RE-Series

Diode-Pumped Nd:YAG Rod Laser Modules

Models RE-50, RE-63, & RE-70
User Manual

NORTHROP GRUMMAN

RE-Sereis Diode-Pumped
Nd:YAG Rod Laser Module
Instruction Manual

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Preface

This manual describes the installation, operation, and service of the RE-Series module.

The RE-Series 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.

The Service and Repair 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 Northrop Grumman Space Technology Cutting Edge Optronics (NGST CEO) for warranty repair.

We welcome your comments on the content and style of this manual. The last page is a form to aid in bringing your thoughts to our attention. Thank you for your purchase of NGST Cutting Edge Optronics components.

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.**

Table of Contents

SI Units

The following System International (SI) units, abbreviations, and prefixes are in Cutting Edge Optronics (CEO) manuals:

Quantity	Unit	Abbr.
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**	**W**
Inductance	**Henry**	**H**
Magnetic Flux	**Weber**	**Wb**
Magnetic Flux Density	**Tesla**	**T**
Luminous Intensity	**candela**	**cd**
Temperature	**Kelvin**	**K**

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**

Acronyms

The following acronyms are used in this manual:

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
MCC	Meters Concave
Nd:YAG	Neodymium-doped Yttrium Aluminum Garnet
NGST	Northrop Grumman Space Technology
NIR	Near Infrared
OSHA	Occupational Safety and Health Administration
PRF	Pulse Repetition Frequency
PSI	Pounds per Square Inch
SHG	Second Harmonic Generator
TTL	Transistor - Transistor Logic
VAC	Volts, Alternating Current

Chapter 1 Introduction

The RE-Series 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.

Theory of Operation

Northrop Grumman Space Technology Cutting Edge Optronics (NGST 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
- More efficient operation

The RE-Series module uses arrays of solid-state laser diodes to optically pump a neodymium-doped yttrium aluminum garnet (Nd:YAG) lasing medium. The diode optical output power is radially coupled into the laser rod. The Nd:YAG laser rod has an anti-reflection coating chosen for the highest gain wavelength of this material, 1064 nm. The RE-Series module is constructed within a durable and rigid structure. Exterior components and connections are shown in Figure 1.

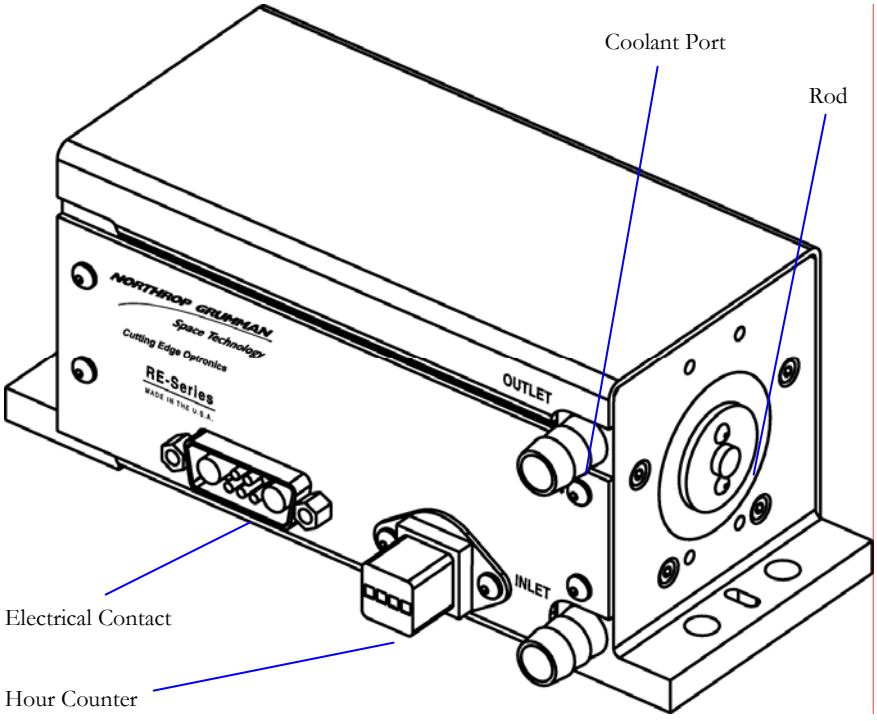

Figure 1 Exterior Components and Connections

Temperature Tuning of Laser Diodes

The laser diodes are located within the RE-Series 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 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.

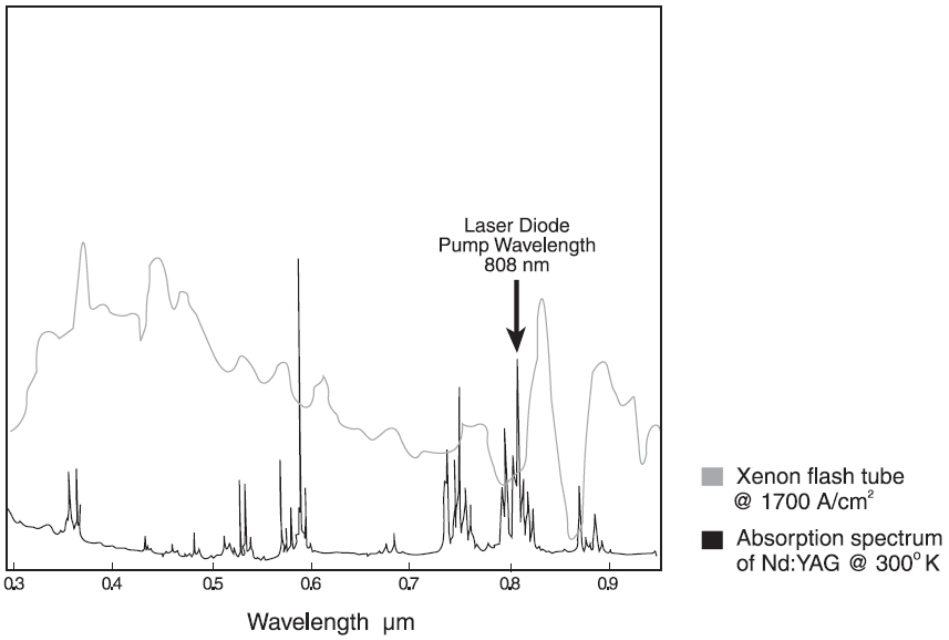

Figure 2 Nd:YAG Absorption Characteristics

A single GaAlAs laser diode bar has a 2 nm FWHM distribution of output wavelengths. However, the process used in the manufacture of GaAlAs laser diodes results in a peak output wavelength for each diode that fits within a 10 nm distribution of wavelengths from 800-810 nm. To match the diode output to an absorption peak of the laser medium, diodes are selected with similar peak output wavelengths within the manufacturing range. Temperature tuning is possible because GaAlAs diode characteristics are such that 0.25 nm of wavelength shift occurs for every 1°C change in temperature of the diode junction. Cooling shortens the wavelength, and heating lengthens it. Figure 3 shows the percentage of pump light of different wavelengths absorbed by two passes through a 6.35 mm thick rod of 0.6% doped Nd:YAG. In CEO modules, the laser diode center wavelength, under normal operating conditions, is near the absorption peak of the laser medium. The operating temperature of closed loop chiller is carefully chosen to shift the diode temperature, so that the wavelength matches the absorption peak. The final test report, included with each module, indicates the optimum operation temperature for that module.

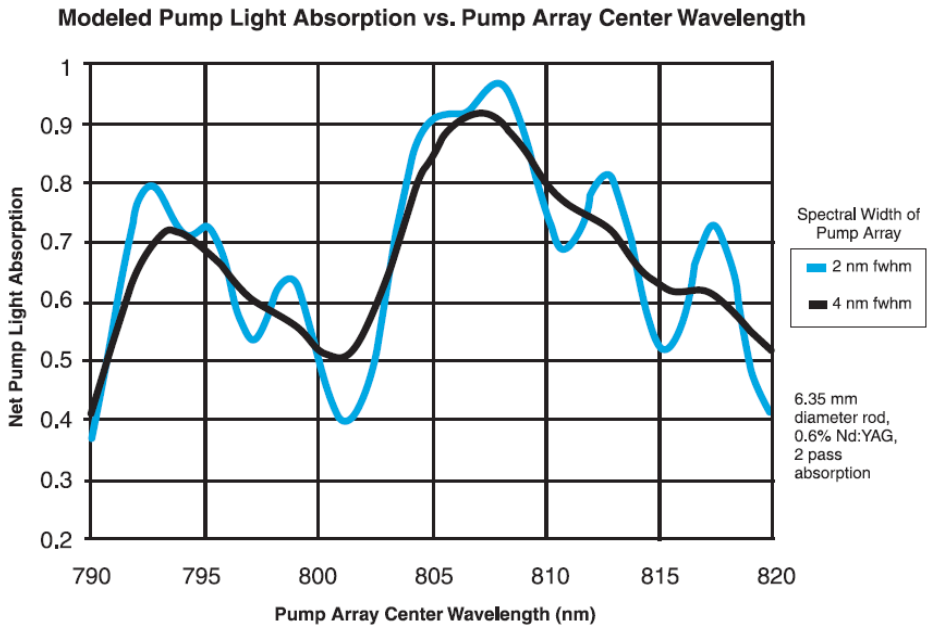

Figure 3 Pump Light Absorption vs. Pump Array Center Wavelength

RE-Series Description

The RE-Series module utilizes a radial transverse pump geometry to excite the solid-state laser medium (see Figure 4). This pump geometry results in excellent gain uniformity and lensing performance. The reflector directs the divergent diode light back to the laser medium, which is kept in a flow tube for coolant circulation. The laser medium is a 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 ends of the Nd:YAG rod may be curved to compensate for thermal lensing, depending on module configuration.

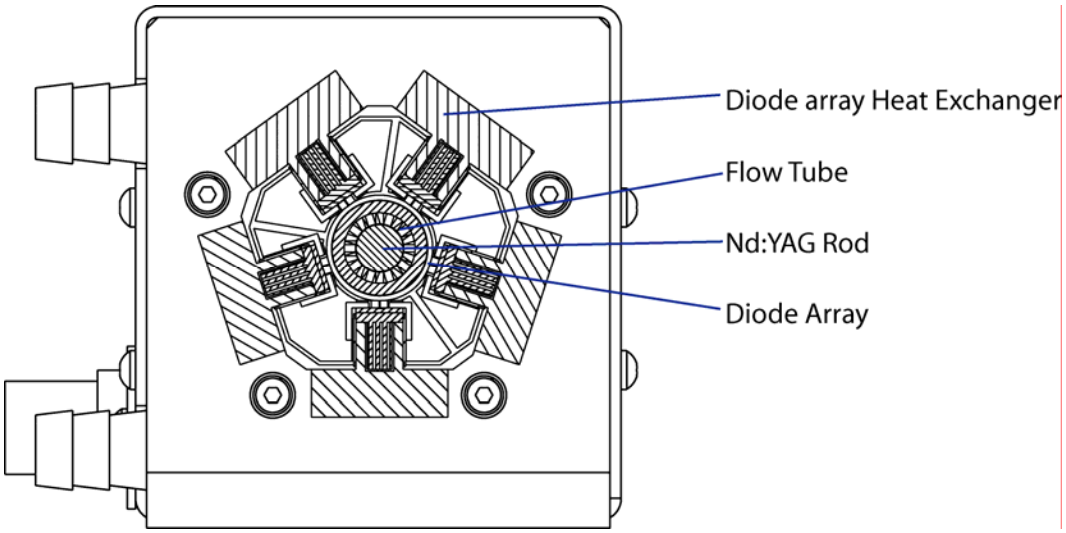

Figure 4 Radial Pump Geometry

The five diode arrays that radially pump the rod can each have one or two parallel lines of diode bars. The single line version is called the 1C2 in CEO literature, while the double bar version is called the 2C2. Naturally, the double

bar (2C2) version requires twice the diode bias voltage and twice the input power of the single bar version of the pumphead.

The laser medium is a 146 mm long rod of neodymium-doped yttrium aluminum garnet (Nd:YAG). The rod is 5 mm diameter for RE-50, 6.35 mm for RE-63, and 7 mm in RE-70. Both ends of the rod are optically polished and include anti reflection coatings at the lasing wavelength. The Nd:YAG rod ends are curved to compensate for thermal lensing, unless otherwise requested.

Closed Loop Re-circulating Chiller

Coolant flow direction is polarized on the RE-Series pump module. Inlet and Outlet hose barbs are marked on the pumphead. Be sure to connect the coolant filter for the selected chiller on the Inlet connection, so only clean coolant from the filter flows through the pumphead. Dirty coolant deposits dirt on the Nd:YAG rod, which results in low output power.

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 power consumption for the specific model of RE-Series module.

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 (figure 5) gives the CEO recommendations.

60 Hz Electrical Outlets

Model	EOL Current	Waste Heat	Polyscience Chiller No.	Chiller Capacity
REXX-1C2	32 A	2304 W	6160T11CE30D	2900 W
REXX-2C2	32 A	4608 W	6860T56CE70D	5200 W

50 Hz Electrical Outlets

Model	EOL Current	Waste Heat	Polyscience Chiller No.	Chiller Capacity
REXX-1C2	32 A	2304 W	6150T21CE30E	2407 W
REXX-2C2	30 A	4320 W	DCA206D1FF	5810 W

Figure 5 CEO Recommended Chiller Table

Specifications[1]

RE-Series modules are tested to exceed the following specifications. The standard production test configuration consists of a 280 ± 5 mm cavity utilizing a flat high reflector and a flat 70% reflective output coupler.

Model	RE50-1C2	RE63-		RE70-	
		1C2	2C2	1C2	2C2
Output Power (W)	200	200	450	200	450
Rod Diameter (mm)	5	6.35	6.35	7	7
Diode Bias Voltage @ 27 A (VAC)	72	72	144	72	144
Power Consumption (W)	2810	2810	5600	2810	5600

	All RE-Series Models
Type	CW Diode Pumped Nd:YAG Rod[4]
Standard Dopant	0.6%
Output Wavelength	1064 nm
Polarization	Random
Cooling	Closed Loop Recycling Coolant[5]
Coolant Flow	> 2.0 GPM
Coolant Pressure[6]	50 PSI
Operating Temperature	20-30 °C non-condensing
Optical Center from Base	1.50 inches
Module Dimensions (inches)	2.81 H x 2.62 W x 6.75 L
Nominal Weight	4.4 lbs.
eDrive Dimensions (inches)	3.48 H x 19 W x 17.65 D inches

Figure 6 RE-Series Specifications Tables

1. Specifications subject to change without notice
2. Output power from the production test cavity (280 mm ± 5 mm cavity utilizing a flat HR and flat 70% reflective output coupler)
3. At end of life [(Operating current x Diode voltage) x 130%]
4. The Continuous Wave (CW) diode arrays are sensitive to excessive thermal cycling. Current should not be turned off completely and then restored to full operating current more than 6 times per day. Current should be gradually (~1A/s) ramped up when operating current restored. See chapter 3 for more details.
5. CEO recommends Purelase 180 coolant.
6. CEO modules are leak tested to 60 psi with Nitrogen gas. CEO recommends 50 psi of chiller water for actual operation.

Chapter 2 Laser Safety

Please read this section carefully before installing or operating your RE-Series module. We recommend that all service and repair operations be performed by a NGST Cutting Edge Optronics service engineer. If you do plan to service your laser module, please follow the procedures in the Service section of this manual.

Caution & Warning Statements

WARNING

The NGST Cutting Edge Optronics RE-Series 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 RE-Series are sensitive to Electro-Static Discharge (ESD). Never handle the RE-Series module without being properly grounded through the use of properly installed and maintained grounding wrist straps or other ESD control devices. Subjecting the RE-Series 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 NGST CEO laser 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.
• Insure 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.

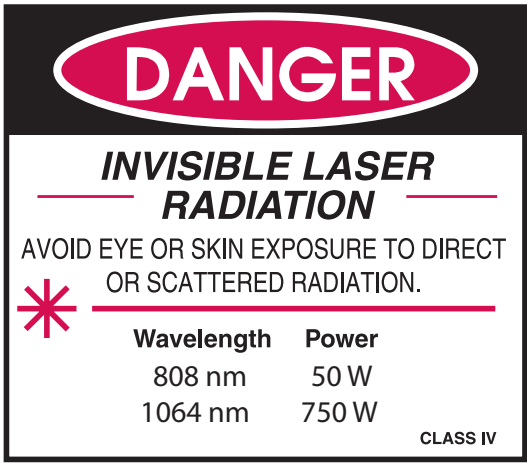

Figure 7 Standard Safety Warning Sign

Center for Devices and Radiological Health (CDRH) OEM Product

The RE-Series 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 RE-Series 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.

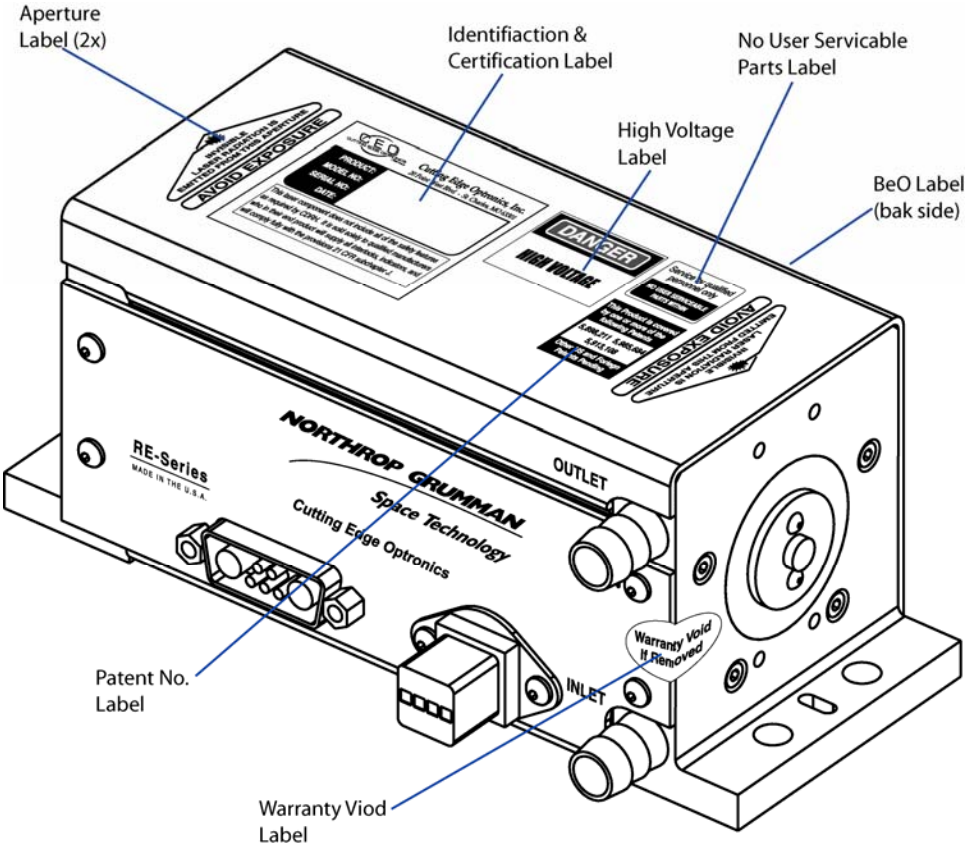

Figure 8 Radiation Control Drawing

Figure 9 Warning Labels

Key to Radiation Control Drawing

Item	Description
1	Identification Label w/ OEM Component
2	Warranty Void Label
3	No Serviceable Parts Label
4	Patent Number Label
5	BeO (Beryllium Oxide) Alert

Safety Device Checklist

1. Verify that all labels are securely affixed.
2. Verify that the safety interlock system is working properly.
3. Locate the module so that operation of laser and/or adjustment of control electronics do not require exposure to laser radiation.

Chapter 3 Operation

Unpacking your Module

Your NGST Cutting Edge Optronics Model RE-Series 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 NGST Cutting Edge Optronics representative. NGST 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.

A manual and a final test report should accompany each unit shipped.

RE-Series Module

Proper storage of the RE-Series module involves three steps:

1) Remove all water from module by blowing dry air through it for 20 minutes.
2) Place a shorting connector across the module electrical contacts.
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 approximate diode bias voltage for the different models of RE-Series module can be found in the Specifications table at the end of chapter one. The electrical system should deliver approximately 10 more volts, depending on the FET used. The final test report shipped with the RE-Series module indicates the beginning of life current required to obtain the module's rated output power in a short cavity test. NGST CEO recommends users not exceed the listed current, as overdriving the module reduces diode lifetime.

The RE-Series module connects to a diode driver in one of three ways: a D-sub connector (Positronics 7W2, see Figure 12) on the base of the pumphead module (Figure 10), a D-sub connector on wire from the base of the module (Figure 11), or Anderson connectors on wire from the base of the module (see Figure 13).

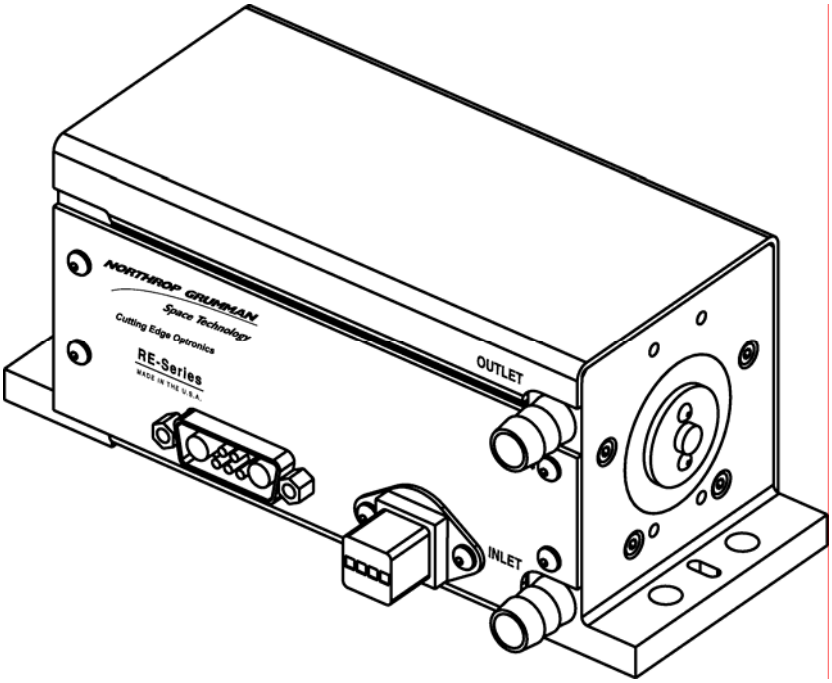

Figure 10 RE-Series with Pin D-Sub Connector

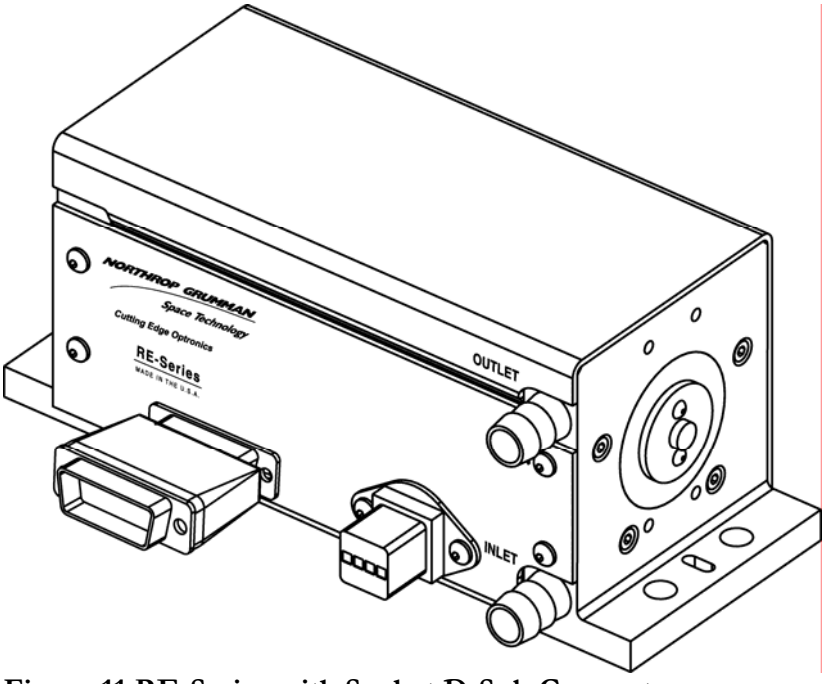

Figure 11 RE-Series with Socket D-Sub Connector

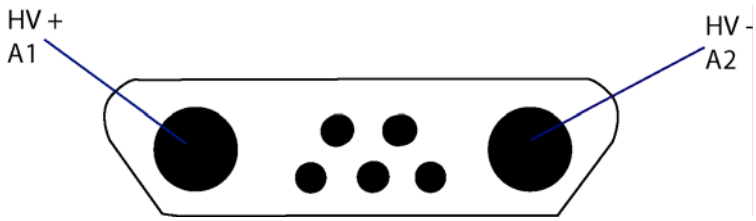

Figure 12 D-Sub Connector Pin Out

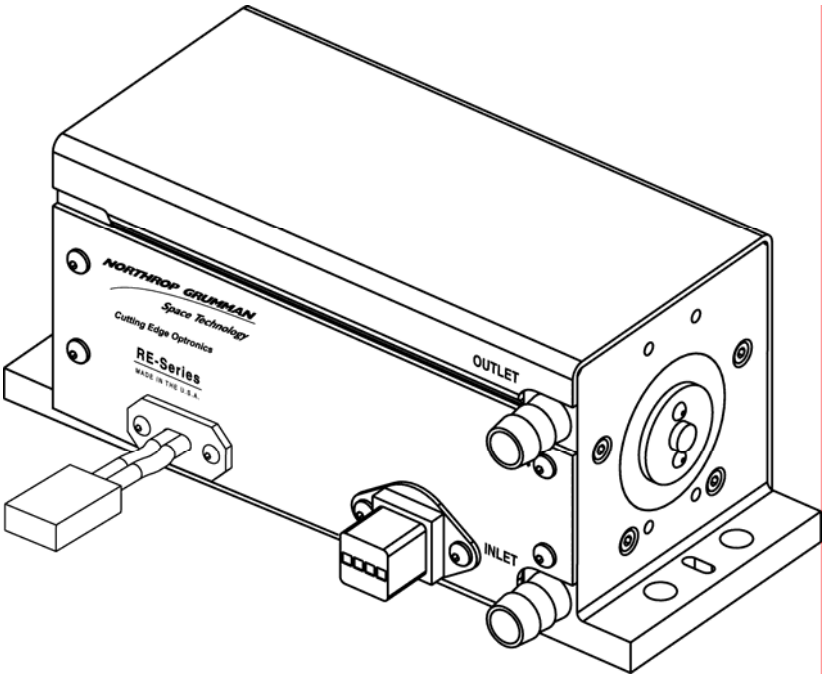

Figure 13 RE-Series with Pin D-Sub Connector

Some users have experienced a problem with modules with Anderson connectors. The wire to the Anderson connector is designed to bend, but the connector itself should be kept straight. When the connectors are stressed (e. g. twisted, pulled, pinched) the electrical connection can be weakened. The inefficient connection causes resistance, which causes waste heat to be dumped into the plastic connector. The connector then melts, and must be replaced.

RE-Series module output is a result of the optical pump power from the continuous wave laser diodes. These continuous wave diodes are sensitive to thermal shock from repeatedly applying and removing drive current. Diodes should not be cycled on/off more than 6 times a day. When initially applying power to the module, the current should be gradually increased (~3 A/s) until the normal operating current is achieved (see final test report for initial recommended operating current). This "ramping" process reduces thermal shock and helps prolong diode lifetime. If the RE module is going to be installed in a system where quick transitions between lasing and non-lasing are repeatedly required, then drive current to the diodes should be maintained at ~ 3 A below normal operating current when the system is not lasing. This "simmer" current will keep the diodes at close to the operating (lasing) temperature and thereby reduce thermal shock.

The diode arrays within the RE-Series module are aligned and sealed at the factory. Other than the laser rod, there are no user serviceable parts within the module. Contact a NGST 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 RE-Series module, so customer should be careful to connect diode drive current correctly.

In order to provide the RE-Series modules with some protection against reverse biasing, all RE-Series 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 14). 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.

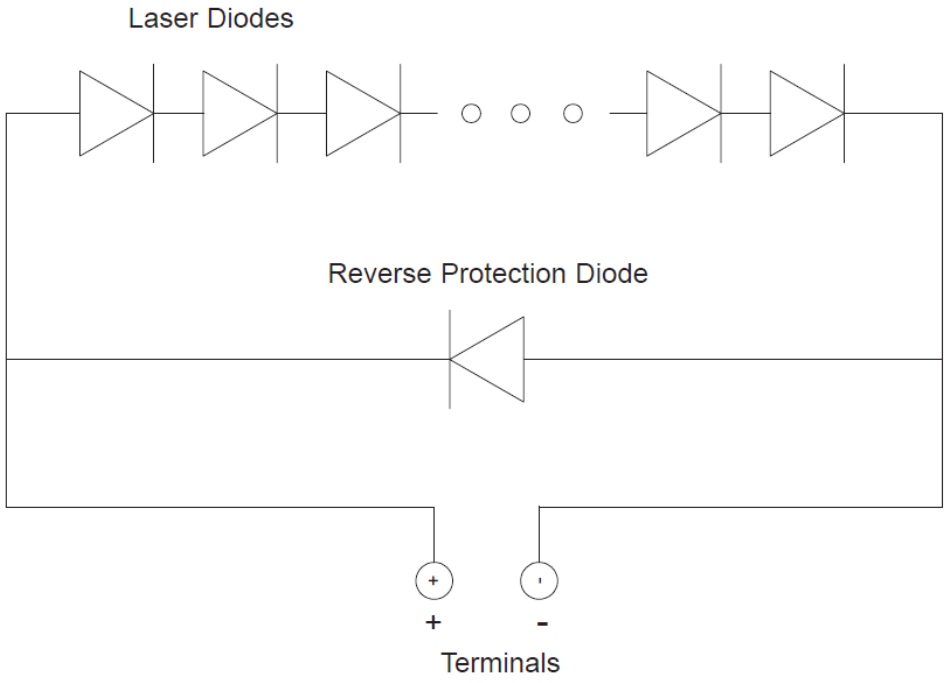

Figure 14 Reverse Bias Protection Diode Circuit

NGST 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 NGST 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

CAUTION

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

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 NGST CEO laser modules. Read the following section carefully to avoid damaging arrays.

Chiller requirements:

- Purelase 180 coolant[1, 2]
- Coolant circulated at 50 psi.
- Filter (connected between chiller and inlet on module)[3, 4]
- Module first in coolant loop[5]
- Heat Capacity > Power Consumption (Fig. 5)
- 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. Purelase 180 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. Purelase 180 is available through NG CEO.
2. If Purelase 180 is not available, CEO recommends distilled water and the combined algaecide and corrosion inhibitor Optishield Plus from Opti Temp, Inc (Traverse City, MI, phone number 231-946-2931).
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 when ever 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 CEO drive electronics, verify that flow sensor interrupts current to diodes less than 500 milliseconds after a low flow condition occurs.

Avoid with chillers:

- Untreated De-ionized water[1]
- Iron or Aluminum parts in plumbing loop
- Operation below air condensation temperature

1. 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.

If you ever notice water in the immediate vicinity of the module, shut the laser down immediately. Check to see if the water is coming from the module. If so, then return the module for repair. If not, repair leak and allow the module to dry thoroughly before resuming lasing.

The RE-Series module has a coolant loop to prevent thermal damage to the laser diodes. The diodes should be kept at approximately 20-35 °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 NGST 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. It is a good idea to test the function of the flow sensor before firing when first setting up the

laser system. 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.

CAUTION

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

The air condensation temperature (dew point) is the highest temperature a surface can be at to cause water to form on the surface from the ambient air vapor. The air condensation temperature 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.

$$T_d = \frac{237.7 \times \alpha(T, RH)}{17.27 - \alpha(T, RH)} \qquad \alpha(T, RH) = \frac{17.27 \times T}{237.7 + T} + \ln\left(\frac{RH}{100}\right)$$

T is the ambient air temperature in Celsius $\{0 < T < 60\}$,
RH is the relative humidity $\{0.01 < RH < 1.0\}$ and
T_d is the air condensation temperature.

For example, if the chiller is running at 22 °C then look at the curve labeled 22 °C. Suppose the ambient air near the laser is at 28 °C (82 °F), look where the grid-line for air temperature of 28 °C intersects the curve for diode temperature of 22 °C. At a relative humidity of 70% or greater, condensation will form on the laser diodes.

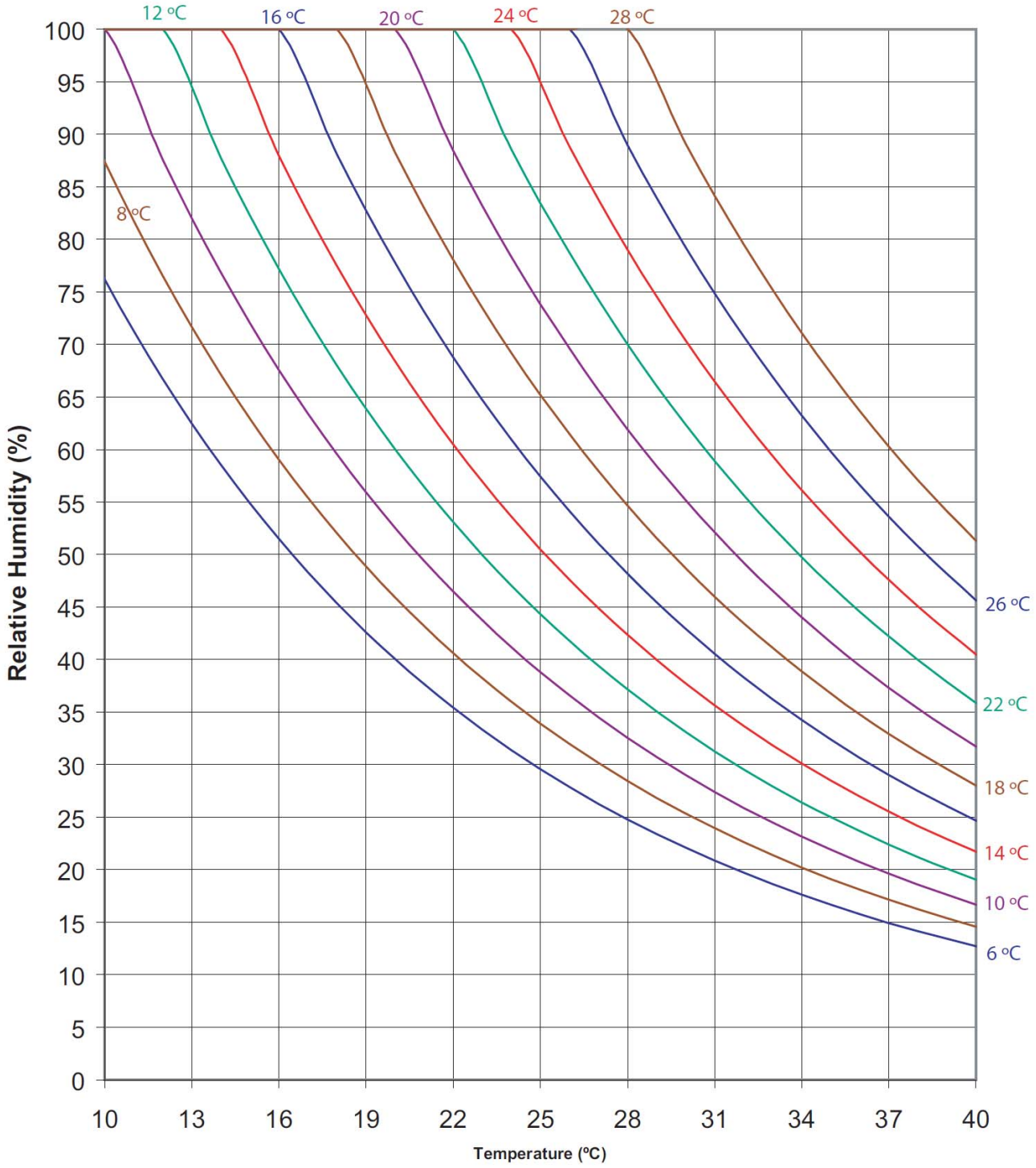

Figure 15 Constant Dew Point Lines for Ambient Temperature and Relative Humidity

Temperature	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

Figure 16 Table of Air Condensation Temperature at Given Ambient Air Temperature (C) and Relative Humidity (%)

If required to operate a laser system 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 gaseous N_2 or encased in a sealed enclosure with a desiccant.

Chapter 4 Installation and Operation

When NGST CEO sells diode drive electronics with the RE-Series module, we sell our eDrive diode driver. When NGST CEO sells a closed loop water chiller with the RE-Series module, we provide a Polyscience chiller (see Chapter 1 for chiller capacities). The following chapter contains step by step procedures detailing the installation and operation of the RE-Series module with these peripherals.

CAUTION

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

RE-Series Laser Module Assembly and Connections

1. Check to make sure the AC power switch located on the rear panel of the eDrive Laser Diode Controller is in the OFF position.
2. Connect D-sub on the base of the RE-Series to the Laser Drive Output located on the rear of the eDrive.
3. Connect the lab door interlock switch (or other interlock used) to the Interlock connector on the rear of the eDrive. If multiple interlocks are needed, be sure all interlocks are connected in SERIES to this port. If no remote interlocks are used, short the connection to allow for normal laser operation.
4. If an external power supply is used, check to make sure the AC power switch located on the front of the external power supply is in the OFF (O) position. Then, connect the output of the supply to the input power lugs of the eDrive located at the upper left of the rear panel.
5. Verify the eDrive has clear space in rear and on each side of unit to allow proper air flow.
6. Plug the eDrive and external power supply (if used) cords into the appropriate facility power. The eDrive diode driver is equipped with universal power circuitry accepting voltages ranging from 100-260 VAC and a frequency range of 47-63 Hz.

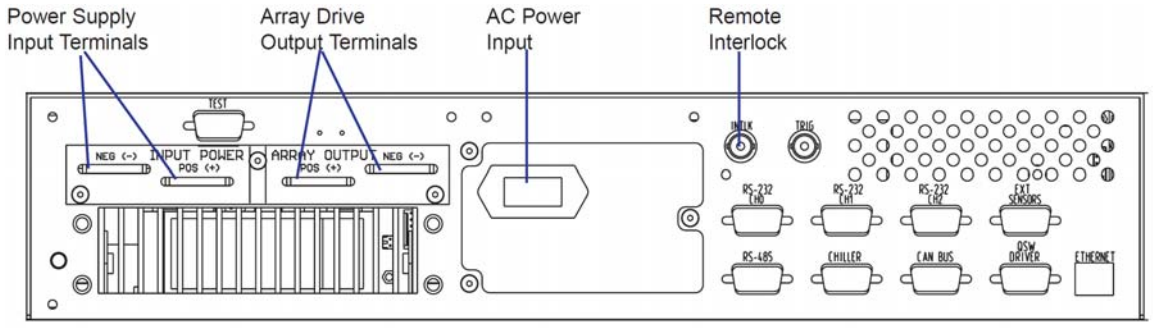

Figure 17 eDrive Rear Panel

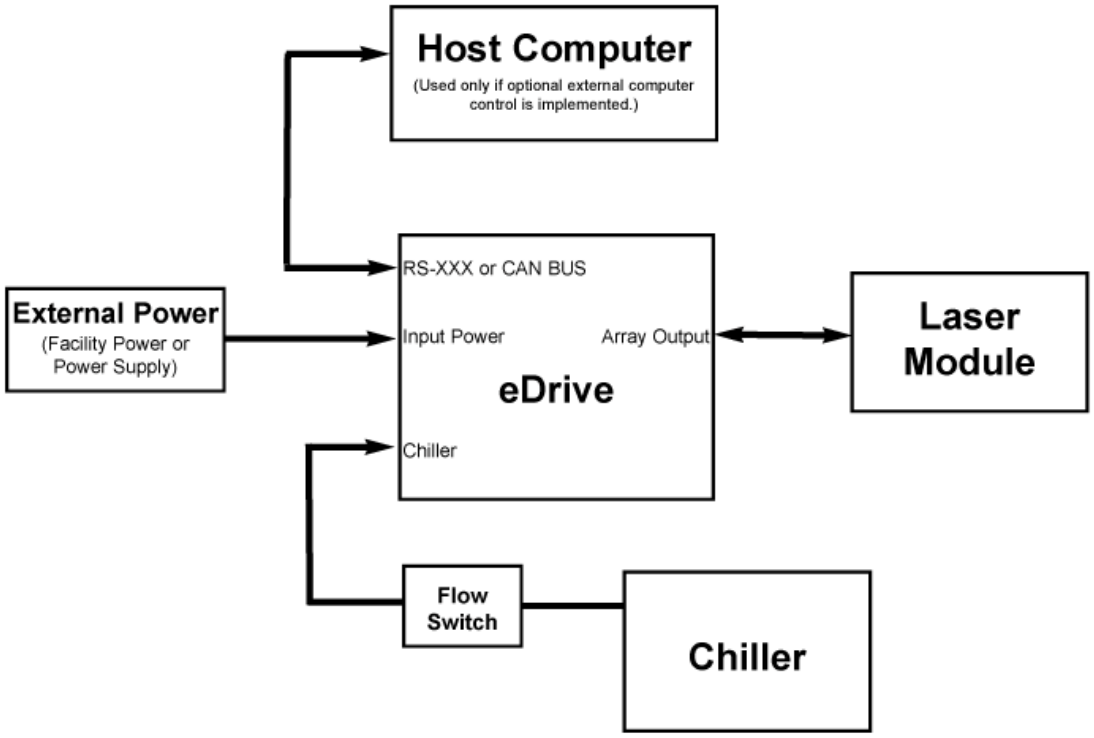

Figure 18 System Connections

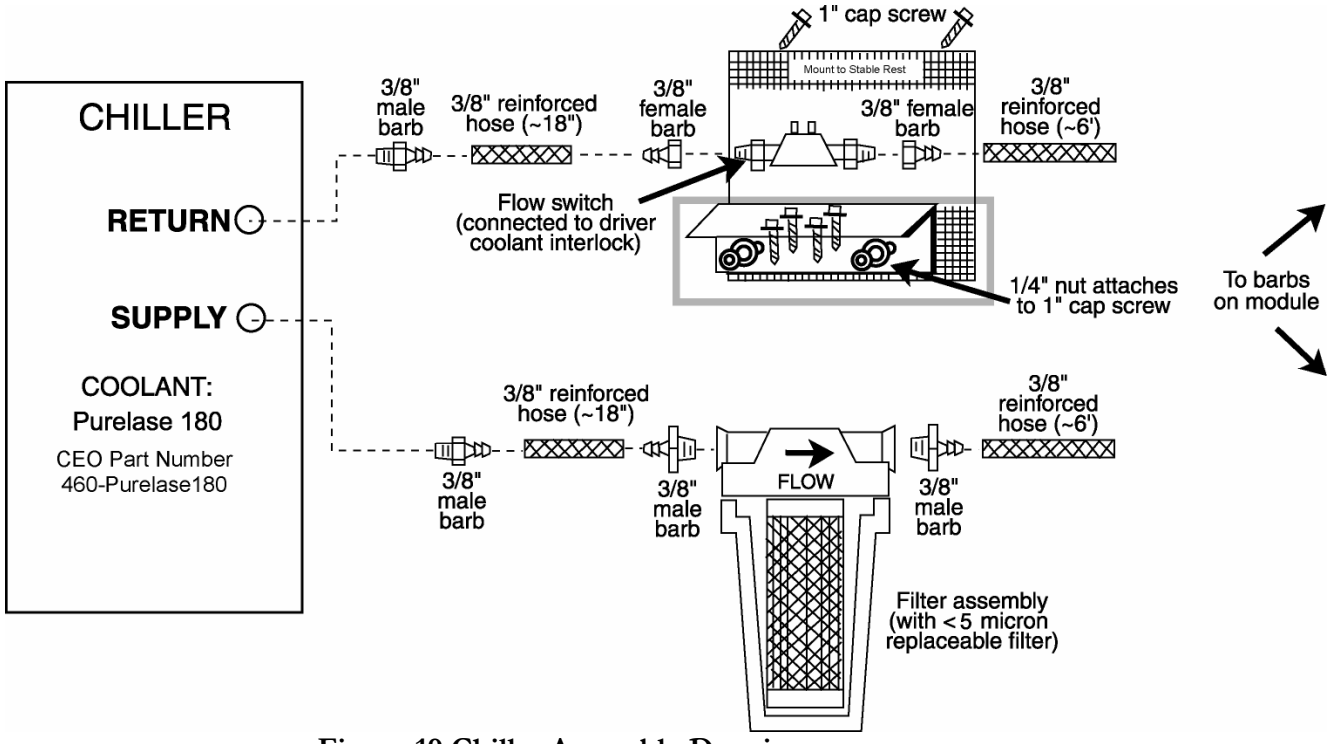

Figure 19 Chiller Assembly Drawing

Closed Loop Water Chiller Assembly

1. Place the chiller on the floor near the RE-Series laser module. Refer to the chiller instruction manual for power requirements, settings and instructions on how to set up the chiller.

2. Attach the cooling lines (included with the plumbing accessory kit) to the hose barb fittings on the chiller and on the RE-Series laser module. Remember to attach the water filter between the chiller and the laser head. The filter may be attached to the back of the chiller or to some other stable mounting point (i.e. wall).

The standard plumbing arrangement for a typical closed loop chiller (including hose diameters) is shown in Figure 19. The input/output water connections on the RE-Series are not polarized. Either hose barb on the RE-Series laser module can be arbitrarily chosen as the coolant inlet. Water flow direction is not important, as long as the water passes through the filter before entering the RE-Series laser module.

CAUTION

Do not use de-ionized (DI) water in the closed loop chiller based system. If you must use DI water, monitor the resistivity (less than 1.0 MΩ) closely and avoid iron or aluminum parts in the coolant loop.

3. Fill the chiller reservoir and filter housing manually with Purelase 180 coolant (part number 460-Purelase180). Purelase 180 is made from DI water with additives to control the PH. By using Purelase 180, scale will not form in the cooling loop. Purelase 180 contains biocide to prevent algae growth and corrosion inhibitors to protect yellow metals and aluminum.

CAUTION

Do not allow chiller to fill the filter housing, as air can become trapped within the system.

4. Turn ON the chiller

5. Make sure no air remains trapped in the lines resulting in a positive back pressure when chiller is turned off. Positive back pressure can hold the flow switch closed even though flow is not being supplied to the laser module. Air is trapped in the lines if water level drops when chiller is turned on and then rises when turned off. Failure to heed this warning may result in the destruction or serious damage to the device, and will void the product warranty.

6. Verify the pressure gauge located on the front panel of the chiller reads approximately 50 psi. If it does not, adjust the bypass valve on the rear of the chiller. Minimum water flow is one gallon per minute. See final test report for optimum flow rate, which should be ~2 gallons per minute.

7. Verify the temperature located on the front panel of the chiller reads appropriately. Optimum temperature is listed on the final test report but will be between 20-35 °C.

CAUTION

Do not allow chiller to fill the filter housing, as air can become trapped within the system.

8. Connect water flow switch to coolant interlock on rear of eDrive diode driver. When connecting the water flow switch, make sure that it is connected to the return line of the chiller and the arrow located on the top of the switch is pointing in the direction of water flow.

Starting the Laser System

Pre-start Conditions

1. Wear laser safety goggles which protect user from1064 nm (fundamental) and 808 nm radiation.
2. Position the RE-Series module in a laser cavity such the output will be directed toward a safe target.
3. Verify that the system is correctly assembled.
4. Verify that the rod faces are clean and not capped or covered.
5. Verify that the filter on the closed loop chiller is connected to the inlet hose barb.
6. Switch the Closed Loop Chiller to the ON position. Verify water flow from chiller.

CAUTION

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

Turning On The Laser System

1. Switch the Closed Loop Chiller to the ON position. Verify water flow from chiller.
2. Verify coolant temperature and flow rate are correct.
3. Turn power switch on external power supply to ON position.
4. Turn the AC power switch on rear of the eDrive to the ON position.
5. Turn the Key switch to the ON position.
6. Before applying current to diodes, shut off chiller to verify that the Coolant Fault interlock comes on.
7. Restart the chiller. Press clear and verify the error display is no longer present.

WARNING

The output beam and fluorescence of the RE-Series module is a safety hazard. Avoid direct viewing of the beam or its specular reflection.

Powering the RE-Series Module

1. Form main menu, select Channel Setup ▸ Channel 1 ▸ Set Current Limit. Use the selection knob to set your maximum current amplitude to a value considered safe for the intended module. The eDrive will not allow the current amplitude to be set higher than the limit. RE-Series modules should never be run with more than 32 Amps, however to prevent premature diode degradation, you may wish to set this limit at the beginning of module life to 5 Amps greater than the recommended operating current.

2. From the main menu, select Channel Setup ▸ Channel 1 ▸ Set Current. Use the selector knob to select a low current level of approximately 10A.

3. Press EMISSION. After a few warning beeps (approximately 4 second delay), the eDrive begins to drive the array.

4. Slowly begin to adjust the current amplitude setting until the desired current level is achieved. Rate f increase in current should not exceed 3A/s. (For initial operation, see final test report for current.)

5. Using an infra-red viewer or phosphor card continue increasing the current checking for output at the laser threshold current indicated on the final test report.

6. Continue increasing the current until the desired output is obtained or until the current reaches approximately 5 A greater than the current used that last time an acceptable laser output was achieved. (For beginning of life operation, see final test report for current.)

7. If you cannot achieve desired output within 5 A, contact CEO for assistance.

Standby Condition

If you are finished using the module but want to use it again within the next hour, it is best to go to "standby". To go to standby from a lasing condition, press the EMISSION button on the eDrive Laser Controller. In this condition, the drive current to the laser diode shuts off but the closed loop chiller maintains the optimum diode temperature.

To resume lasing, press the EMISSION button on the eDrive laser controller. Again an audible warning will sound for approximately 4 seconds prior to firing the laser.

Turning Off the System

1. Press the EMISSION button to turn off drive current.
2. Close shutter (if installed).
3. Switch the main AC power switch on the external power supply, located on the front panel, to the OFF position.
4. Press the main AC power switch of the eDrive, located on the front panel. Hold down for approximately 5 seconds until the eDrive shuts down.
5. Allow chiller to run for a couple of minutes (1-2 minutes).
6. Switch the closed loop chiller to the OFF position.
7. Turn off the key switch.
8. Remove the key. Do not leave the laser accessible to people who are untrained in laser safety or operation.

WARNING

Hazardous voltages are present in this system during normal operation. Before removing the cover, 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.

Chapter 5 Maintenance

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.

Adjusting the Operating Current

The specification for laser module optical output is provided in the final test report delivered with the system. During its early lifetime, the laser diodes will deliver this specified power at or below 25 A of current. Due to the high average powers of the diode bars used in your NGST Cutting Edge Optronics laser module, it is reasonable to expect the diode array to gradually degrade with use.

Determining when the current limit requires adjustment:
Make sure the temperature is at the correct set point. If the temperature is incorrect low output power can result, leading to unnecessary current increases. Check to make sure the rod faces are clean. If the rod faces are dirty low output power will result, leading to unnecessary current increases. Check to make sure the coolant and filter are clean. If the coolant is dirty, deposits accumulate on the Nd:YAG rod, which prevents absorption of diode light. This results in low output power, leading to unnecessary current increases. If the temperature is correct and the rod faces and coolant are clean, yet the output power is still low, the operating current may need to be slightly raised. Contact your NGST Cutting Edge Optronics field service engineer if you have any doubts.

CAUTION

Raising the current limit before it becomes necessary can severely shorten diode lifetime.

Adjusting the Temperature Set Point for the Re-circulating Water Chiller: The temperature set point for the water chiller was determined at NGST CEO and indicated on the Final Test Report. Normally the temperature will not need adjustment. It is possible however, that this adjustment may be recommended by your Cutting Edge Optronics field service engineer during the later part of the laser diodes' lifetime and after several current increases.

Increasing the diode drive current increases the heat load on the diode, resulting in a shift in diode wavelength. In order to compensate for this shift a slight adjustment, most likely colder, of the temperature set point on the recirculation water chiller may be required. Changing the temperature set point will change the output wavelength of the laser diode; this adjustment should be done in one degree Celsius increments. Look for an increase in optical output power on an external power meter. Wait a few minutes between each adjustment allowing the chiller to stabilize. Continue until you obtain the maximum possible power.

CAUTION

Do not operate coolant system below air condensation temperature (dew point) at laser head. Condensation on the diode arrays can seriously damage the laser head.

Cleaning the Chiller

Every six months, the chiller should be drained and cleaned. The filter should be replaced, and new clean coolant should be used in the chiller. The recommended procedure for cleaning a chiller is detailed below.

1. Drain chiller completely.
2. Remove filter from housing.
3. Add the 460-CCL2567 cleaning solution to the cooling system till full.
4. Circulate the cleaner for a minimum of 30 minutes.
5. Drain system completely.
6. Refill system with cleanest water available (preferably distilled, demineralized, or reverse-osmosis)
7. Circulate rinse water for 20 minutes.
8. Drain system completely.
9. Refill system with cleanest water available (preferably distilled, demineralized, or reverse-osmosis)
10. Circulate second rinse water for 10 minutes.
11. Drain system completely.
12. Install new 5 micron filter into housing.
13. Record cleaning date on sticker with a six-month reminder to drain & clean the system. Affix sticker to chiller (or cabinet).
14. Refill chiller coolant reservoir with Purelase 180 coolant.
15. Chiller ready to use.

Chapter 6 Service

The only user serviceable part in the RE-Series 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 RE-Series module. Contact Cutting Edge Optronics if you have any further questions.

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.

1. Remove four fasteners releasing Macor shields.
2. Using hemostats and lens tissue, wetted with acetone or methanol, wipe the rod face in a circular motion from the center of the rod to the edges.
3. Inspect the rod for cleanliness.
4. Reinstall Macor shields. Ensure that the gap is minimal between Macor shield and laser rod. The Macor shields protect the retainer nut and O-rings from stray laser radiation.

Rod Removal and Replacement

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.

1. Remove four fasteners releasing Macor shields.
2. Remove the two retainer nuts from the ends of the module using the CEO spanner wrench#60-590-1.

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. Extract one of the O-rings that hold the rod in place using a dental pick or other similar tool. Stick the sharp end of the dental pick into the O-ring and pull away from the pump module. New O-rings will be used during the installation of the new rod. Be very careful not to damage the rod ends, or barrel, with the extraction tool.
4. Remove the rod by applying slight pressure in order to break the O-ring seal on the opposite end. Partial extraction of the O-ring on the opposite end may

be needed. If necessary, loosen the O-ring with the dental pick. Once again, be careful not to damage the rod ends, or barrel.

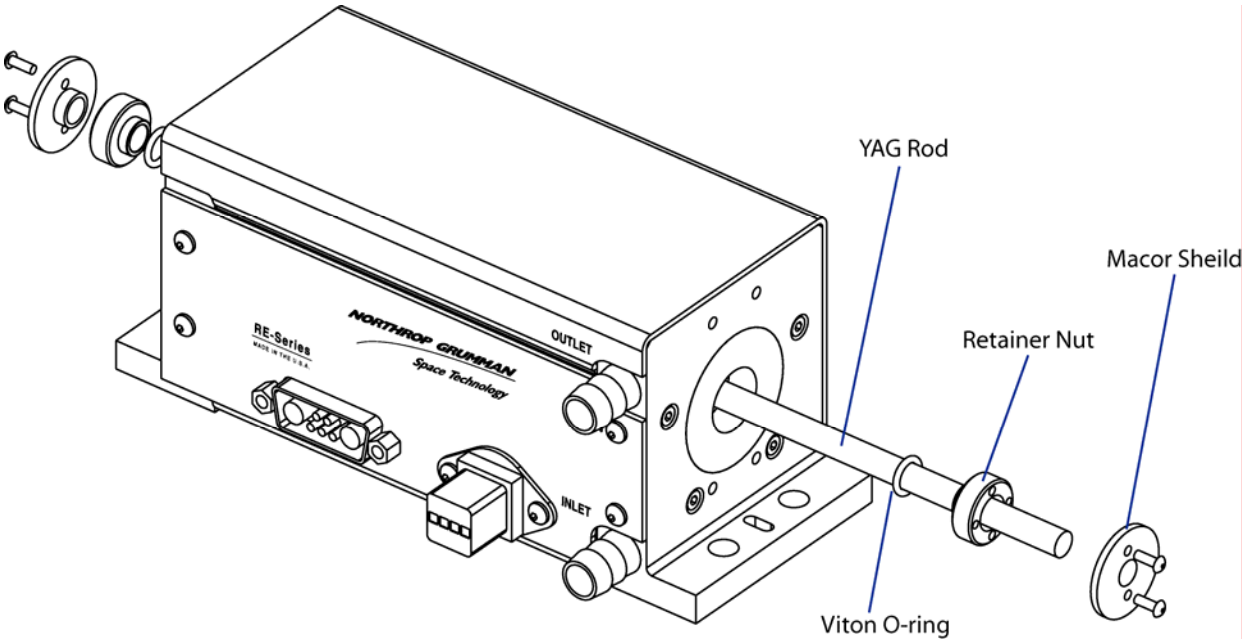

Figure 20 Rod Replacement Drawing

5. Clean threads on endcaps and retainer nuts with a Q-tip . This should ensure that the parts are free of debris.
6. Unwrap the new rod and inspect the end faces.
7. Obtain two #010 white Viton O-rings when using a 6.35mm diameter rod.
8. 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.
9. 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. The rod is very fragile. Be careful not to chip or scratch the rod while inserting it.
10. Inspect the rod end (with o-ring) for cleanliness. If needed, clean the end of the rod with methanol and cotton swabs.
11. Place one of the retainer nuts over the end of the rod with the O-ring. Thread the retainer nut in until it is finger-tight.
12. Place the second white O-ring over the opposite end of the rod.
13. Inspect this rod end for cleanliness. If needed, clean the end of the rod with methanol and cotton swabs
14. Thread the second retainer nut into the pump module.
15. Using the retainer nut, carefully push the o-ring into the groove. Seat O-ring into groove.
16. Position the rod equidistant from each end of the pump module using the soft end of a cotton swab.

17. Tighten the retainer nuts with the spanner wrench just enough to compress the O-rings. Do not over-tighten. Over-tightening may cause unwanted strain, or possibly damage the rod. Tighten the retainer nuts approximately a quarter turn past finger-tight.
18. Reinstall Macor shields. Ensure that the gap is minimal between Macor shield and laser rod. The Macor shields protect the retainer nut and O-rings from stray laser radiation.
19. Inspect both rod ends for cleanliness. Due to the abrasive nature of threading two metal parts together metallic dust particles may have found there way onto the rod ends. If necessary, clean the ends of the rod with a puff of dry nitrogen or moisture-free canned air.
20. 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.
21. 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.

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.

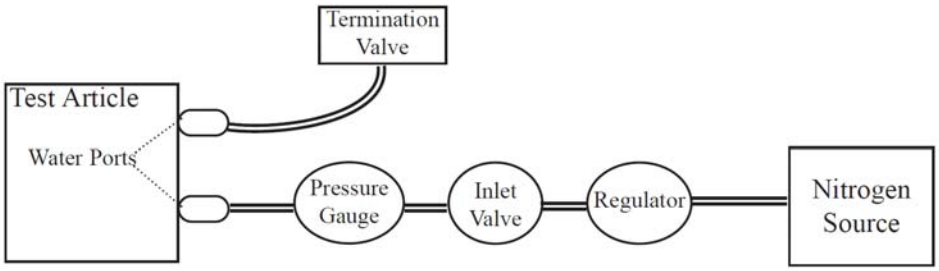

Figure 21 Nitrogen Leak Test Layout

1. Attach a nitrogen source to one of the water ports on the module being tested (test article) and attach the termination valve to the other water 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.

Chapter 7 Return for Repair

At NGST 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 that we provide 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 inside the United States, dial 636.916.4900. To phone for service in other countries, contact your sales agent.

Return of the Instrument for Repair

Contact NGST Cutting Edge Optronics or your local distributor for shipping instructions, and forward the instrument prepaid to the destination indicated.

WARNING

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

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

Special NGST Cutting Edge Optronics packing boxes designed to securely hold instruments during shipment should be used. If shipping boxes have been lost or destroyed, we recommend that you obtain a new one, for a nominal charge, from NGST CEO.

WARNING

Residual water damage, due to condensation or expansion when tightly sealed, can catastrophically damage the diode arrays or laser rod. Such damage is excluded from warranty coverage.

Warranty

NGST CEO sends the applicable warranty to the prospective purchaser with each quote. Contact NGST CEO Sales and Marketing personnel for additional copies or to answer any warranty questions.

Disposal

In accordance with WEEE (Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment), Cutting Edge Optronics accepts the return of our products for disposal. Please package the products as directed for a return for

repair. Contact NGST CEO or your local distributor for shipping instructions and indicate inform them of a return for disposal. Forward the instrument prepaid to the destination indicated.

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, NGST CEO includes the following information about our laser modules.

The translation document below is according to clause 6.2 of SJ/T 11364:2006

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

部件编号	部件名称	有毒有害物质或元素					
		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							

Figure 22 ROHS Declaration Table

Northrop Grumman Space Technology
Cutting Edge Optronics
20 Point West Boulevard
Saint Charles, MO 63301 USA
636.916.4900 phone • 636.916.4994 fax