The Complete Guide to

Gas Sample Drying

for Your Analyzer or Process

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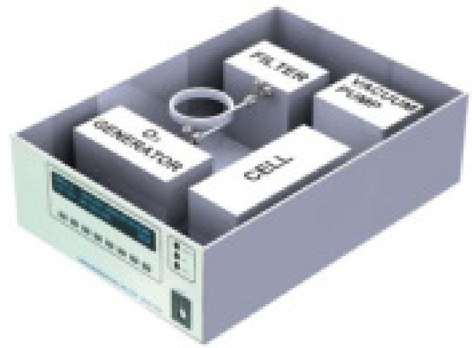

The Complete Guide to Gas Sample Drying

Creating a dry gas sample stream or a source for dry air is essential for the successful operation of a wide range of gas analysis equipment. Water vapor interferes with the proper operation of equipment in many ways. When designing your analysis equipment, it is important to understand the common methods used to remove moisture and understand their strengths and limitations. This short guide was written to help you determine the best method for your application.

To begin, we'll start with describing five common applications where moisture removal methods are critical to obtaining accurate results. There are many more than are listed here, but these can give you a good starting point:

- **Infrared Analysis used for CO2 Monitoring & Measurement -** Commonly used for breath gas analysis among other applications, water vapor appears on the scale in the same region of the CO2 making the results inaccurate unless removed.
- **CEMS and Process Analyzers used in the Chemical, Petrochemical and Power Generation Industries** – Critical chemicals such as SO2, NO2 and Cl are extremely water soluble and the SO2 can react to form harsh acids that ruin the chemical sensors. Water Vapor must be removed in the vapor phase to that the chemical composition of the sample gas remains intact.
- **Sample Combustion used in Total Organic Carbon, Elemental and Mercury Analyzers –** Samples are combusted and analyzed in the gaseous state at a temperature close to ambient. The moisture originally present in the sample or generated by the combustion process must be removed in the vapor phase so that the chemical composition of the sample gas remains intact and condensation on the sensor is prevented.
- **Electrochemical Sensors used for Gas Detection -** Condensation from the gas sample stream can do irreparable harm to the sensor and render the equipment unusable – a problem commonly found when a sample is taken from outside on a hot humid day and analyzed in a climate controlled environment.

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- **Intake Air Drying for Chemiluminescence (NOx Monitoring) or Ion Mobility Spectroscopy (IMS)** – Ambient intake air needs to be dried to a low moisture level before it is used upstream to generate ozone or in the analysis process.

Conventional gas sample drying methods are fraught with difficulties and compromises, making it difficult and or costly to get consistent and accurate results. The most common methods are listed below with their limitations:

Water Traps are inexpensive devices which simply allow the water to condense out as the temperature of the gas cools to ambient, and are placed in line with the gas flow. Unfortunately, they are very non-specific; not only do they remove whatever gases condense at lower temperature, but also at least a portion of whatever gases dissolve in the condensate, potentially making your analysis inaccurate.

Desiccant dryers function by binding water to an absorbent. The absorbent may be a solid (such as silica gel) or a liquid (such as sulfuric acid) that binds water to its chemical structure as water-of-hydration. Desiccants are very simple to operate. Unfortunately, like water traps or thermo electric coolers, they are very non-specific, and remove many compounds other than water. Unlike coolers or water traps, water cannot be removed from desiccants by simply draining it away. While in operation, desiccants become progressively loaded with water, and must periodically be regenerated by replacement of the desiccant or by driving off the water. For most analyzer applications, this means a regular change-out of the desiccant which is time consuming and expensive over the life of the analyzer. However, they can dry to dew points as low as – 60°C.

Peltier or Thermoelectric Coolers are the most common method used to remove moisture. They act as condensers by cooling a gas stream until water and other liquids coalesce, then collecting the condensate and draining it away. Like water traps, they are very non-specific; not only do they remove whatever gases condense at lower temperature, but also at least a portion of whatever gases dissolve in the condensate. Large amounts of gases such as sulfur dioxide are lost, and such coolers are entirely inappropriate for dry gas streams containing hydrogen chloride or chlorine (unless its removal is desired). They are also limited to dew points of +4°C. Peltier Coolers are also subject to regular repair or replacement in many applications, which increases cost and equipment down time.

Perma Pure's Unique Nafion®-based Gas Sample Dryers – The Best Performance Option

Nafion®-based gas dryers take advantage of the unique moisture transfer properties of Nafion ® in tubing form. They function on a principle of selection on the basis of affinity for the sulfonic acid group in the material's structure, allowing water to be transferred chemically from one side of the membrane to another. Depending on the relative water vapor pressure difference between the inside and the outside of the tube, moisture will rapidly move from one side of the membrane to the other. Pressure is not required to drive the process. Unlike other methods, the tubing is extremely selective, only

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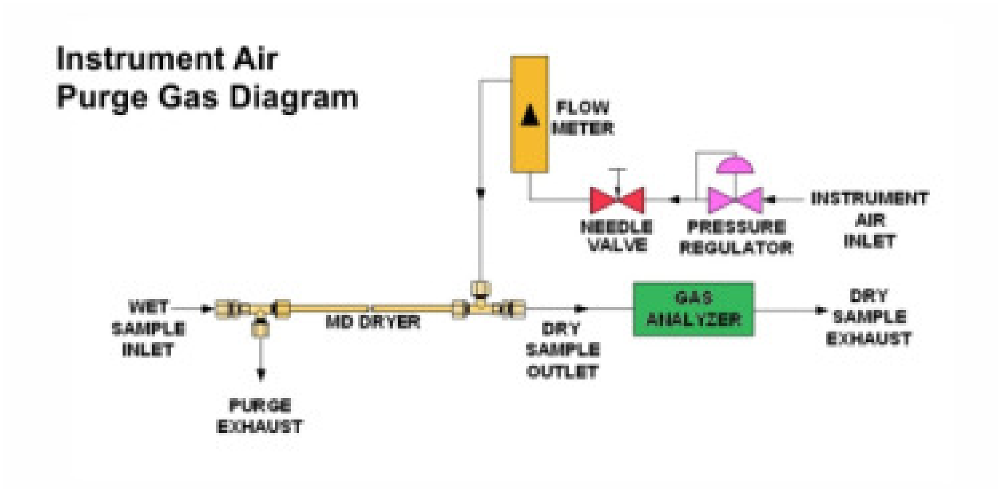
transferring moisture out of a gas stream while leaving the other components intact. This makes Nafion® ideal for gas conditioning applications. When configured properly, Nafion® based dryers can easily reach dew points below – 20°C.

Perma Pure has developed a full line of products to match your specific flow and target dew point (moisture level) requirements.

Drying or humidifying to ambient humidity – We developed the ME Series of moisture exchangers with the Nafion® tubing exposed to atmosphere as a cost effective way to dry sample gases to ambient levels. The limitation is that the performance is dependent on the ambient conditions at the time of use.

Drying to a level as low as possible or a specific dew point (moisture level) – We developed the MD Series (for flows of 0-2 lpm) and the PD series (flows of 1-40 lpm) with a special tube and shell design for use with a dry purge gas to provide a controlled environment for the moisture transfer to occur. Heated versions are available when the sample gas temperature is higher than ambient to prevent condensation in the tubing. The end performance is controllable and dependent on the purge gas set up used, which include a variety of methods successfully deployed by Perma Pure customers:



Instrument Air – Dried compressed or "Instrument" Air is typically found at most industrial plants and in many labs and serves as an excellent purge gas. The dew point of this purge gas is typically -40° to -45°C. Most of our performance curves have been made from test data using instrument air. We recommend the purge gas flow be 2-3x of the sample gas flow for optimal drying performance.

Nitrogen or other Cylinder gas – Using dried cylinder gas with a typical dew point of -60° or -70°C can yield even lower results than shown on our performance curves. Often used for lab applications, this

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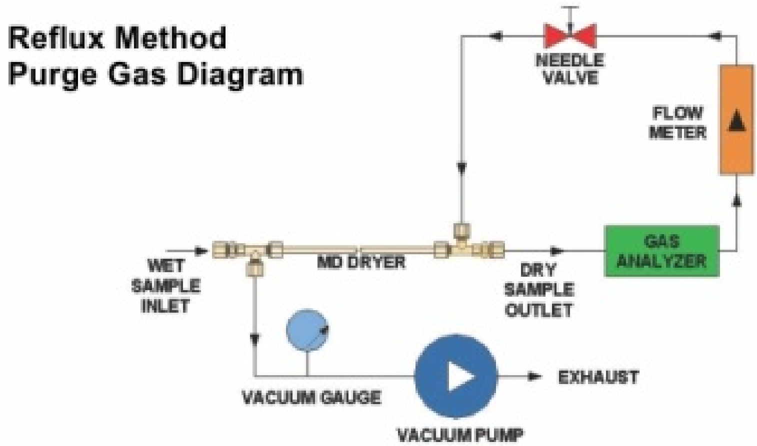
method might not be cost effective for continuous or high flow applications. We recommend the purge gas flow be 2-3x of the sample gas flow.



Recycled Sample Gas (Reflux) Method – Where no instrument air is available, the dried sample gas may be used after analysis as the purge gas by piping it in back to the purge gas inlet. For best results, a vacuum should be pulled through the purge gas path by installing the vacuum pump ahead of the purge gas outlet and a flow restriction (a needle valve or capillary tube) before the purge gas inlet. For maximum performance, the vacuum level should be no less than 7 psi (1/2 atmosphere). A higher vacuum will improve performance. With lower vacuum levels – or no vacuum – the performance will be reduced accordingly. We recommend the purge gas flow be 2-3x of the sample gas flow, which can be achieved with the vacuum.

Atmospheric Vacuum Method – Similar to the Reflux Method, a vacuum is pulled over the tube as the purge gas, but instead of recycling the sample gas, atmospheric air is used. The same set up would apply (vacuum pump plus flow restriction). The only issue here is that the target dryness of the sample would vary with temperature and moisture level of the atmospheric air being used.

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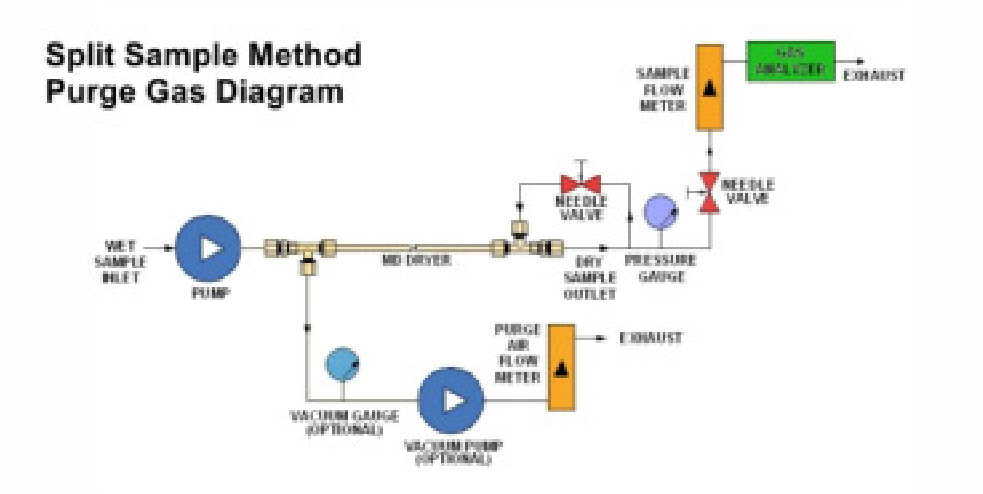

Split Sample Gas Method– Where no instrument air is available, this method - similar to the Reflux Method described above – can be used. The split sample method channels a portion of the gas being dried back over the Nafion tubing as the purge gas. The other portion is routed to the analyzer. A similar set up with the vacuum pump and flow restriction would be created. Because we recommend the purge gas flow be 3x of the sample gas flow, the sample gas flow rate required for analysis needs to be increased accordingly, taking the vacuum effect into account.

Combination Dryer Methods – In order to get to target dryness levels lower than what the Nafion-based products allow, a combination of dryers is often used. The Nafion based dryer can be used as the first dryer stage, removing up to 95% of the moisture in the gas stream. This set-up effectively extends the service life of the secondary desiccant or coalescing filter, greatly reducing costs and extending equipment service intervals.

It makes the most sense to design a Nafion-based Gas Sample Dryer from Perma Pure into your analyzer or Gas Sampling System. You will see increased drying performance, longer life and more accurate results. Let Perma Pure help you select the right dryer for your application. Visit our website at www.permapure.com and contact us with your application details and questions.