GE

Sensing & Inspection Technologies

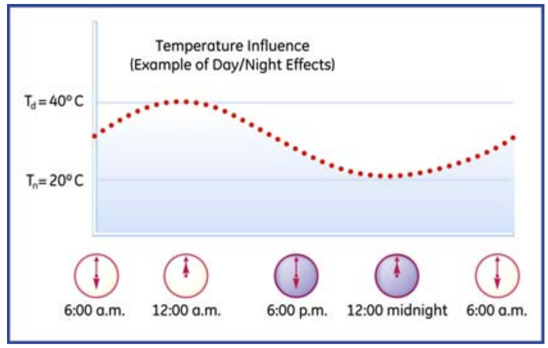
Trace Moisture Diurnal Effects in Process Applications

In trace moisture measurement applications typically below 1-5 PPM, users may see a cyclic effect on the moisture reading referred to as *diurnal effect*. Diurnal effect refers to temperature changes that occur from day-to-night (diurnal). Typically, these application points are located in process plants in outdoor locations.

This effect is a real moisture change in the process piping of the process system and to a minor level, the sample system where the moisture analyzer is plumbed into the process.

Strong polarity of water molecules

An important feature of water is its polar nature. The water molecule forms an angle, with hydrogen atoms at the tips and oxygen at the vertex. Since oxygen has a higher electronegativity than hydrogen, the side of the molecule with the oxygen atom has a partial negative charge. The polar nature of the water molecule allows for it to adsorb to all surfaces of a wetted system.



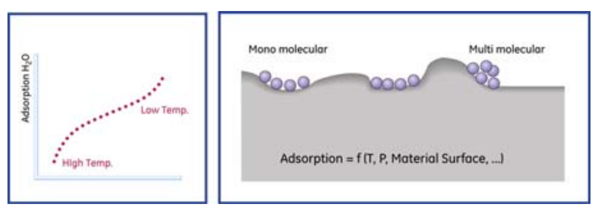
Diurnal Effect is typically observed on a day-to-night cycle corresponding to swings in ambient temperature from day-to-night

How the Diurnal Effect Affects Moisture Readings

Process pipes are typically carbon steel and have a layer of corrosion on the inside of the pipe that provides a high surface area with a rough surface finish for water molecules to adsorb. As the pipe is heated during the day, the ambient temperature rises and direct sunlight provides additional solar radiation heating. This heating causes the water molecules that adsorbed onto the pipe wall in equilibrium at the lower nighttime temperature to leave the pipe wall and flow into the gas stream, resulting in higher moisture readings as the system reaches a new equilibrium.

In a trace moisture system, it is not uncommon to see a shift of 1 PPM moisture jump to 3 PPM moisture during daytime operation. This change in reading is due to the non-equilibrium condition of the water in the system. While this seems like a large change in reading, it really is not considering 1 PPM equates to one part of water in 1,000,000 parts of other gases in the system.

While this example gives you an idea of the impact of diurnal effects, real-world conditions, such as process gas flow rate, gas density, corrosion layer thickness, surface finish roughness, flow dynamics and many other factors contribute to the overall diurnal effect observed. For example, applications with high flow rates or higher gas density may see relatively smaller shifts in reading. The high flow rate and density in these applications cause a "scrubbing" effect of the pipe wall that provide better system equilibrium.



Diagrams showing adsorption dynamics for surfaces

Diurnal effects are not usually noticeable in liquid process applications since the density of liquids is much greater than gases. In addition, the liquid flow provides for much greater system equilibrium with respect to temperature that the effect is not typically witnessed. Absolute trace moisture concentrations in the range of 1-5 PPM on a weight basis in liquids typically have much higher water vapor pressures compared to gas applications.

imagination at work

Thus the relative change in water adsorption or desorption from the pipe wall is small compared to the higher water vapor pressure found in liquid applications.

For customers monitoring the performance of their processes in gas applications, diurnal shifts in the moisture reading are cause for concern from a process control perspective. Questions typically arise such as:

- Is the process really changing?
- Is there some problem with temperature effect on the moisture analyzer?
- Are changes in the process control of the plant or process warranted?

Other Factors Affecting Moisture Readings

Apart from the diurnal effect, moisture readings can also be influenced by the sample system and the transport tubing from the sample tap to the sample system. From an installation of the moisture analyzer and sample system perspective, there are some steps that can be done to minimize any impact of diurnal effect caused to the wetted parts of the sample system and installation of the moisture sensors and/or analyzer.

- Use Stainless Steel (SS) tubing - Process moisture analyzer sample systems should use SS tubing at a minimum. SS tubing has low moisture adsorption characteristics and a fairly good surface finish that minimizes moisture adsorption.

- Maintain temperature - The sample system tubing and components upstream of the moisture sensor should be at a nominal constant temperature. This may involve several steps:

  1. Heat trace the stainless steel tubing from the sample tap into the process line to the sample system panel. Customers normally use an electrical heat tracing system that meets the hazardous area of the installation. The heat tracing system includes a thermostat to turn power on/off to the heating element. Insulation is wrapped around the line and heating element to insulate the system. The set point is typically 40°C or 50°C. This temperature is sufficiently high enough to cut out lower temperature swings experienced during day-night ambient temperature changes, but not so hot that it exceeds moisture analyzer application requirements.

  2. Put the sample system panel in an insulated enclosure with a suitable enclosure heater rated for the hazardous area requirements of the installation. Enclosure heaters are the preferred method of keeping the sample system panel and gas in the sample panel location. Heat tracing is not practical at the sample system panel due to the irregular shape and size of the sample system components. Again, The set point is typically 40°C or 50°C.

These steps will help minimize the impact of moisture adsorption/desorption for the sample transport lines and sample system. Users may still see diurnal effects in trace moisture applications related to their process that are real in terms of processes variation of moisture due to ambient temperature.

Example of moisture analyzer sample system panel for an aluminum oxide moisture sensor. The enclosure is insulated and an explosion proof heater (shown in bottom left of panel) is used to maintain temperature.

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