Sampling Compressed Gas with the Lasair III Particle Counter

Abstract

This document provides technical information and recommended methods for sampling compressed gas using the Lasair® III Particle Counter in combination with the High Pressure Diffuser III (HPD III).

Introduction

The Lasair III is an airborne particle counter designed for sampling air at standard pressure conditions. The instrument measures the mass flow using a differential pressure sensor that regulates the pressure drop in the sampling region. Pressure drops across the inlet and outlet jets is measured and provides the most precise measurement of flow.

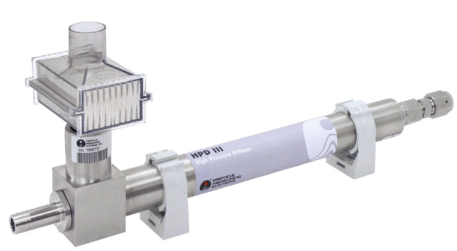
Mass flow is corrected to volumetric flow by using data from an additional atmospheric sensor. The volumetric flow is calculated using the mass flow measured value and the atmospheric pressure.

The [Lasair III Aerosol Particle Counter] and the [IsoAir® 310P Aerosol Particle Sensor] use a sophisticated system described by U.S. Patent 6167107 that controls the volumetric flow.

The instrument flow controller is calibrated for air sampling at standard pressure conditions in accordance with ISO 21501-4; for this reason, it is important to consider several factors while sampling gas other than air.

Gas Pressure

Sampling gases at pressures greater than sea level, such as 25 – 100 psi, is challenging for particle counters. Connecting pressurized air or gas to a particle counter can defeat its flow-metering system and possibly damage the instrument.



High Pressure Diffusers (HPDs) have been developed to address these issues. HPDs reduce the pressure of the gas to about that of sea level by allowing some of the air/gas to diffuse out of the system and allow the particle counter's flow-metering system to function as designed.

The HPD III is an aerosol monitoring accessory compatible with non-toxic, non-flammable gases such as Clean Dry Air (CDA), Argon, Nitrogen, and CO_2. The higher pressure gases are reduced to a level acceptable for particle counters designed to operate at atmospheric pressure.

Gas Density

Another important aspect to consider for compressed gas sampling is the specific gas to be sampled and possible effect on the flow rate measurement accuracy.

As stated above, the Lasair III is capable of sampling compressed gas using the HPD III accessory. However, the flow measurement and fine adjustment is in charge of the particle counter flow rate sensor which is calibrated for air.

Different gases, such as Argon, Nitrogen or CO_2, have different densities which may affect the instrument's flow sensor accuracy. This document provides a guideline to properly collect the required volume of air while considering different gas densities.

Table 1. Compressed Gas Density Table

Gas	Formula	Molecular Weight (g/mol)	Density, ρ (kg/m³)	Density, ρ (lb/ft³)
Air	-	29	1.205 (1)	0.07520 (1)
			1.293 (2)	0.08060 (2)
Argon	Ar	39.948	1.661 (1)	0.10370 (1)
			1.784 (2)	0.11135 (2)
Carbon Dioxide	CO_2	44.01	1.842 (1)	0.11500 (1)
			1.977 (2)	0.12340 (2)
Nitrogen	N_2	28.02	1.165 (1)	0.07270 (1)
			1.251 (2)	0.07807 (2)

Table Legend:

1. NTP - Normal Temperature and Pressure - is defined as 20°C (293.15 K, 68 °F) and 1 atm (101.325 kN/m², 101.325 kPa, 14.7 psia, 0 psig, 30 in Hg, 760 torr)
2. STP - Standard Temperature and Pressure - is defined as 0°C (273.15 K, 32 °F) and 1 atm (101.325 kN/m², 101.325 kPa, 14.7 psia, 0 psig, 30 in Hg, 760 torr)

Correction Factors

The correction factors provided in Table 2 are based on the gas density at the "Normal Temperature and Pressure" condition (NTP).

Particle concentrations are characterized as particles per unit volume, so controlling the correct volume of gas sampled is essential.

In order to calculate the correct sample volume to be configured in the instrument, one must consider the difference in density between air and other gases.

The below formula has been used to calculate this difference and the consequent correction factor.

$$Gas\ flow\ rate\ = Flow\ rate\ measured\ by\ device \times \left(\frac{Specific\ density\ flow\ meter\ is\ calibrated\ to}{Specific\ density\ of\ gas\ going\ through\ flow\ meter}\right)^{0.5}$$

This formula can be applied to any gas. In the following example, CO_2 gas and a flow rate of 1 cfm (28.3 lpm) are considered in the calculation.

$$Gas\ flow\ rate\ = 28.3\ lpm\ (1\ cfm)\ \times\ \left(\frac{1.205}{1.842}\right)^{0.5}\ = 22.89\ lpm\ (0.81\ cfm)$$

The calculation result demonstrates that, while sampling CO_2 using the Lasair III, the "real" volume of gas flowing through the instrument is lower than the instrument reading (22.89 liters per minute flow versus the instrument's reading of 28.3 liters per minute).

Assuming this difference, we can calculate the theoretical correction factor to apply in order to achieve the required sample volume of 1 cubic foot or 1 cubic meter.

Table 2. Compressed Gas Instrument Real and Theoretical Flowrates and Target Settings

Gas	Real gas flowrate while the instrument is showing the nominal value	Theoretical instrument reading to obtain the real nominal flowrate	Correction factor	Target volume setting to sample a real cubic foot	Target volume setting to sample a real cubic meter
Air	**28.30 lpm**	**28.30 lpm**	**1.000**	**28.3 liters**	**1000 liters**
Argon	24.10 lpm	33.23 lpm	1.174	33.2 liters	1174 liters
Carbon dioxide	22.89 lpm	34.99 lpm	1.236	35.0 liters	1236 liters
Nitrogen	28.78 lpm	27.83 lpm	0.983	27.8 liters	983 liters

CO_2 has a Health Rating of 3 on the NFPA 704 Rating System. Use Argon, CO_2 and N_2 as sampling mediums with caution, and contact PMS for assistance.

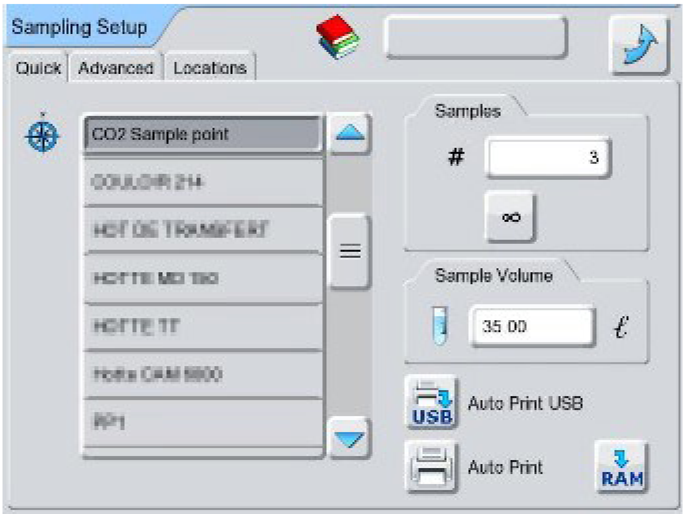
As shown in the above table, sampling of compressed air does not require a correction, because the instrument flow meter is calibrated for its specific density.

Sampling of different gases requires the use of the specified correction factor in order to achieve the expected volume and consistently evaluate particle concentration.

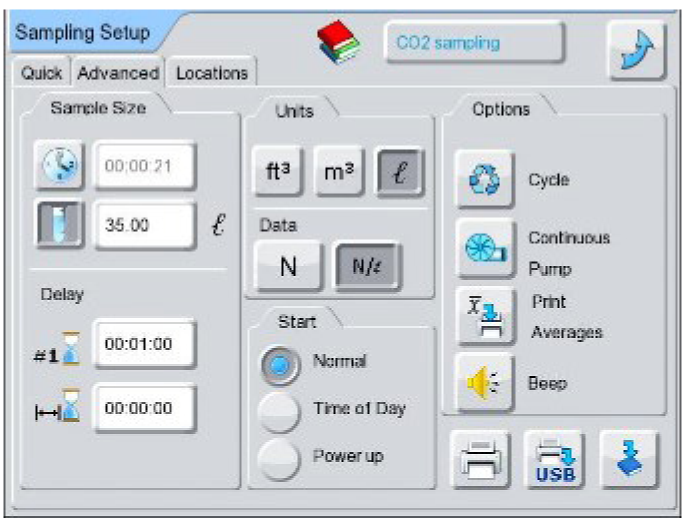
How to Configure the Lasair III

The Lasair III particle counter provides a user friendly interface, which helps the user in properly configuring the main sampling parameters such as sample time/volume, number of samples and alarm limits.

In the following example, the Lasair III will be configured to sample one cubic foot of CO_2 gas:



1. Navigate to the **Sampling Setup** menu.
2. Create the appropriate sample point name (in this example, the sample point/location is called: CO_2 Sample point.)
3. Configure the number of repeated samples. (For this example: 3)
4. Select the instrument **Auto Print** or **Print to USB** functions as appropriate.



5. Navigate to the **Advanced** tab.
6. Configure the corrected sample volume for CO_2 gas sampling:
   - In this example, the corrected sample volume will allows the user to collect 28.3 liters or 1 cubic foot for each sample.
   - Configure the volume and data units as appropriate.
   - Configure a reasonable sample delay to allow the HPD III and tubing to be flushed before starting the particle count.
7. Ensure the compressed gas line, the HPD III, and the sample tubing are properly connected and securely tight. Return to the main screen to start the sample.

For more information about compressed gas sampling, contact your Particle Measuring Systems local representative or navigate to our Customer Service webpage.

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Mr. Pandolfi is the Global Product Line Manager, Aerosol for Particle Measuring Systems' Life Science Division. He has over ten years' experience in particle counter instrumentation and cleanroom contamination control, helping customers solve their cGMP issues.

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