SYNRAD Technical Bulletin

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Technical Issue: Purge Gas Conditioning for f201/f400, i401, & p100/p250 Lasers

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Description:

This Technical Bulletin describes how to prevent condensation or optics damage to your Firestar f201, f400, i401, p100, or p250 laser by using an appropriately filtered purge gas.

This Bulletin covers the following topics:

- Importance of purge gas
- Recommended purge gases and specifications
- Proper conditioning of compressed air
- Connecting purge gas to the laser
- Summary
- Equipment recommendations

Importance of purge gas

Purge gas is important because it protects against two important sources of laser damage—condensation and particulate matter. Condensation and particulates can cause catastrophic (and expensive) damage to your laser that is <u>not</u> covered under warranty.

Purge gas creates a slight positive pressure inside the laser housing that prevents particulate matter such as dust and debris from accumulating on optical surfaces and electronic circuit boards. In condensing atmospheres, purge gas reduces the potential for condensation because a nitrogen or oil-free, dried air purge displaces moisture-laden environmental air from the laser housing.

Condensation

Condensation forms when the laser's coolant temperature is lower (cooler) than the dew point of the surrounding air. Water vapor in the surrounding warm, moist air condenses into liquid water onto cooler surfaces of the laser, including internal and external coolant lines, electronic circuit boards, and optical components.

Liquid water on circuit boards, especially on high-power RF boards, causes catastrophic board damage, requiring replacement of the RF pan and associated electronic assemblies. Water droplets or moisture on optical surfaces leads to spotting, which increases power absorption and ultimately, optics failure. In an enclosed beam path, failed optics tend to release particulates that quickly coat other optics, causing a cascade effect that could lead to complete tube failure.

Particulate matter

Particulate contamination like the dust, dirt, debris, and vapor produced by laser material processing is a problem when it coats optical surfaces in the beam path or when it accumulates on circuit boards, especially if the material is conductive.

Circuit elements coated with particulates lose their ability to transfer heat, which leads to shortened component lifetimes and premature part failure. At the high voltages and currents produced by RF circuitry, conductive dust may cause short circuits and catastrophic circuit board damage. Dust, dirt, or vapor deposited on optical components leads to increased power absorption that causes optics failure and the potential of a cascade effect that may damage multiple optics up to, and including, the laser tube.

Recommended purge gases and specifications

SYNRAD recommends only two types of gas for purging the laser or external beam delivery optics—nitrogen (N_2) or air. If air is used, it can be breathing grade (available in bottled gas cylinders) or oil- and water-free, dry air provided by an on-site air compressor.

Bottled purge air and nitrogen, as well as bottled assist gases used for laser processing, must be filtered to meet ISO 8573 Class 1 specifications because bottled gases may still contain particulates that can damage optical surfaces. Compressed air must be filtered ***and*** dried to ISO 8573-1:2010 Class 1, 2, 1 specifications which includes a –40 °F (–40 °C) vapor pressure dew point. Table 1 lists purity specifications for acceptable types of purge gas.

Danger!

You must not use any other type of inert gas, including argon (Ar) as a purge gas. Some inert gases, like argon, have low dielectric breakdown voltages that can cause an arc or explosion within the laser housing.

Table 1 Purge gas specifications

Purge Gas	Type	Specification
Nitrogen	High Purity Grade	$\geq$ 99.9500% purity; filtered to ISO Class 1 particulate level
Air	Breathing Grade	$\geq$ 99.9996% purity; ; filtered to ISO Class 1 particulate level
Air	Compressed	Instrument-grade air filtered and dried to ISO 8573-1:2010 Class 1, 2, 1 ($\leq$ 10 1.0-5.0 µm particles/m^3; $\leq$ –40 °F (–40°C) dew point; $\leq$ 0.01 mg/m^3 oil vapor)

Important Note: As shown in Table 1 above, on-site compressed air **must** be filtered to remove water and oil, which are by-products of the air compression process. In addition to filtering, it is usually necessary to dry the filtered air before it reaches the laser. The dryer should be capable of lowering the dew point temperature to –40 °F (–40 °C) to ensure the dew point of the filtered air is much lower than the laser’s inlet coolant temperature.

Proper conditioning of compressed air

Important Note: The integrator or end-user must provide a purge gas that meets the requirements described above in Table 1. Using a purge gas that does not meet ISO 8573-1:2010 Class 1, 2, 1 specifications (or a lack of purge gas) will void the laser warranty and may lead to catastrophic and expensive laser damage. Even bottled gas must be filtered to ISO Class 1 specifications to eliminate particulates from the gas cylinders.

Compressed air is widely available in most facilities; however it is usually contaminated by traces of oil and water vapor during the compression process. These contaminants must be removed before they reach the laser. Figure 1 illustrates the components required for conditioning compressed air in a laser application. The subsections below describe how to choose filtering and drying components necessary to condition compressed air for use as a laser purge gas. The numbered components in Figure 1 correspond to the item numbers in the subsections below.

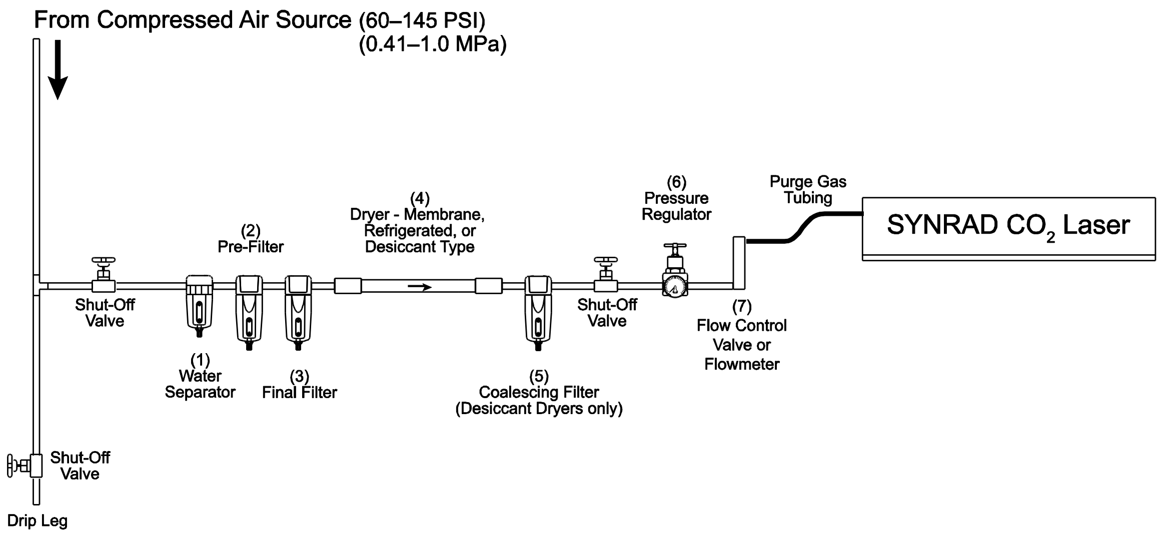

Figure 1 Conditioning compressed air for laser purge

Compressed air sources

In large facilities, the compressed air source is typically from one or more large air compressors that distribute air throughout the facility in overhead compressed air piping. Although most compressor installations include aftercooler, condensate separator, and filtering equipment, these units do not usually condition the compressed air to instrument-grade specifications. Air from these types of distribution systems still contain particulates as well as oil and water vapor and must be carefully conditioned before use by laser systems.

In some facilities, oilless air compressors are used to provide a dedicated air source for one or more lasers or other equipment that requires instrument-grade compressed air. Oilless compressors are designed using diaphragms or non-metallic seals, allowing them to compress air without the need to lubricate rotating and reciprocating parts. This design eliminates oil vapor from the compressed air stream. Oilless compressors are available in many sizes depending upon capacity and several manufacturers build units small enough to fit within an electronics enclosure.

For a dedicated oilless air source you can choose a standard compressor with storage tank or use a continuous-duty tankless type compressor. Size the compressor for a minimum flow rate of 2.5–3 cubic feet per minute (CFM) at a minimum of 25 PSI. A compressor rated for 1/2 horsepower should be sufficient.

Even when using an oilless compressor, you must still install water separation, filtering, and drying equipment in order to deliver ISO Class 1, 2, 1 instrument-grade air to the laser.

Filtering

Filtering compressed air is done using a three step process—first, a water separator to remove large particulates and bulk water/oil condensates; a 93% pre-filter to remove 93% of 0.01 micron, or larger, particles; and finally a 99.99% coalescing filter to remove liquid aerosols and any remaining particles above 0.01 micron in size.

Note: Filter assemblies with automatic drains are highly recommended; however, you must ensure the drain lines are routed into a suitable container or drain so that oil and water aerosols are not vented in the vicinity of optical components.

The numbered items below correspond to the numbered components in Figure 1:

Item 1 A water separator is the first component located at the point-of-use air line drop in the filtering/conditioning process. The separator is designed to remove bulk liquid contamination and large particulates from the air stream.

Item 2 A pre-filter is installed as the first component of a two-stage filtering system. The pre-filter should have an ISO Class 1 element rated to remove 93% of particles 0.01 micron or larger.

Item 3 The second-stage final (coalescing) filter is installed downstream of the pre-filter. It should have an ISO Class 1 element rated to remove 99.99% of 0.01 micron particles as well as liquid aerosols (water vapor) and hydrocarbons (oil vapor).

Drying

Item 4 A dryer (desiccant, membrane, refrigerated, or regenerative type) is required to ensure the dew point temperature of the filtered air is much lower than the dew point of the laser coolant. Each type of dryer has trade-offs between initial cost and periodic maintenance costs. When specifying a dryer, be sure it is sized to match the flow rate of the process.

A dryer at point-of-use removes all remaining water vapor from the air stream while lowering the compressed air dew point to –40 °F (–40 °C), which is well below the dew point temperature of the laser coolant. Some dryer manufacturers offer dryer assemblies that include Items 1 through 3.

Item 5 If a desiccant dryer is used, then install a coalescing filter with an ISO Class 1 element downstream of the dryer. This filter is required to remove any abrasive particles that escape from the desiccant dryer.

Regulating (pressure and flow)

Item 6 A pressure regulator is required to reduce facility air line pressure down to between 2–5 PSI (13.8–34.5 kPa), which is the laser's recommended purge pressure.

Caution: Do not exceed a gas purge pressure of 5 PSI (34.5 kPa). Excessive pressure may damage the purge assembly or other internal laser components.

Item 7 A flow control valve and/or flowmeter helps minimize air consumption by allowing you to fine-tune purge gas delivery based on actual flow through the laser and any mounted beam delivery components. The flowmeter should be accurate for an airflow rate between 30–60 SCFH, Standard Cubic Feet per Hour (0.85–1.7 m^3/hr).

It is important to meter airflow so you do not exceed the dryer's outlet air flow capacity. Outlet flow rates in excess of design specifications will cause an overflow condition where outlet air may not meet the manufacturer's dew point specifications.

Maintenance

Daily/Weekly–

If your filters (Items 1, 2, 3, and 5) do not have an automatic drain feature, you should inspect and drain the filter bowls daily or weekly depending on the amount of liquids trapped by your system. If the liquid level in the filter bowl becomes too high, then bulk liquids are passed through the filter(s) into downstream components (like the dryer and laser), leading to expensive repair or replacement.

Yearly–

Replace all filter elements every 12 months; sooner if the pressure drop across an element exceeds 10 PSI (69 kPa).

Tip: An oil sheen on water drained from the water separator, or other filters, indicates the facility air compressor or it's associated filters and/or dryers requires service.

Connecting purge gas to the laser

To connect purge gas to the *Gas Purge* port on Firestar f201, f400, i401, or p100 lasers, perform the following steps:

Important Note: The *Gas Purge* port must be connected to a source of nitrogen or oil- and water-free, dried air. Do not use any other gases for purging as this will damage internal components inside the laser housing.

1 Connect your nitrogen or oil- and water-free dried air source to the *Gas Purge* port using 1/4-inch (6.4 mm) O.D. plastic tubing.

2 Push the tubing completely into the fitting and then lightly pull the tubing to verify it is locked into the fitting.

Note: To disconnect gas purge tubing, first push and hold the tubing slightly into the fitting. Next push the white fitting ring evenly towards the fitting and then pull the tubing free.

3 Set a purge pressure between 2–5 PSI (13.8–34.5 kPa). If a flowmeter is available, set a flow rate of 30–60 SCFH, Standard Cubic Feet per Hour, (0.85–1.7 m^3/hr) at a pressure not to exceed 5 PSI (34.5 kPa).

Caution: Do not exceed a gas purge pressure of 5 PSI (34.5 kPa). Excessive pressure may damage the purge assembly or other internal laser components.

Summary

The use of an appropriate purge gas can improve the reliability and operation of your laser by reducing the volume of moisture and particulates inside the laser housing. The most important factor is purge gas purity. SYNRAD highly recommends using filtered, high-purity grade (99.9500%) nitrogen or breathing grade (99.9996%) bottled air for your laser purge gas. A less expensive alternative is compressed air; HOWEVER, it must be oil- and water-free and dried (to ISO 8573-1:2010 Class 1, 2, 1 specifications) to prevent any trace of oil or water vapor from contaminating laser optics or electronics.

Equipment recommendations

For conditioning compressed air, your pneumatics vendor is the best source for recommending equipment that conforms to ISO 8573-1:2010 Class 1, 2, 1 and works with your existing compressed air or bottled gas infrastructure. For reference, the following equipment has been proven to work well in SYNRAD customer applications:

From Parker-Balston:

- Parker-Balston Compressed Air Membrane Dryer Assembly (120 SCFH), part number AD0020-40-DX. [Corresponds to Items 1, 2, 3, and 4 in Figure 1]
- Parker-Balston Compact Regulator (0-60 PSI), part number 06R116AC. [Corresponds to Item 6 in Figure 1]

From SMC Pneumatics:

- SMC Compressed Air Membrane Dryer Assembly (156 SCFH), part number IDG30LM3. [Corresponds to Items 1, 3, and 4 in Figure 1]
- SMC Regulator (0.7-29 PSI), part number IR1000-01. [Corresponds to Item 6 in Figure 1]

For further information, contact SYNRAD, Inc. at 1.800.796.7231; outside the U.S., dial +1.425.349.3500 or email us at synrad@synrad.com.