Module Coolant Recommendations

Laser diodes are the single most expensive component in a solid-state laser system. Field data indicates the most common cause for diode failure is insufficient coolant flow or contaminated coolant causing reduced flow through the array heat exchangers. To prevent damage to the laser diodes, Northrop Grumman Cutting Edge Optronics (NGCEO) requires that the following guidelines be followed when designing the cooling water system for a laser.

General Chiller Information

NGCEO 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 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.

Module type	Minimum Flow Rate (gallons per minute, liters per minute)
All RB & RBA	1.0 gpm or 3.8 lpm
All RB Plus	1.0 gpm or 3.8 lpm
REA	2.0 gpm or 7.6 lpm
RGA	2.5 gpm or 9.5 lpm

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

All NGCEO modules should be used in conjunction 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.

NGCEO pump modules should always begin life with the chiller set at the temperature recommended on the final test report (usually 20-30 °C). As the module ages, it will be necessary to operate the chiller at a colder temperatures to compensate for reduced efficiency and wavelength shift. As the diodes degrade, more drive current may be required to produce the required output power.

NGCEO does not endorse one model of chiller over another. However, when NGCEO provides a laser system complete with chiller, we generally offer a PolyScience model with the laser. The recommended chiller is selected based on the expected end of life heat load for the module, with a slight allowance for heat load of a Q-switch capable of handling the module's laser output.

CEO Module [1]	EOL Load (W)	60 Hz Electrical Outlet		50 Hz Electrical Outlet	
		Capacity	Model #	Capacity	Model #
RBAX0-1C2	576 [2]	800	6260T11CE20C	664	6250T21CE30E
RBAX4-1C2	768 [2]	1200	6360T11CE20C	996	6350T21CE30E
RBAX5-1C2	960 [2]	1200	6360T11CE20C	996	6350T21CE30E
REAXX06-1C2	1920 [2]	2500	6760T21CE30D	2075	6750T21CE30E
REAXX06-1C4	3300 [3]	5200	6860T56CE70D	4316	6850T56CE70E
REAXX08-1C2	2560 [2]	2900	6160T21CE30D	4316	6850T56CE70E
REAXX08-1C4	4400 [3]	5200	6860T56CE70D	5810	DCA206D1FF
REAXX10-1C4	5225 [3]	7000	DCA203D1FF	5810	DCA206D1FF
REAXX12-1C4	6600 [3]	7000	DCA203D1FF	8715	DCA306D1FF

[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 NGCEO for chiller recommendations for PowerPulse™ QCW pumped modules and lasers.

Possible Coolants

NGCEO recommends that an algaecide and a corrosion inhibitor be used with all modules and lasers. Coolant should be drained and replaced when the filter is changed (at a minimum interval of every 6 months). Dispose of old chiller coolant in accordance with local environmental regulations.

Recommended a, b, or c:

a. Purelase 180

NGCEO has teamed with Nalco Company to provide a treated cooling water program designed to maintain cooling performance and protect the equipment in the system. The cooling management program, including the Purelase 180 cooling fluid, is designed to minimize the effects of corrosion, scale, fouling, and microbial contamination in these systems. The cooling management program also allows the system to continue providing reliable service with optimal efficiency for the life of the equipment.

b. Distilled (steamed) Water with Optishield

NGCEO recommends a mix of one part Optishield Plus for every 10 parts water. Optishield Plus is a combined algaecide and anti-corrosive which will help protect the module. Optishield Plus can be ordered from Opti-Temp at www.optitemp.com

c. Ethylene Glycol and Distilled Water

Cutting Edge Optronics recommends a 50/50 mix of lab grade (99% pure) ethylene glycol with distilled water.

Not Recommended:

* De-Ionized Water (Not Recommended)

NGCEO laser diodes have exposed, bare copper inside the heat exchanger. For this reason, NGCEO does not recommend use of DI water. DI water attacks the exposed copper causing severe corrosion internal to 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).

Filtration

Chillers used with NGCEO 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 six months or more frequently if the chiller manufacturer recommends a shorter interval or if operating conditions warrant. If the filter becomes noticeably dirty (most have an inspection port for viewing) sooner than the recommended 6 months interval, it should be changed immediately.

Every time the filter is changed, the coolant should also be completely drained and replaced. When using Purelase 180 coolant, CEO recommends cleaning the chiller with 460-CCL2567 cleaning fluid before refilling the chiller with Purelase 180 coolant. See module user's manual for details.

Select a filter that is appropriate for its intended use. Improper filters can become a source of contamination causing reduced flow through the array heat exchangers and potential damage to the diode arrays.

Calculating Air Condensation Temperature

The air condensation temperature (dew point) is the temperature at which moisture in air condenses on a surface. The air condensation temperature is dependent on the ambient air-temperature and relative humidity. If a surface such as a module end plate or 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.

$$T_{\mathrm{d}} = \frac{237.7\alpha(T, RH)}{17.27 - \alpha(T, RH)} \quad \text{where} \quad \alpha = \frac{(17.27)T}{237.7 + T} + \ln\left(\frac{RH}{100}\right)$$

T is the ambient air temperature in Celsius ($0 < T < 60$) near the laser,

RH is the relative humidity in percent ($1 < RH < 100$) of the air near the laser, and

T_d is the temperature in Celsius at which condensation will accumulate on the module.

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

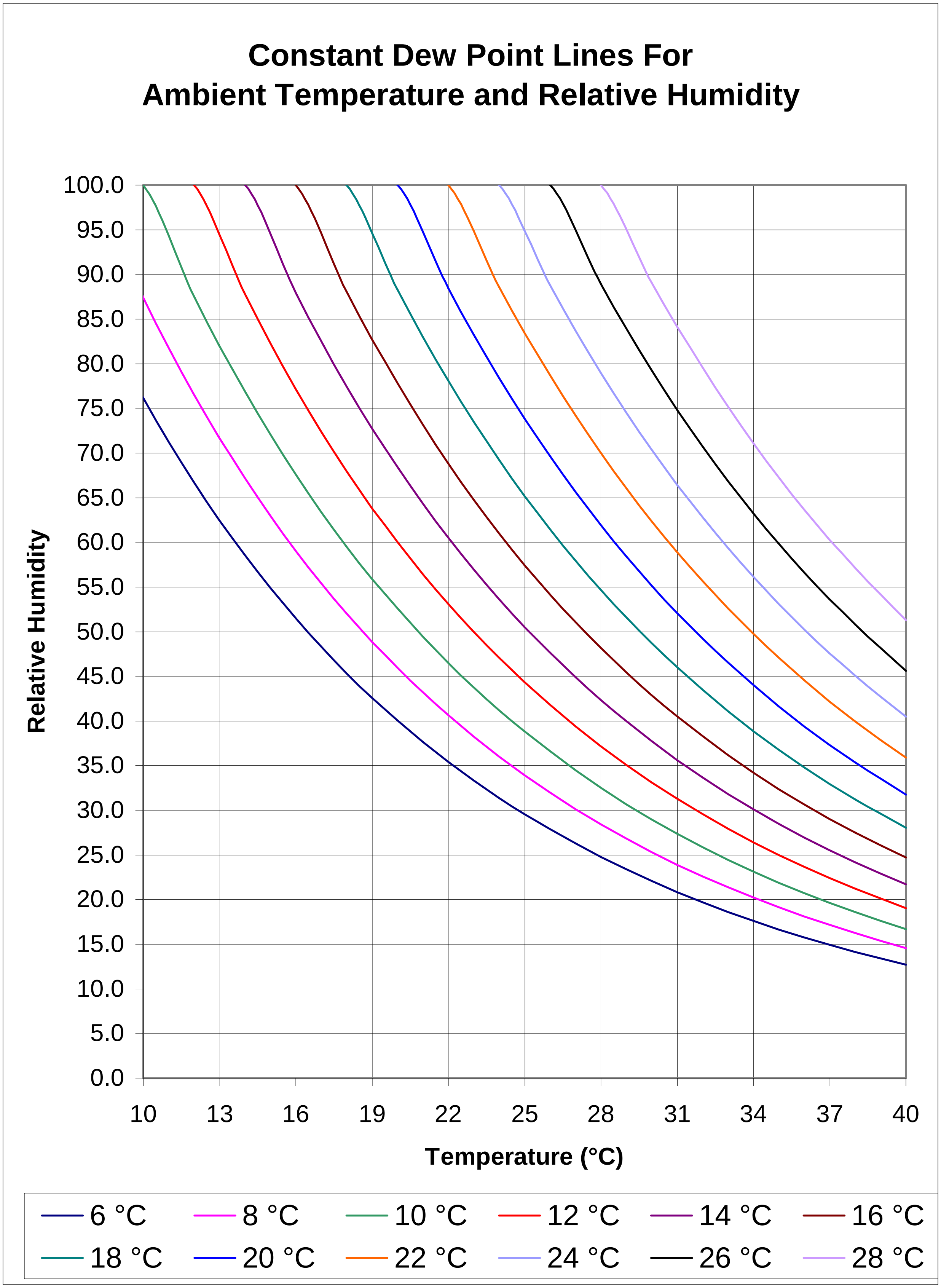
Water on the arrays causes catastrophic damage to the arrays, requiring them to be replaced. Condensed water on the module end plates can cause damage to the rod ends and surrounding equipment.

Table of Dew Point Temperatures for Given Ambient Temperature and Relative Humidity

							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
T	**16**	-40.2	-15.6	-7.0	-1.6	2.4	5.6	8.2	10.5	12.5	14.4	16.0
E	**18**	-39.0	-14.1	-5.3	0.2	4.2	7.4	10.1	12.4	14.5	16.3	18.0
M	**20**	-37.8	-12.5	-3.6	1.9	6.0	9.3	12.0	14.4	16.4	18.3	20.0
P	**22**	-36.6	-11.0	-2.0	3.6	7.8	11.1	13.9	16.3	18.4	20.3	22.0
E	**24**	-35.4	-9.5	-0.4	5.3	9.6	12.9	15.7	18.2	20.3	22.3	24.0
R	**26**	-34.2	-8.0	1.3	7.1	11.3	14.8	17.6	20.1	22.3	24.2	26.0
A	**28**	-33.0	-6.5	2.9	8.8	13.1	16.6	19.5	22.0	24.2	26.2	28.0
T	**30**	-31.8	-4.9	4.6	10.5	14.9	18.4	21.4	23.9	26.2	28.2	30.0
U	**32**	-30.6	-3.4	6.2	12.2	16.7	20.3	23.2	25.8	28.1	30.1	32.0
R	**34**	-29.5	-1.9	7.8	13.9	18.5	22.1	25.1	27.7	30.0	32.1	34.0
E	**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

The graph on the next page shows the dew point temperature for some common ranges of temperature and relative humidity. All temperatures are given in Celsius.

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 ^{o}F), look where the gridline for air temperature of 28 °C intersects the curve for diode temperature of 22 °C, and you will see that at a relative humidity of 70% or greater condensation will form on the laser diodes.


Constant Dew Point Lines For
Ambient Temperature and Relative Humidity
Relative Humidity
100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
10
13
16
19
22
25
28
31
34
37
40
Temperature (°C)
6 °C
8 °C
10 °C
12 °C
14 °C
16 °C
18 °C
20 °C
22 °C
24 °C
26 °C
28 °C

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

Failure of Module

The most frequent cause for failure in NGCEO modules is characterized as customer damage. The most frequently observed types of customer damage are (in order):

Operating a module without coolant
Using contaminated coolant or DI water
Condensation on the diode (Operation of chiller at temperatures below dew point)

Customer damage invalidates the module warranty.