NORTHROP GRUMMAN

| FIELD SERVICE BULLETIN | |
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| Bulletin No. | SVC-FSB-0009 |
| Release Date | 3/5/13 |
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## Product

Laser Modules

## Category

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# Laser Module Coolant Recommendations

Laser diodes are usually the most expensive component in a solid-state laser system. The most frequent cause for failure in NG CEO laser modules is customer damage. The most frequently observed types of customer damage are (in order):

- Operating a laser module without coolant
- Using contaminated coolant
- Condensation on the diode (Operated chiller at less than dew point temperature)

To prevent damage to the laser diodes, NG CEO requires that the following guidelines be followed when designing the cooling water system for a laser module.

## General Chiller Information

1. NG CEO equipment requires a chiller which can provide at least 60 psi (4.14 bar) water pressure. If your chiller can achieve the required minimum flow rate through the laser module with a lower water pressure (typically 30-50 psi [2.07-3.45 bar]), it is acceptable. The flow rate must be at or above the minimum flow rate listed in the table below.

| Laser Module type | Minimum Flow Rate (gallons per minute, liters per minute) |
|---|---|
| All RB, RBA, RBAT | 1.0 gpm or 3.8 lpm |
| RD | 1.5 gpm or 5.7 lpm |
| REA | 2.0 gpm or 7.6 lpm |
| RGA | 2.5 gpm or 9.5 lpm |

2. Chillers used with NG CEO laser modules must have a heat capacity greater than the total power consumption of the unit(s) being cooled. Power consumed by the laser module is the power input into the laser module minus the optical power extracted from the module.

3. All NG CEO laser modules should be used with a flow interlock installed on the water output side of the module. If the chiller water is not flowing, or if the water drops below the minimum flow rate, the interlock should interrupt power to the diodes.
4. NG CEO laser modules should always begin life with the chiller set at the temperature recommended on the final test report (usually 20-30 °C). As the laser module ages, it will be necessary to run the chiller at a cooler temperature to compensate for reduced efficiency and wavelength shift. Also, as the diodes degrade, more drive current may be required to produce the required output power.
5. NG CEO does not endorse one chiller manufacturer over another. However, when NG CEO provides a module complete with chiller, we generally offer a Polyscience model with the laser. The following table lists the Polyscience chillers offered with NG CEO module types. The chiller is selected based on the expected end of life heat load for the laser module, with a slight allowance for heat load of a Q-switch capable of handling the module's laser output.

| NG CEO Module[1] | EOL Load (W) | 60 HZ Electrical Outlet | | 50 HZ Electrical Outlet | |
|---|---|---|---|---|---|
| | | Capacity | Model # | Capacity | Model # |
| RBATX0-1C2 | 576[2] | 850 | 6262T31CE10B | 700 | 6252T41CE30E |
| RBATX4-1C2 | 768[2] | 1400 | 6362T31CE20C | 1280 | 6352T41CE30E |
| RBATX5-1C2 | 960[2] | 1400 | 6362T31CE20C | 1280 | 6352T41CE30E |
| REAXX06-1C2 | 1920[2] | 2300 | 6762T41CE30D | 2200 | 6752T41CE30E |
| REAXX06-1C4 | 3300[3] | 5200 | 6862T66CE70D | 4371 | 6852T66CE70E |
| REAXX08-1C2 | 2560[2] | 2900 | 6162T41CE30D | 4316 | 6852T66CE70E |
| REAXX08-1C4 | 4400[3] | 5200 | 6862T66CE70D | 4316 | 6852T66CE70E |
| REAXX10-1C4 | 5225[3] | 5200 | 6862T66CE70D | Contact NG CEO | |
| REAXX12-1C4 | 6600[3] | Contact NG CEO | | Contact NG CEO | |

[1] The X in the model number refers to digits which specify the rod diameter in mm, and does not affect the heat load.

[2] End of Life heat load (EOL) at 32A.

[3] End Of Life heat load (EOL) at 50A

*Please contact NG CEO for PowerPulse$_{TM}$ QCW pumped laser module chiller requirements*

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## Filtration

1. Chillers used with NG CEO laser modules should always have a water filter installed on the input line to the laser module. The filter should be capable of removing particles 5 µm or larger. The filter should be changed at a minimum of every one month. If the filter becomes noticeably dirty (most have an inspection port for viewing) it should be changed immediately.
2. Every time the filter is changed, the coolant should be completely drained and replaced. NG CEO recommends cleaning the chiller with 3% Hydrogen Peroxide.
3. Select a filter that is appropriate for its intended use. Improper filters can become a source of contamination causing reduced flow through the diode array heat exchangers and potential damage to the diode arrays.

## Possible Coolants

NG CEO recommends that an algaecide and a corrosion inhibitor be used with NG CEO laser modules.

### Distilled Water with Optishield Plus

NG CEO recommends a mix of one part Optishield Plus for every 9 parts water. Optishield Plus is a combined algaecide and anti-corrosive which will help protect the laser module. Optishield Plus can be ordered from Opti-Temp at www.optitemp.com

### Ethylene Glycol and Optishield Plus in Distilled Water

NG CEO recommends a solution of 30% lab grade (99% pure) ethylene glycol, 10% Optishield Plus, and 60% distilled water by volume. See SVC-FSB-0005 for more information.

The ethylene glycol mixture does not have heat transfer capability as good as the distilled water and Optishield mixture. The chiller will need to be operated at a lower temperature to properly cool the diodes. Verify that the temperature is not in the range that will cause condensation inside the laser. The customer will also need to dispose of the used ethylene glycol in accordance with local regulations.

### De-Ionized Water (Not Recommended)

NG CEO laser diodes have exposed bare copper inside the coolant loop. For this reason, NG CEO does not recommend using DI water. It attacks the copper in the diode heat exchangers. If DI water is used as the coolant, it is very important to maintain the water resistivity between 300 - 700 K ohms, and to keep the water slightly basic (i.e. keep the water between 7.0 – 8.0 pH).

## Cleaning the Cooling Fluid System

NG CEO recommends using 3% Hydrogen Peroxide to clean the cooling fluid system. The cleaning process steps are drain the expired cooling fluid, replace the filter, refill with distilled water and circulate for 5 minutes, drain and refill with 3% Hydrogen Peroxide and circulate for 40 minutes, drain and refill with distilled water and circulate for 5 minutes, replace the filter, drain and refill with cooling fluid, run for 30 minutes with the reservoir cap loose, top off and tighten the reservoir cap. See SVC-FSB-0001 for more information.

## Maintenance Frequency

The cooling system should be drained, cleaned and refilled at an interval of every 1 month. Also replace the cooling fluid 5 micron filter. Dispose of old chiller coolant in accordance with local environmental regulations. It is crucial that the cooling fluid filter be inspected at least once a week for any signs of contamination such as color change or residue. The laser also needs to be monitored for signs of contamination such as power loss or increased current to reach the rollover point during optimization.

# Calculating Air Condensation Temperature

The air condensation temperature (or dew point) is the highest surface temperature that allows water to form from the ambient water vapor. The dew point is dependent on the surrounding air temperature and relative humidity. If a surface (such as a laser diode) is cooled at or below the condensation temperature, water may collect on that surface. Water on the diode arrays causes catastrophic damage to the arrays, requiring them to be replaced. Condensed water on the laser module end plates can cause damage to the rod ends and surrounding equipment.

A formula for calculating dew point is given below, along with a calculated table. All temperatures are given in Celsius.

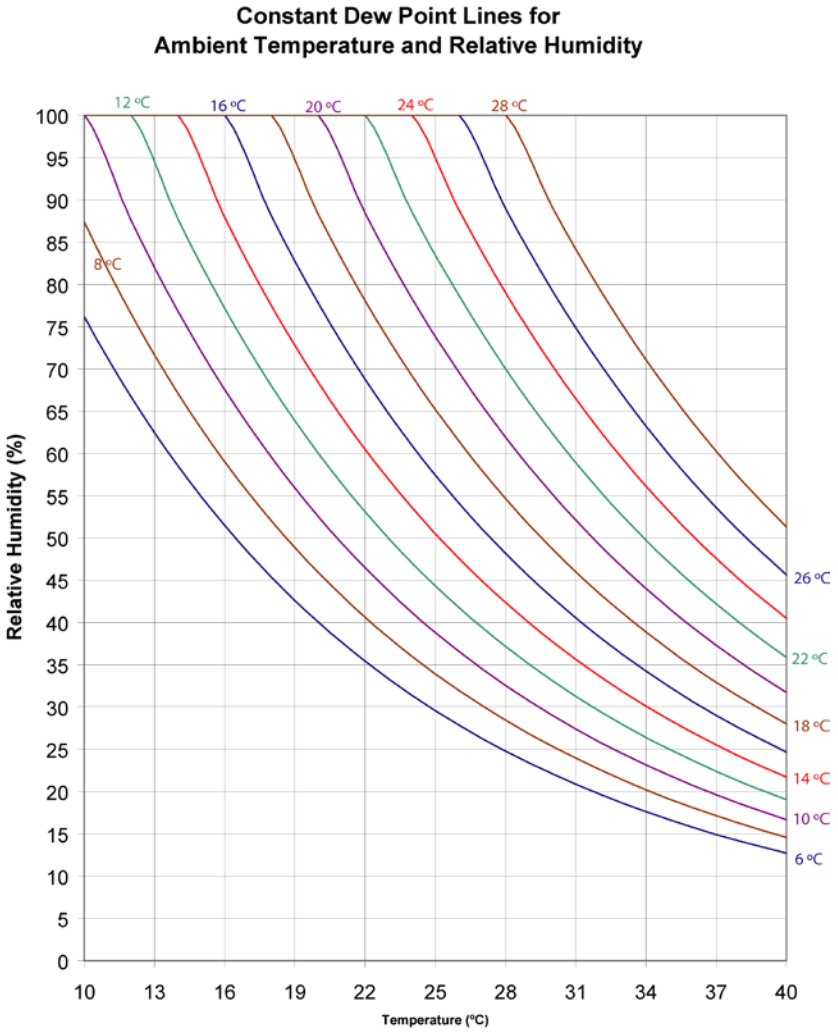
| **Condensation Temperature** |
|---|
| $T_d = \frac{237.7 \times \alpha(T, RH)}{17.27 - \alpha(T, RH)}$ where $\alpha(T, RH) = \frac{17.27 \times T}{237.7 + T} + \ln\left(\frac{RH}{100}\right)$ |
| T is the ambient air temperature in degrees Celsius (0 < T < 60) |
| RH is the relative humidity in percent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

Table of Air Condensation Temperature at Given Ambient Air Temperature (Celsius) and Relative Humidity (percent)

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

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

Operating the chiller at a temperature equal to or lower than the dew point temperature (*Td*), will cause condensation to form on the diode arrays.




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

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