# Service Manual

## Iklwa II $TEM_{00}$ Green Laser
## Patara II $TEM_{00}$ Green laser


SVC-UMAN-0007 C
JANUARY 2019

NORTHROP GRUMMAN

## Worldwide Technical Support and Product Information

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## Product End-of-Life Handling

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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 includes the following translation about our products.

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 | IKA-012-QTGP-XXXX　PA-016-QTGP-XXXX<br>IKA-016-QTGP-XXXX　PA-020-QTGP-XXXX<br>IKA-020-QTGP-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 | 外壳 | O | O | O | O | O | O |
| 第二组 | 电线/ 连接插头 | X | O | X | X | X | X |
| 第三组 | 安装组件 | O | O | O | X | O | O |
| 第四组 | 开关组件 | O | O | O | X | X | X |
| 第五组 | 电路板/ 开关组件 | X | O | O | O | X | X |
| 第六组 | 阵列前端次模组 | O | O | O | O | O | O |
| 第七组 | 接触板 | X | O | O | O | X | X |
| 第八组 | 热交换组件 | O | O | O | O | O | O |
| 第九组 | 16 进制硬件 | O | O | X | O | O | O |
| 第十组 | 焊锡 | X | O | X | O | O | O |
| 第十一组 | 电线/ 连接插头 | X | O | O | O | X | X |
| 第十二组 | 基部/ 端帽 | X | O | O | X | O | O |
| 第十三组 | 硬件/ 装配 | O | O | O | X | O | O |
| 第十四组 | 时计组件 | X | O | O | X | X | X |
| 第十五组 | 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**<br>**O** | Power Switch Position Symbols<br>I = On  O = Off |

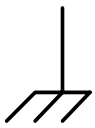
The following conventions may appear on the product:

| | |
|---|---|
| **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

## Additional Resources

NG is committed to providing support for all customers. Installation how-to videos, technical manuals, and descriptions and specifications of products can be found by visiting http://www.ngceoservice.com.

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# Chapter 1: General Instructions

## Safety

Some repair and diagnostic procedures require the opening of the laser while the system is running. Wear the correct eye protection and also be careful of electrical hazards. The laser system has been designed to minimize the risk, but still be cautious and conscious of your and others safety.

### 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 (532 nm, 808 nm and 1064 nm).
- 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 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.

## Caution & Warning Statements

**WARNING** The NG 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 Laser Diode Module are sensitive to Electro-Static Discharge (ESD). Never handle the module without being properly grounded through the use of properly installed and maintained grounding wrist straps or other ESD control devices. Subjecting the module 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.

**WARNING** NG recommends that a qualified service technician perform the service on the laser to avoid any damage.

**NOTE:** Laser safety goggles for 532nm must be worn during lasing process.

**NOTE:** Gloves must be worn at all times during service. Service procedures must be performed in a clean room environment when the cover is removed.

# Cleanliness

The laser is a delicate piece of hardware and is susceptible to optical damage due to contamination. WEAR GLOVES AND OPEN THE LASER IN THE CLEANEST ENVIRONMENT AVAILABLE. Do not use any unauthorized epoxy or glue in the laser housing. DO NOT TOUCH THE OPTICAL SURFACES. Optical surfaces should be inspected using a 10x microscope with 15 W illumination. Optical surfaces should only be cleaned if there is visible contamination. Only optical grade methanol or acetone should be used with lint free lens tissue. Failure to keep a clean environment may lead to permanent damage to optical surfaces.

After performing any procedures contained in this manual, always inspect the laser for debris before replacing the cover.

# Tools, Equipment, and Materials

- TechniCloth III™ wipes
- Isopropyl alcohol
- Streamlight™ Stylus Green LED pen
- Allen wrenches
- Torque wrench
- Spanner wrench
- SwageLok Go No Go Gauge
- Open ended wrenches
- Heat Gun

- Power Meter (minimum 30W rating)
- Camera System (Spiricon preferred)
- Fused silica 3% wedge
- Filter Wheel
- 0.391 meter focal length lens  PLCX-50.8-180.3-UV-1064/532
- Fast Photodiode with BNC cable and oscilloscope (100 MHz min)
- Neg Lens part number PLCC-25.4-25.8-UV-1064/532
- HeNe alignment laser and turn mirrors
- Microscope with surface illumination
- 60-658-1 Alignment Aperture without Alignment Pin
- Desiccant cartridge NG part no. 42-228
- Desiccant Refill part number 643665
- Desiccant Refill tool 980412
- McMaster Disposable Tube-Fitting Filter part no. 4795K22
- McMaster Female QD part no. 5012K83
- McMaster ¼” Hose part no. 52375K32
- McMaster 3/16” Hose part no. 52375K31
- Male QD O-Rings #011 Black Viton (2 required)
- Output Window O-Rings #020 Black Viton (2 required)
- 8” Nylon clear cable ties
- Side cutters
- 3M 2216 two part epoxy
- X-ACTO Knife

# Alignment Reference, Test Set-up and Laser Layout

If possible, the laser should be referenced to a HeNe (or similar alignment laser) prior to any modifications to the laser. The ideal testing and tuning set-up is shown in **Figure 1-1**. The layout and location of the laser components are shown in **Figure 1-2**.

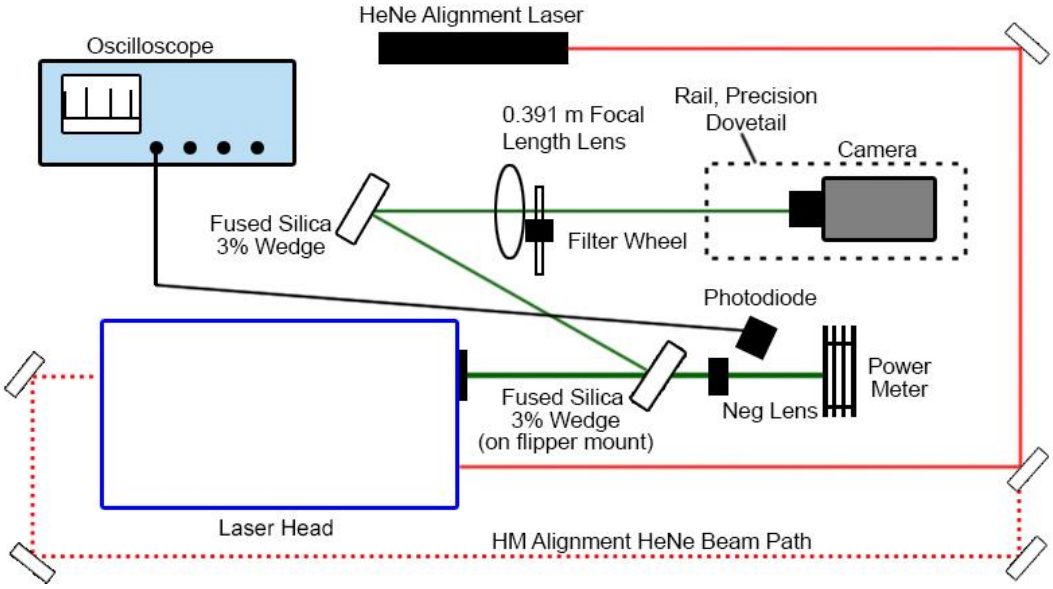


**Figure 1-1:** Laser Alignment and Test Set-up Diagram

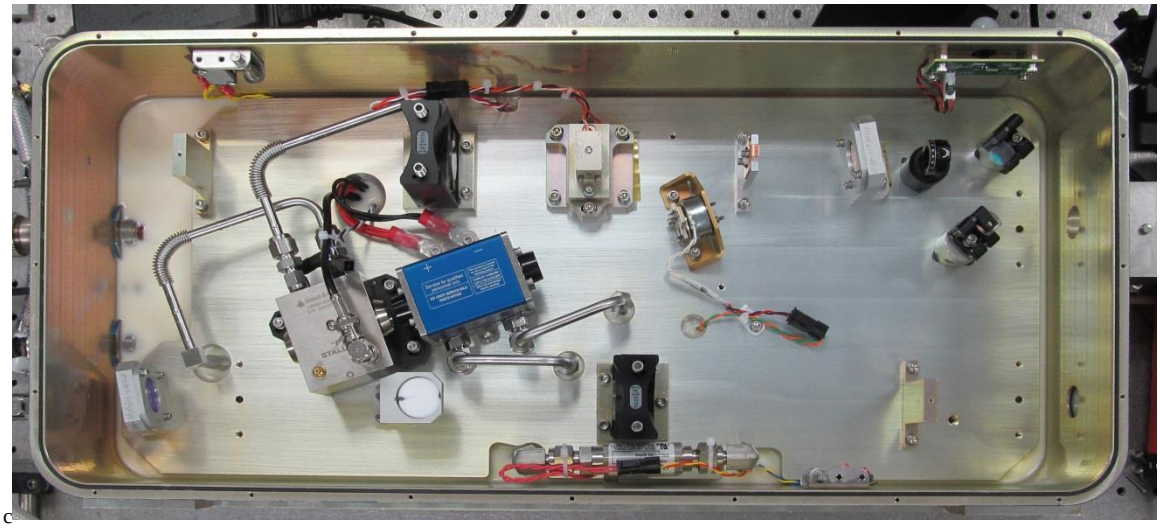

**Figure 1-2:** Optical Bench Overview

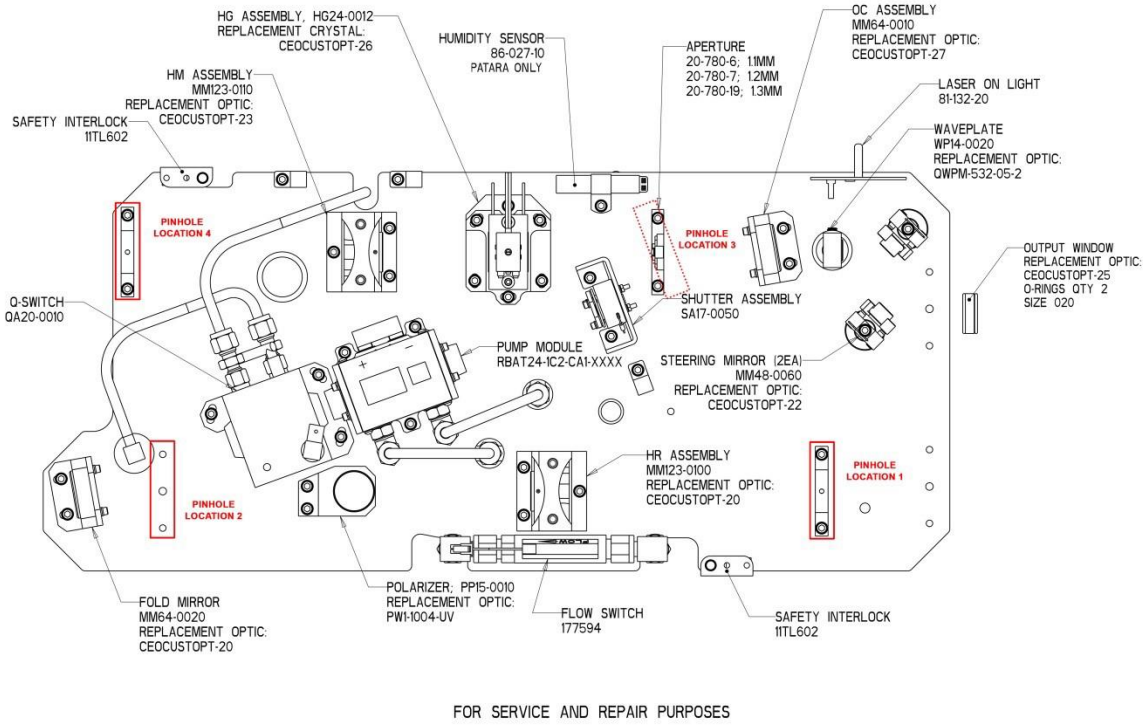


**Figure 1-3:** Laser Layout and Component Locations

# Fastener Torque and Tack Locations

After replacement of laser components, all fasteners should be tightened, unless otherwise specified, to the recommended torque value contained in **Table 1-1**, below

**Table 1-1:** Recommended Torque Values

| Fastener Size | Recommended Torque (IN-LBS) |
|---|---|
| 4-40 | 5.5 +/- 0.5 |
| 6-32 | 14 +/- 1 |
| 8-32 | 25 +/- 1 |
| 10-32 | 40 +/- 2 |
| 1/4-20 | 80 +/- 3 |

Tack locations are shown in **Figure 1-3**. NG recommends using 3M 2216 for tacking components and fasteners as indicated. Allow for a minimum of 12 hours of curing time before closing the laser housing.

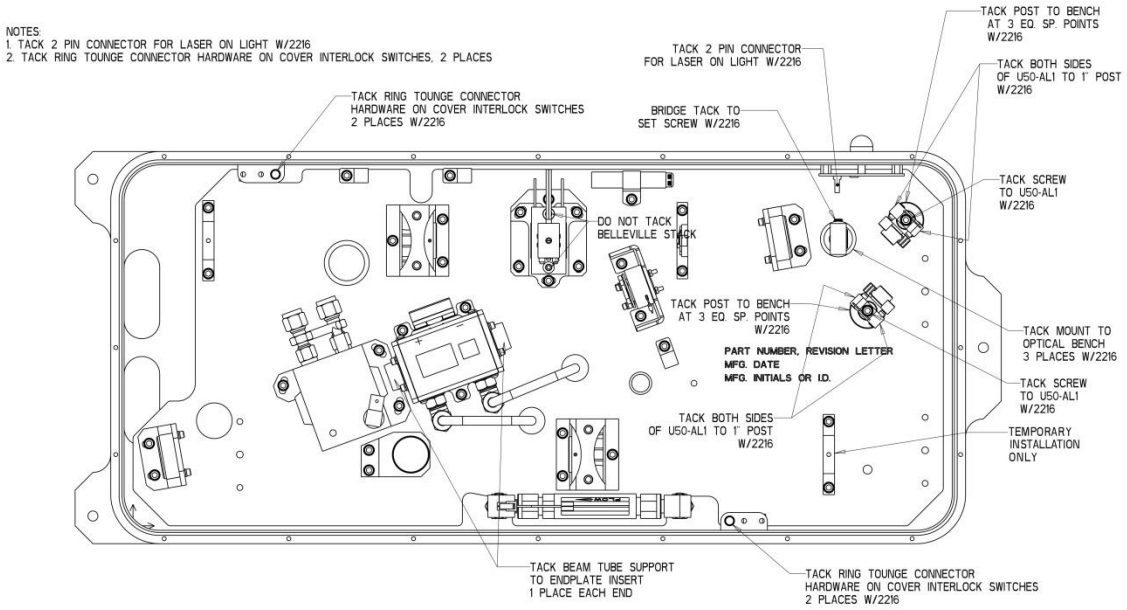


**Figure 1-4:** Laser Tack Locations

# Servicing the Laser

The following table lists the recommended order of procedures to successfully perform service operations on the laser. Refer to the sections contained in this service manual for detailed instructions.

**Table 1-2:** Service Action Table

| Service Operation | Order of procedures |
|---|---|
| Replacing the Aperture | 1. Remove Cover (page 28)<br>2. Aperture Removal (page 13)<br>3. Aperture Replacement (page 14)<br>4. Tack Components (page 6)<br>5. Install Cover (page19)<br>6. Laser Optimization (page 43) |
| Replace Desiccant | 1. Desiccant Replacement (page 14) |
| Replacing the Emission Light | 1. Remove Cover (page 28)<br>2. Emission Light Replacement (page 16)<br>3. Tack Components (page 6)<br>4. Install Cover (page19) |

| Service Operation | Order of procedures |
|---|---|
| Replacing the Flow Switch | 1. Remove Cover (page 28)<br>2. Coolant Line Purge (page 14)<br>3. Flow Switch Assembly Replacement (page 16)<br>4. Leak Test (page 45)<br>5. Install Cover (page19) |
| Replace the Fold Mirror or OC Optic | 1. Remove Cover (page 28)<br>2. Fold Mirror / Output Coupler Replacement (page 17)<br>3. Defeat Cover Interlocks (page 41)<br>4. Power Laser for Alignment (page 39)<br>5. Check for Bullseye (page 40)<br>• If concentric go to step 7<br>6. HR/HM Alignment (page 17-18) (HR first if replacing Fold Mirror, HM first if replacing OC)<br>7. Check Hold-Off (page 40)<br>8. Install Cover (page19)<br>9. Laser Optimization (page 43)<br>10. Check Hold-Off (page 40) |
| Replace the HM | 1. Remove Cover (page 28)<br>2. Align HeNe to Optic (page 12) (reference point)<br>3. HM Replacement (page 17)<br>• Use HM adjustment screws to align HeNe reflection back to reference point.<br>4. Defeat Cover Interlocks (page 41)<br>5. Power Laser for Alignment (page 39)<br>6. Check for Bulleye (page 40)<br>• If concentric go to Step 8<br>7. HR/HM Alignment (page 17-18) (HR alignment may not be necessary)<br>8. Check Hold-Off (page 40)<br>9. Tack Components (page 6)<br>10. Install Cover (page19)<br>11. Laser Optimization (page 43)<br>12. Check Hold-Off (page 40) |

| Service Operation | Order of procedures |
|---|---|
| Replace the HR | 1. Remove Cover (page 28)<br>2. Align HeNe to Optic (page 12) (reference point)<br>3. HR Replacement (page 18)<br>4. Defeat Cover Interlocks (page 41)<br>5. Power Laser for Alignment (page 39)<br>6. Check for Bullseye (page 40)<br>• If concentric go to step 8<br>7. HR/HM Alignment (page 17-18) (HM alignment may not be necessary)<br>8. Check Hold-Off (page 40)<br>9. Tack Components (page 6)<br>10. Install Cover (page19)<br>11. Laser Optimization (page 43)<br>12. Check Hold-Off (page 40) |
| Replacing the Interlocks | 1. Remove Cover (page 28)<br>2. Interlock Replacement<br>3. Install Cover (page19) |

| Service Operation | Order of procedures |
|---|---|
| Replacing the Module | 1. Coolant Line Purge (page 14)<br>2. Remove Cover (page 28)<br>3. Polarizer Removal and Installation (page 26)<br>• Step 1-2<br>4. HR Replacement (page 18)<br>• Step 1<br>5. Laser Module Replacement (page 23)<br>6. Aperture Remove (page 13)<br>7. HM Replacement (page 17)<br>• Removal Only<br>1. Remove Q-switch from Beam Path (page 29)<br>2. SHG Crystal Replacement and Alignment (page 30)<br>• Step 1-2<br>3. Laser Module Alignment (page 20)<br>4. Q-Switch Replacement (page 27)<br>• Replacement Steps Only<br>5. Polarizer Removal and Installation (page 26)<br>• Installation Only<br>6. Leak Test (page 45)<br>7. Defeating the Cover Interlocks (page 41)<br>8. Power the Laser for Alignment (page 39)<br>9. SHG Replacement and Alignment (Step 15-20)<br>10. HR/HM Alignment (page 17-18)<br>11. Align Q-switch for Hold-Off (page 39)<br>12. Aperture Replacement (page 14)<br>13. Tack Components (page 6)<br>14. Install Cover (page19)<br>15. Laser Optimization (page 43)<br>16. Check Hold-Off (page 40) |
| Replacing the Output Window | 1. Output Window Replacement (page 26) |
| Replacing the Polarizer Assembly | 1. Remove Cover (page 28)<br>2. Polarizer Assembly Removal and Replacement (page 26)<br>3. Tack Components (page 6)<br>4. Install Cover (page19)<br>5. Power Laser on for Alignment (page 39)<br>6. Laser Optimization (page 43)<br>7. Check Hold-Off (page 40) |

| Service Operation | Order of procedures |
|---|---|
| Replacing the Q-switch | 1. Remove Cover (page 28)<br>2. Coolant Line Purge (page 14)<br>3. Q-switch Replacement (page 27)<br>4. Leak Test (page 45)<br>5. Defeating the Cover Interlocks (page 41)<br>6. Power the Laser on for Alignment (page 39)<br>7. Aligning the Q-switch for Hold-Off (page 39)<br>8. Tack Components (page 6)<br>9. Install Cover (page19)<br>10. Laser Optimization (page 43)<br>11. Check Hold-Off (page 40) |
| Replacing the SHG Crystal | 1. Remove Cover (page 28)<br>2. Defeat Cover Interlocks (page 41)<br>3. SHG Replacement and Alignment (page 3)<br>4. HR/HM Alignment (page 17-18) (HR alignment may not be necessary)<br>5. Aperture Replacement (page 14)<br>6. Tack Components (page 6)<br>7. Install Cover (page19)<br>8. Laser Optimization (page 43)<br>9. Check Hold-Off (page 40) |
| Replacing the Shutter | 1. Remove Cover (page 28)<br>2. Shutter Replacement (page 34)<br>3. Tack Components (page 6)<br>4. Install Cover (page19) |
| Replacing Steering Mirrors | 1. Remove Cover (page 28)<br>2. Defeat the Cover Interlocks (page 41)<br>3. Steering Mirror Replacement (page 35)<br>4. Tack Components (page 6)<br>5. Install Cover (page19) |
| Optics Bonding Procedure | 1. Install Mirror/Lens Into Mount (page 24) |
| Replacing the Waveplate | 2. Remove Cover (page 28)<br>3. Defeat Cover Interlocks (page 41)<br>4. Waveplate Replacement (page 37)<br>5. Tack Components (page 6)<br>6. Install Cover (page19) |

# 2

# Chapter 2: Laser Component Replacement Procedures

**NOTE:** Gloves must be worn at all times during service. Service procedures must be performed in a clean room environment when the cover is removed.

## Align HeNe to Optic

1. Mount HeNe at least 2 meters from the laser housing HR or HM access port. See **Figure 1-1**. The HR access port is the plug on the front of the laser housing. The HM access port is the screw below the J1 connector on the rear of the laser housing.
2. For HR alignment, remove the pin hole from location 1. For HM alignment, remove the pin hole from location 4. See **Figure 1-2**.
3. Mark the location of the HeNe reflection from the mirror. The replacement optic will be aligned to this reference point.

# Aperture Removal

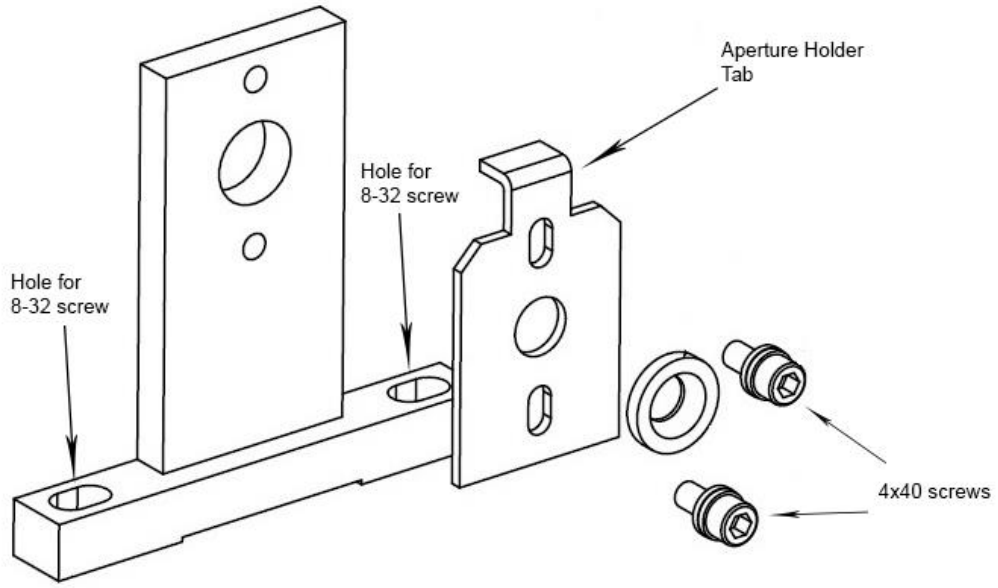


**Figure 2-1:** Aperture Assembly (AA21)

1. Remove the 8-32 screws and locking hardware holding the aperture mount to the laser bench. Care should be taken to clean any debris from the inside of the laser housing that may be generated from breaking the epoxy bonds.
2. Place the aperture assembly on a flat surface. If applicable, heat the epoxy on the 4-40 screws of the aperture mount with a heat gun and remove the epoxy. Remove any residual epoxy from the mount.

# Aperture Replacement

1. Turn the laser current down below threshold.
2. Install the aperture assembly in **Figure 2-1** to the laser bench with the (2) 8-32 fasteners and locking hardware. Center the mount to the screw locations. To allow adjustment, do not tighten the fasteners.
3. Increase the current to just above threshold.
4. Adjust the mount side to side to achieve bulleye.
5. While holding the tab of the aperture holder, loosen the 4-40 screws to allow vertical adjustment of the aperture.
6. Adjust the aperture holder up and down to achieve bullseye.
7. Increase the current to the full power level. Repeat steps 4-6 with minor adjustments to achieve maximum power.
8. Torque 8-32 screws to 25 in-lbs. Torque 4-40 screws to 5.5 in-lbs.

**NOTE:** Typical aperture size is 1.2 mm. If the insertion loss (decrease of output power) of the aperture is not approximately 1 Watt, then the aperture size should be changed. To increase the insertion loss (decrease output power), install a 1.1 mm aperture. To decrease the insertion loss (increase output power), install a 1.3 mm aperture. Contact NG technical service for replacement apertures.

# Coolant Line Purge

1. Turn off the drive electronics and chiller.
2. Disconnect the coolant lines with the quick disconnects.
3. Connect a dry nitrogen (or oil free dry clean air line).
4. Connect a hose with proper quick disconnect fitting to the outlet port to drain the coolant.
5. Turn on the air slowly to purge the coolant.
6. Run the air at 3-5 psi through the system for at least ½ hour.
7. Turn off the air and remove the hoses.

# Desiccant Replacement

1. Blow off debris outside of laser housing using nitrogen or dry Class 0 air.
2. Wipe the housing clean using TechniCloth III™ wipes and isopropyl alcohol.

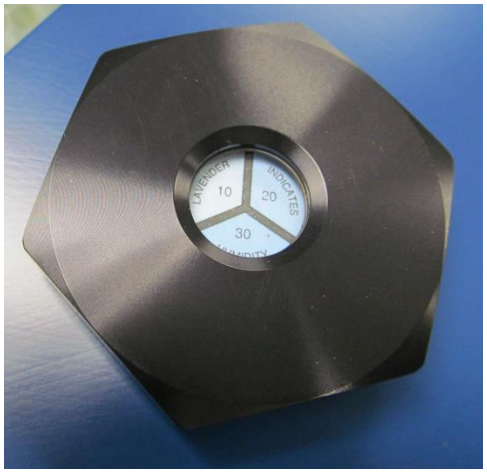


**Figure 2-2:** 40 Gram Desiccant Cartridge Top

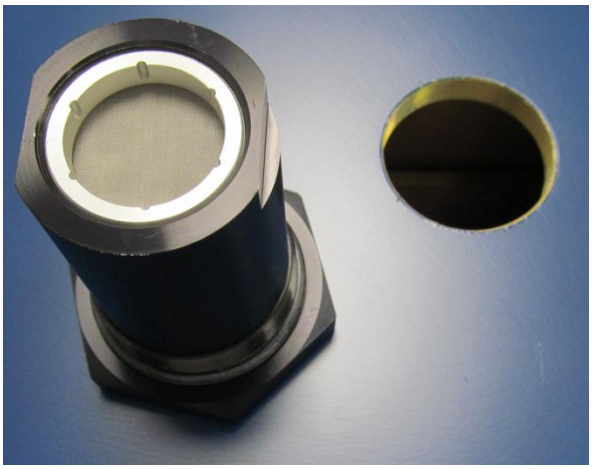

**Figure 2-3:** 40 Gram Desiccant Cartridge Bottom

3. Remove the desiccant cartridge from the top cover of the laser housing. Use the refill tool to remove the retainer ring, and exchange the desiccant. The refill package contains 50 grams of desiccant. Fill the cartridge to the counter-bore surface where the filter is mounted. Do not overfill. Fill as shown in Figure 2-4.


**Figure 2-4:** 50 Gram Refill and Refill Tool

4. Make sure that there are no desiccant beads on the surface where the filter is mounted. Install the paper filter, then the screen, then the retainer ring. Hand-tighten the retainer ring with the refill tool. Replace the desiccant cartridge immediately to minimize the amount of time that the desiccant cartridge is removed from the laser housing.
5. Tighten the desiccant cartridge by hand. DO NOT OVERTIGHTEN.

**WARNING**. Do not operate the laser without a functional desiccant cartridge. Condensation on the diode arrays or other optics can seriously damage the laser and may void warranty.

# Emission Light Replacement

1. Break the epoxy bond on the connector of the emission light circuit card and disconnect the connector.
2. Remove the (4) 6-32 screws and locking hardware that secure the emission light circuit card to the standoffs inside the laser housing.
3. Attach the new emission light circuit card to the laser housing using the (4) 6-32 screws and locking hardware and torque to 14 in-lbs.

# Flow Switch Assembly Replacement

1. Cut wire bundle zip ties as needed and disconnect the electrical quick disconnect.
2. Note the coolant flow direction as indicated on the flow switch housing. The flow switch is on the return side of the coolant loop. The arrow should point towards the Coolant Out quick disconnect on the back of the laser housing.
3. Loosen the SwageLok fittings highlighted in **Figure 2-5**. Remove HR mirror if needed.

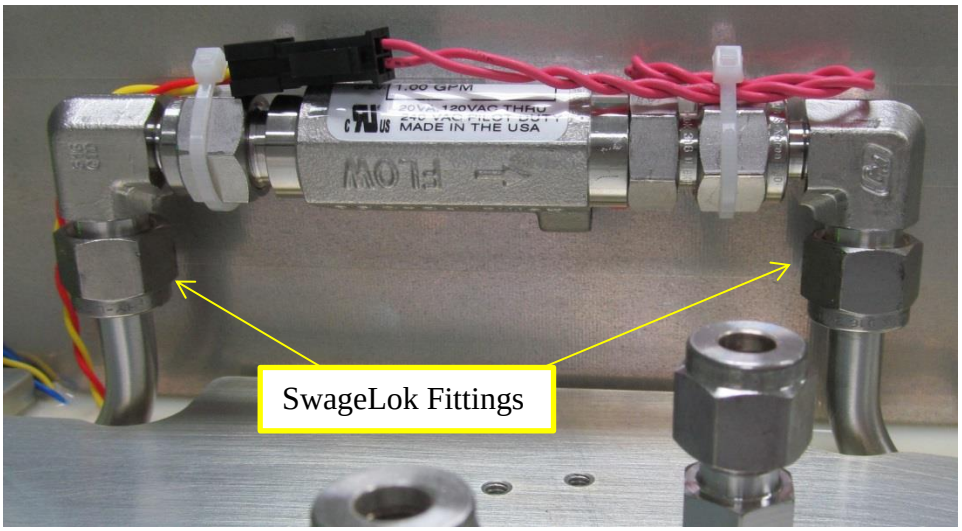


**Figure 2-5:** Flow Switch Assembly (177594)

4. Remove the flow switch assembly. Remove any debris from the laser housing.
5. Once out of the laser, remove the SwageLok elbows from the flow switch. Place the elbows on the replacement flow switch. Do not tighten.

6. Install the new flow switch in the same orientation as noted in step 3. Tighten all SwageLok fittings.
7. Reconnect the electrical connector and secure wires with zip ties. Replace HR mirror if needed.

# Fold Mirror / Output Coupler Replacement

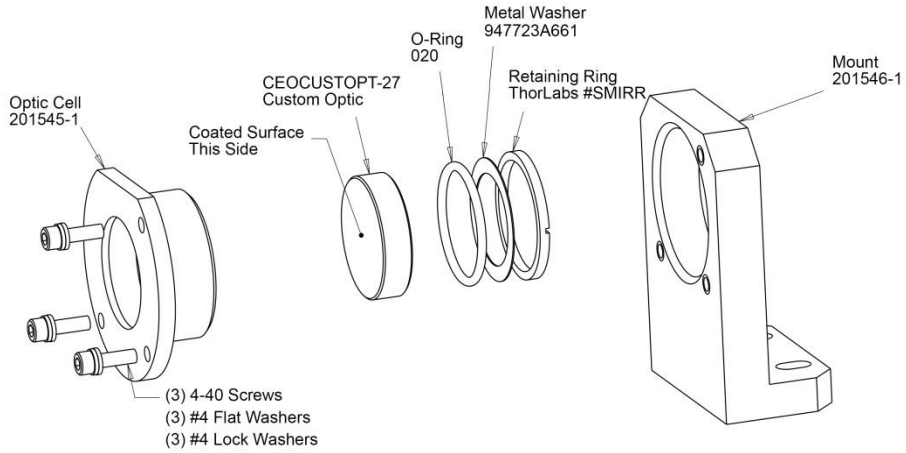


**Figure 2-6:** Optical Mount (MM64), Exploded View

1. Remove the optic assembly from the mount by removing the (3) 4-40 screws, flat washers, and lock washers.
2. Hold the optic assembly with the retaining ring on the bottom side. Use a spanner wrench to remove the retaining ring. Carefully remove the o-ring, metal washer, and optic from the cell.
3. Inspect the new optic and clean as needed. Identify the coated surface, an arrow on the side of the optic points toward the coated surface.
4. Place the new optic in the cell with the coated surface oriented as shown in **Figure 2-6**. Install the o-ring, the metal washer, and the retaining ring. Hold the optic assembly with the retaining ring on the bottom side. Hand-tighten the retaining ring using the spanner wrench.
5. Place the optic assembly into the mount and replace the (3) 4-40 screws, flat washers, and lock washers. Torque to 5.5 in-lbs.

# HM Replacement

1. Remove the laser optic mount and riser block (MM123-0110 – HM assembly) from the laser bench by removing the (3) 8-32 x 5/8” screws.

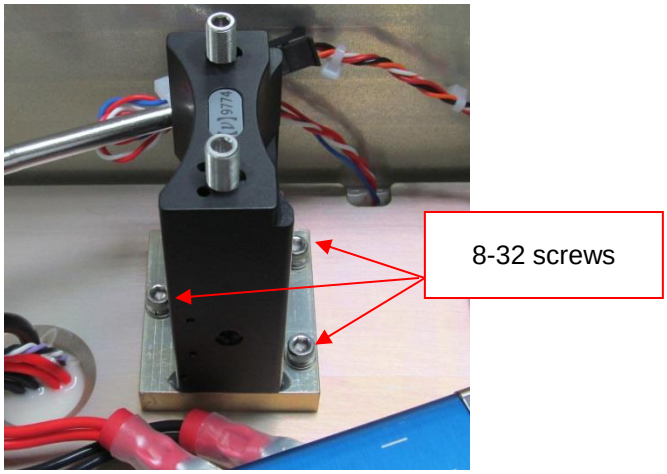


**Figure 2-7:** Optical Mount Showing Screw Locations

2. To replace the optic, heat the epoxy with a heat gun. Using a sharp blade, gently pry or cut the epoxy away from the optic and mount. Care should be taken to avoid injury.
3. Clean any residual 2216 epoxy from the mount.

**NOTE:** Use gloves when handling optics

4. Inspect the new optic and identify the optical surfaces. Lay the 9774 mount flat on its back. Place 3 tack points of 2216 epoxy on the inner lip of the mount to bond the optic in place approximately 120 degrees apart. Only a very small amount of epoxy is needed. Place the optic in the 9774 mount with the coated surface facing up. An arrow on the side of the optic points toward the coated surface. Avoid getting the epoxy on the optical coatings. Additional epoxy may be used on the front edges of the optic as seen in the *Optics Bonding* (page 24) section. Allow 12 hours to cure the epoxy.
5. Re-inspect the optic and clean as needed after the 12 hour cure time.
6. Clean any residual 2216 epoxy from the mount.
7. Install the HM assembly to the bench using the (3) 8-32 x 5/8” screws. Torque the 8-32 screws to 25 in-lbs.

# HR Replacement

1. Remove the laser optic mount and riser block (MM123-0100 – HR assembly) from the laser bench by removing the (3) 8-32 x 5/8”screws.

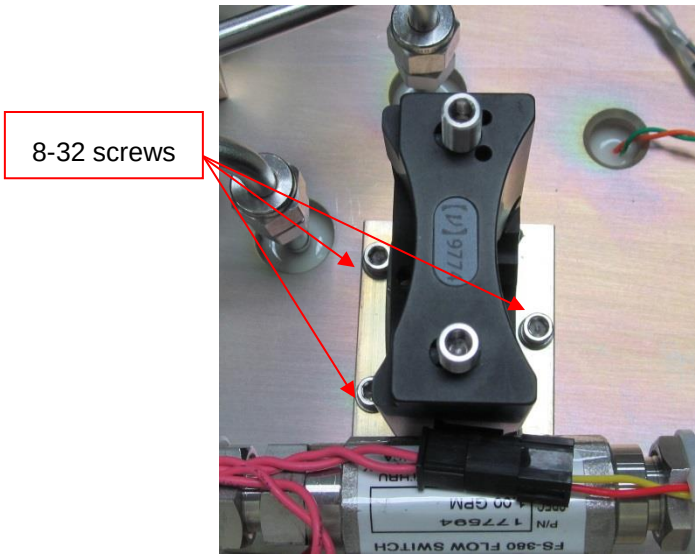


**Figure 2-8:** Optical Mount Showing Screw Locations

2. To replace the optic, heat the epoxy with a heat gun. Using a sharp blade, gently pry or cut the epoxy away from the optic and mount. Care should be taken to avoid injury.
3. Clean any residual 2216 epoxy from the mount.

**NOTE:** Use gloves when handling optics

4. Inspect the new optic and identify the optical surfaces. Lay the 9774 mount flat on its back. Place three tack points of 2216 epoxy on the inner lip of the mount to bond the optic in place approximately 120 degrees apart. Only a very small amount of epoxy is needed. Place the optic in the 9774 mount with the HR coating facing up. An arrow on the side of the optic points toward the HR coating. Avoid getting the epoxy on the optical coatings. Additional epoxy may be used on the front edges of the optic as seen in the *Optics Bonding* (page 24) section. Allow 12 hours to cure the epoxy.
5. Re-inspect the optic and clean as needed after the 12 hour cure time.
6. Clean any residual 2216 epoxy from the mount.
7. Install the HM assembly to the bench using the (3) 8-32 x 5/8” screws. Torque the 8-32 screws to 25 in-lbs.

# Install Cover

1. Visually inspect internal laser housing and optical bench for cleanliness using a high intensity light. Remove all dust particles and debris.

2. Visually inspect all optics using a Streamlight™ Stylus Green LED pen. Remove all dust particles.
3. Ensure all wires are secured out of the laser beam path
4. Ensure the o-ring is contained in the laser housing groove.
5. Wipe down unpainted surface of cover with TechniCloth III™ wipes and isopropyl alcohol.
6. Place the cover on the laser housing and loosely secure all fasteners with locking hardware.
7. Tighten the 4-40 fasteners using a cross pattern to a torque of 5.5 in-lbs.

# Interlock Replacement

1. Remove the two (2) 6-32 sealing screws holding the interlock onto the side of the laser housing. Remove any debris.
2. Disconnect the leads from the interlock.
3. Attach the leads onto the new interlock.
4. Mount the interlock using the (2) 6-32 sealing screws and hand tighten.

# Laser Module Alignment

1. Align the HeNe laser to pinhole in locations 1 and 2. See **Figure 1-3**.
2. Remove pinhole from location 2.
3. Loosen the plumbing jumpers and 8-32 screws holding the module in place.
4. Make sure the HeNe reflection from the front surface of fold mirror HeNe goes through the center of the YAG rod.
5. Manually rotate the shutter assembly out of the beam path.

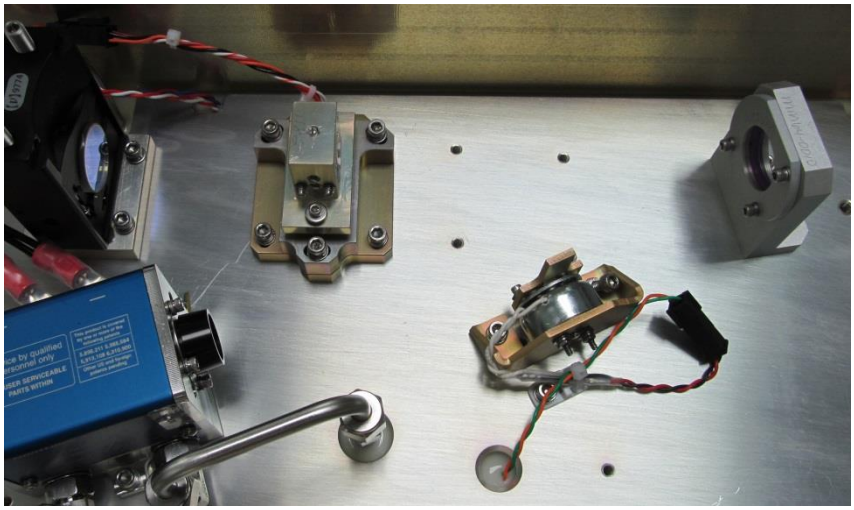

**Figure 2-9:** Shutter Rotated Out of Beam Path

6. Using clean paper as a screen, check for bullseye in front of the output coupler. Check module rod reflection back to pinhole location 1 with the HeNe. See **Figure 2-10**. If needed, adjust the fold mirror mount to obtain the proper bullseye pattern and module rod reflection back to pinhole location 1 as described below.
    a. Adjust Fold Mirror for tip/tilt (shims required), and rotation to get a bullseye.
    b. Verify module rod reflection on pinhole location 1. If needed, move fold mirror forward and backward to adjust module rod reflection horizontally.
    c. Repeat steps a and b as needed to obtain the correct bullseye pattern and module rod reflections in the horizontal axis.

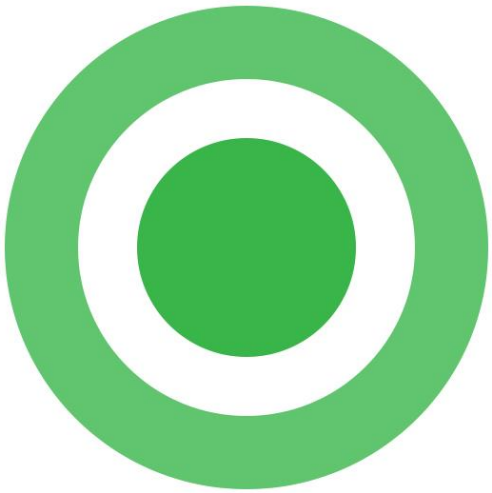

**Figure 2-10:** HeNe Bullseye Pattern

7. Shim and rotate the laser module to align the rod reflection back to the 1st pinhole as close as possible. Verify bullseye pattern as described in step 6.

8. Torque the 8-32 laser module mounting hardware to 25 in-lbs. Tighten the plumbing jumpers.
9. Verify HeNe alignment to pinhole in location 4 of **Figure 1-3**. Rotate and shim the Output Coupler if needed to align the front surface reflection (reflection closest to the module) to pinhole location 4. Replace HM assembly.

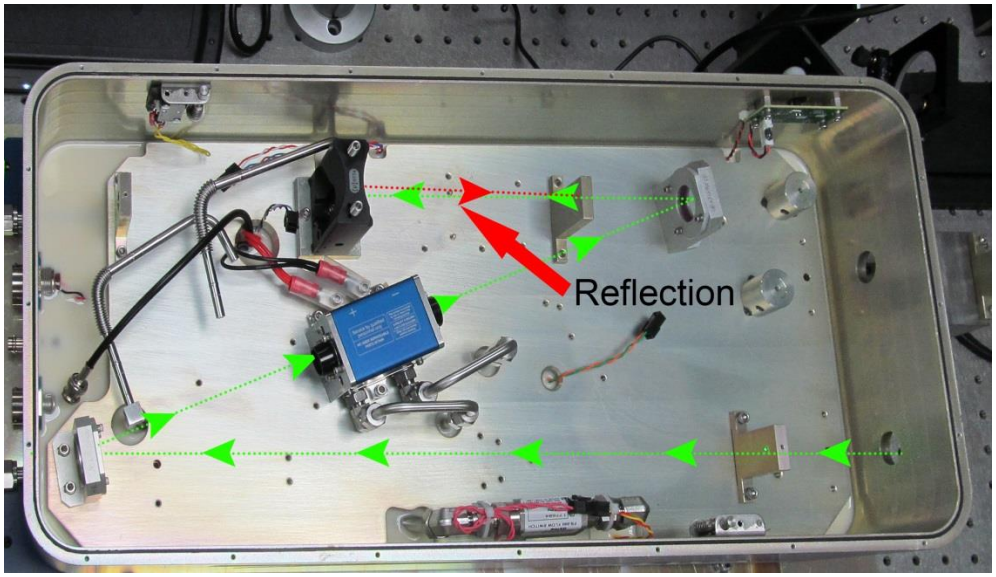


**Figure 2-11:** Pinhole Alignment with Pinless Aperture

10. See **Figure 2-11**, above. Place the pinless alignment aperture in the beam path between the Output Coupler and the HM. Center the alignment aperture with the HeNe so that the HeNe passes through the pinhole. Adjust the HM reflection back onto the pinless alignment aperture.

**NOTE:** Pinless alignment aperture may not be perfectly aligned in the vertical axis during HM alignment. It is acceptable as long as a significant amount of green light passes through the pinhole for alignment.

11. Replace SHG assembly and mount in the center of the mounting slots. Ensure that the HeNe passes through the center of the crystal. Align crystal reflection to the pinless alignment aperture.
12. Remove the pinless alignment aperture.
13. Reposition Q-switch to original location in the beam path. Make sure the HeNe goes through the center of the Q-switch crystal.
14. Align the HeNe reflection to the first pinhole by rotating the Q-switch assembly in the horizontal axis. Tighten the mounting screws.

**NOTE:** Vertical axis reflection may not be perfectly aligned with the pinhole. No adjustment is needed to correct this.

15. Replace HR assembly. Remove pinhole from location 1. Verify HeNe reflection from HR mirror is aligned back to HeNe output.
16. Replace pinhole in location 1.
17. Replace shutter.

# Laser Module Replacement

1. Replacement of the laser module should only be performed if the module fails. Replacing a laser module will change the performance characteristics of the laser from the original ATP Test Report Data Summary provided with the laser.

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

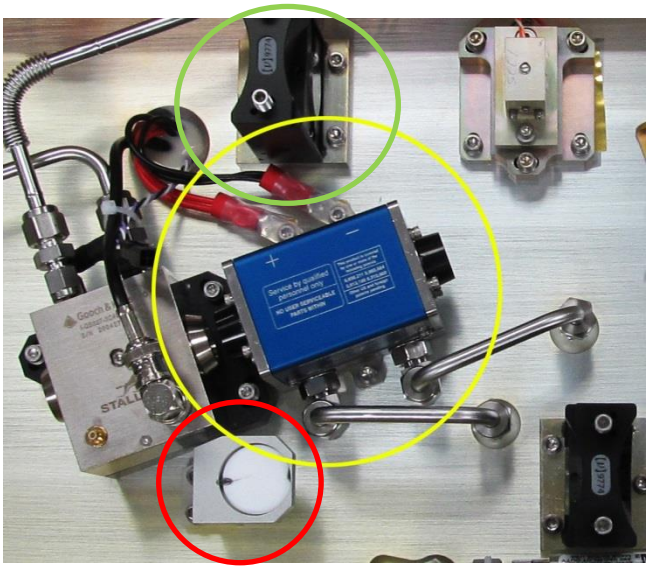

**Figure 2-12:** Location of Laser Module (yellow), HR Mirror (green), and Polarizer (red)

2. If applicable, carefully cut the clear insulation around the electrical lugs on the laser module and disconnect the wires.
3. Identify the plumbing jumper ends that correlate with the positive and negative markings on the diode module cover. Use 11/16 in or 18 mm stub wrench to remove the plumbing jumpers.
4. Remove the three (3) 8-32 x 5/8” screws bolting the module onto the optical bench of the laser. Carefully lift the diode module out of the laser.
5. Remove the rod dust caps from the new pump module and inspect rod ends. Ensure that the sealing nuts on the module elbows are screwed all the way out.

Screw elbows into new module until vertical, leaving a few degrees of rotation in either direction.

6. Remove the electrical shorting strap from the new pump module. Place the new module on the locator pins on the bench and tighten down with the three (3) 8-32 x 5/8” screws.
7. Replace the plumbing jumpers in the locations denoted in step 3 and tighten (do not over-tighten).
8. Tighten the sealing nuts on the diode module.
9. Place new heat shrink insulation on the electrical wire leads and connect each lead to the laser module. Ensure the polarity is correct with red to positive (+). Do not over-torque.
10. Inspect the work to ensure proper installation.

# Optics Bonding

1. Using a dental pick, place three drops of 2216 epoxy on the ledge of the inner diameter of the mirror mount. The diameter of the drops should be 1/16" to 1/8". The three drops should be in a triangular pattern, the first drop at the top with 120 degrees between the remaining drops.

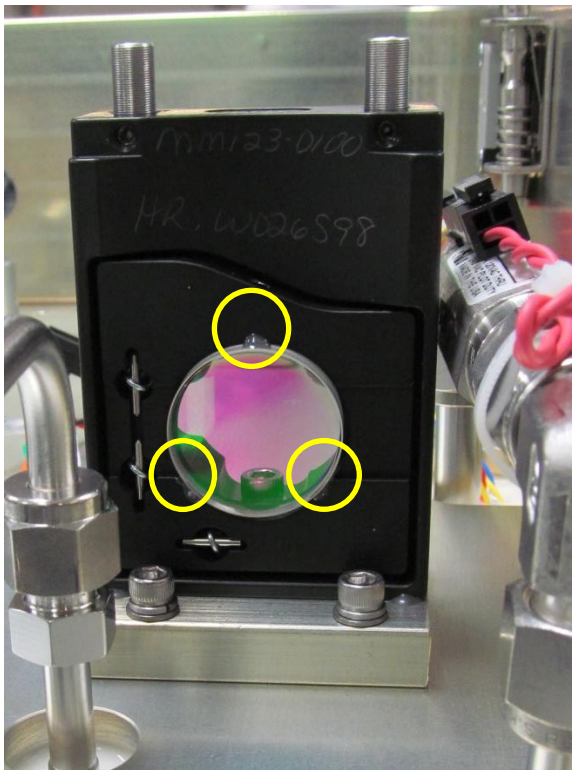

**Figure 2-13:** Mirror/Lens Assembly – Initial Epoxy Locations

2. Place the lens/mirror into the mount. Refer to the engineering drawing for the specific subassembly to ensure the correct orientation of the lens/mirror in the mount.

3. Cut three 3/16" wide by 3/4" long .002" plastic shims. Place the shims between the outer diameter of the lens/mirror and the inner diameter of the mount in three places.
4. Ensure that the outer diameter of the optic does not come into contact with the inner diameter of the mount.
5. Ensure that the optic is flat against the ledge where the epoxy is placed.

**Figure 2-14:** Shim Placement

6. Allow the epoxy to cure at room temperature for 24 hours.
7. Remove the shims and put three additional drops of 2216 epoxy in their place. Allow 24 hours for that epoxy to cure at room temperature.

# Output Window Replacement

1. Blow off debris on outside of laser housing and cover using nitrogen or clean, dry air.
2. Wipe the housing clean using TechniCloth III™ wipes and isopropyl alcohol.
3. Remove the (4) #4-40 screws and locking hardware from the output window frame.
4. Remove the output window frame, o-ring and output window. Ensure the o-ring between the output window and the laser housing remains installed.
5. Inspect the output window and clean if necessary. If damaged, rotate the output window to a new orientation. Replace the output window if needed.
6. Install the output window into the laser housing with the o-rings. There should be one o-ring on each side of the output window.
7. Install the output window frame using 3/32” hex wrench and the mounting hardware. Torque the  #4-40 screws to 5.5 in-lbs.

# Polarizer Assembly Removal and Replacement

1. Locate and remove the two mounting screws securing the polarizer assembly to the optical bench.

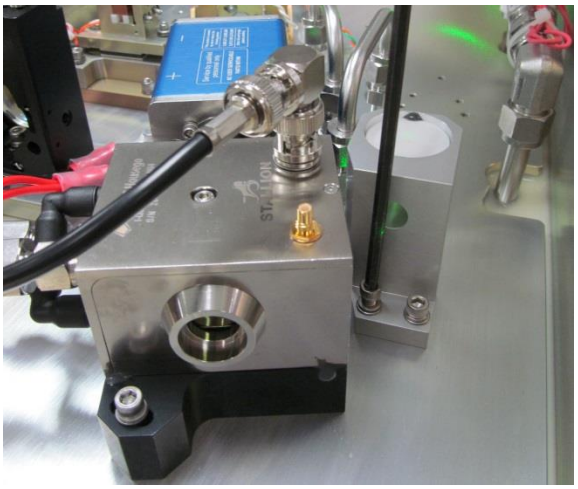

**Figure 2-15:** Polarizer Being Removed

2. Lift the polarizer assembly out of the laser.
3. Install new polarizer assembly with the mounting hardware. The mounting hardware self-aligns the polarizer assembly. Torque the #8-32 fasteners to 25 in-lbs.

# Q-Switch Replacement

**CAUTION** Do not run the chiller or laser with the coolant hoses and RF cable disconnected from the Q-switch

**WARNING:** Flexible tubing can be easily damaged. Use caution when handling.

1. Disconnect the coaxial BNC RF cable to the RF driver.
2. Carefully remove the hard plumbing using two (2) 9/16” (14mm) wrenches. See **Figure 2-16**.

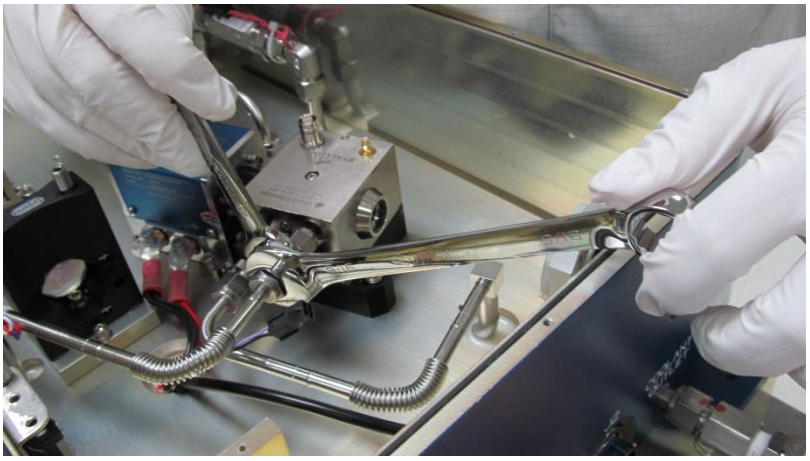

**Figure 2-16:** Loosening Hard Plumbing

3. Remove the three (3) #8-32 x 1 ¼" screws holding the Q-switch mount to the laser bench (see **Figure 2-17** below).

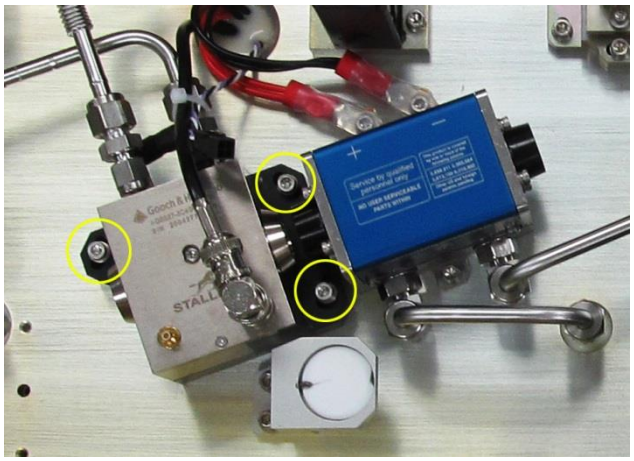

**Figure 2-17:** Location of Q-Switch Attachment Hardware

4. Carefully lift the Q-switch mount out of the laser.
5. Remove the base from the Q-switch by loosening the three (3) M3x15 screws accessible from the bottom of the mounting plate.
6. Inspect and mount the new Q-switch onto the base using the three screws identified in Step 4, above. Torque the screws to the 14 in-lb. Remove the dust caps from the new Q-switch.
7. Inspect the Q-switch optical surfaces.
8. Install the new Q-switch assembly in place. Replace the screws but do not tighten the screws at this time.
9. Tighten the hard-plumbing. Do not over-tighten plumbing fittings.

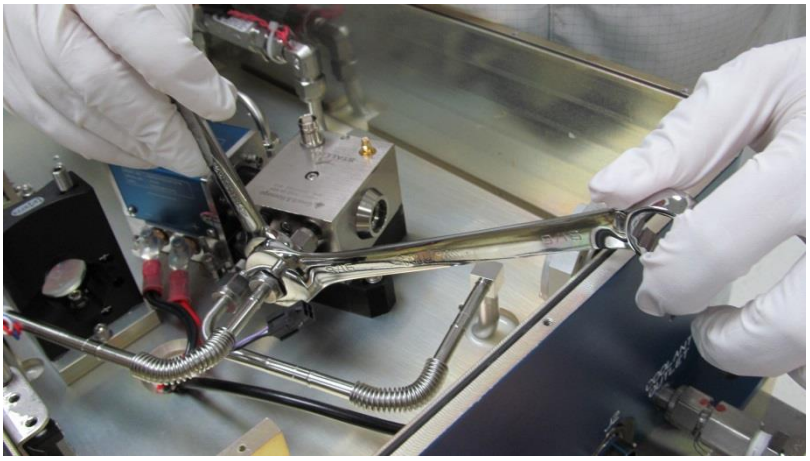

**Figure 2-18:** Tightening Hard Plumbing

10. Connect the coaxial BNC RF cable to the RF driver.
11. Secure coaxial cable and the humidity sensor cable to the hard plumbing lines.

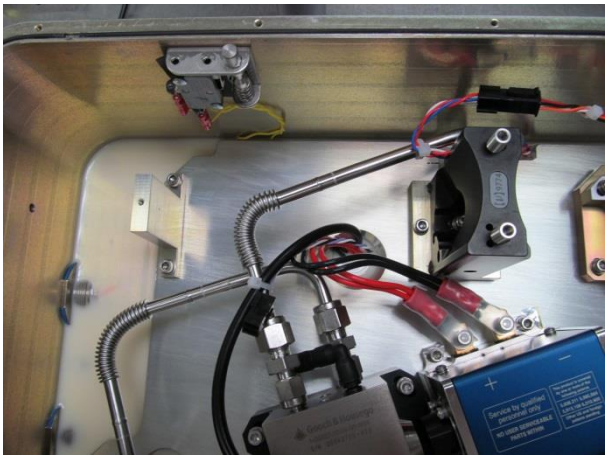

**Figure 2-19:** Cables Secured Out of Beam Path

# Remove Cover

**NOTE:** Gloves must be worn while servicing the laser. Service must be performed in a clean room environment.

1. Blow debris off outside of laser housing and cover using nitrogen or Class 0 dry air.
2. Wipe the housing clean using TechniCloth™ wipes and isopropyl alcohol.
3. Remove the fasteners and lift the cover from the laser housing.
4. Do not remove the o-ring from the top groove of the laser housing.

# Remove Q-Switch from Beam Path

**WARNING:** Flexible tubing can be easily damaged. Use caution when handling.

1. See coolant line purge (page 14).
2. Cut the cable-tie and remove BNC connector.
3. Mark both SwageLok pieces with permanent marker as reference for reinstallation. Carefully remove the hard plumbing using two (2) 9/16" (14mm) wrenches. See **Figure 2-20**.

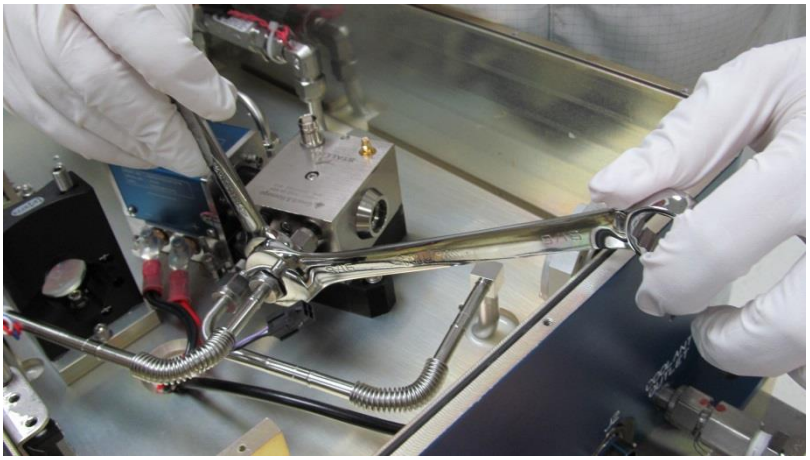

**Figure 2-20:** Removal of the Q-Switch Hard Plumbing

4. Remove the three (3) #8-32 x 1 ¼" screws holding the Q-switch assembly to the laser bench (See **Figure 2-21**, below.)

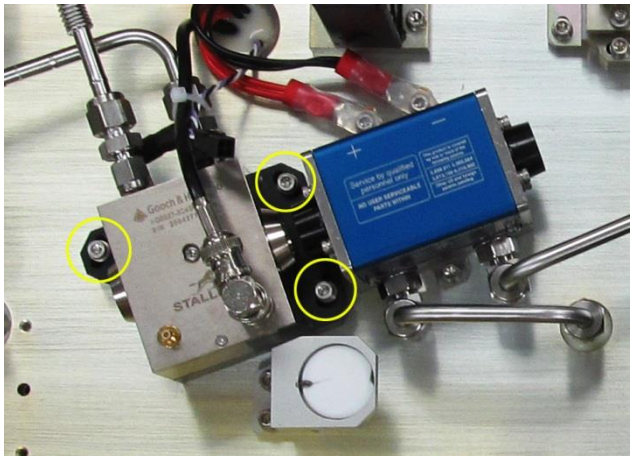

**Figure 2-21:** Location of Q-Switch Attachment Hardware

5. Remove the Q-switch assembly from the housing.

# SHG Crystal Replacement and Alignment

1. Disconnect TEC control cable and cut the cable tie. Remove the top crystal mount by loosening the three # 8 screws (see **Figure 2-22** below).

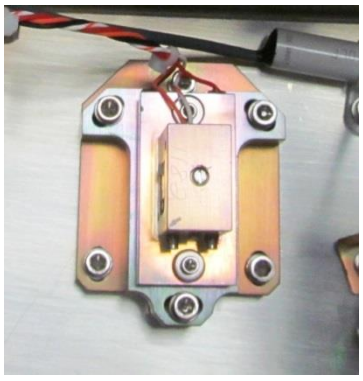

**Figure 2-22:** SHG Mount Location

2. Carefully remove the top mount with the crystal from the laser enclosure Leave the base in place. If replacing the entire second harmonic generator (SHG) assembly (HG24-0011), proceed to step 14.
3. Loosen all 4 ball plunger screws as shown in **Figure 2-23**. Use tweezers to carefully remove the conductive copper block, aluminum load spreader, two macor insulators and SHG crystal seen in **Figure 2-24**. Discard used indium foil.

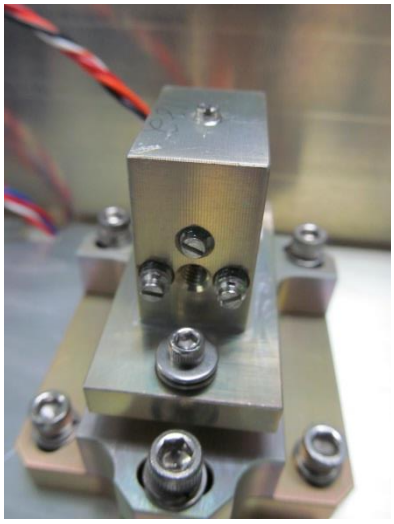

**Figure 2-23:** Ball Plunger Screw Locations

4. Cut 0.002" thick indium foil into (2) 4x9mm pieces, and .010" thick indium foil into (1) 6 x 15mm piece.
5. Press one of the 0.002" pieces onto the bottom (side opposite the arrow on the crystal) of the new crystal, making sure it is centered on the crystal and none of the indium is hanging over the edge.

6. Carefully place the two white insulators on either side of the crystal, making sure that the crystal fits into the groove of each piece. With the arrow on the crystal pointing away from you, place the load spreader next to the insulator on the right-hand side of the crystal as shown in **Figure 2-24**.

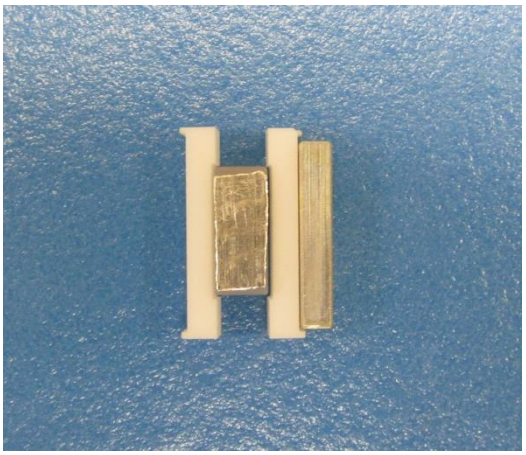

**Figure 2-24:** Insulators, Crystal and Load Spreader

7. Press the other 0.002" piece of indium onto the top of the crystal, making sure it is centered on the crystal and none of the indium is hanging over the edge. Using a pair of tweezers, carefully move the insulators, crystal and load spreader and place them into the SHG mount. Make sure that the Indium foil remains in place on the crystal as shown in **Figure 2-25**.

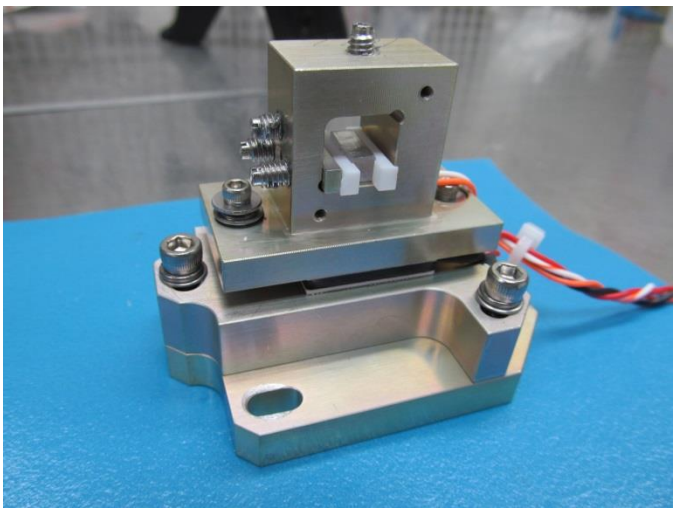

**Figure 2-25:** Indium Foil Placement

8. Thread in the 2 ball plungers (circled in yellow, **Figure 2-26**) until they press the pieces into the wall of the mount. Back them off an eighth-turn as shown in **Figure 2-25**.

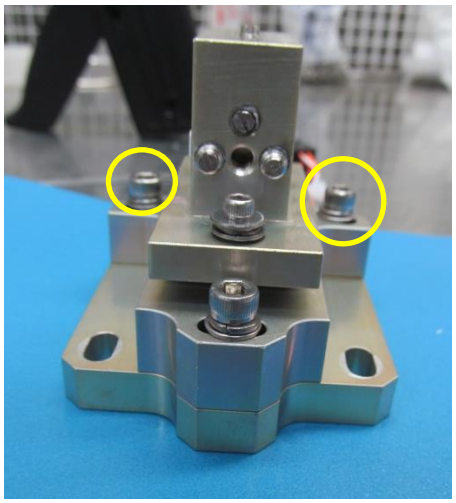

**Figure 2-26:** Ball Plungers for Mount

9. Press the 0.010" indium foil onto the side of the copper block, and carefully place it into the SHG mount with the Indium against the side opposite the ball plungers. Thread in the ball plunger (circled in yellow, **Figure 2-27**) until it presses the contact block into the wall of the mount as shown in **Figure 2-27**. Back it off an eighth-turn.

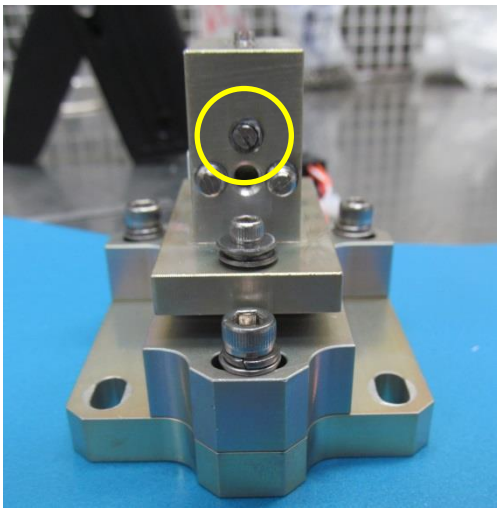

**Figure 2-25:** Ball Plunger Holding Components in Place

10. Thread in the ball plunger on the top of the assembly until tight, then back it off an eighth-turn.
11. Repeat step 10 with the 3 remaining ball plungers. The finished SHG assembly is shown in **Figure 2-26**.

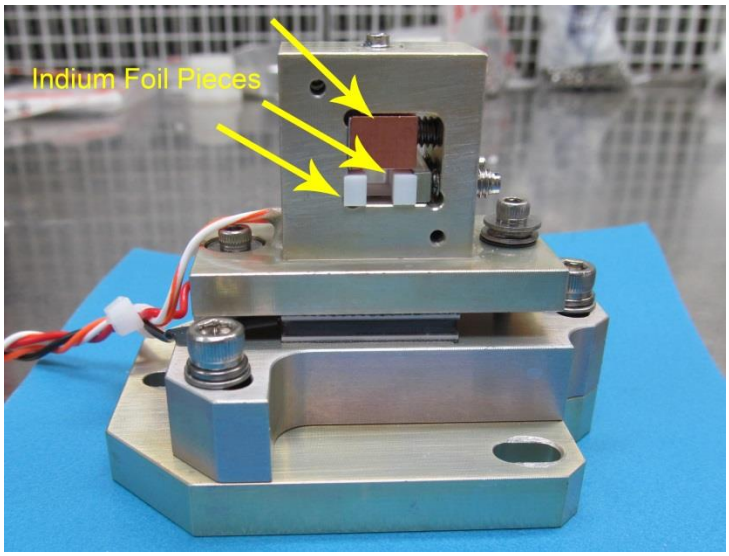


**Figure 2-26:** Finished SHG assembly

12. Inspect the crystal surface for cleanliness under a 10x microscope. Remove any debris using nitrogen or clean, dry air.
13. Bridge tack ball plungers with 2216 epoxy.
14. Install the top mount with new SHG crystal into the laser. Align the assembly so the face of the crystal is perpendicular to the beam path. Don't tighten the three #8 screws at this moment. Connect the assembly to the TEC Controller.
15. Remove the aperture assembly.
16. Turn on the chiller. Set the Q Switch to parameters specified on the ATP Test Report Data Summary. Open the shutter. Set the drive current slightly above the threshold. Set the TEC temperature at 30ºC for the starting point.
17. Verify the beam hits the center of the SHG crystal. See Figure 2-28 for ideal alignment. Base screws can be loosened to center the beam through the SHG crystal.
18. See **Figure 2-27**. If reflections are not vertical, rotate the top of the SHG assembly so the satellite beams seen on the power meter detector overlap the main laser beam as shown in **Figure 2-27**.
19. See **Figure 2-27**. Place a shim with proper thickness between the SHG assembly base and the laser bench to make the beams overlap in the vertical direction as shown in **Figure 2-27**. Loosening the base screws will be required. Tighten all the screws for the SHG assembly and top mount.

(A) Before Alignment (B) After Horizontal Alignment (C) After Vertical Alignment

**Figure 2-27** Alignment Process

20. Decrease the TEC temperature in 1 degree increments to 22ºC while observing the beam on the face of the power meter detector. Note the temperature with the most intense light and set the TEC to this value.
21. Adjust current to 0.2 A below rollover. Adjust TEC 1 degree above and below the set temperature from step 19 in 0.5 degree increments. Note the temperature with the highest power and set the TEC to this value.

# Shutter Replacement

**CAUTION** Removing the shutter compromises one of the safety features of the laser. Only remove when absolutely necessary and use precautions to avoid exposure to any laser radiation.

1. Unplug the electrical connector from the shutter solenoid and cut the cable tie.
2. Locate and remove the (2) #8-32 7/16 screws used to hold the shutter mount in position.
3. Remove the shutter assembly.
4. To remount the shutter, simply place the shutter in the correct position and torque the (2) #8-32 7/16 screws to 25 in-lbs.

**CAUTION** Water ports are routed underneath the shutter screws. Screws that are too long have the potential to damage the water pipe.

5. Reconnect the electrical harness to the shutter solenoid.
6. Secure all wiring to laser bench to prevent entering the laser beam path.

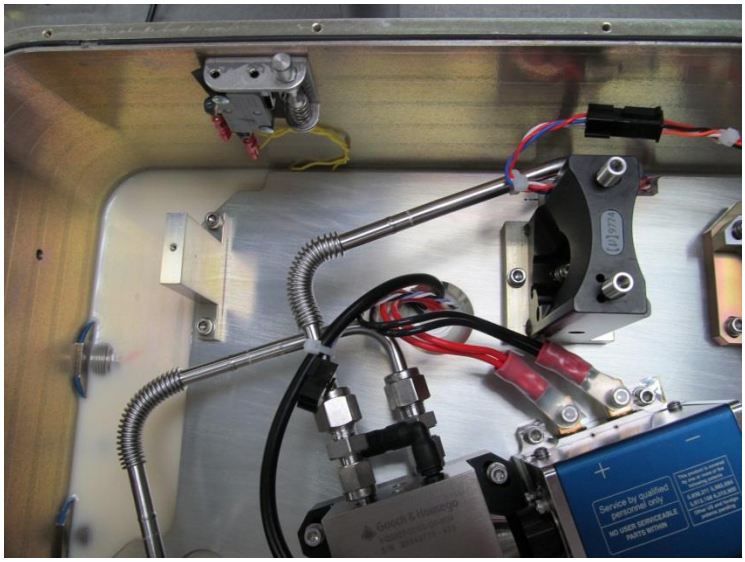

**Figure 2-28:** Location of 2216 on Mount

7. Test the shutter functionality by enabling the laser drive electronics. Set the current to 0A and fire the laser. Observe the shutter while pressing the shutter button on the laser drive electronics and confirm the shutter is functioning.
8. Increase the operating current to just above threshold. Confirm the shutter is blocking the laser beam by verifying there is no laser radiation when the laser is running.

# Steering Mirror Replacement

**NOTE:** Only replace one steering mirror at a time.

1. Turn laser on, just above threshold.
2. Place an aperture just outside of the output window. Mark a reference point at least 1 meter from the output window of the laser. This point will be used to target the laser after steering mirror replacement.
3. Turn off laser.
4. Remove the #8-32 screw and locking hardware holding the steering mirror assembly to the post. Care should be taken to clean any debris from the inside of the laser housing that may be generated from breaking the epoxy bonds.
5. Place the steering mirror assembly on a flat surface. To replace the optic, heat the epoxy with a heat gun. Using a sharp blade, gently pry or cut the epoxy away from the optic and mount. Care should be taken to avoid injury.
6. Remove any residual epoxy from the mount.

7. Inspect the new optic using a microscope for cleanliness and damage. Clean as required.
8. Apply 2216 epoxy to the mount as shown in **Figure 2-29**.


**Figure 2-29:** Location of 2216 on Mount

9. Place optic into mount and bond at the locations as shown in **Figure 2-31** below. Use #8-32 screw and .002 shims (red) to secure and center optic. Be sure that the assembly remains flat until the 2216 is cured.
10. Cure at 66°C for 2 hours, or for a minimum of 12 hours at room temperature.
11. Remove #8-32 screw and shims. See **Figure 2-30** for how it should look.


**Figure 2-30:** Location of 2216 on Optic

12. Orient steering mirrors according to **Figure 2-31**.

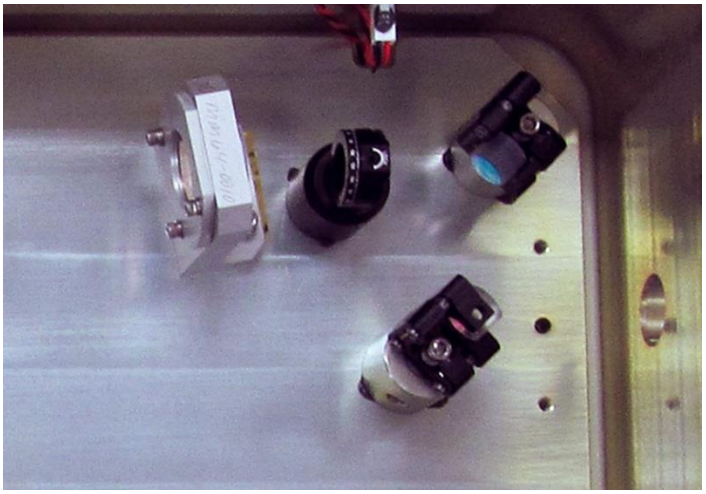

**Figure 2-31:** Steering Mirror Layout

13. Turn laser on, just above threshold.
14. Adjust steering mirror to align beam back to the reference target from step 2.

# Waveplate Replacement

1. Using a heat gun, loosen the epoxy holding the rotation mount to the post. Unscrew the rotation mount. Care should be taken to clean any debris from the inside of the laser housing that may be generated from breaking the epoxy bonds.

**NOTE:** On new lasers and assemblies, only the 1/4-20 set-screw is bridge tacked to the post holder.

2. Place the rotation mount on a flat surface and use a spanner wrench to remove the retainer ring. Care should be taken to clean any debris that may be generated from breaking any epoxy bonds.
3. Remove the waveplate optic.
4. Inspect the new waveplate optic and clean if necessary.
5. Install the new waveplate optic. Replace the retainer ring and tighten using the spanner wrench.
6. Repeat step 4.
7. Reinsert the post into the post holder until it bottoms out. Set the laser to operate at threshold. Verify the perpendicularity of the assembly to the beam path by aligning the retro reflection from the waveplate back to the output aperture. Bridge tack a 1/4-20 3/8 long set screw to post holder.
8. The waveplate must now be rotated to achieve vertical polarization.

a. Set the laser on a test bench for operation at power level above threshold. The power should be set at 5 mw.

b. Install an external 532 nm polarizer cube onto the laser test bench in front of the output window. Ensure the 532 nm polarizer cube retro reflection is on axis with the laser beam. Ensure that the 532 nm polarizer cube is oriented to transmit horizontal polarized light and reject vertical polarized light.

c. Loosen the set screw on the top of the waveplate assembly. Using the dial on the rotation mount, adjust for minimum transmission through the cube.

d. Tighten the set screw to lock the waveplate location.

# Chapter 3: Tuning and Testing Procedures

**NOTE:** Gloves must be worn at all times during service. Service procedures must be performed in a clean room environment when the cover is removed.

## Align for Q-Switch Hold-Off

1. Turn the current down to the laser threshold. Ensure that the RF driver signal is at maximum power with no triggers or gates.
2. Open the shutter.
3. Observe the beam output on the power meter while turning up the current to the operational value. The proper "Hold-off" condition is met when no green light is visible through the current range. If no green light is observed, skip to step 7.
4. Loosen the three screws holding the Q-switch in place.

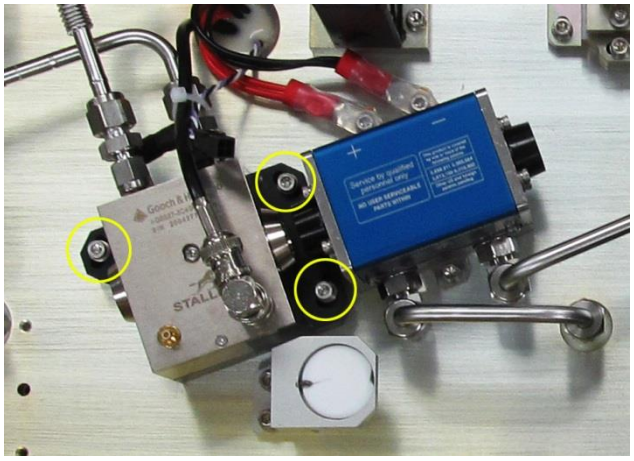

**Figure 3-1:** Location of Q-Switch Attachment Hardware

5. Rotate the Q-switch until no green beam is observed. Proper "Hold-off" conditions are met when no green light is visible.
6. Tighten the screws while holding the Q-switch in position and ensure "Hold-off" is maintained.
7. Turn down the current to the threshold.
8. Return the laser drive electronics to normal repetition rate and check the pulse-to-pulse stability. Ensure that pulse stability meets specifications.
9. If laser will not hold off, check the RF power.

## Power the Laser for Alignment

1. Turn the chiller on.
2. Ensure that the TEC is at the temperature specified on the test data sheet.
3. Set the Q Switch to parameters specified on the test data sheet.
4. Open the shutter.
5. Gradually increase the current from 0A until green light is visible. Do not exceed the operating current on the test data sheet.

# Check Hold Off

Checking "Hold-off" is a technique needed to verify proper operation of the laser. To check hold off, perform the following steps:

1. Turn on the laser and run for at least 20 minutes.
2. Lower the operating current to 10 A.
3. Ensure that the RF driver signal is at maximum power with no triggers or gates.
4. Observe the beam output on the power meter while turning up the current to the operational value. "Hold-off" condition is met when no green light is visible.
5. If green light is observed, the laser does not hold off refer to Align for Q-switch "Hold-off".
6. Reduce the current to 10 A.
7. Return the Q-switch controller to the normal operating settings.
8. Gradually increase the current to the full operational current.

# Check for Bullseye

1. Adjust current to just above threshold.
2. Place a white card in the beam path in front of negative lens or observe the beam on the power detector head surface.
3. The bullseye image is shown in **Figure 3-2** below. The outer ring of the bullseye should be concentric to the main beam.

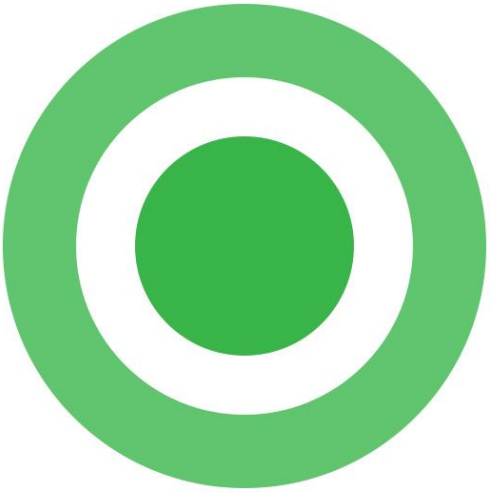

**Figure 3-2:** HeNe Bullseye Pattern

# Defeating the Cover Interlock

**CAUTION** Defeating the cover interlock should only be used when the laser is being serviced and the laser needs to be operated with the cover off in order to adjust an optical component.

1. Pull the pin up to disable the cover interlock switch. See **Figure 3-3**.
2. Repeat for the second cover interlock switch.

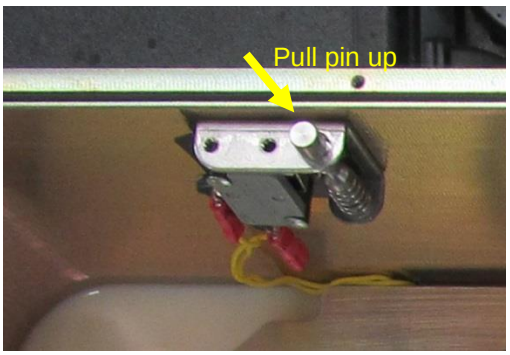


**Figure 3-3:** The Cover Interlock Switch

# HR/HM Alignment

1. Locate the access holes for high-reflection (HR) and harmonic mirrors (HM). Notice the positions of HR and HM mirrors with respect to the direction of the laser output in Figure 3-3.

**NOTE:** HR aligns the beam through the center of the diode module rod and should never be moved. HM aligns the beam through the SHG crystal and may need to be aligned occasionally.

2. Before removing the access hole screws, clean the cover with TechniCloth III™ wipes and isopropyl alcohol. Remove screws.
3. Use a 1/8" ball driver to make adjustments. Start with HM adjustments only. A fine adjustment is a 1° or less rotation. A small adjustment is about a 2° rotation. A coarse adjustment is 15° to 20° rotation. If coarse adjustments are needed to obtain performance, reduce operating current by 2 A. Return to normal operating current when making small and fine adjustments.
4. The screws for the adjustments of the vertical tilt angle and the horizontal tilt angle are illustrated in **Figure 3-4**.

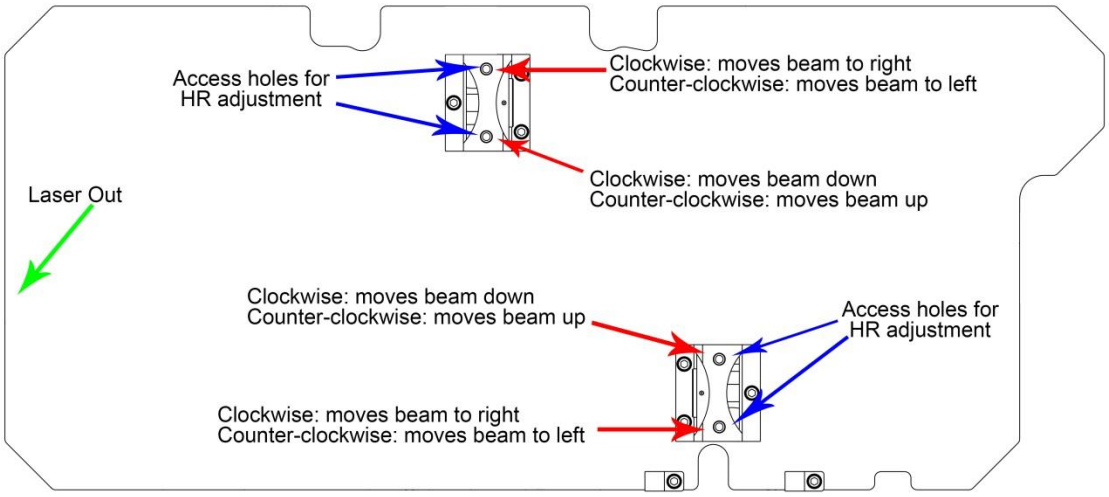


**Figure 3-4:** Accessible Holes for HR and HM Cavity Mirror Adjustment

5. Make small adjustments to the horizontal angle of HM mirror and observe the output power.
6. Once a maximum is found, adjust the vertical control of HM mirror to maximize power.
7. If the laser output returns to original specifications, alignment is complete. If not, proceed to Step 8.
8. Make small adjustments to the horizontal angle of HR mirror and observe the output power.
9. Once a maximum is found, adjust the vertical control of HR mirror to maximize power.
10. Repeat the alignment steps with both the HR and HM until there is no significant performance improvement.

11. If the laser is still not within 5% of the original power or is not stable, repeat the steps in *Laser Optimization* and *HR/HM Alignment* until there is no significant performance improvement.
12. If the laser power can't be restored to the specification, or the laser is not stable, then the *Walking the Cavity* procedure can be tried.

# Laser Optimization

1. Turn the laser to operate at normal output power. Check the settings of the diode power supply operating current, chiller temperature, and TEC controller temperature.
2. Check the performance with all operating parameters set to the values on the ATP test report data summary.
3. Make sure that the flow rate is 1.4 – 1.5 gpm and the temperature of the chiller matches results from the original test report. The coolant flow rate and temperature have a significant impact on the laser performance.
4. Run the laser for a minimum of 1 hour and wait for the laser to reach thermal stabilization.

Both the laser bench temperature and environmental temperature significantly impact the laser power. Wait for the laser to be thermally stabilized before attempting any adjustment.

5. Peak up the laser power by tuning the temperature of the TEC controller. Do not adjust TEC in more than .2°C increments. Adjusting TEC at full power can cause optical damage to the SHG crystal.

The phase matching of the SHG crystal is crucial for the laser. This is achieved by setting the proper temperature on the SHG crystal, which is controlled by the TEC controller.

**Figure 3-4** illustrates an example of the dependency of power and pulse-to-pulse instability of the laser to the SHG crystal temperature. As shown in the example, the midpoint of the temperature band is around 28.5 ºC; the midpoint of the temperature band is the normal operating temperature. The laser may have peak power at 29.3 ºC in this example, but a small temperature change on the SHG crystal could result in a power fluctuation.

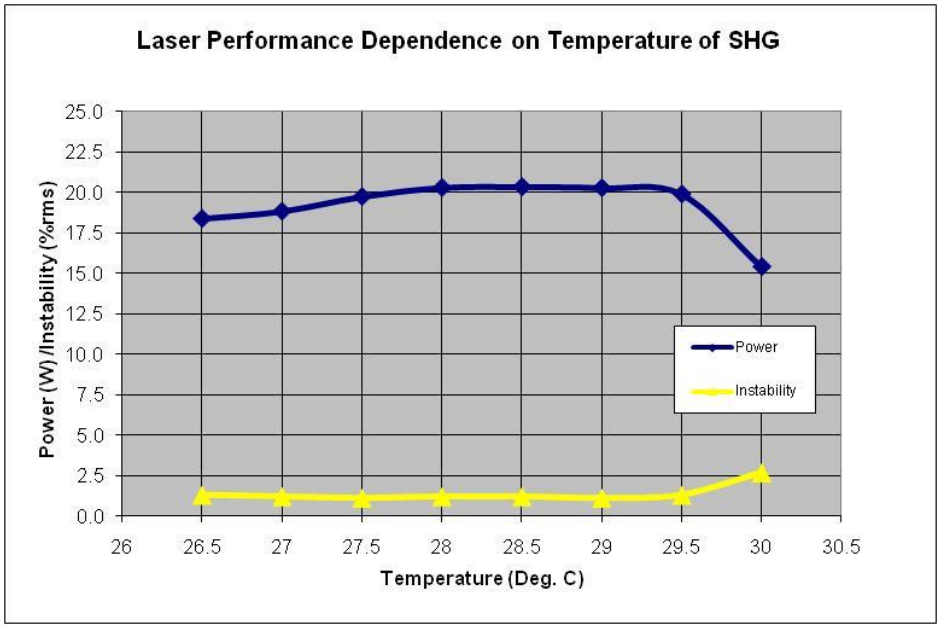


**Figure 3-5:** Example of Laser Performance Dependence on the SHG Temperature

6. Peak the laser power by increasing the current. Search for the peak power by changing the current 0.1 A increments around the operating current. Once the peak power is found, lower the current to reach 99.5 percent of the peak power.

**Figure 3-5** illustrates an example of the dependency of the output power and pulse-to-pulse instability of the laser to operating current. Notice that the laser power increases as the operating current is increased. The laser reaches peak power around 23 A. In this example 23A is the rollover current, and the operating current would be 22.5 A to 22.7 A. Fine-tune the current to optimize pulse-to-pulse stability and roundness.

The slight difference between the actual operating current and the test report value may be due to the performance difference of the chillers. An increase in the operating current can compensate for the aging of the laser diodes.

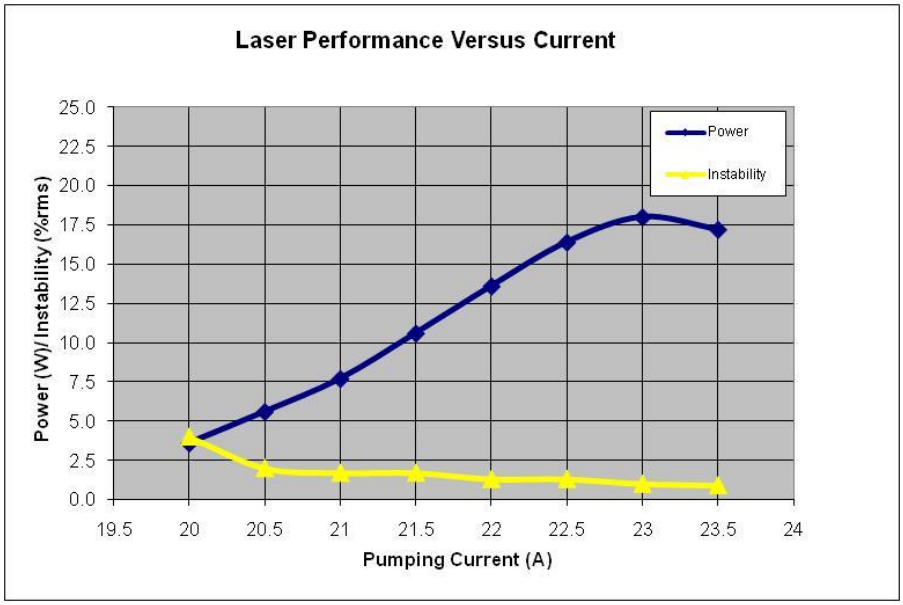


**Figure 3-6:** Example of Laser Performance Dependence on the Operating Current

7. Lower the current to threshold and check the bullseye on the face of the power detector to verify proper alignment and operating parameters.

# Leak Test

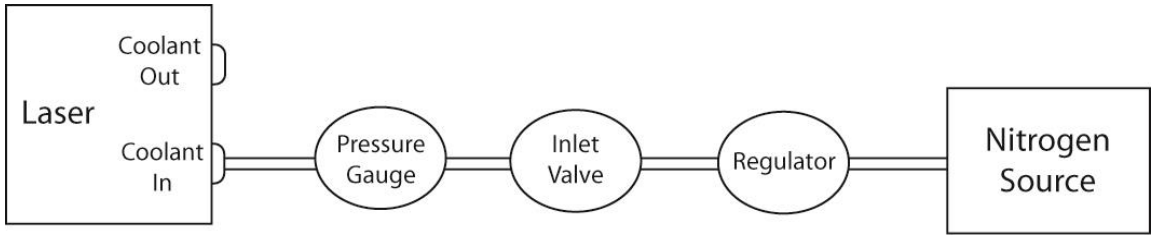


**Figure 3-7** Nitrogen Leak Test Layout

1. Ensure the laser has been purged of any coolant.
2. Attach a nitrogen source to the **COOLANT IN** port on the laser (see **Figure 3-7**).
3. Open the inlet valve and adjust the regulator to obtain 80 psi on the pressure gauge.
4. Close the inlet valve. Wait 5 minutes and repeat step 3 once.
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 4 psi the leak test fails, if the pressure drop is less than 4 psi the leak test passes.

7. Release the pressure in the laser by pressing the center of the **COOLANT OUT** quick disconnect.

# Walking the Cavity

Walking the cavity is sometimes required to optimize the laser and involves combining mirror mount and SHG crystal temperature adjustments.

**WARNING**. Making mirror adjustments can be non-reversible. Do this step only when all the steps above have been completed and the laser does not meet the specifications with the correct settings.

1. Locate the access holes for high-reflection (HR) and harmonic mirrors (HM). Notice the positions of HR and HM mirrors with respect to the direction of the laser output in **Figure 3-3**.
2. Remove screws from access holes only in a dust free environment.
3. Use a 1/8" ball driver to make adjustments. A fine adjustment is a 1° or less rotation. A small adjustment is about a 2 degree rotation. A coarse adjustment is 15 degrees to 20 degrees rotation. If coarse adjustments are needed to obtain performance, reduce operating current by 2 A. Return to normal operating current when making small and fine adjustments.
4. The screws for the adjustments of the vertical tilt angle and the horizontal tilt angle are illustrated in **Figure 3-3**.
5. Make a horizontal adjustment to the HM mount. Recover the laser power by making a similar adjustment to the horizontal control of the HR mount. Check and adjust the temperature of SHG crystal. Do not adjust TEC in more than .2°C increments. Adjusting TEC at full power can cause optical damage to the SHG crystal.
6. Continue if improvement is noted. If there is no improvement, try the opposite direction.
7. Perform the same procedure with the vertical adjustments of the HM and HR mount.
8. Typically, SHG temperature adjustment is not needed when adjusting vertically. Periodically check for hold off when making these adjustments (see *Check Hold Off* section in this chapter).
9. If laser power is within +/-5% of nominal (typical power meter accuracy), and it has good beam shape and stability, stop and replace the access screws in the cover.

# 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 NG 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: |

| | |
|---|---|
| Laser Model Number: | Serial Number: |
| Chiller Model Number: | Serial Number: |
| Laser Drive Electronics Model Number: | Serial Number: |
| Laser Manufacture Date: | Total Laser Lifetime (hours): |

# Questions

What is the coolant flow rate (GPM)?

What is the set temperature on the chiller (°C)?

What is the coolant pressure on chiller (PSI)?

What are the temperature set and actual reading from TEC controller (°C)?

What are the set current and actual current from laser drive electronics (A)?

Is Q-switch enabled (yes/no)?

Is Q-switch triggered internally or externally?

What is the pulse repetition frequency (Hz)?

Is the output power measured directly from the laser (yes/no)?

What is the measured power (W)?

When did the problem happen?

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

Have you adjusted the laser to try to fix the problem (yes/no)?

What are the changes made recently to the system?

Please describe the problem or laser 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: ngceoservice@ngc.com**

# Appendix B: System International Units

The following System International (SI) units, abbreviations, and prefixes are used throughout NG 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 Conference of Governmental Industrial Hygienists |
| ANSI | American National Standards Institute |
| AO | Acusto-Optical (type of Q-switch) |
| AR | Anti-Reflective |
| ASM | Array Sub-Module |
| CDRH | Center for Devices and Radiological Health - U.S. Food and Drug Administration |
| CFR | Code of Federal Regulations |
| CW | Continuous Wave |
| DC | Direct Current |
| DPSS | Diode-Pumped Solid-State |
| EO | Electro-Optical (type of Q-switch) |
| ESD | Electro-Static Discharge |
| FET | Field Effect Transistor |
| FDA | U.S. Food and Drug Administration |
| FPS | First Pulse Suppression |
| FWHM | Full Width at Half Maximum |
| GaAlAs | Gallium Aluminum Arsenide |
| GPM | Gallons Per Minute |
| HeNe | Helium Neon |
| HG | Harmonic Generator |
| HM | Harmonic Mirror |
| HR | High Reflector |
| HV | High Voltage |
| IEC | International Electrotechnical Commission |
| IR | Infrared |
| KTP | Potassium Titanyl Phosphate |

| Acronym | Description |
|---|---|
| LPM | Liters per Minute |
| LBO | Lithium Triborate |
| MCC | Meters Concave |
| $N_2$ | Nitrogen |
| Nd:YAG | Neodymium-doped Yttrium Aluminum Garnet |
| Nd:YLF | Neodymium-doped Yttrium Lithium Fluoride |
| NG | Northrop Grumman |
| NIR | Near Infrared |
| OC | Output Coupler |
| OSHA | Occupational Safety and Health Administration |
| PRF | Pulse Repetition Frequency |
| psi | Pounds per Square Inch |
| QCW | Quasi-Continuous Wave |
| QSW | Q-switch |
| RF | Radio Frequency |
| RH | Relative Humidity |
| RMS | Root Mean Square |
| SHG | Second Harmonic Generator |
| TEC | Thermal Electric Cooler |
| TEM | Transverse Electromagnetic Mode |
| TTL | Transistor - Transistor Logic |
| UV | Ultra Violet |
| VAC | Volts, Alternating Current |