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Chilled Mirror Hygrometer Technology, a fundamental first principal measurement for dew point

In this paper, we explain the technology of chilled mirror and why chilled mirror hygrometer (CMH), a primary measurement is used as a NIST traceable reference standard use to calibrate other capacitive polymer sensor, which are a non-fundamental (secondary) measurement of Relative Humidity.

Chilled mirror hygrometers use a primary fundamental principal measurement which is a change in resistance. This principle works when a sample of process gas flows across a special polished coated mirror. The mirror temperature is lowered by thermal electric coolers (located beneath the mirror block/mirror) until the water vapor of gas condenses out on to the mirror in the form of either dew or frost. There is an optical circuit which constantly monitors the mirror surface and looks for equilibrium between the optical LED detectors (a reference and the dew detector). The temperature of the mirror surface is measure by a highly accurate Platinum Resistance Thermometer (PRT) which is embedded and sealed in the mirror block which is thermally connected to the mirror. The PRT resistance measurement is what makes this a fundamental dew point measurement.

In more detail, a fundamental measurement is such that the parameter being measured, is the same as the Standard International definition of that parameter. In the case of the Chilled Mirror Hygrometer, that measurement is the temperature of the mirror surface covered by a water layer that is in equilibrium between the liquid and gaseous phases of water. If that temperature measurement is accomplished by a platinum resistance thermometer, the measurement is equivalent to the definition of dew point. Tables constructed by NIST, notably by Wexler and Greenspan, establish the equivalence of dew point and the vapor pressure of water. Using this equivalence and a second, fundamental, temperature measurement, realizes the definition of Relative humidity: Vapor pressure of water/saturation vapor pressure (temperature) of the gas being measured, X100(%) i.e. %RH $=100*P_{H2Ov}/P_{SAT}$. Addition of a 3rd measurement, the pressure of the gas being sampled, allows measurement of almost every other humidity parameter. Some further unit examples: absolute Humidity (g_{H2Ov}/m^3), mixing ratio (g_{H2Ov}/kg_{DRY}), Parts per million ($P_{H2Ov}/(P_{Tot}-P_{H20})$), enthalpy(h), to name a few.

Chilled mirrors hygrometers are used where accuracy, typically +-0.2°C or better, repeatability, stability and no drift are paramount. CMH are the preferred reference standard in most calibration labs. Also, CMH work well due to their ruggedness, their inertness, their simple maintenance and ability to accurately measure sample gasses remotely from process, i.e. ovens, dryers, furnaces, etc. Dew points above ambient can be measured by heating the chilled mirror and associated components. Chilled

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mirrors can be, and are, constructed as an insertion probe, provided the temperature of the process is < ~95 °C.

In closing, the upside of the chilled mirror hygrometer is that it uses a fundamental principal, it can be designed to be inert to many corrosive gases, it is a repeatable in its measurement, there is no measurable hysteresis, it is very accurate and has a very long operating life. The downside is that it is expensive and is typically slower in response time when compared to other secondary principal humidity measurements.

A portable chilled mirror hygrometer.

The DewTran-remote chilled mirror hygrometer

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