Humidity School

Lesson 1

Theory and hygrometric units

1. Fundamentals

Humidity is a measure of the water vapor present in the air or in other gases and the discipline of humidity measurement is called hygrometry. Water vapor is present in quantities of up to around two percent by volume in ambient air and present, at least in trace quantities, in industrial gases. There is no such thing as a totally dry gas! Water vapor in a gas can be treated as a gas itself, behaving in accordance with the gas laws. Therefore the total pressure (Pt) of a gas is composed of the partial pressures of the gas (Pg) plus the partial pressure of the water vapor which it contains (Pw). The fundamental measure of humidity is therefore water vapor pressure (wvp).

If a sealed vessel containing moist gas is halved in volume, then both the total pressure of the gas and the water vapor pressure is doubled. However, if the total pressure is doubled by introducing dry gas into the vessel, the water vapor pressure is unaltered. From the fundamental unit are derived several other practical units in common use: Saturation water vapor pressure (swvp): The maximum attainable water vapor pressure of a gas at a given temperature and pressure.

If a sealed vessel contains a quantity of water with an air space above it, then at constant temperature and pressure evaporation takes place from the water until the air becomes "saturated". It can not accept any more water. The air has achieved saturation water vapor pressure.

2. Hygrometric units

Dewpoint (dp): The temperature at which saturation water vapor pressure would occur if the gas were to be cooled (at constant pressure). Although below freezing point the appropriate term is “frost-point”, the practice has developed of using the term “dewpoint” irrespective of temperature. Dewpoint is measured by finding the temperature of a gas at which dew or frost begins to form on a solid object, which is at the same temperature and immersed in the gas. Dewpoint is a directly related unit to water vapor pressure and excellent tabulated data exists between the two.

Absolute Humidity (ah): The ratio of the amount of water vapor to the amount of dry carrier gas. It can be expressed as a percentage, parts per million or parts per billion.

Parts per million (ppm): The number of parts of water to one million parts of dry gas expressed either by volume (ppmV) or by weight (ppmW).

Relative Humidity (rh): The ratio of water vapor pressure to saturation water vapor pressure at a given temperature and expressed as a percentage.

The adjacent table gives the relationship between the most common hygrometric units. Note the general relationships between them. In particular, observe the relative-humidity scale against the dewpoint scale; a gas at 5%RH is very dry to most people, yet at a temperature of 20°C it would have a dewpoint of -18°C or 1000 parts per million on the ppmV scale. This would be a very wet gas in many industrial applications. Take note of the severely non-linear relationship between the dewpoint and the ppm scales.

Dewpoint °Cdp	Vapor Pressure Pa	Relative Humidity % (at 21 °C)	Parts per Milion ppm(V)
-100	0,001	0	0,01
-80	0,002	0,002	0,54
-60	1,18	0,043	10,7
-40	12,0	0,517	127
-20	103	4,15	1020
0	611	24,5	6068
+20	2338	94	23624
+40	7381	-	78571
+60	19933	-	244902
+80	47374	-	878122
+100	101324	-	-

3. Some important points on units

Relative Humidity varies with temperature as well as with absolute humidity. Dewpoint varies only with the absolute humidity.

Pressure variations have an effects on the absolute unit of water vapor pressure therefore they also affect the derived units. In most applications when measuring at nominal atmospheric pressure, small variations can be ignored. But at higher pressures or under vacuum these must be taken into account. However, note also that the pressure dewpoint is frequently more important to the user than an atmospheric dewpoint.

Many instruments which are called “Dewpointmeters” do not actually cool the gas to the dewpoint but depend on a secondary method such as impedance (the STORK bi-ceramic sensor). Such instruments must be calibrated by reference to a calibration system. STORK manufactured impedance instruments are calibrated in our Calibration Laboratory against internationally traceable standards.