How To Use Air Sampling Pumps Effectively in Cold Temps

Winter is still here – You should know how to correct for cold temperatures!

Personal air sample pumps are devices used to collect and analyze air samples in order to detect the presence of certain gases, particulates or biological contaminants. While these pumps can be utilized in a variety of environmental conditions, there are certain issues of concern that can arise when using them in the winter months.

Three Main Issues

One common issue is that the pumps may not function properly in extremely cold temperatures. Many air sample pumps have temperature limits within which they can operate accurately. If the temperature drops below this limit, the pumps may not produce accurate results or may even malfunction. This can be a particular concern in outdoor environments or in unheated indoor areas. Flowrate stability becomes more variable in conditions less than -10ºC and continues to worsen at lower temperatures.

Second, pump components may become damaged in extremely cold temperatures, as plastic and elastic parts may become brittle and break. Additionally, cold temperatures can greatly reduce battery charge and thus terminate your sample prior to the desired full shift sampling event. Furthermore, air sample pumps and the media that is capturing the contaminant of concern are sensitive to both temperature and humidity. Any moisture in the air can freeze on either the media or inlet block filter, and restrict or block airflow. This may cause your pump to fault out due to back pressure constraints.

Finally, standard protocol requires the pump's flow rates to be set using a Flow Meter before use and verified after use in the conditions that the sampling will take place. However, the use of these flow meters often occurs indoors at typical room temperatures, as opposed to the conditions outside in the extreme cold. The difference in temperature during this flow verification may cause a significant difference in the flow rate when the user operates outside in the extreme cold. This is even more of a concern when sampling using a size selective accessory, such as a cyclone or PPI sampler. Either over sampling or under sampling of a particle size may occur if the flow stability is altered due to the extreme cold temperatures.

It is important to follow the manufacturer's guidelines for using and storing the pumps. This may include keeping the pumps inside of insulated pouches or clothing to keep the pumps stability from diminishing. In regards to the restricted air flow from media freezing, you may want to choose a pump with higher back pressure capability.

How to Correct for Cold

To address issues of flow verification in different environmental conditions, correction to a standard temperature and pressure may be required. The corrections are made using the following equation known as the combined gas law, which is derived from Charles's and Boyle’s Laws of classic chemistry.

$$\frac{P1 \times V1}{T1} = \frac{P2 \times V2}{T2}$$

Where:
P = barometric pressure
V = air volume in liters or cubic meters (1 M3 = 1000 L)
T = temperature in Kelvin (Kelvin = 273 + ºC)

Standard Temperature and Pressure (STP), refers to nominal conditions in the atmosphere at sea level. This value is important to physicists, chemists, engineers, and pilots. It should be noted that different agencies around the world determine their own STP values. It is important that you list your STP values when a corrected volume is given. The most used standards are those of the International Union of Pure and Applied Chemistry (IUPAC) and the National Institute of Standards and Technology (NIST), although these are not universally accepted standards. Since 1982, the IUPAC defines STP with a temperature of 273.15 K (0 °C, 32 °F) and an absolute pressure of exactly 105 Pa (100 kPa, 1 bar, 750 mmHg, 14.5 psi, 29.53 inH20).

In order to correct volume to a reference STP, the following equation is utilized:

$$Vs = \frac{Vm \times Pm \times Ts}{Tm \times Ps}$$

Where:
Vs = air volume in liters at referenced STP
Vm = air volume in liters as measured (Calculated from flow rate and time sampled)
Pm = barometric pressure in mm Hg as measured (millimeters of Mercury)
Ts = temperature in Kelvin at referenced STP
Tm = temperature of the sample air in Kelvin (273 + º C)
Ps = barometric pressure in mm Hg at referenced STP

Sensidyne Solutions

The Gilian® pumps that offer constant flow control always hold flow rate constant, within 5%, at ambient conditions. This allows size selective devices such as cyclones and impactors to hold their cut points stable. The GilAir® Plus will measure the ambient temperature and pressure and calculate the standard volume. The standard conditions can be set by the user.

A key feature in the Gilian GilAir Plus STP pumps allows for compensation of barometric and temperature changes after flow verification is performed, such as using the flow meters in an office setting where it is warm versus utilizing the pump outside in the extreme cold. The result from the GilAir Plus STP pump is accurate flow control as ambient temperature and pressure changes. This capability allows the pump to measure the real-time conditions that exist during the sampling event and provide a corrected volume using the formula listed above.

Conclusion

It is critical to know the pump's specification that sets limits to operating and storing temperatures. Performing sampling outside the manufacturer's set range may cause instability or failures during the event. While some factors may be managed in extreme cold temperatures, others may prevent accurate sampling and therefore should be avoided. By following proper guidelines and taking appropriate precautions, it is possible to ensure accurate and reliable readings even in the winter months.

Aaron W. Apostolico, CIH, CSP, CIEC
Corporate Industrial Hygienist
Product Applications and Research Manager – Health & Safety Products
Sensidyne, LP