User Manual

Pulsed RB *Plus* Diode-Pumped Nd:YAG Rod Laser Modules

- RBAX0-XP

CEO-UMAN-0011 C

MARCH 2013

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Important Information

Warranty Summary

Northrop Grumman Cutting Edge Optronics (NG CEO) warrants that the products that it manufactures and sells will be free from defects in materials and workmanship for a period of one year from the date of shipment from an authorized NG CEO distributor. If a product proves defective within the respective period, NG CEO will provide repair or replacement as described in the complete warranty statement.

To arrange for service or obtain a copy of the complete warranty statement, please contact your nearest NG CEO sales and service office.

EXCEPT AS PROVIDED IN THIS SUMMARY OR THE APPLICABLE WARRANTY STATEMENT, NG CEO MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PUPOSE. IN NO EVENT SHALL NG CEO BE LIABLE FOR INDIRECT, SPECIAL, OR CONSEQUENTIAL DAMAGES.

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Safety Information

Product End-of-Life Handling

NG CEO is committed to protecting the environment. In accordance with the Waste Electrical and Electronic Equipment directive (WEEE) and Restriction of Hazardous Substances in the European Union (RoHS EU) directives, NG CEO accepts the return of our products for disposal. When you are ready to reclaim the instrument, you must properly transfer it according to local regulations concerning WEEE equipment. Contact NG CEO or your local distributor for shipping instructions. Please package the products as directed for a return for repair.

ROC ROHS Declaration

In accordance with the Clause 6.2 of Marking for Control of Pollution Caused by Electronic Information Products (SJ/T11364:2006) for Measures for the Administration on Pollution Control of Electronic Information Products No. 39, Order of the Ministry of Information Industry of the Peoples Republic of China, NG CEO includes the following translation about our laser modules.

中华人民共和国，电子讯息产品管理办法：自我声明

生产商	**Northrop Grumman Cutting Edge Optronics**
生产商地址	20 Pointe West Blvd St. Charles, MO 63301 USA
产品名称 / 编号	**Laser Modules** **RBxx-xxx-xxx-xxxx or RBxx-xxxxxx-xxx-xxxx** **RBAxx-xxx-xxx-xxxx or RBAxx-xxxxxx-xxx-xxxx** **RDxx-xxx-xxx-xxxx** **RExx-xxx-xxx-xxxx**

有毒有害物质或元素标认表

		有毒有害物质或元素					
部件编号	部件名称	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (CrVI)	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
第一组	电线/ 连接插头	X	O	O	O	X	X
第二组	基部/ 端帽	X	O	O	X	O	O
第三组	硬件/ 装配	O	O	O	X	O	O
第四组	时计组件	X	O	O	X	X	X
第五组	阵列前端次模组	O	O	O	O	O	O
第六组	接触板	X	O	O	O	X	X
第七组	热交换组件	O	O	O	O	O	O
第八组	16 进制硬件	O	O	X	O	O	O
第九组	焊锡	X	O	X	O	O	O
第十组	包装物料	O	O	O	O	O	O

O：表示该有毒有害物质在该部件所有均质材料中的含量均在 SJ/T 11363-2006 规定的限量要求以下

X：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出 SJ/T 11363-2006 规定的限量要求

Conventions

The following conventions appear in this manual:

	This icon denotes a caution or a warning, which advise you of precautions to take to avoid injury, data loss, or a system crash.
Initial Capped	The first letter in uppercase refers to menu options, e.g., **Phase Delay**, **Pulse Width**.
CAPS	Front-panel buttons, knobs, and connectors appear in all uppercase letters, e.g., **MENU, CURRENT**.
▸	The ▸ symbol separates a sequence of button pushes, e.g., **MENU** ▸ **CHANNEL SETUP** ▸ **PULSE WIDTH** means that you push the **MENU** button, then push the **CHANNEL SETUP** soft key, and then push the **PULSE WIDTH** soft key.
italic	Italic text denotes references to other resources that may be helpful to you or to bring attention to important information.
	This icon denotes a note, which alerts you to important information.
I **O**	Power Switch Position Symbols I = On O = Off

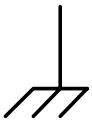
The following conventions may appear on the product:

DANGER	An injury hazard immediately accessible as you read the marking.
WARNING	A hazard not immediately accessible as you read the marking.
CAUTION	A hazard to property including the product.
	ESD: Handle Appropriately

Laser Emission: Use caution.

Shock Hazard: Use caution.

Caution: Risk of danger. Refer to manual.



Chassis Ground

General Safety Summary

The Pulsed RB *Plus* module emits laser radiation that can permanently damage eyes and skin, ignite fires, and vaporize substances. The Laser Safety section (Chapter 2) contains information and guidance about these hazards. To minimize the risk of injury or expensive repairs, carefully follow these instructions.

Do not open the factory packaging before carefully reading this complete operation and maintenance manual. If you have any questions on the product which have not been discussed sufficiently within the manual, contact the manufacturer for complete instructions. **Failure to heed this warning may result in the destruction or serious damage to the device, and will void the product warranty.**

The *Service* section is intended to help guide you to the source of problems. Do not attempt repairs while the unit is under warranty; instead, report all problems to NG CEO for warranty repair.

Use the form in *Appendix A: Customer Service* to describe issues with the module. We also suggest that you record information about the module such as power, settings, time and date.

About this Manual

This manual describes the installation, operation, and service of the Pulsed RB *Plus* module. The manual consists of the following chapters:

- *Chapter 1: Introduction* provides a theory of operation description of the module and specifications
- *Chapter 2: Laser Safety* describes proper safety procedures you should understand before operating the module.
- *Chapter 3: Module Details* provides information about unpacking, storing and proper environmental conditions for operation.
- *Chapter 5: Maintenance* provides information on proper maintenance of your module.
- *Chapter 6: Service* provides resources to help fix problems with the Pulsed RB Plus module
- *Appendix A: Customer Service* provides information to expedite any service request before contacting NG CEO.
- *Appendix B: System International Units* identifies commonly used units of measurement found in this manual.
- *Appendix C: Acronyms* provides a list of commonly used abbreviations and their descriptions used throughout this manual.

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Chapter 1: Introduction

This introduction provides the following information:

- Theory of operation
- Temperature Tuning of Laser Diodes
- Pulsed RB *Plus* description
- Closed Loop Re-circulation Chiller
- Specifications

Theory of Operation

NG CEO diode pumped, solid-state lasers and pump modules use temperature-tuned GaAlAs laser diodes. These diodes replace arc lamps or incandescent light sources as the optical pump source. The principal advantages of this approach include:

- Longer lifetime
- More compact size
- Elimination of the need for external cooling tower water
- Reduced thermal lensing in the active medium

The Pulsed RB Plus module utilizes a radial transverse pump geometry to excite the solid0state laser medium. Exterior components and connections are shown in Figure 1-1. The laser medium is either a 2 mm or 3 mm diameter by 63 mm long rod of neodymium-doped yttrium aluminum garnet (Nd:YAG). Both ends of the rod are optically polished and include anti-reflection coatings at the lasing wavelength. The rod may include curvature to compensate for thermal lensing, depending on module configuration.

The RB *Plus* module is available in Nd:YAG with the laser rod AR coated for the highest gain wavelength of this material, 1064 nm. The RB *Plus* module is constructed within a durable and rigid structure. The diode optical output power is radially coupled into the laser rod.

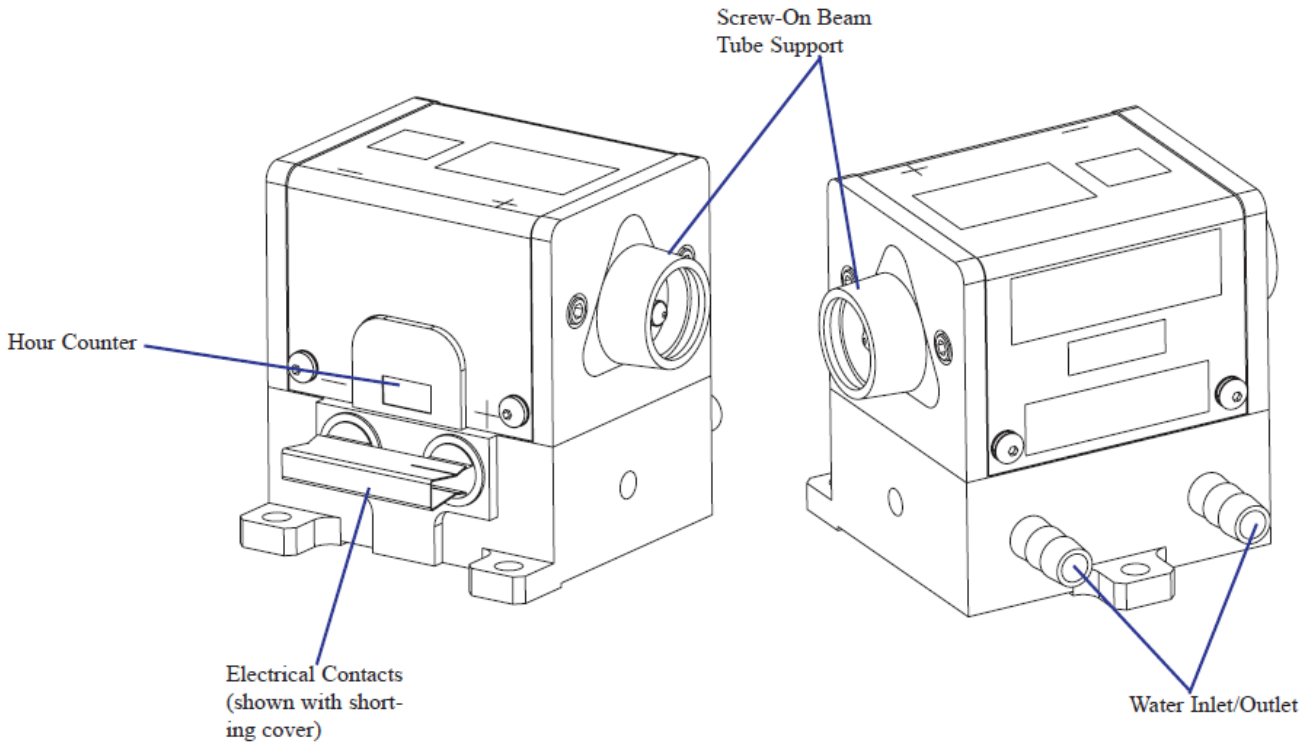

Figure 1-1 Exterior Components and Connections

Temperature Tuning of Laser Diodes

The laser diodes are located within the RB *Plus* module and tuned, wavelength matched, via the closed loop chiller. For maximum efficiency, the diode output wavelength must match the laser medium absorption characteristics (see Figure 1-2). The output spectrum of a conventional pump source for Nd:YAG operation, the xenon arc lamp, and 808 nm diode array is also shown.

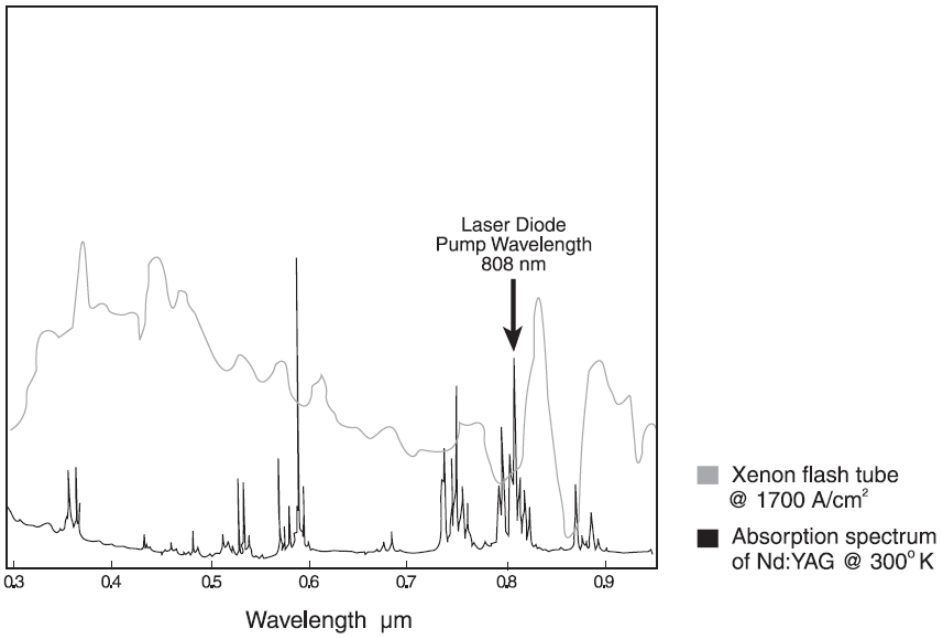

Figure 1-2 Nd:YAG Absorption Characteristics

The processes used in the manufacture of GaAlAs laser diodes result in a broad distribution of output wavelengths. To match the diode output to an absorption peak of the laser medium, diodes are selected with outputs near the absorption peak and then temperature tuned for maximum absorption. When temperature tuned, diode characteristics are such that 0.25 nm of wavelength shift occurs for every 1oC change in temperature of the diode junction. Cooling shortens the wavelength, and heating lengthens it. In RB Plus, the laser diode wavelength is longer than the absorption peak of the laser medium. The closed loop chiller pulls or shifts the diode temperature down, so that the wavelength matches the absorption peak.

Pulsed RB *Plus* Description

The RB Plus module was designed for use as a building block “engine” in the development or production of medium power rod laser systems or as a drop-in replacement for arc lamp pump chambers in industrial lasers. It is well suited for medium power applications such as laser marking, and can provide high stability and beam quality for more precise micro-machining and scientific applications.

The RB Plus is a completely maintenance-free and factory sealed unit that is about 1/2 the size of a standard arc lamp pump chamber. It employs the firm's proprietary pumping scheme utilizing a radial array of close-coupled diode laser arrays for efficient direct side pumping of the solid-state host material. This pump geometry results in excellent gain uniformity and lensing performance, see Figure 1-3. In order to optically pump the length of the rod, arrays are three diode bars long. In the Pulsed RB Plus pumphead, NG CEO uses a stack of either 2, 3,

or 4 bars in each array. This makes for RB Plus modules with 18, 24, or 36 diode bars.

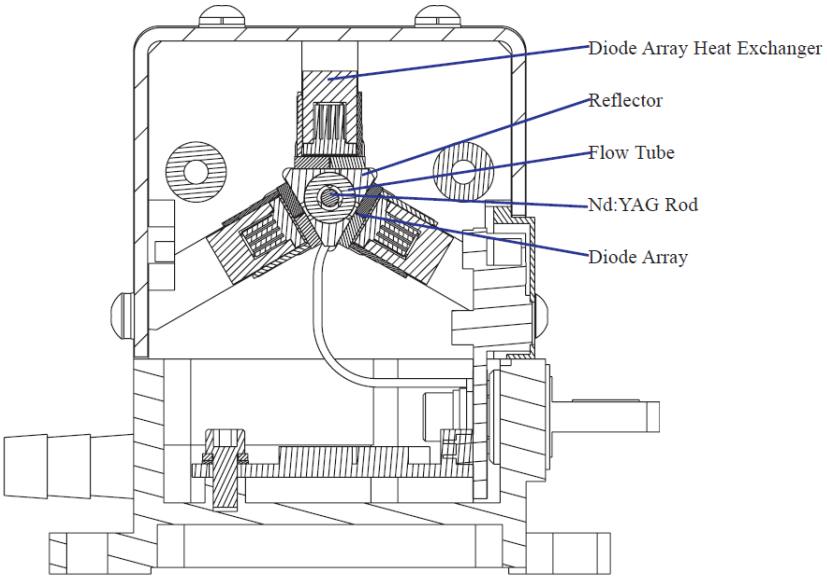

Figure 1-3 Radial Pump Geometry

Nd:YAG is the standard host material however, other pump wave-lengths and host materials are available. The laser medium can be a 2mm or 3mm diameter Nd:YAG rod depending on the model selected. The laser diode emission wavelengths are selected specifically for pumping the host material of choice. Nd:YAG has an absorption peak of 808 nm.

Closed Loop Re-circulating Chiller

The module coolant loop is designed for an operating pressure of 50 psi. Chillers which deliver the required flow rate at lesser pressure do not provide adequate cooling. The selected chiller must have a heat capacity of greater than the waste heat for the specific model of RB *Plus* module. Depending on the model of RB *Plus*, the module dimensions, rod size, output power, duty cycle (max 20% for pulsed RBA) and power consumption varies. Therefore, NG CEO recommends different model of chiller depending on the number of diode bars in a module and the local electricity which will power the chiller. The following table (Table 1-1) gives the NG CEO recommendations.

Table 1-1 CEO Recommended Chiller Table

60 Hz Electrical Outlets				
Model	**EOL Current**	**Waste Heat**	**Polyscience Chiller No.**	**Chiller Capacity**
RBA30-2P	70 A	504 W	6260T11CE20C	800 W
RBA30-3P	70 A	756 W	6360T11CE20C	1200 W
RBA30-4P	70 A	1008 W	6360T11CE20C	1200 W
50 Hz Electrical Outlets				
Model	**EOL Current**	**Waste Heat**	**Polyscience Chiller No.**	**Chiller Capacity**
RBA30-2P	70 A	504 W	6250T21CE30C	800 W
RBA30-3P	70 A	756 W	6350T21CE30E	996 W

Specifications

RB *Plus* modules are tested to exceed the following specifications[1]. The standard production test configuration consists of a 165 ± 5 mm cavity utilizing a 0.75 mcc high reflector and a flat 40% reflective output coupler.

Table 1-2 Pulsed RB Plus Series Model Specifications1

	RBA20-			RBA30-		
MODEL	**2P**	**3P**	**4P**	**2P**	**3P**	**4P**
Rod Size (mm)	2 x63			3 x 63		
Diode Bias Voltage	40-45 V	60-70 V	75-80 V	40-45 V	60-70 V	75-80 V
Power Consumption[3] (W)	0-1800	0-2700	0-3200	0-1800	0-2700	0-3200
Output Energy[2] (mJ)	10	25	40	10	25	40

[1]Specifications subject to change without notice

[2] Output power from the production test cavity (165 mm ± 5 mm cavity utilizing a 0.75 mcc HR and flat 40% reflective output coupler)

[3]At end of life [(Operating current x Diode voltage) x 130%]

Table 1-3 RB *Plus* General Specifications

All RB *Plus*-Series Models	
Type	Pulsed Diode Pumped Nd:YAG Rod
Standard Dopant	0.6%
Output Wavelength	1064 nm
Pulse Repetition Rate	1 – 2000 Hz
Duty Cycle (max)	15%
Pointing Stability	<5% of cavity divergence
Nominal Peak Current	35-40 A
Electrical Connection	D-sub connector
Cooling	Closed Loop Recycling Coolant[5]
Coolant Flow	> 1.0 GPM
Coolant Pressure[6]	50 PSI
Operating Temperature	20-35 ^{o}C
Optical Center from Base	1.75 inches
Module Dimensions	2.55 H x 3.30 W x 3.07 L inches

[5]CEO recommends Optishield Plus$_{TM}$ /distilled water coolant (10% Optishield Plus$_{TM}$, 90% distilled water).

[6]CEO modules are leak tested to 80 psi with Nitrogen gas. CEO recommends 50 psi of chiller coolant for actual operation

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Chapter 2: Laser Safety

Please read this section carefully before installing or operating your Pulsed RB *Plus* module. We recommend that all service and repair operations be performed by a NG CEO service engineer. If you do plan to service your laser module, please follow the procedures in the Service section of this manual.

Sections included in this chapter provide the following information:

- Caution & Warning Statements
- Precautions for Safe Operation of Class IV Lasers
- Center for Devices and Radiological Health (CDRH) OEM Product
- Safety Device Checklist

Caution & Warning Statements

WARNING The NG CEO RB *Plus* component when used as a laser oscillator is a Class IV-High Power Laser whose beam is, by definition, a safety hazard. Avoid eye or skin exposure to direct or scattered laser radiation. Avoid direct viewing of the beam or its specular reflection. When energized, a large amount of high power invisible laser radiation is emitted from the laser module.

Follow instructions contained in this manual for proper installation and safe operation of your laser. We recommend the use of protective eyewear at all times; selection depends on the energy and wavelength of the laser beam as well as operating conditions. Consult ANSI, ACGIH, or OSHA standards for guidance.

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

WARNING At all times during installation, operation, maintenance, or service of your laser, avoid exposure to laser or collateral radiation exceeding the accessible emission limits listed in “Performance Standards for Laser Products,” United States Code of Federal Regulations, 21 CFR 1040 10(d).

ESD CAUTION The laser diodes in the RB *Plus* are sensitive to Electro-Static Discharge (ESD). Never handle the RB *Plus* module without being properly grounded through the use of properly installed and maintained grounding wrist straps or other ESD control devices. Subjecting the RB *Plus* to static shock can seriously damage or destroy the diode bars, and will void the product warranty.

ELECTRICAL WARNING The voltages in this system can be harmful or even lethal. Whenever handling or servicing the laser, always disconnect the power cord to the power supplies and drivers. Allow at least five (5) minutes for all electronics to discharge before touching or grounding of electrical connections.

Precautions for Safe Operation of Class IV Lasers

- Never look directly into the laser beam or at specular reflection, even with protective eye-wear on.
- Always wear laser safety eye-wear that is appropriate for the output power at the wavelengths of operation (808 nm pump light and 1064 nm fundamental).
- Set aside a controlled-access area for laser operation; limit access to those trained in the principles of laser safety.
- Post readily readable warning signs in prominent locations near the laser operation area.
- Use safety interlocks on all entryways. All NG CEO system control electronics are provided with interlock inputs to preclude operation with an open safety door. NOTE: when multiple interlocks are used, they must be connected in SERIES for proper function.
- Restrict access to laser areas to those who have been instructed in the necessary safety precautions.
- Enclose beam paths wherever possible.
- Set up experiments so the laser beam is below eye level.
- Work in an area that is well lit to avoid dilation of pupils.
- Set up a target for the beam.
- Set up shields to prevent reflected beams from escaping the laser operation area.
- The Q-switched output power of the laser emits extremely high peak optical powers, powers that can severely damage a wide array of optical components and detectors. Know the limits of your components before exposing them to the Q-switched beam.
- View an infrared laser beam with a protected image converter at an oblique angle reflecting from a diffuse surface. Do not use phosphorus cards in the Q-switched beam.
- Ensure that all electrical connections are made in a safe manner.
- Where possible, position equipment so that electrical connections are shielded from accidental touch.
- No smoking, eating, or drinking should be allowed in laser areas.
- Never leave an operating laser unattended.

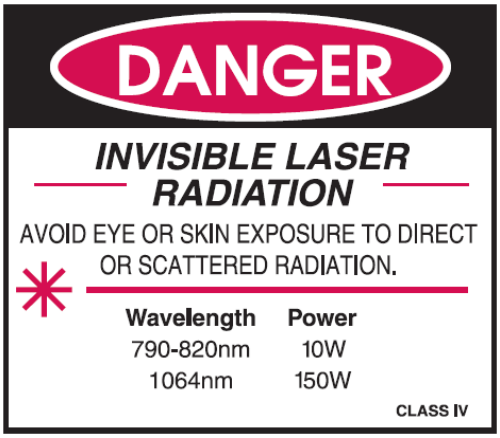

Figure 2-1 Standard Safety Warning Sign

Center for Devices and Radiological Health (CDRH) OEM Product

The RB *Plus* module is considered a component according to the Food and Drug Administration, Code of Federal Regulations Title 21, Section 1002.1(b) for use in an end system, and therefore does not fully comply with all the requirements of the Code of Federal Regulations for laser-based systems. The RB *Plus* module is capable of emitting Class IV radiation, and extreme care must be exercised in its installation and operation. Only persons familiar with the safety precautions and practices in this manual should operate the laser product.

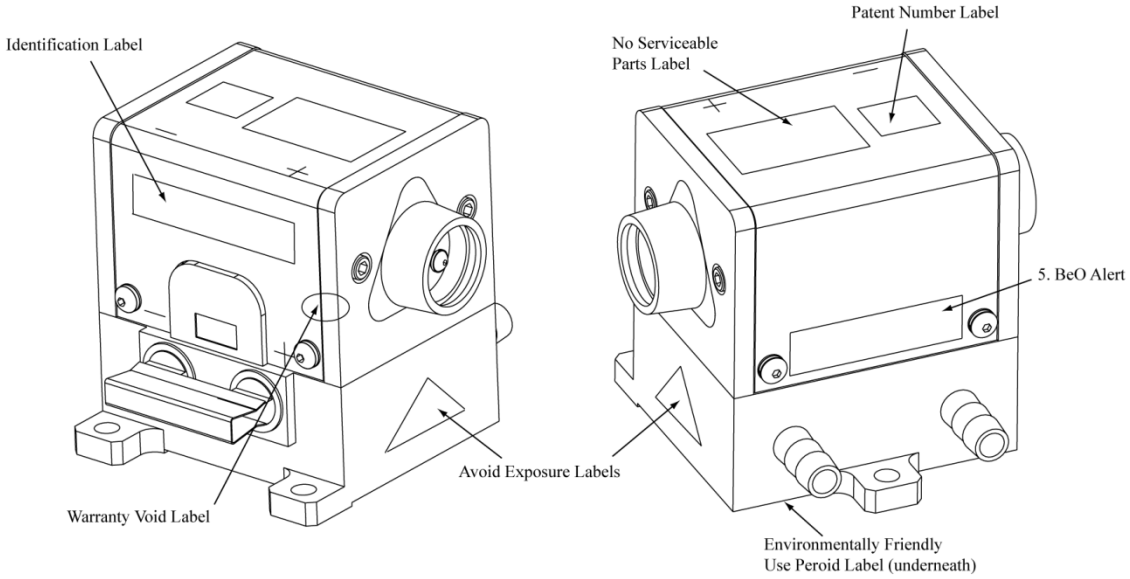

Figure 2-2 Radiation Control Drawing

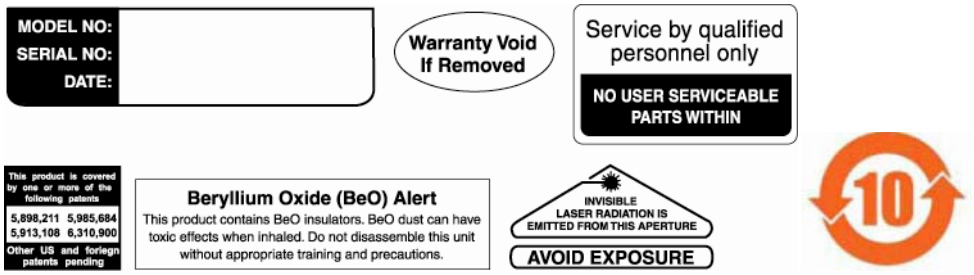

Figure 2-3 Warning Labels

Safety Device Checklist

1. Verify that all labels are securely affixed.
2. Verify that the safety interlock system is working properly.
   a. Verify that removing the remote interlock prevents laser operation.
   b. Verify laser can only be turned on when the key switch is in the **ON** position.

c. Verify the key can only be removed when in the **OFF** position.

d. Verify the emission indicator provides a visible signal then laser emits accessible laser radiation.

e. Verify the emission indicator signal provides advanced warning sufficient to allow action to avoid radiation exposure.

3. Locate the module so that operation of laser and/or adjustment of control electronics do not require exposure to laser radiation.

3

Chapter 3: Module Details

This chapter describes basic operation of your Pulsed RB *Plus* module. This chapter discusses:

- Unpacking your Module
- Pulsed RB *Plus* Module
- Closed Loop Chiller

Unpacking your Module

Your NG CEO Model RB *Plus* module was carefully packed for shipment. If the carton appears to have been damaged in transit, have the shipper's agent present when you unpack.

CAUTION The module is susceptible to damage due to electro-static discharge (ESD). Always use proper ESD control devices when handling the module.

CAUTION Do not open sealed package until package has normalized to room temperature. Condensation can seriously damage the diode arrays in the laser module and may void warranty.

Inspect the unit as you unpack it, looking for dents, scratches, or other evidence of damage. If you discover any damage, immediately file a claim against the carrier and notify your NG CEO representative. NG CEO will arrange for repair without waiting for settlement of your claim.

Keep the shipping container. If you file a damage claim, you may need it to demonstrate that the damage occurred as a result of shipping. If you need to return the unit for service, the specially designed carton assures adequate protection. A manual and a final test report should accompany each unit shipped.

Pulsed RB *Plus* Module

Proper storage of the RB *Plus* module involves three steps:

1. Remove all coolant from module by blowing dry air through it for 20 minutes.
2. Place a shorting connector across the module electrical contacts (see example Figure 1-1).
3. Store module in a clean, dry atmosphere (relative humidity less than 30%). If necessary, place module in a sealed bag with some form of desiccant.

The RB *Plus* module connects to diode drive current via the D-sub connector on the base of the pumphead module. The diodes in the Pulsed RB Plus module require ~ 33 V for the RB-18P or 65 V for the RB-36P. Depending on the FET used, the electrical system should need approximately 10 more volts. The RB Plus module is designed for a nominal peak cur-rent of 35 - 45 A. Higher currents are possible with this unit; please consult a NG CEO field service engineer for more detail.

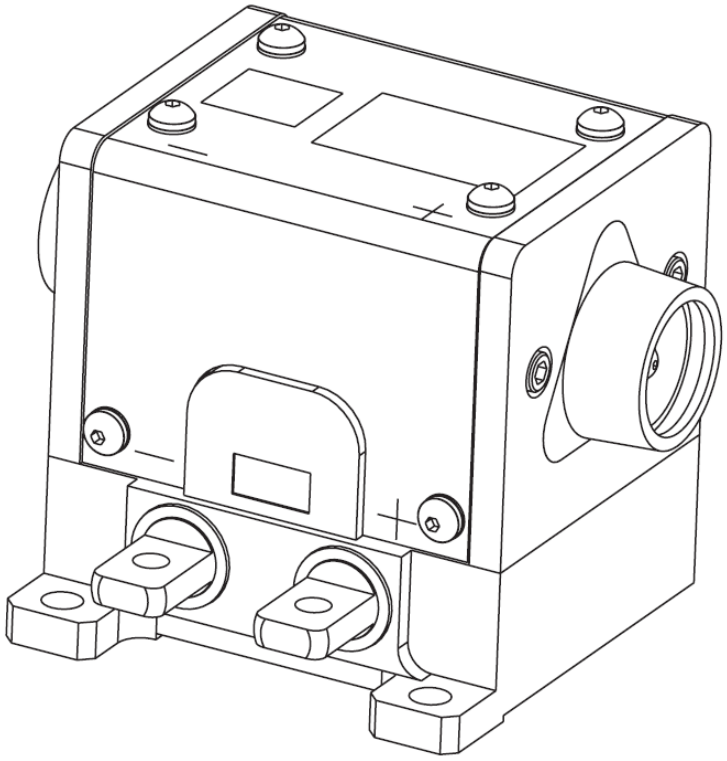

Figure 3-1 RB *Plus* with Ring Tongue Terminals

RB Plus module output is a result of the optical pump power from the pulsed laser diodes. If laser diode current / optical power is lowered, the output from the RB Plus module will also decrease. The diode arrays within the RB Plus module are aligned and sealed at the factory. There are no user serviceable parts within the

pumphead module. Contact a CEO field service engineer for repairs. Before lasing, the operator should verify that rod faces are clean. If necessary, the rod faces can be cleaned by using lens tissue, wetted with acetone or methanol, to wipe the rod face.

Reverse Bias Protection

Diodes are polarized with respect to electrical flow. A forward biased diode readily conducts; while a reverse biased diode blocks conduction. If sufficient voltage is applied in the reverse direction, the diode is permanently damaged. Laser diodes are the single most expensive component of a RB *Plus* module, so the customer should be careful to connect diode drive current correctly.

In order to provide the RB *Plus* modules with some protection against reverse biasing, all RB *Plus* modules are equipped with a reverse protection diode. This is another diode, usually located in the module, which forms a circuit across the laser diode arrays in the opposite flow direction (Figure 3-2). In the event of the laser diode drive current being reversed, the reverse bias protection diode will act like a short circuit, allowing the electricity to flow for a brief time with no resistance. However, the reverse bias protection diode is not able to withstand the high currents that laser diodes require. The protection diode will burn out after a brief time, and the drive current will be sent through the laser diodes in reverse.

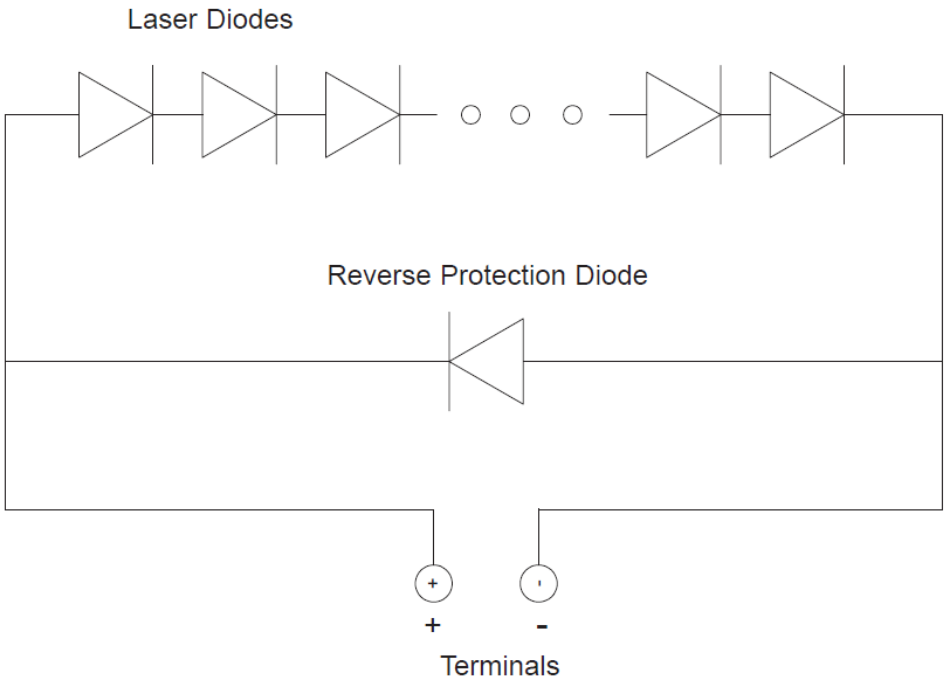

Figure 3-2 Reverse Bias Protection Diode Circuit

NG CEO drive electronics are designed to detect the shorted reverse protection diode, and suspend drive current before damaging the laser diodes. Customers who use third party manufactured drive electronics must configure them for use with NG CEOs reverse bias protection diodes. The driver should be able to detect the shorted condition because with a short across the array, the full power supply voltage will

suddenly be impressed across the driver control FETs. For drivers which have a fixed power supply voltage, a much larger voltage across the drive FETs will increase the heat load and cause a dramatic rise in their temperature. For third-party drivers which have the capability to servo the voltage to produce the necessary current, a sudden decrease in output voltage should cause a corresponding large decrease in the voltage required internally within the driver, which could be detected and reported. If any of the conditions are detected, the driver should suspend diode drive current and send the operator an error message.

Closed Loop Chiller

The single most common cause of laser module return for repair involves customer damage. More than one third of all customer damaged laser modules involve cooling problems. Coolant problems almost always require the replacement of the diode arrays - the single most expensive component in NG CEO laser modules. Read the following section carefully to avoid damaging arrays.

CAUTION Do not operate module without cooling. Inadequate heat dissipation will seriously damage the laser diodes and will void warranty.

Table 3-1. Cooling System Requirements

Chiller and Cooling System Requirements
Optishield Plus™ /distilled water coolant (10% Optishield Plus™, 90% distilled water) [1, 2]
Coolant circulated at 50 psi.
Filter connected between chiller and inlet on module [3, 4]
Module first in coolant loop [5]
Chiller Heat Capacity > Power Consumption (Table 1-1)
Flow sensor (connected to coolant interlock on drive electronics) [6]

[1] Clean coolant is important to keeping coolant lines from clogging. Untreated tap water is not an acceptable coolant and may cause damage. Optishield Plus™ is the recommended coolant. It is made from DI water with additives to control the pH. By using DI water in the solution, scale will not form in the cooling loop. It contains biocide to prevent algae growth and corrosion inhibitors to protect yellow metals and aluminum.

[2] Optishield Plus is available from Opti Temp, Inc (http://www.optishield.net/home.php?cat=103).

[3] The filter should be capable of removing particles 5 µm or larger. The filter should be changed at a minimum of every six months. The filter should be changed more frequently if the chiller manufacturer recommends a shorter interval.

[4] Every six months, or whenever the filter is changed, the coolant should be drained. The chiller should then be cleaned. Finally clean coolant should be circulated.

[5] This ensures the cleanest, coolest coolant passes through the diodes (the most expensive component of most lasers).

[6] When not using NG CEO drive electronics, verify that flow sensor interrupts current to diodes less than 500 milliseconds after a low flow condition occurs.

Table 3-2. Avoid with Chillers

Avoid with Chillers
Untreated De-ionized water[1]
Iron or aluminum parts in plumbing loop
Operation below air condensation temperature[2]

[1] NG CEO recommends chiller water have a resistivity of less than 1.0 MΩ. Deionized water can be used if the resistivity is closely monitored and the coolant loop does not have iron or aluminum parts.

Operating the Chiller

WARNING. Do not operate module without cooling. Inadequate heat dissipation will seriously damage the laser diodes and will void warranty. If you notice coolant in the immediate vicinity of the module, shut the laser system down immediately. Check to see if the coolant is coming from the module. If so, return the module for repair. If not, repair the source of the leak and allow the module to dry thoroughly before resuming operation.

The RB *Plus* module has a coolant loop to prevent thermal damage to the laser diodes. The diodes should be kept at approximately 20 °C to 35 °C. See the final test report for optimum temperature and flow rate settings.

Operating the laser diodes for even a short period of time (less than 1 second) without coolant will cause permanent damage. To help prevent this, all NG CEO drive electronics are equipped with a coolant interlock. This interlock interrupts drive current to the diodes when coolant flow rate drops below set point. For this to function properly, a flow sensor must be used in the coolant loop. When setting up the laser system for the first time, NG CEO recommends testing the flow interlock before firing. This can be accomplished by setting the drive current to a very low level (~ 1 A) then attempting to fire the laser with the chiller off. In case interlock does not function correctly, be prepared to manually turn off laser. By testing the interlock with a minimal current, the risk to the laser diodes is minimized.

WARNING. Do not operate the coolant system below air condensation temperature (dew point) at the laser head. Condensation on the diode arrays can seriously damage the laser head and will void the warranty. Consult a NG CEO field service engineer if you have any questions.

Air Condensation Temperature

The air condensation temperature (or dew point) is the highest surface temperature that allows water to form from the ambient water vapor. The dew point is dependent on the surrounding air temperature and relative humidity. If a surface (such as a laser diode) is cooled at or below the condensation temperature, water may collect on that surface. A formula for calculating dew point is given below, along with a calculated table. All temperatures are given in Celsius.

Condensation Temperature
$T_d = \frac{237.7 \times \alpha(T, RH)}{17.27 - \alpha(T, RH)}$ $\alpha(T, RH) = \frac{17.27 \times T}{237.7 + T} + \ln\left(\frac{RH}{100}\right)$
where
T is the ambient air temperature in degrees Celsius (0 < T < 60)
RH is the relative humidity in percent (1% < RH < 100%)
T_d is the air condensation temperature

For example, suppose your chiller is running at 22 °C and the ambient air temperature near the laser is 28 °C (82 °F). Referring to Figure 3-4 and Table 3-4, find the intersection of the 28 °C air temperature and the curve for the 22 °C diode temperature. At a relative humidity of 70 percent or greater, condensation will form on the laser diodes.

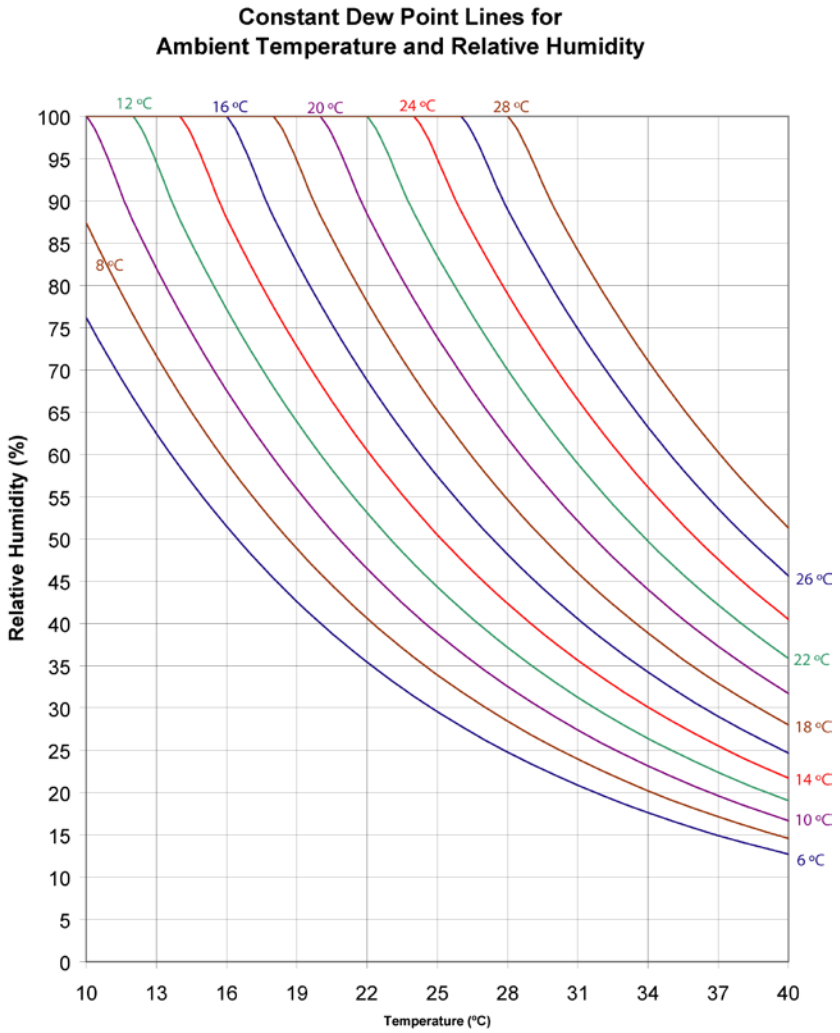

Figure 3-1. Constant Dew Point Lines for Ambient Temperature and Relative Humidity

Table 3-3. Table of Air Condensation Temperature at Given Ambient Air Temperature (Celcius) and Relative Humidity (percent)

Air Temperature °C	Relative Humidity										
	1%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
10	-43.9	-20.2	-11.9	-6.8	-3.0	0.1	2.6	4.8	6.7	8.4	10.0
12	-42.6	-18.7	-10.3	-5.0	-1.2	1.9	4.5	6.7	8.7	10.4	12.0
14	-41.4	-17.1	-8.6	-3.3	0.6	3.7	6.4	8.6	10.6	12.4	14.0
16	-40.2	-15.6	-7.0	-1.6	2.4	5.6	8.2	10.5	12.5	14.4	16.0
18	-39.0	-14.1	-5.3	0.2	4.2	7.4	10.1	12.4	14.5	16.3	18.0
20	-37.8	-12.5	-3.6	1.9	6.0	9.3	12.0	14.4	16.4	18.3	20.0
22	-36.6	-11.0	-2.0	3.6	7.8	11.1	13.9	16.3	18.4	20.3	22.0
24	-35.4	-9.5	-0.4	5.3	9.6	12.9	15.7	18.2	20.3	22.3	24.0
26	-34.2	-8.0	1.3	7.1	11.3	14.8	17.6	20.1	22.3	24.2	26.0
28	-33.0	-6.5	2.9	8.8	13.1	16.6	19.5	22.0	24.2	26.2	28.0
30	-31.8	-4.9	4.6	10.5	14.9	18.4	21.4	23.9	26.2	28.2	30.0
32	-30.6	-3.4	6.2	12.2	16.7	20.3	23.2	25.8	28.1	30.1	32.0
34	-29.5	-1.9	7.8	13.9	18.5	22.1	25.1	27.7	30.0	32.1	34.0
36	-28.3	-0.4	9.5	15.7	20.2	23.9	27.0	29.6	32.0	34.1	36.0
38	-27.1	1.1	11.1	17.4	22.0	25.7	28.9	31.6	33.9	36.1	38.0
40	-26.0	2.6	12.7	19.1	23.8	27.6	30.7	33.5	35.9	38.0	40.0

If required to operate a laser in conditions near to the condensation temperature, take precautions to keep the RB module dry. The module should be operated inside an area that is purged with nitrogen (N_2) or encased in a sealed enclosure with a desiccant.

4

Chapter 4: Maintenance

The RB Plus module is factory assembled by trained technicians at NG CEO. Most service and maintenance needed by the RB Plus module should be addressed to your NG CEO field service engineer. (Refer to *Chapter 5: Service* for complete information on this topic.)

The chapter contains information in these sections:

- Rod Removal and Replacement
- Rod Cleaning
- Leak Test Procedure

Rod Removal and Replacement

The only user serviceable part in the RB *Plus* module is the Nd:YAG rod, which can be replaced by the user. YAG rods rarely break, frequent replacement may be a sign of another problem in the RB *Plus* module. Contact NG CEO if you have any further questions.

CAUTION. The module is susceptible to damage due to electro-static discharge (ESD). Always use proper ESD control devices when handling the module.

CAUTION. Ensure gloves or finger cots are worn during this procedure and that it is carried out in a clean environment, preferably under a laminar flow hood.

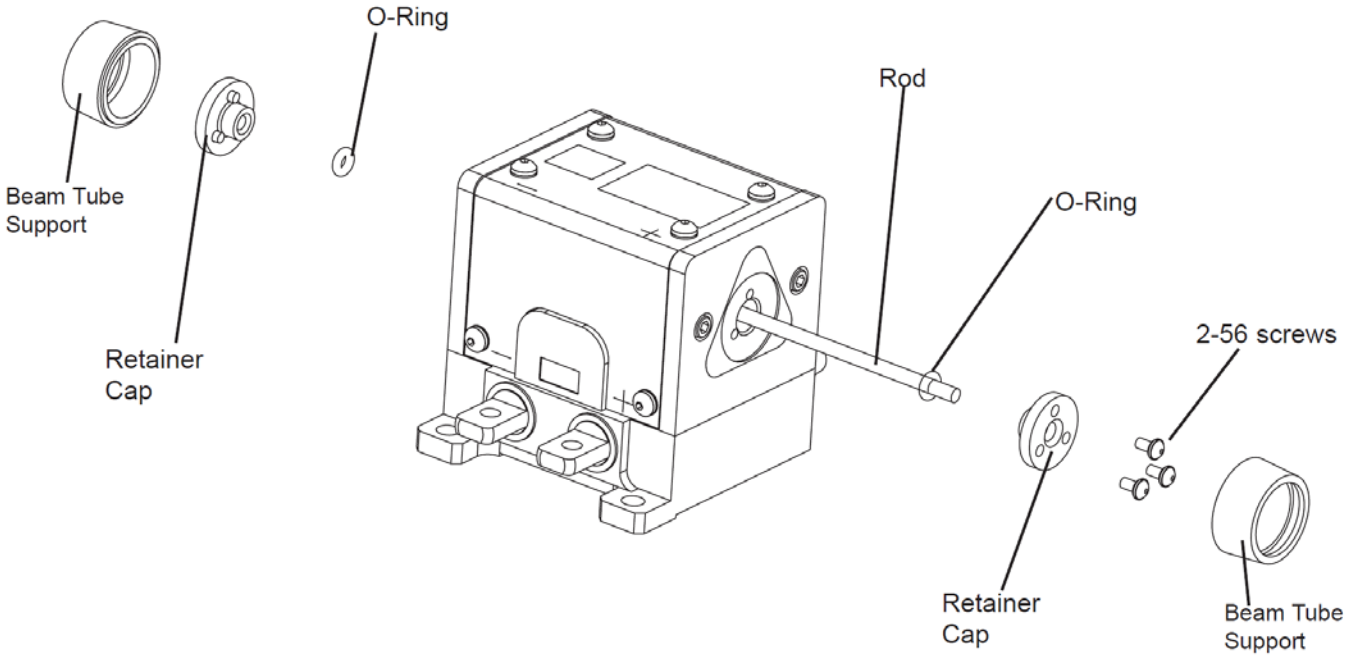

Figure 4-1 Rod Replacement Drawing

1. Remove the beam tube supports from the retainer caps. These are just threaded on.
2. Remove the retainer caps by removing the six 2-56 button head screws with a 0.50” allen wrench.

CAUTION. Use extreme caution during the remaining steps of this procedure to insure that the rod faces and/or coatings are not damaged. Never use a tool that can scratch the rod on the O-rings.

3. To extract the O-rings that hold the rod in position, place index fingers on each end of rod and apply pressure first at one end, then the other. Press back and forth until one of the O-rings slides out of its notch.
4. Once O-ring is dislodged, press on same end of rod to dislodge the other O-ring. Repeat this until O-ring moves to the end of the rod, where it can be easily removed by hand. Remove the rod. If necessary, loosen an O-ring with plastic or fiberglass tool. (NG CEO recommends Techni-Tool #43SO122.) Be careful not to damage the rod (end faces or barrel).
5. Unwrap the new rod and inspect the end faces.
6. Obtain two 70-60 Viton O-rings if using a 2mm rod or two 70-9855 Viton O-rings if using a 3mm rod. These o-rings are supplied with the module.
7. Place one of the corresponding O-rings over one end of the rod. Position the O-ring approximately 10mm from the end of the rod.
8. Insert the opposite end of the rod into the corresponding hole in one end of the module until it protrudes from the hole in the opposite end. Be careful not to chip or scratch the rod while inserting it.
9. Place one of the retainer caps onto the endplate and start the three 2-56 screws (with lock and flat washers).
10. Place the second O-ring over the opposite end of the rod.
11. Place the remaining cap onto the second endplate and start the three 2-56 screws (with lock and flat washers).
12. Position the rod equidistant from each end of the pump module using gloved fingers or the soft end of a cotton swab soaked in acetone or methanol.
13. Tighten the retainer caps with the 0.50” Allen wrench.
14. Inspect both rod ends for cleanliness. If necessary, clean the ends of the rod with a puff of dry nitrogen or moisture-free canned air.
15. Look at rod reflections with either an autocollimator or a HeNe to verify there is no rod stress. When a HeNe beam is shot down an unstressed rod the reflections from the front near and far surfaces align. If the reflections are separated, the rod is stressed.
16. Leak test according to the following procedure. Alternately, turn on the chiller and allow coolant to flow for approximately 20 minutes. Examine pump module for leaks.
17. If pumphead leaked: first fix the leak, then test again for leaks, finally allow module to dry thoroughly before lasing. Firing wet diodes will permanently damage them.

Rod Cleaning

CAUTION. Ensure gloves or finger cots are worn during this procedure and that it is carried out in a clean environment, preferably under a laminar flow hood.

First, blow optical surface with dry nitrogen. Then, use either hemostats and lens tissue or a tight-wrapped cotton tipped applicator, lightly wetted with acetone or methanol to wipe the rod face. The wipe pattern should be in a circular motion from center towards edge. Inspect the rod for cleanliness. Repeat if necessary.

Leak Test Procedure

Laser diodes are very sensitive to water damage. If you have access to pressurized nitrogen and a pressure gage, you can test for leaks without exposing the diodes to water.

1. Attach a nitrogen source to one of the coolant ports on the module being tested (test article) and attach the termination valve to the other coolant port on the test article.
2. Close the termination valve.
3. Open the inlet valve and adjust the regulator to obtain 80 psi on the pressure gauge.
4. Close the inlet valve. Wait.
5. Return after 30 minutes and record pressure on the gauge. Subtract this pressure from starting pressure of 80 psi to get the pressure drop over 30 minutes.
6. Pass/Fail requirements: if the pressure drop is greater than 3 psi FAIL, if the pressure drop is less than 3 psi PASS.

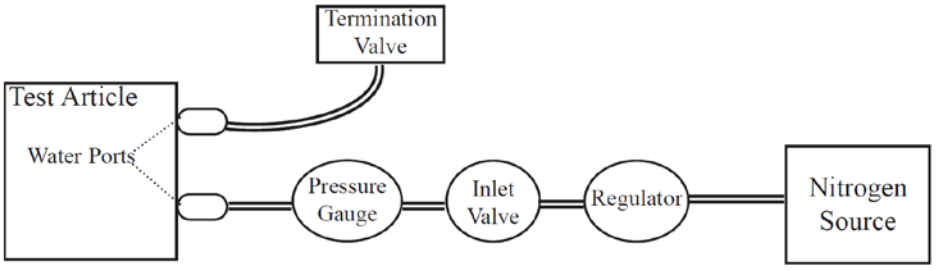

Figure 4-2 Nitrogen Leak Test Layout

5

Chapter 5: Service

At Northrop Grumman Cutting Edge Optronics, we are proud of the durability of our products. Our manufacturing and quality control processes emphasize consistency, ruggedness, and high performance. Nevertheless, even the finest instruments break down occasionally. We believe that the reliability record of our instruments compares favorably with that of our competition, and we hope to demonstrate our superior service by providing dependable instruments and, if the need arises, service facilities that can restore your instrument to peak performance without delay.

When calling for service in the U.S., dial (636) 916-4900. To phone for service in other countries, contact your sales agent.

This chapter provides reference to types of customer service needs:

- Contacting customer service
- Return the instrument for repair

Contacting Customer Service

To expedite your service needs, please complete the questionnaire in *Appendix A: Customer Service* ***before*** you contact NG CEO Customer Service. Complete the questionnaire with as much detail as possible and retain a copy for your records.

E-mail or fax the form to NG CEO (refer to the second page of this manual for contact information) and notify your customer service representative that it has been sent.

Return the Instrument for Repair

A return merchandise authorization (RMA) *is required* prior to shipping any instruments to NG CEO. Contact NG CEO or your local distributor for RMA and shipping instructions.

CAUTION. Failure to obtain proper shipping instructions may result in damage to the instrument.

Use the packing boxes supplied by NG CEO to ship your instruments. If shipping boxes have been lost or destroyed, replacements are available for a nominal charge from NG CEO.

Remove all coolant from module by blowing dry air through it for 20 minutes, prior to packaging for shipment. Place a shorting connector across the electrical connector (see example Figure 1-1). Place module in a sealed bag inside shipping container. Place some form of desiccant in bag with module.

WARNING. Damage from residual water due to condensation or expansion can be catastrophic to the diode arrays or laser rod if not dealt with properly. Such damage is excluded from warranty coverage.

A

Appendix A: Customer Service

This form has been provided to encourage you to tell us about any difficulties you may have experienced while using your Northrop Grumman Cutting Edge Optronics instruments or user manuals. Call or write our customer service department to bring attention to problems that you may not have personally experienced. We are always interested in improving our products and manuals, and we appreciate all suggestions.

Date:
Name:
Company or Institution:
Department:
Address:

RB Plus Model Number:	Serial Number:
Chiller Model Number:	Serial Number:
eDrive Model Number:	Serial Number:
RB Plus Manufacture Date:	RB Plus Operating Hours:

Questions

What is the coolant flow rate (GPM)?

What is the set temperature on the chiller (^{o}C)?

What is the coolant pressure on chiller (PSI)?

What are the set current and actual current from eDrive (A)?

What is the laser cavity configuration?

What is the measured CW power (W)?

When did the problem happen?

Have you changed any settings recently (yes/no)?

What are the changes made recently to the system?

Please describe the problem or RB Plus behavior as detailed as possible:

Suggestions

Email or fax to:

Northrop Grumman
Cutting Edge Optronics, Inc.
20 Point West Boulevard
Saint Charles, MO 63301 USA
Phone: (636) 916-4900
Fax: (636) 916-4994
Email: st-ceolaser-info@ngc.com

Appendix B: System International Units

The following System International (SI) units, abbreviations, and prefixes are used throughout NG CEO user manuals:

Quantity	Unit	Symbol
mass	gram	g
length	meter	m
time	second	s
frequency	Hertz	Hz
force	Newton	N
energy	Joule	J
power	Watt	W
electric current	Ampere	A
electric charge	Coulomb	C
electric potential	Volt	V
resistance	ohm	Ω
inductance	Henry	H
magnetic flux	Weber	Wb
magnetic flux density	Tesla	T
luminous intensity	candela	cd
temperature	Kelvin	K

Abbrv.		Prefixes
tera	(10^{12})	T
giga	(10^{9})	G
mega	(10^{6})	M
kilo	(10^{3})	k
deci	(10^{-1})	d
centi	(10^{-2})	c
milli	(10^{-3})	m
micro	(10^{-6})	µ
nano	(10^{-9})	n
pico	(10^{-12})	p
femto	(10^{-15})	f
atto	(10^{-18})	a

Appendix C: Acronyms

Acronym	Description
ACGIH	American Council of Government Industrial Hygienists
ANSI	American National Standards Institute
AR	Anti-Reflective
AO	Acusto-Optical (type of Q-switch)
CDRH	Center for Devices and Radiological Health - U.S. Food and Drug Administration
CEO	Cutting Edge Optronics, Incorporated
CFR	Code of Federal Regulations
CW	Continuous Wave
DC	Direct Current
EO	Electro-Optical (type of Q-switch)
ESD	Electro-Static Discharge
FET	Field Effect Transistor
FDA	U.S. Food and Drug Administration
FWHM	Full Width - Half Max
GaAlAs	Gallium Aluminum Arsenide
GPM	Gallons Per Minute
HR	High Reflector
HV	High Voltage
IR	Infrared
KTP	Potassium Titanyl Phosphate
LBO	Lithium Triborate

Acronym	Description
MCC	Meters Concave
Nd:YAG	Neodymium-doped Yttrium Aluminum Garnet
Nd:YLF	Neodymium-doped Yttrium Lithium Floride
NG	Northrop Grumman
NIR	Near Infrared
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
PRF	Pulse Repetition Frequency
PSI	Pounds per Square Inch
SHG	Second Harmonic Generator
TEC	Thermo-Electric Cooler
TTL	Transistor - Transistor Logic
USA	United States of America
VAC	Volts, Alternating Current