

SAMPLING SYSTEMS

EdgeTech Dew Point Hygrometer Sampling Systems



Overview

Of all the factors which need to be considered in humidity measurement, one of the most important, and that which is often given the least attention is the sampling system. Considerations of leakage, pressure and temperature gradients, and moisture absorption characteristics are often overlooked.

The problem of leakage is relative; i.e., if the dew point being measured is close to the ambient room dew point, leakage into the system may not bias the reading substantially. If however, the system is pressurized above atmospheric so as to create a leakage out of, rather than into, the system, the error introduced will be less.

The degree to which leakage can be tolerated also depends heavily on the actual dew point being measured. As an example, when measuring a dew point of -100°F (-73°C) with a sample flow rate of 4 SCFH, at an ambient or surrounding dew point of 50°F (10°C), a leakage in flow of 5×10^{-5} SCFH will cause an error of 1°F (0.56°C). However, at a measured dew point of 100°F (38°C), the same leakage rate would cause an error of only 0.00001°F . The area of leakage becomes significantly more important and the error becomes much larger in systems operating below ambient pressure.

Pre-Heating

If the dew point of the gas under measurement is greater than the ambient temperature of the installation and the sampling lines, both the lines and the sensor must be heated with some type of heater tape, or the line must be steam-traced in the usual fashion. The approach used will vary widely with the specific nature of the installation, and the user must use their own ingenuity to assure that none of the sampling components be at a temperature lower than the highest dew point anticipated. If electrical heater lines are used, it is desirable to connect these to a variable transformer or controller to adjust the heating level. If the sample lines are too long, it may be necessary to wrap them in insulation to minimize the amount of heat required to accomplish the preheating. The line should be heated well above the dew point and should not exceed the temperature rating of the sensor. A maximum of 200°F (93°C) is usually recommended. Heating above the dew point does not change the dew point of the sample.

Selection of Sampling Components

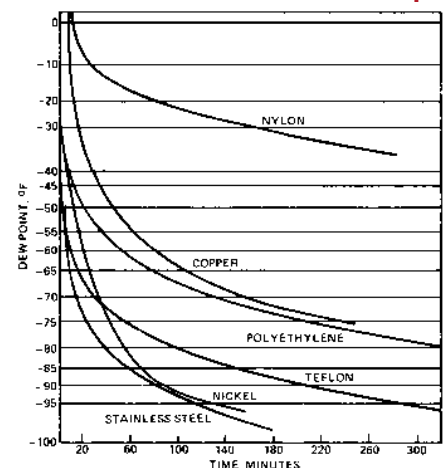
Of equal importance is the effect that material absorption/desorption characteristics have on overall system response. Although not true of all applications, stainless steel, glass and nickel alloy tubing are the best possible non-hygroscopic materials and should be used for low dew point applications (0°F to -100°F [-18°C to -73°C] and below). Teflon is also satisfactory, but begins reducing system response due to desorption at the lower dew points. Copper and aluminum alloys, as well as stabilized polypropylene tubing are acceptable above 20°F (-7°C) dew point. Most plastic and rubber tubing is unacceptable in all ranges. Unless attacked by the sample, the effect of the more hygroscopic materials is not of contaminating nature, but actually one of introducing severe lag into the system during the establishment of an equilibrium condition. For example, plastics such as nylon cannot be used at low dew points simply because the equilibrium condition may actually take days to stabilize. The actual selection of the sample line material should be based on the degree of permanency of the installation, with a minimum of joints, fittings, and other plumbing prior to the hygrometer. Generally, stainless steel is preferred for permanent installations operating at low dew points. On stainless steel lines, either swage or flare-type fittings can be used.

Pressure Measurements

The dew point temperature of gas is a measure of the absolute moisture content of the gas, regardless of the temperature and pressure of the gas. Most conversion tables for dew point (or frost point), to parts-per-million, grains-per-pound, etc., are normalized at atmospheric pressure (14.7 psia); therefore, if accurate absolute moisture content measurements are to be converted to atmospheric-pressure-referenced values, the pressure must be known. A pressure tap after the hygrometer sensor can be fitted with an appropriate pressure gauge. *Basic Humidity Definitions are explained in a separate EdgeTech document.*

Material Moisture Properties

All materials will absorb moisture to some extent. The curves relate typical desorption properties of common sampling line materials after being exposed to a "wet" gas such as the ambient atmosphere. The curves illustrate the difficulty of obtaining a fast system response when switching from a high dew point sample to a low dew point sample. Even if the instrument responds instantly, the sampling lines dictate the overall response.



Cleaning Sampling Systems

Most types of metal tubing contain oil deposits on the interior walls due to the manufacturing process. This residue must be removed before putting the lines into service in a gas sampling system. The lines should be cleaned and purged dry with air or nitrogen before being placed into service. In addition to the initial installation, the process itself may constitute a source of contamination and in many applications these are volatile hydrocarbons. Care should be taken not to introduce such hydrocarbons. Dew point hygrometers are provided with a cleaning solution for use in cleaning and conditioning the sensor mirror. The cleaning solution is Isopropyl alcohol (IPA) and is also locally available.

Contamination Effects

System contamination and its effect on dew point measurement can be subdivided into two categories: condensables and noncondensables. Before proceeding, it is important that one understands that the optical dew point analyzer measures the dew point, hence the vapor pressure, of any substance that condenses on its mirror surface. Conversely, regardless of concentration, contamination constituents in a sample will not condense on the mirror unless its dew point temperature is reached.

Condensables

Condensables can be further subdivided into soluble and insoluble condensables. If insoluble, and its dew point is at or above that of the constituent being measured, the relative concentration level will mainly determine the effect on the measured dew point. If the concentration level of the contaminant is low, i.e., has a low partial pressure compared to the water vapor, then the effect of its presence can be standardized periodically before it degrades the primary measurement. This is done by heating the mirror surface to evaporate the condensate and rebalancing the optical detection system. At high concentration levels, the dew point analyzer may measure the dew point of the contaminant rather than the water vapor dew point. This problem is lessened due to the high attenuation characteristics of dew or frost compared to many of the common contaminants. For example: if a water vapor dew point of 32°F [0°C] was being measured at atmospheric pressure (760 mm Hg) and the ethylene oxide were present as a contaminant

at a concentration level of 10% [76 mm Hg], its dew point would be -31°F [-35°C]. Since this is below the water vapor dew point, it will not condense on the sensor's mirror. However, this means that there would be interference if the water vapor dew point was below -31°F [-35°C]. If the contaminant is, in addition, soluble in the constituent being measured, it will modify the vapor pressure and, hence, the dew point of the sample. The overall effect will depend on the degree of solubility.

Noncondensable

The secondary category of contaminant is the noncondensables, which can again be subdivided into solubles, primarily salts, and insolubles, consisting of particulate matter. The soluble contaminant similarly will modify the partial pressure, or dew point, being measured. This type of contaminant affects all types of humidity instruments and necessitates frequent cleaning of the dew point mirror, since heating the mirror will not remove the salts. Insoluble matter is most easily avoided through sample line filtration.

Sampling Configurations

A suggested sampling system for use with dew point hygrometers would be one where a portion of the gas line to be sampled is brought to the hygrometer location from a pressure tap either by using a suitably designed vacuum pump, or by expanding the sample to a lower pressure. The flow rate through the main sampling line should be sufficient to ensure continuous flushing of the

lines, in order to provide a fast response time for the sampling system. Usually, the flow rate of 0.5 - 5.0 SCFH in a 1/4" line is adequate; however, this number must be adjusted with the length of the line, the level of absolute moisture content of the sample, and the desired response time of the sampling system. A bypass line may be used to increase the main sampling line velocity and improve the overall response time. It is necessary that the sampling line be equipped with a valve for adjusting the sample flow rate. The sample for the hygrometer is obtained from the pressure drop across the bypass as shown. It is desirable to provide the hygrometer input with a filter, especially if the gas under study contains particulate contaminants. Several sintered stainless steel filters are available which are suitable. It must be remembered that the filter element is considered a hygroscopic item, which will contribute some lag to the sampling system. A rule-of-thumb in the design of hygrometer sample systems is to minimize the number of components, such as valves, tees, and filters prior to the hygrometer input. The hygrometer output is connected to a flow meter and valve for adjusting the flow rate to the recommended range of 0.5-5.0 SCFH.

NOTE: Considerable cost savings can sometimes be made by recognizing that the sample exhaust lines and related components need not be as high a quality and as non-hygroscopic as those prior to the hygrometer.

