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Technical Bulletin

Preventing Condensation When Operating a SYNRAD Water-Cooled Laser

Description:

This Technical Bulletin describes steps you can take to prevent condensation when operating your water-cooled SYNRAD laser. Condensation can damage electrical components as well as internal laser optics.

This Bulletin covers the following topics:

- How condensation forms
- Dew point temperature calculations
- Coolant recommendations and guidelines
- Setting chiller temperature
- Steps to prevent condensation
- Summary

Important Note:

It is the customer's responsibility to eliminate any possibility of condensation damage to the laser. Condensation causes severe laser damage that is not covered under warranty and leads to very expensive repair costs.

How condensation forms

Condensation is a concern with all water-cooled lasers and is especially dangerous when water-cooled lasers operate in high temperature / high relative humidity environments. Condensation forms when the laser's coolant temperature is lower than the dew point temperature of the surrounding air. This causes water vapor in the warm, moist air to condense into liquid water on the colder surfaces of the laser, including internal / external coolant lines, electronic circuit boards, and optical components.

Condensation damage occurs when moisture condenses out of the surrounding air, causing water droplets to form inside the laser housing. This can lead to catastrophic failure of laser electronics and/or damage to optical surfaces.

Dew point temperature calculations

To determine the dew point temperature of your operating environment, refer to Table 1 below. Note that temperatures are shown in degrees Fahrenheit; values in parenthesis are degrees Celsius. Look down at the Air Temp column on the left and locate an air temperature that corresponds to the air temperature in the area where your laser is operating. Follow this Air Temp row across until you reach a Relative Humidity column matching the relative humidity percentage of the laser's environment. The value at the intersection of the Air Temp row and Relative Humidity column is the Dew Point Temperature in °F (°C).

The chiller's temperature setpoint must be set above the dew point temperature. For example, if the ambient air temperature is 85 °F (29 °C) and the relative humidity is 60%, then the dew point temperature is 70 °F (21 °C). Adjust the chiller's temperature setpoint to 72 °F (22 °C) to prevent condensation from developing inside the laser.

Table 1 *Dew Point Temperature Chart in Degrees Fahrenheit (°Celsius)*

	Relative Humidity (%)															
Air Temp °F (°C)	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**
60 (16)	--	--	--	32 (0)	36 (2)	39 (4)	41 (5)	44 (7)	46 (8)	48 (9)	50 (10)	51 (11)	54 (12)	55 (13)	57 (14)	59 (15)
65 (18)	--	--	33 (1)	37 (3)	40 (4)	43 (6)	46 (8)	48 (9)	51 (11)	53 (12)	55 (13)	57 (14)	59 (15)	60 (16)	62 (17	64 (18)
70 (21)	--	33 (1)	37 (3)	41 (5)	45 (7)	48 (9)	51 (11)	53 (12)	56 (13)	58 (14)	60 (16)	62 (17)	64 (18)	65 (18)	67 (19)	69 (21)
75 (24)	--	37 (3)	42 (6)	46 (8)	49 (9)	52 (11)	55 (13)	58 (14)	60 (16)	62 (17)	65 (18)	67 (19)	68 (20)	70 (21)	72 (22)	73 (23)
80 (27)	35 (2)	41 (5)	46 (8)	50 (10)	54 (12)	57 (14)	60 (16)	62 (17)	65 (18)	67 (19)	69 (21)	71 (22)	73 (23)	75 (24)	77 (25)	78 (26)
85 (29)	40 (4)	45 (7)	50 (10)	54 (12)	58 (14)	61 (16)	64 (18)	67 (19)	70 (21)	72 (22)	74 (23)	76 (24)	78 (26)	80 (27)	82 (28)	83 (28)
90 (32)	44 (7)	50 (10)	54 (12)	59 (15)	62 (17)	66 (19)	69 (21)	72 (22)	74 (23)	77 (25)	79 (26)	81 (27)	83 (28)	85 (29)	87 (31)	88 (31)
95 (35)	48 (9)	54 (12)	59 (15)	63 (17)	67 (19)	70 (21)	73 (23)	76 (24)	79 (26)	81 (27)	84 (29)	86 (30)	88 (31)	90 (32)	92 (33)	93 (34)
100 (38)	52 (11)	58 (14)	63 (17)	68 (20)	71 (22)	75 (24)	78 (26)	81 (27)	84 (29)	86 (30)	88 (31)	91 (33)	93 (34)	95 (35)	97 (36)	98 (37)

Coolant recommendations and guidelines

Using the proper coolant greatly increases the heat removal capacity and efficiency of your chiller. SYNRAD recommends the laser's cooling fluid contain at least 90% distilled water by volume. In closed-loop systems, use a corrosion inhibitor/algaecide such as Optishield® Plus or equivalent as required. Avoid glycol-based additives because they reduce the coolant's heat capacity and high concentrations may affect power stability. For SYNRAD lasers, the minimum coolant setpoint is 18 °C (64 °F) so glycol is not necessary unless the chiller is subjected to freezing temperatures.

If tap water is used, chloride levels should not exceed a concentration of 25 parts per million (PPM) and total hardness should be below 100 PPM. Install a filter on the chiller's return line and inspect frequently.

Note: DO NOT use de-ionized (DI) water as a coolant. DI water is unusually corrosive and is not recommended for mixed material cooling systems.

Setting chiller temperature

SYNRAD water-cooled lasers are designed to operate and perform to their stated specifications at a coolant temperature between 18 °C–22 °C (64 °F–72 °F). When the dew point temperature is above the coolant temperature, condensation can occur and there are two very important factors to consider: (1) Operating the laser at a coolant temperature lower than the dew point temperature will cause condensation that could shorten laser lifetime significantly. (2) Raising the coolant temperature setpoint above the dew point temperature will help prevent condensation; however, a coolant temperature above 22 °C (72 °F) can affect laser performance and shorten laser component lifetimes.

As a guide to adjusting your coolant temperature setpoint, consider the following example. The normal room air temperature where your laser is operating is around 29 °C (85 °F) and the relative humidity is around 70%. From Table 1 above, this corresponds to a dew point temperature of 23 °C (74 °F). Remember that condensation on cooling tubes occurs when their surface temperature is below the dew point temperature.

In order to prevent condensation, adjust the chiller setpoint a few degrees above the dew point temperature. Do not choose an arbitrarily large number, but instead choose a setpoint value just above the dew point, like 25 °C (77 °F), and then carefully monitor the laser (and external RF supply, if applicable) for signs of condensation during and after operation.

The chiller temperature setpoint must be set as low as practical because coolant temperature above our specified maximum coolant temperature range of 22 °C (72 °F) will affect laser performance. Mode quality and power stability degradation is the most noticeable short-term effect of under-cooling the laser. Long-term, the laser may suffer a shortened lifetime due to excessive heating of the laser's RF circuitry. Please note that laser specifications quoted in the Operator's Manual are valid only in the specified coolant range of 18 °C–22 °C (64 °F–72 °F).

The best way to achieve long laser life and optimum laser performance is to air-condition the laser environment and then maintain a coolant temperature setpoint between 18 °C–22 °C (64 °F–72 °F).

Steps to prevent condensation

The most effective step an end-user can take to prevent condensation in a high heat / high humidity operating environment is to install an air-conditioning system!

In addition to lowering the ambient air temperature around the laser, an air-conditioning system will also lower relative humidity. The cost of a robust air-conditioning system is far less than the cost of repairing a damaged laser.

Implementing one or more of the practices described below may reduce the risk of condensation enough that coolant temperatures can be set within the recommended range of 18 °C–22 °C (64 °F–72 °F).

1. For Firestar f201/f400, i401, and p100/p250 lasers, apply 2 to 5 PSI (0.14 to 0.34 bar) of high-purity grade nitrogen, breathing grade air, or compressed clean, dry air to the Gas Purge port. See Technical Bulletin #15 for details and gas filtering specifications.
2. Incorporate a small air-conditioner into the laser system to ventilate the laser enclosure. Air-conditioning lowers ambient air temperature and reduces relative humidity so that the laser's operating environment becomes independent of the end-user's industrial environment. Consistent operating conditions lead to better laser performance and longer lifetime while minimizing service costs.
3. Duct an existing air-conditioning vent directly over the laser housing to lower local air and dew point temperatures.
4. Install a local dehumidifier to reduce the relative humidity level in the area of the laser.
5. Increase the recommended coolant flow rate by 1.0 to 1.5 gallons per minute (3.8–5.7 liters per minute). However, do not allow coolant pressure to exceed 60 PSI (4.14 bar).

6. An often-overlooked procedure to minimize condensation is to simply turn off the chiller any time the laser is not lasing. Turn off the chiller and remove DC power from the laser anytime the laser is not processing material—overnight, during shift changes, or during lunch and operator breaks.

Summary

All water-cooled lasers can develop condensation when operating in high temperature / high relative humidity environments. The coolant temperature must always be adjusted a few degrees above the dew point temperature to prevent condensation; however, if coolant temperature is too high, then laser performance may degrade, and service lifetime is reduced.

The best choice to protect your laser processing investment is to air-condition the laser environment. Lowering the dew point temperature by reducing ambient air temperature and relative humidity means that coolant temperature can be set within the recommended range for optimum laser performance and lifetime.

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