MOISTURE THEORY AND MEASUREMENT

In industrial measurements of moisture in a gas the usual practice is to express the reading in either Dew Point or in terms of Concentration, e.g. ppm (v). Systech manufacture moisture analysers using two different types of sensor, the electrolytic (P_2O_5) sensors, which measure moisture concentration and the aluminium oxide sensors that measure Dew point. All of our analysers include the facility to convert the readings so they can be displayed in both types of unit.

Dew point

The amount of water vapour that a gas can hold depends on the temperature of the gas, the higher the temperature the more water vapour can be present. When a gas is cooled it eventually reaches a temperature where it cannot hold any more water vapour (it is saturated) and any excess condenses as liquid water. This temperature is known as the Dew point.

This can often be seen in nature when the air temperature cools to below the Dew point and fog forms or when condensation forms on a cool window.

In a very dry gas the saturation temperature will be below 0 deg C and water vapour will condense as ice (solid water); in this case the condensation point is know as the Frost point. When discussing moisture analysis of gases the terms Frost point and Dew point are used interchangeably.

The Dew point temperature also depends upon the pressure of the gas being measured. Higher pressures equate to higher Dew point temperatures, for the same concentration of water vapour present, so it is important to know the pressure when using instruments that measure in Dew point.

Concentration

The concentration of water vapour in a gas mixture is usually expressed in terms of mass per unit volume, ppm(v), or occasionally as mass per unit mass, ppm(w). Pressure or temperature of the gas does not affect measurements of this type as neither factor affects the mass of the water vapour or the gas involved.

P_2O_5 Analysers and Sensors

The Systech 500 series and MM2000 moisture analysers utilise P_2O_5 sensors, also known as electrolytic sensors. These devices measure concentration of by volume and are independent of pressure or temperature effects. A description of the principle of operation is given in the P_2O_5 sensors datasheet.

Analysers using this technology are ideal for measuring low moisture levels in all inert gases. A major benefit of these sensors is they do not require calibration, provided the flow rate is known, and this is controlled within the 500 series analysers, the measurement of the moisture level is determined by Faradays Law of Electrolysis.
P_2O_5 sensors require periodic recoating, a simple process which can be performed by the customer. The lifetime of the coating is dependent on the moisture level of the gas being measured, another reason why these instruments are optimised for measuring very low levels of moisture.

When measuring in gases containing either hydrogen or oxygen, an effect known as recombination must be considered. The P_2O_5 sensor works by electrolysing water into hydrogen and oxygen. Some of this hydrogen will combine with the oxygen in the gas stream (and vice versa) to form water (H_2O) which is then re-electrolysed giving a false reading. Fortunately the recombination effects are simple to characterise and can be easily corrected. All Systech P_2O_5 analysers include correction factors for use with hydrogen or oxygen containing gas streams.

Special sensors are available for measuring in corrosive gases such as HCl and CL2.

AlOx Analysers and Sensors

Systech Instruments moisture analysers in the 400 series employ aluminium oxide sensors to determine the moisture level. These sensors measure Dew point, therefore consideration must be made to the temperature and pressure of the measured gas. A full description of the principle of operation can be found in the data sheet for Al_3O_2 sensors.

These analysers are used for measuring moisture in a wide range gases, such as Natural gas, Propane, Butane, Freons etc, with a wide range of moisture levels. They are tolerant of much higher moisture levels than the P_2O_5 analysers.

The major drawback with AlOx sensors is the requirement for recalibration, recommended annually. These sensors continuously de-rate throughout their lives, which can lead to under readings (too dry). This is especially important when measuring dry gases. Systech offer a recalibration service for these sensors from our Thame factory.

Sample Systems Considerations

Of all the factors involved in moisture analysis, one of the most important, and often given the least attention, is the sampling system. When designing a sample system leakage, pressure, temperature and moisture adsorption/desorption should all be considered.

Moisture, more than most gases, tends to stick to the walls and joints of pipework. Sample systems should have a minimum of fittings, no 'dead legs' and use good quality materials and fittings. Flexible or PVC tubing should never be used, these materials are often permeable to moisture. The stickiness of the water molecules can cause problems with achieving equilibrium and lines may need to be purged for a long time.

Sample lines should be kept as short as possible, if this is not practical consideration should be given to using a higher, bypass, flow rate to improve the response of the analyser and to purge the sample lines of unwanted moisture.

Temperature changes are perhaps the most significant, especially when measuring at very low moistures. Changes in temperature cause changes in the adsorption and desorption from the walls of the tubing or the sample cylinder. This results in a change of moisture content in the gas, which is then measured. Special consideration of this effect should be made when checking the calibration of a moisture analyser.

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