipment to be operating.

2. Do not short or ground the power supply output. Protection against possible hazards requires proper connection of the ground terminal on the power cable, and an adequate external ground. Check these connections at the time of installation, and periodically thereafter.

3. Never work on electrical equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment, and who is competent to administer first aid.
4. When possible, keep one hand away from the equipment to reduce the danger of current flowing through the body if a live circuit is touched accidentally.

5. Always use approved, insulated tools.

**Safety Features and Compliance with Government Requirements**

The following features are incorporated into the instrument to conform to several government requirements:

**United States of America:**
The applicable United States Government requirements are contained in 21 CFR, Subchapter J, Part 1040 administered by the Center for Devices and Radiological Health (CDRH).

Integrators who incorporate a Cx-10 laser into other products that they introduce into United States commerce are defined in the law as manufacturers who are thus required to manufacture their products to conform to the Federal standard, certify them, and submit product reports to the CDRH.

For jurisdictions outside of the United States, it is the responsibility of the buyer of this laser device to ensure that it meets the local laser safety requirements.

**Europe:**
The European Community requirements for product safety are specified in the Low Voltage Directive (LVD) (published in 2014/35/EU). The Low Voltage Directive requires that lasers comply with the standard EN 61010-1/IEC 61010-1 “Safety Requirements For Electrical Equipment For Measurement, Control and Laboratory Use” and EN 60825-1/IEC 60825-1 “Safety of Laser Products”. Compliance of this laser with the European requirements is certified by the CE mark.

**Laser Classification**

Governmental standards and requirements specify that the laser must be classified according to the output power or energy and the laser wavelength. The Cx-10 is classified as Class 4 based on 21 CFR, Subchapter J, Part 1040, section 1040.10 (c) and/or IEC/EN 60825-1;2007, Clause 8 and IEC/EN 60825-1:2014, Clause 4. In this manual, the classification will be referred to as Class 4.
Protective Housing

The laser head is enclosed in a protective housing that prevents human access to radiation in excess of the limits of Class radiation as specified in the 21CFR, Part 1040 Section 1040.10 (f)(1) and EN 60825-1/IEC 60825-1 Clause 6.2 except for the output beam, which is Class 4.

Protective Covers (Safety Interlocks)

The laser’s protective covers are not interlocked and should only be removed by trained service technicians.

WARNING!
Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.

DANGER!
To avoid potentially fatal electrical shock hazards from electrical equipment, follow all applicable electrical codes such as (in the U.S.) the National Electrical Code.

Compliance to Standards Relevant to CE Mark

The Cx-10 lasers are OEM products, and are sold as components for integration into complete laser systems by a system integrator. These products are tested and CE Marked as independent products. For specific details regarding what applicable compliance directives and standards the products have been tested to, please refer to the Declaration of Conformity which is available upon request from Coherent, per contact information on page ii of this manual.

Compliance to applicable standards for a particular laser tool incorporating Cx-10 lasers must be demonstrated by the manufacturer of the complete system. The primary issue for the system integrator is to design covers, shielding, grounding, routing of electrical cable assemblies, and control elements with the proper safety features so that during subsequent testing the system meets the appropriate standards.

Coherent recommends the following guidelines to control the amount of radiated interference:

- Use high quality cables and connectors for all electrical connections
- Verify grounding of cable shields, generally at both ends of the cable
Environmental Compliance

This section describes compliance with various environmental regulator directives to identify hazardous substances.

Electromagnetic Compatibility

Compliance of this laser with the Electromagnetic Compatibility (EMC) requirements is certified by the CE mark. For more information about the CE mark see “Compliance to Standards Relevant to CE Mark” on page 1-7.

RoHS Compliance

The RoHS directive restricts the use of certain hazardous substances in electrical and electronic equipment. Coherent can provide RoHS certification upon request for products requiring adherence to the RoHS Directive.

China-RoHS Compliance

Coherent products supplied by Coherent are in conformity with applicable requirements of China's “Management Methods”, commonly referred to as China-RoHS, and associated standards and applies to the production, sale, and import of products in the People's Republic of China.

The China RoHS Regulation requires that the Environment-Friendly Use Period (EFUP) symbol be displayed on any product. This symbol indicates an environmental-friendly use period with the number of years inside the circle (Figure 1-2).

![Image](image_url)

**Figure 1-2. Environmentally Use Period Symbol**

This regulation also requires that the date of manufacture be identified (in Chinese characters) on the product label (Figure 1-3).

![Image](image_url)

**Figure 1-3. Manufacture Date**
The China RoHS Hazardous Substance Marking Table is located in the shipping document packet shipped with the product (or laser system).

**EU REACH**

REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) is a European Union Commission (EUC) Regulation on chemicals and their safe use (EC 1907/2006) entered into force on 01 June, 2007 and will be phased in until 2018.

Coherent products are “articles” as defined in REACH Article 3(3) and do not release substances under their normal use. Suppliers of articles must provide recipients with information on Substances of Very High Concern (SVHC) if those are present above a concentration limit of 0.1% on an article level. As Coherent's duty to communicate information on substances in articles, the delivered product(s), based on Coherent's knowledge, may contain the listed chemical substance(s) included on the REACH Candidate List at this link:

https://edge.coherent.com/assets/pdf/reach_article_33_statement.pdf

The current Candidate List of SVHCs can be found on the ECHA website https://echa.europa.eu/home

Coherent will post information on SVHCs to this website as the information becomes available and assures its customers that our products are in full compliance the EU REACH requirement.

**Waste Electrical and Electronic Equipment**

The European Waste Electrical and Electronic Equipment (WEEE) Directive (2012/19/EU) is represented by a crossed-out waste material container label. The purpose of this directive is to minimize the disposal of WEEE as unsorted municipal waste and to facilitate its separate collection.

The WEEE Directive applies to this product and any peripherals marked with this symbol. Do not dispose of these products as unsorted municipal waste. Contract the local distributor for procedures for recycling this equipment.

![Figure 1-4. Waste Electrical and Electronic Equipment Label](image-url)
Location of Safety Labels

Refer to Figure 1-5 for a description and location of all required safety labels. These include warning labels indicating removable or displaceable protective housings, apertures through which laser radiation is emitted, and labels of certification and identification [21 CFR § 1040.10(g), 21 CFR § 1010.2, and 21 CFR § 1010.3/EN 60825-1/IEC 60825-1, Clause 7].

Figure 1-5. Location of Safety Labels (Sheet 1 of 3)
1. IDENTIFICATION LABEL - LASER SYSTEM

2. IDENTIFICATION LABEL - RF MODULE

3. IDENTIFICATION LABEL - LASER HEAD

4. DANGER OF LASER RADIATION LABEL

Figure 1-5. Location of Safety Labels (Sheet 2 of 3)
5. TAMPER PROOF LABEL

![Tamper Proof Label](image)

6. VOLTAGE WARNING LABEL

![Voltage Warning Label](image)

7. WARNING APERTURE LABEL

![Warning Aperture Label](image)

8. COOLANT SUPPLY LABEL

![Coolant Supply Label](image)

9. COOLANT RETURN LABEL

![Coolant Return Label](image)

10. COOLANT WARNING

![Coolant Warning Label](image)

Figure 1-5. Location of Safety Labels (Sheet 3 of 3)
Sources of Additional Information

The following are sources for additional information on laser safety standards and safety equipment and training.

Laser Safety Standard

*American National Standard for Safe Use of Lasers*
ANSI Z136 Series
American National Standards Institute (ANSI)
[www.ansi.org](http://www.ansi.org)

*Performance standards for light-emitting products*
21 CFR Title 21 Chapter 1, Subchapter J, Part 1040
U.S. Food and Drug Administration
[www.fda.gov](http://www.fda.gov)

Publications and Guidelines

International Electrotechnical Commission (IEC)
[www.iec.ch](http://www.iec.ch)

*A Guide for Control of Laser Hazards*
American Conference of Governmental and Industrial Hygienists (ACGIH)
[www.acgih.org](http://www.acgih.org)

*Laser Safety Guide*
Laser Institute of America
[www.lia.org](http://www.lia.org)
SECTION TWO: DESCRIPTION AND SPECIFICATIONS

Introduction

In this section, specifications and characteristics of the Cx-10 laser will be discussed. Characteristics to be discussed include mechanical, thermal, electrical, and optical interfaces; and environmental requirements and limitations.

The Cx-10 laser is a sealed-off, RF-excited CO₂ laser, capable of continuous wave (CW) or modulated operation. From the laser safety point of view, this laser is considered to be a component and must be integrated into a system by a qualified original equipment manufacturer (OEM) prior to delivery to the end user. See “Safety Features and Compliance with Government Requirements” on page 1-6 for a complete discussion of laser safety issues.

Purpose of This Manual

This manual is designed to assist the OEM during the integration of the Cx-10 laser. It contains information on the performance and operation of the laser as well as installation and control methods.

Figure 2-1. Cx-10 Liquid-Cooled Laser
Specifications and Input Requirements

Table 2-1 on page 2-4 provides specifications, configurations, and facility requirements for the Cx-10 laser. Laser performance specifications are provided in the Cx-10 data sheet available online at www.coherent.com and in the test report provided with each laser.

Figure 2-1 illustrates the baseline configuration (i.e., without any optional hardware additions or deletions) of the Cx-10 laser. Each laser system consists of a laser head assembly and an integrated radio frequency (RF) power supply. The RF power module converts 48 VDC electrical power to radio frequency power.

Connection of the customer-supplied DC power supply to the Cx-10 is via a barrier strip with screw terminals on the RF power module. These terminals should also be used for the connection of wires for remote voltage sensing. Such sensing is recommended to control the voltage at the input to the RF power module more precisely.

Hardware Overview

The Cx-10 laser is a waveguide, carbon dioxide (CO₂) laser. RF electric fields provided by the RF power module excite the CO₂ gas mixture. The standard configurations of this laser operate at wavelengths between 9 μm and 11 μm in the infrared region of the electromagnetic spectrum.

DC Input Power

DC input power is provided by the user through customer-supplied bus wiring, which goes to the RF power module. The RF power module converts this DC electrical power into RF power, which is used to excite the gas in the laser head. The DC power supply requirements are discussed in detail in “DC Power Supply Requirements” on page 3-16.

Cooling Requirements

Total heat dissipation for the laser is specified in Table 2-1 on page 2-4. The laser head typically dissipates 1200 W from its base surface while the RF power module typically dissipates 300W, for a total typical heat dissipation of 1,550 W (maximum total heat dissipation is 1,700 W). The Cx-10 must be provided adequate cooling to keep the laser operating temperature within acceptable limits. The cooling method that is used must not induce stresses that will result in misalignment of the laser resonator.
Installation requirements related to the liquid-cooling of the Cx-10 laser are discussed in detail in “Liquid-Cooling” on page 3-6. This section is a quick overview only. Figure 3-2 shows the recommended connection from the customer-supplied refrigerated recirculator to the Cx-10 laser system.

It is mandatory that the outlet water from the refrigerated water re-circulator be delivered only to the inlet water connection on the laser. The outlet port on the laser delivers used water back to the recirculator. Refer to Figure 3-2 on page 3-4. A customer provided flow switch or interlock device must be installed in the cooling water return line to detect the presence of cooling water at the required flow rate, and to shut down the laser if adequate coolant flow is not present.

NOTICE!
To avoid damage to the laser, never operate the laser without a supply of cooling water meeting the requirements indicated in Table 2-1 on page 2-4.

The laser head takes RF input power and converts some of it to laser radiation. The rest of the RF input power is exhausted as waste heat. For the Cx-10 liquid-cooled laser, this waste heat is exhausted into the cooling water that flows through the laser head. The laser head consists of the folded optical waveguide resonator, the all-metal gas envelope structure, and RF power module. Infrared laser radiation is emitted from the optical aperture. Pictures and dimensions drawings for the Cx-10 liquid-cooled laser is shown in Figure 2-1 on page 2-1 and Figure 3-2 on page 3-4.

The Cx-10 RF power module converts DC input power to RF energy, which is sent to the laser head. Heat from the RF power module is exhausted into the liquid-cooling water. An RJ-45-type connector is used to control the laser system. All of the user interfaces (DC power cooling water, and signal interface) are on one panel of the RF power module.
Table 2-1 on page 2-4 provides configuration and facility requirements for the Cx-10 laser. Laser performance specifications are provided in the Cx-10 data sheet available online at www.coherent.com and in the test report provided with each laser.

Table 2-1. Configuration & Facility Requirements

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>14.5 kg (32 lbs)</td>
</tr>
<tr>
<td>Dimensions (L x W x H)</td>
<td>563 x 132 x 106 mm (22.17 x 5.20 x 4.17 in.)</td>
</tr>
<tr>
<td>Input Power</td>
<td>48 VDC, 38 A</td>
</tr>
<tr>
<td>Heat Dissipation (W)</td>
<td>≤ 1700</td>
</tr>
<tr>
<td>Maximum Case Temperature</td>
<td>&lt; 60°C (140°F)</td>
</tr>
<tr>
<td>Operating Environment</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>5 to 45°C (41 to 113°F)</td>
</tr>
<tr>
<td>Altitude</td>
<td>≤ 2,000 m (&lt; 6,500 ft.)</td>
</tr>
<tr>
<td>Humidity</td>
<td>Non Condensing ≤ 95%</td>
</tr>
<tr>
<td>Shipping/Storage Environment</td>
<td>-10°C - + 60°C (14 - 140°F), Non-condensing</td>
</tr>
<tr>
<td>Coolant</td>
<td>Distilled or deionized water plus corrosion inhibitor (see “Coolant Composition” on page 3-10 and “Alternative Coolant Composition” on page 3-11)</td>
</tr>
<tr>
<td>Coolant Flow Rate</td>
<td>≥ 5.7 lpm (1.5 gpm)</td>
</tr>
<tr>
<td>Maximum Coolant Pressure</td>
<td>827 kPa (120 psi)</td>
</tr>
<tr>
<td>Max. Pressure Differential (at 1.5 gpm)</td>
<td>&lt; 206 kPa (30 psig)</td>
</tr>
<tr>
<td>Coolant Temperature</td>
<td>15°C - 30°C (59 to 86°F)</td>
</tr>
<tr>
<td>Recommended DC Power Cables (2 Red and 2 Black)</td>
<td></td>
</tr>
<tr>
<td>DC Cable Length (each)</td>
<td>3 m (10 ft.)</td>
</tr>
<tr>
<td>DC Cable Wire Gauge (each)</td>
<td>AWG 10</td>
</tr>
</tbody>
</table>

The above values subject to change without notice. Please refer to the data sheet available online at www.coherent.com
SECTION THREE: UTILITY REQUIREMENTS AND SYSTEM INSTALLATION

NOTICE!
Before installation, it is essential that the customer read this manual thoroughly. It is important that the user become familiar with all aspects of the installation and operation of the Cx-10 laser system, including and specifically the information contained in Section One: Laser Safety.

Unpacking and Inspection
Before unpacking the laser components, inspect the shipping carton for evidence of rough handling, and note any damage. If damage to the shipping carton is evident, request the carrier's agent be present when the unit is unpacked. Inform the shipping carrier and Coherent of any evidence of damage in shipment. The Buyer and its shipping carrier are responsible for any damage which occurs during shipment.

Verifying Delivery
The shipping container contains the following:

- Laser system with integrated RF power module
- Final Test Sheet
- Manual packet containing the CD

If any of these items are missing, report this to Coherent immediately.

Shipping Container and Packing Materials
Coherent recommends that the shipping box and packing materials be saved. These will be required if the laser system is to be shipped to another location after initial installation, or returned for service or replacement.

If the original shipping carton is unavailable, contact Coherent Product Support to purchase a new one.
Protective Shipping Tape

The front of the Cx-10 laser head is protected by a blue adhesive film or tape (see Figure 3-1). This tape is designed to protect the optics during shipping and must be removed prior to operating the laser.

---

**NOTICE!**

To avoid damage, the blue protective tape must be removed BEFORE operating the laser.

---

**Tape Removal**

To remove the protective tape:

1. Pinch one corner of the tape between the thumb and index fingers.
2. Gently pull the tape off of the laser.
3. Discard the tape and do not place the tape anywhere near or on the laser.

---

**Figure 3-1. Protective Shipping Tape**
Installation of the Cx-10 laser must comply with all applicable electrical safety and laser safety laws and regulations. Review Section One: Laser Safety for important information relating to safety.

The negative (return) side of the DC input connection to the Cx-10 RF power module is connected internally to the chassis. The user must assure that the system into which the Cx-10 is built protects against the possibility that the Cx-10 laser head or RF power module chassis could be at a hazardous voltage and that personnel could be exposed to these voltages.

**DANGER!**
To avoid potentially fatal electrical shock hazards from electrical equipment, be sure to follow all applicable electrical codes such as (in the U.S.) the National Electrical Code (NEC).

The laser must be secured properly to avoid the possibility of the laser shifting unexpectedly during operation, creating a hazardous condition. The location of the output beam of the Cx-10 laser head is shown in Figure 3-2. The laser output is emitted from the aperture shown in the referenced figures and propagates within a full cone angle up to 5°. The acceptance angle of the system aperture must intercept all of the output of the laser.

It is also extremely important to understand the direction, divergence, and magnitude of all reflections that will occur from optical surfaces. Infrared (IR) beams, such as those from Cx-10 lasers, can also be located with commercially available IR screens, such as those produced by Macken Instruments, Inc. [Tel. (707) 566-2110]. Coherent recommends that all beam propagation paths be enclosed and that personnel operating the laser be qualified optical technicians who are familiar with this type of hardware.
**Mechanical Mounting**

The dimensions for the Cx-10 laser head are shown in Figure 3-2. Mechanical mounting of the Cx-10 laser head must result in no distortion or stress to the laser head in any way. Otherwise, optical alignment and power stability could be adversely affected.

---

<table>
<thead>
<tr>
<th>Component</th>
<th>Dimension</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Connection</td>
<td>106.6 mm</td>
<td>4.20 in.</td>
</tr>
<tr>
<td>BEAM OUTPUT</td>
<td>132.3 mm</td>
<td>5.21 in.</td>
</tr>
<tr>
<td>DC Input</td>
<td>20 mm</td>
<td>0.79 in.</td>
</tr>
<tr>
<td>RJ45</td>
<td>463.5 mm</td>
<td>18.25 in.</td>
</tr>
<tr>
<td>COOLANT OUTLET</td>
<td>6.3 mm</td>
<td>0.25 in.</td>
</tr>
<tr>
<td>COOLANT INLET</td>
<td>6.3 mm</td>
<td>0.25 in.</td>
</tr>
<tr>
<td>Ø8 mm</td>
<td>40 mm</td>
<td>1.57 in.</td>
</tr>
</tbody>
</table>

**Figure 3-2. Cx-10 Liquid-Cooled Laser Dimensions**
Certain aspects of specific customer applications may preclude absolute interchangeability of laser heads. For example, for certain applications, the sensitivity of the application to optical beam pointing errors may require external optical realignment after the laser head is replaced in the customer’s integrated system. Depending on the method of mounting and the sensitivity of the integrated customer system to beam pointing errors, even removing a laser head from the customer’s system, then replacing the same laser head back into the customer’s system may require external optical realignment. This external alignment would be a repositioning of the head itself or adjustment of beam delivery mirrors (positions and angle). Consult Coherent if there is any question about such interchangeability issues.

Coherent recommends use of the optional brackets (part number 1101-12-0016 for a set of 4) that are designed for mounting the laser safely without inducing any stress onto the laser. Care must be taken not to induce stress onto the laser head, as optical mis-alignment of the laser resonator can occur, which would require the laser to be returned to Coherent for service. A mechanical drawing for this bracket is provided in Appendix A: Parts List in the operator’s manual. Coherent strongly encourages use of this bracket or a similar design in order to accommodate temperature changes in operation while providing secure mounting.
Liquid-Cooling

The Cx-10 liquid-cooled laser is cooled by means of liquid coolant. The cooling system, external to the laser head and the RF power module, is the responsibility of and must be supplied by the user. A schematic of the recommended configuration of the cooling system is shown in Figure 3-3.

Cooling System Layout

The integrated laser tube and RF power module coolant lines are connected to each other by a factory installed tube so that they are always cooled in series. Do not change this coolant flow scheme or direction (e.g. do not remove the connection tube and cool the laser tube and RF power module in parallel).

Following the flow of coolant from the refrigerated recirculator, coolant flows through a particle filter to the laser head “supply” connection. This assures that the laser head receives the cleanest temperature stable coolant possible. The coolant flows through the laser tube to the RF power module via a factory installed connection tube. After the RF power module, coolant flows out of the laser “return” connection to a flow switch, then back to the refrigerated recirculator.

To prevent inadvertent operation of the laser without adequate coolant, connect the flow switch to a power control device (power relay or contactor) on the DC power supply mains. By doing this, flow must be established before the laser is powered, and if flow is interrupted, laser operation is halted. Refer to coolant requirements in Table 2-1 on page 2-4.
Re-Circulation and Coolant Flow Interlock Switch

The coolant flow switch should be the last element traversed by the coolant before it returns to the refrigerated recirculator “return” line. This assures that the flow switch verifies that coolant is flowing through the laser system. The flow switch must not be placed in any other position. The interlock, which is tripped when the coolant switch indicates no flow or low flow, cuts off AC power to the DC power supply to prevent the system from overheating.

Signal Interface

The signal interface in the laser interlock system may be used to turn the laser off when the coolant interlock is breached. With this approach, the laser is commanded to shut down via the signal interface, in the event that the coolant interlock system detects a coolant fault. Coherent recommends that both RF Enable and Control Enable be commanded to the OFF state when the coolant interlock system detects a coolant fault. These signals are listed in Table 4-1 on page 4-1 and described in subsections of Section Four: Laser Operation in the operator’s manual.

Thermal Shutdown Switch

The Cx-10 laser has a thermal protection switch that protects the system at case temperatures over 60ºC. Coherent recommends, however, that the OEM install sensors that detect coolant flow and shuts the laser down in the event of loss of coolant.

The system also provides a high temperature warning. This warning is used to alert the user to the need of maintenance in order to return the cooling system performance back to normal, full cooling capacity. Failure to take action regarding the temperature warning will result in poorer product performance (outside specifications) and lesser product life time.

AC Power Relay

The recommended AC power relay used to cut mains to the DC power supply, in the event of cooling system failure, can also be used as part of the laser safety interlock system. Similarly, if the signal interface is used to shut down the laser when there is a cooling system fault, the signal interface can be used to shut down the laser in the event that there is a breach of a safety interlock. The design of the interlock controls must be in compliance with applicable safety standards, including those described in Section One: Laser Safety.
Water Leak Precautions

Coolant leaks are unlikely if coolant connections are properly made. However, it is advisable to take precautions to avoid damage in the event of leaks in the cooling system. One such precaution is to arrange cooling lines and connections such that coolant leaks would not result in coolant coming into contact with sensitive electronic equipment and components.

Condensation of Water Vapor

If the coolant temperature is below the dew point of the ambient air, water will condense out of the air onto the outside of the laser head, and onto the outside surface and internal surfaces of the RF power module. Condensation can damage the output optical element of the laser head when the laser is turned on, and could damage internal components of the RF power module if power is applied while condensate is present.

**NOTICE!**

To avoid damaging the system, never allow the coolant temperature to fall below the dew point of the ambient air. Turn the coolant flow off if the laser will be off or stored for an extended period of time in humid conditions.

If necessary, the laser system can operate with coolant temperatures slightly below the dew point of the ambient air. This requires special procedures to be followed, such as shutting off the coolant flow at all times when the laser is not producing laser output. Contact Coherent Product Support for more information about this option before attempting to operate the system in ambient air below the dew point.

**NOTICE!**

To avoid possible damage to the laser head, never attempt to change the coolant fittings at the locations where the coolant enters the laser head. If the fittings must be changed for any reason, return the laser head to Coherent to be serviced by Coherent technicians.
Coolant Fittings on Laser System

The Cx-10 liquid-cooled laser has 8 mm. O.D. tubing for the connection interface. The user must supply an appropriate compression fitting to make the connection with the rest of the user’s system.

Figure 3-4. Cx-10 Liquid-Cooling Connections

Cooling Capacity

The cooling system must have sufficient capacity to maintain the coolant temperature at the outlet of the refrigerated recirculator within the range given in Table 2-1 on page 2-4. With the laser operating at its maximum output power, the cooling system must dissipate up to 2800 W and maintain a coolant temperature of 20°C.

Coolant Filtering

To avoid the accumulation of debris in the cooling system, it is recommended that the user of Cx-10 lasers incorporate coolant filtering in the coolant return line, as shown in Figure 3-3 on page 3-6. The filter should trap particles larger than 30 µm in size unless specified otherwise by the manufacturer of the refrigerated recirculator.
Coolant Composition

The recommended coolant composition is a mixture of clean distilled or deionized water containing a low toxicity corrosion inhibitor. Coherent has tested two different solutions that will prevent corrosion within the laser coolant circuit.

These are described in Table 3-1:

Table 3-1. Recommended Coolant for Cx-10 Lasers

<table>
<thead>
<tr>
<th>PRODUCT NAME</th>
<th>MANUFACTURERS NAME AND CONTACT</th>
<th>HEAT TRANSFER FLUID TYPE</th>
<th>REQUIRED HEAT TRANSFER FLUID CONTENT</th>
<th>FREEZING BURST PROTECTION</th>
<th>OTHER PRECAUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optishield</td>
<td>OptiTemp. Inc. <a href="http://www.optitemp.com">www.optitemp.com</a> US/Canada 231-946-2931</td>
<td>Corrosion Inhibited Water</td>
<td>10% solution in water</td>
<td>Does not reduce the water freezing point</td>
<td>Use may be restricted in geographical locations outside the US</td>
</tr>
<tr>
<td>Trac-100 (US)</td>
<td>Nalco Inc. <a href="http://www.nalco.com">www.nalco.com</a> US 630-305-1000</td>
<td>Corrosion Inhibited Water</td>
<td>2500 ppm in water (2.5 mL per liter of water)</td>
<td>Does not reduce the water freezing point</td>
<td>Use may be restricted in geographical locations outside the US</td>
</tr>
</tbody>
</table>

Figure 3-5 shows system components from water circuits treated with inhibitor and a water circuit without inhibitor.
Freeze/Burst Protection

The recommended coolant mixture does not provide freeze protection; therefore the coolant temperature must be maintained above the freezing point of water. Since lower temperatures may occur during shipment and storage, the Cx-10 laser system should never be stored or transported unless the coolant has been completely removed by using a compressed air supply to blow out all coolant passages.

**NOTICE!**
Never store or ship a complete Cx-10 laser system with coolant installed, as the coolant may freeze and cause permanent internal damage. Always remove the coolant prior to storage or shipment by using a compressed air supply to blow out all coolant passages. Plug or cap coolant inlet and outlet fittings after draining to prevent residual coolant leaks during storage or shipment. Damage to the laser during storage or shipment, as a result of failure to remove coolant and plug the inlet and outlet fittings after coolant removal, is specifically excluded from the product warranty.

Alternative Coolant Composition

An alternative coolant composition is a mixture of water and DOWFROST, a low toxicity, corrosion inhibited, propylene glycol based heat transfer fluid available from The Dow Chemical Company. Because this fluid consists of propylene glycol and non-toxic corrosion inhibitors, the legal and regulatory restrictions on its use and disposal are less demanding than is the case for fluids containing ethylene glycol. The required mixture is 25% to 30% DOWFROST by volume, with the balance consisting of water. In addition to DOWFROST, alternative propylene glycol based heat transfer fluids may also be used, as indicated in Table 3-2 on page 3-12. In addition, for those applications where the user determines that the higher toxicity of an ethylene glycol based heat transfer fluid is acceptable, the fluids indicated in Table 3-3 on page 3-12 may be used.

Coherent has found that to be safe, distilled water is highly recommended as the dilution water component of the coolant mix. Recommended guidelines on dilution water quality are as follows:

- Chlorides and sulfates in dilution water less than 25 ppm
- Total hardness as calcium carbonate less than 100 ppm
The manufacturers listed in Table 3-2 and Table 3-3 offer prediluted mixtures. The water dilutions indicated in these tables are appropriate only for the undiluted product in each case.

See Section Five: Maintenance and Troubleshooting in the operator’s manual for maintenance and replacement requirements for the coolant.
NOTICE!
To prevent damage to the laser system, never operate any Cx-10 liquid cooled laser using only ordinary water, such as tap water or deionized water, as a coolant. These lasers contain materials which will suffer corrosion damage when exposed to plain water without corrosion inhibitors. Corrosion caused by improper coolant voids the warranty.

It is important to neither use too much, nor too little corrosion inhibited glycol in the coolant mix. Too much glycol will result in poor cooling performance, and possibly overheating of parts of the laser system. Too little glycol will result in reduced protection against corrosion, freezing, and bursting. Glycol fluid levels lower than the recommended amount may also encourage microbial growth, which can result in fouling and blockage of the cooling system.

Freeze/Burst Protection

With the recommended alternative coolant mixes, burst protection is assured down to a temperature of -18°C (0°F) for the propylene glycol based fluids (Table 3-2) and to -27°C (-17°F) for the ethylene glycol based fluids (Table 3-3). Since lower temperatures may occur during shipment and storage, Cx-10 lasers should never be shipped or stored unless the coolant has been drained. And it is strongly suggested that the coolant within cooling lines of the laser system components be blown out with dry air or Nitrogen.

NOTICE!
To avoid damage, never ship or store any Cx-10 laser system containing coolant if it is possible it will be exposed to temperatures below the freezing point of the coolant during such shipment or storage. Plug or cap coolant inlet and outlet to prevent coolant leaks during shipment or storage.
Coolant Flow Rate and Pressure

Requirements on coolant flow rate are listed in Table 2-1 on page 2-4. To prevent damage to the laser head or the RF power module, the gauge pressure of the coolant at the laser head and at the RF power module must not exceed 120 psig (i.e. the gauge pressure – the difference between the absolute pressure of the coolant and the absolute pressure of the ambient air – must not exceed 7 kg/cm², or 690 kPa). Note that the gauge pressure at the laser system includes the effect of the gravitational pressure change if the refrigerated recirculator is mounted much higher than the laser system.

**NOTICE!**

Exceeding the maximum allowed gauge pressure in the laser head or RF power module, even for a short period of time, may cause irreversible damage and result in permanent coolant leaks.

Depending on the customer’s overall cooling system design, portions of the cooling system, other than the laser head and the RF power module, may limit the maximum-allowed gauge pressure of the coolant to a lower pressure than the value noted above for the laser head and the RF power module.

Pressure Drop

The pressure drop from the coolant outlet to the coolant inlet of the refrigerated recirculator will depend on many factors, including:

- Flow rate
- Temperature
- Length and inside diameter of coolant hoses and connections
- Coolant composition

To achieve the minimum flow rates given in Table 2-1 on page 2-4, provide a pressure drop of no more than < 206 kPa (30 psi) between coolant inlet and coolant outlet of the laser. In addition, there is some pressure drop in the cooling lines, which depends primarily on the diameter and length of these lines.

The selected arrangement, once configured, should be checked for adequate flow within the specified pressure limits.
Materials Used in Cooling Systems

Although the coolant mix recommended above will control corrosion in the cooling system to some degree, certain materials must be avoided to further reduce corrosion problems. In particular, galvanized steel must be avoided in all user-supplied cooling system components which come into contact with the coolant because zinc will react with the corrosion inhibitor.

In general, corrosion problems in the cooling system will be minimized if only aluminum, stainless steel, nickel plated brass, and plastic materials come into contact with the coolant.

Electrical Power Connection

The Cx-10 laser requires 48 VDC input DC power. This power is carried from the power source to the system through the terminal block on the Cx-10. The maximum current required is 38 A. See Figure 3-6.

Note: Pin #1 of RJ45 control interface is on the left as viewed.

Connect leads to the user-supplied power source last after other connection are made.

Figure 3-6. Electrical Connections to Cx-10
The negative (return) side of the DC input connection to the Cx-10 RF power module is connected internally to the chassis. The user must assure that the system into which the Cx-10 is built protects against the possibility that the Cx-10 chassis could be at a hazardous voltage and that personnel could be exposed to these voltages.

**DANGER!**
To avoid potentially fatal electrical shock hazards from electrical equipment, be sure to follow all applicable electrical codes such as (in the U.S.) the National Electrical Code (NEC).

Coherent requires that the user review the precautions described in Section One: Laser Safety regarding electrical safety before using the Cx-10 laser. It is the user’s responsibility to provide circuit breakers and/or fusing of the AC power source, in accordance with all applicable laws and regulations.

**DC Power Supply Requirements**

The following are the requirements for the customer-supplied DC power supplies:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Voltage</td>
<td>48 VDC measured at the terminals</td>
</tr>
<tr>
<td>Peak Current</td>
<td>120 A for a minimum of 1 ms with a maximum voltage drop of 1.5 V</td>
</tr>
<tr>
<td>Max. Continuous Current</td>
<td>≤ 38 A at 100% duty</td>
</tr>
<tr>
<td>Regulation</td>
<td>&lt; ± 2%</td>
</tr>
<tr>
<td>Ripple and Noise</td>
<td>&lt; 1% p-p (20 MHz BW limit)</td>
</tr>
<tr>
<td>Overload and Short Circuit Protect</td>
<td>Automatic Recovery</td>
</tr>
</tbody>
</table>

**DC Power Supply Cabling Requirements**

The user must connect both positive supply terminals to the DC power supply. The two positive supply leads should be 10 AWG or larger. The negative supply connection may also be made with two 10 AWG leads, or a single 8 AWG lead. These recommendations assume that the power leads are no longer than 3 meters in length. For longer leads, the wires must be sized appropriately.

Typically, doubling the cross-sectional area of a wire at a given length will reduce the AWG by 3.
Electrical control of the Cx-10 laser is achieved via an RJ-45 connector built into the system. The signals carried on each of the pins are indicated in Table 4-1 on page 4-1 in the operator’s manual. Details about controlling the laser through the signal interface are discussed in Section Four: Laser Operation in the operator’s manual.

---

**NOTICE!**

Coherent highly recommends use of shielded interface cables. The interface cable shield must connect to the chassis ground of the controller. In addition to proper shielding, this shield provides a secondary connection for the signal ground (Pin 8).

A floating ground connection (use of un-shielded interface cable or no return path between the host control electronics and the laser) can present an unsafe condition and result in unstable or unexpected operation of the laser. This condition can arise when the control signal ground connection (Pin 8) is lost and the Control Enable (Pin 7) and RF Enable (Pin 1) remain high. Therefore, Coherent strongly recommends that a second safety ground be provided either via a shielded control cable or common potential chassis mounting between the laser head and the control electronics.

---
Beam Propagation

The true waveguide structure of the Cx-10 delivers a 1.8 mm $1/e^2$ diameter beam with a nominal 7.5 mrad $1/e^2$ full angle divergence. The typical beam diameter as a function of distance from the laser is shown in Figure 3-7.

Figure 3-7. Beam Diameter vs. Distance From Laser Head