eyc-tech
溫濕度感測原理
Temperature and humidity sensing principle

濕度感測器原理 Humidity sensor principle

電容式感測元件中之聚合物層吸收水氣使介電係數改變導致電容值改變。

In capacitive sensing elements, the polymer layer absorbs moisture, causing a change in the dielectric constant and thus a change in capacitance.
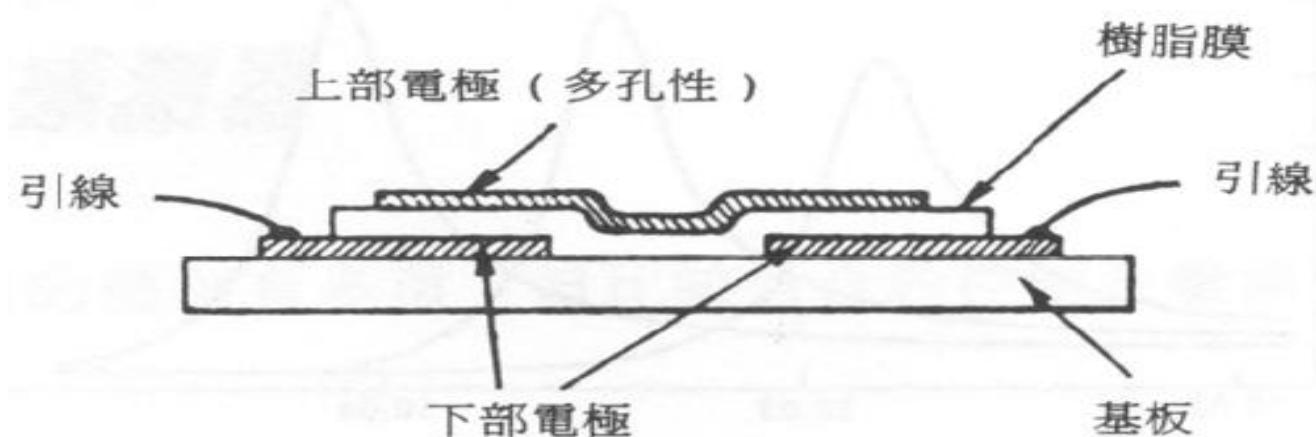
相對濕度 Relative humidity

是指同一溫度下氣體，水氣的分壓除以飽和蒸氣壓的百分比率。

This refers to the percentage of the partial pressure of water vapor in a gas at the same temperature divided by its saturated vapor pressure.

$$\varphi := \frac{\rho_w}{\rho_{w,max}} \cdot 100\ \% = \frac{e}{E} \cdot 100\ \% = \frac{s}{S} \cdot 100\ \%$$
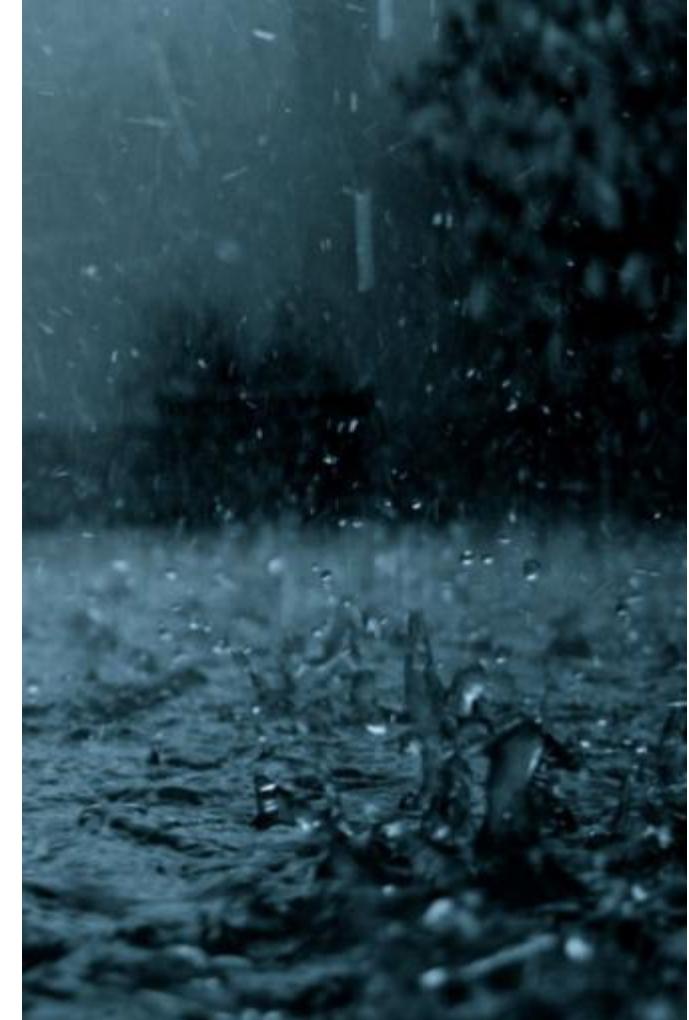
絕對濕度 Absolute humidity

空氣濕氣水氣質量 kg/kg

Air humidity (kg/kg)

在濕空氣中，每單位乾空氣所含的水蒸氣之重量(kg水/kg乾氣)，
定溫下，空氣越乾燥則濕度比越小，反之則越大。

In humid air, the weight of water vapor (kg water/kg dry air) per unit
of dry air is the ratio of moisture content to humidity. At a constant
temperature, the drier the air, the lower the humidity ratio, and vice
versa.

$$\text{絕對濕度} = \frac{\text{水氣質量(kg)}}{\text{乾空氣質量(kg)}}$$

$$\text{Absolute humidity} = \frac{\text{Water vapor mass (kg)}}{\text{Dry air mass (kg)}}$$

露點溫度 Dew point temperature

空氣濕氣結露溫度
Air moisture condensation temperature

空氣在氣壓及水氣的含量不變的情況下，逐漸將低溫度，知道水氣量達到飽和，多餘水分解析出而凝結成小水滴，第一滴水滴凝結時的溫度即為露點，相態為氣體→液體。

When air pressure and water vapor content remain constant, the temperature gradually decreases until the water vapor content reaches saturation. Excess water is released and condenses into small water droplets. The temperature at which the first water droplet condenses is the dew point, and the phase changes from gas to liquid.

霜點溫度 Frost point temperature

空氣濕氣結霜溫度
Air humidity frosting temperature

與露點溫度相似，但相位為氣態不通過液態而轉換成固態，此固態即為霜，當地一顆冰晶凝結出來的溫度即為霜點溫度。

Like the dew point temperature, but the phase is gaseous and does not transform into a solid state through a liquid state. This solid state is frost, and the temperature at which an ice crystal condenses is the frost point temperature.

熱焓 Enthalpy

空氣濕氣所含熱量KJ/kg
Heat content of air moisture (kJ/kg)

物質能量的一種狀態表示，每單位重量之乾空氣中，其乾濕混合氣體所含之熱容量，單位為KJ/kg，而反應中熱量的變化，即為焓的變化。

A state of matter and energy, enthalpy is the heat capacity contained in a dry-wet mixture per unit weight of dry air, expressed in kJ/kg. The change in heat during a reaction is the change in enthalpy.

量測濕度方法 Humidity measurement methods

- 乾濕球法
- 飽和鹽液法
- 雙溫雙壓法
- 乾濕分流法

- Dry-bulb method
- Saturated brine method
- Dual-temperature dual-pressure method
- Dry-wet split method

乾濕球法 Dry-bulb method

在進行相對濕度計的性能校正時，需要將濕度計置於具有〝標準相對濕度值〞的環境，以此標準值與濕度計讀出值加以比較，並建立校正曲線。因此可知產生此標準值之設備其準確度直接影響濕度計之校正功能。

When calibrating a relative humidity meter, it is necessary to place the hygrometer in an environment with a "standard relative humidity value," compare this standard value with the hygrometer reading, and establish a calibration curve. Therefore, the accuracy of the device generating this standard value directly affects the hygrometer's calibration function.
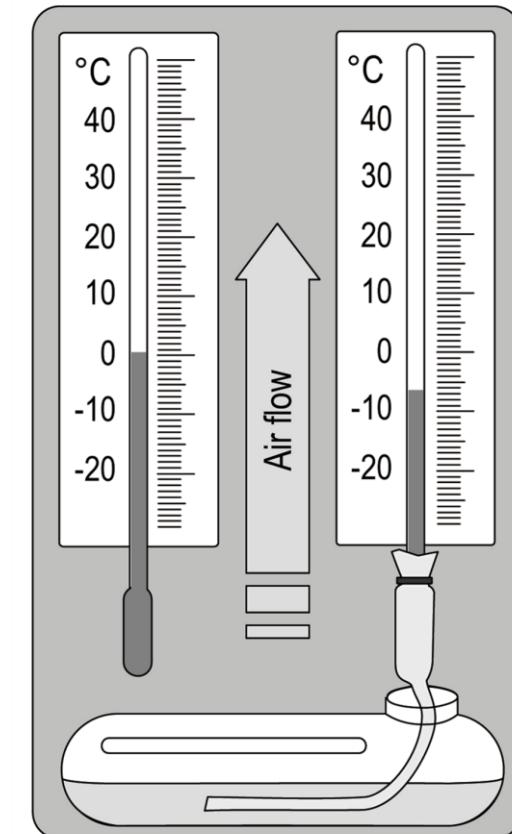
飽和鹽液法 Saturated salt solution method

將化學鹽類溶於密閉空間內的純水，其鹽份添加之數量必須使溶液內產生結晶，因此密閉空間內之空氣與此鹽類飽和液產生平衡。不同飽和鹽產生不同數值之相對濕度值。此方法成本低廉且作業簡易，通常為研究人員採納已進行相對濕度計之性能校正。

In this method, chemical salts are dissolved in pure water in a sealed space. The amount of salt added must be sufficient to induce crystallization in the solution, thus creating an equilibrium between the air in the sealed space and the saturated salt solution. Different saturated salts produce different relative humidity values. This method is inexpensive and easy to operate and is commonly adopted by researchers after calibrating the relative humidity meter.

| Salt	(1)25℃	(2)20℃ 數字±量測不確定度	(3)20℃	(4)25℃ 數字±量測不確定度
LiCl	11.3	12.0	11.5	NA
CH_3COOK	22.5	23.1±0.3	23.1	22.7±0.3
$MgCl_2$	32.8	33.1±0.2	33.14	32.6±0.3
K_2CO_3	43.2	43.2±0.4	43.3	43.5±0.4
NaBr	57.6	59.1±0.5	58.8	NA
KI	68.9	69.9±0.3	70.4	68.7±0.4
NaCl	75.3	75.5±0.2	75.6	75.5±0.2
KCl	84.3	85.1±0.3	83.7	NA
K_2SO_4	97.3	97.6 ±0.6	98.3	97.4±0.4

雙溫雙壓法
Dual-temperature dual-pressure method

雙溫度法(Dual-temperature method) :

將氣體在第一溫度下(T1)通過飽和水槽，使氣體為百分之百飽和狀態，再將此氣體導入另一高於第一溫度之空間內(其溫度為T2)，由於溫度之增加使相對濕度降低。由T1與T2值之調整可得不同之相對濕度值，此設備之特點在於相對濕度產生裝置之準確度受到兩溫度維持準確性之影響。

Air is passed through a saturated water tank at a first temperature (T1) to achieve 100% saturation. This air is then introduced into another space at a higher temperature (T2). The increased temperature lowers the relative humidity. Different relative humidity values can be obtained by adjusting the values of T1 and T2. A key feature of this equipment is that the accuracy of the relative humidity generator is affected by the accuracy of maintaining the two temperatures.

Two-Temperature Humidity Generator Schematic
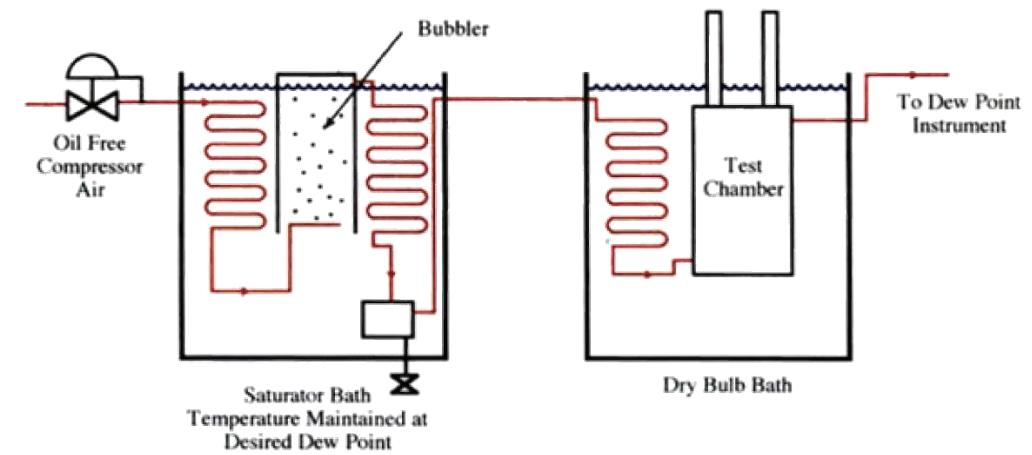
雙壓力法(Dual-pressure method)：

將一定溫下之飽和氣流通過膨脹閥進入另一相同溫度之空間內，由氣體定律可知，經膨脹後壓力降低，因氣流中水分質量不變，其分壓水蒸氣壓力亦降低，而無法仍存在於飽和狀態。因此由氣體膨脹前後壓力的調整可產生不同之相對濕度環境，此方法產生濕度之準確性受到膨脹過程前後溫度，壓力的控制所影響。美國國家標準局(NBS)採用此方法為其標準相對濕度產生器。

A saturated gas stream at a certain temperature is introduced through an expansion valve into another space at the same temperature. According to gas laws, the pressure decreases after expansion. Since the mass of water in the gas stream remains unchanged, its partial pressure (water vapor pressure) also decreases, and it can no longer remain in a saturated state. Therefore, adjusting the pressure before and after gas expansion can create different relative humidity environments. The accuracy of humidity generation using this method is affected by the control of temperature and pressure before and after the expansion process. The National Bureau of Standards (NBS) uses this method for its standard relative humidity generator.

$$RH\% = PC/PS \times 100\ \%$$

Saturation Pressure, P_s — Expansion Valve — Chamber Pressure, P_c — Exhaust Valve — Inlet Valve — High Pressure Source — Saturator — Thermal Barrier — Chamber, or Point of Use — Controlled Temperature, T_s — Controlled Temperature, T_c
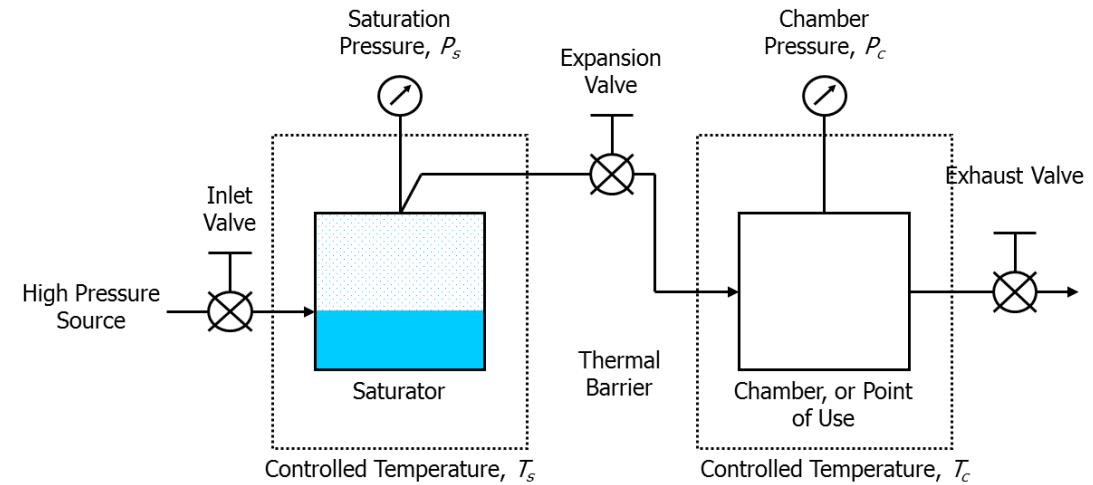
乾濕分流法 Wet-dry split method

此方法係在一恆定溫度空間之下，將兩股流量不同的氣體，一為絕乾，另一種為完全飽和，在充分混合下產生不同範圍的相對濕度值。由兩股氣體之質量比例與混合前後各階段之壓力，可加以計算相對濕度值，此方法之主要特點在於可以快速產生任意濕度值，缺點在於不容易精確控制兩股氣流之比例。商業化之分流式相對濕度產生裝置已日益普遍。但其價格十分昂貴。

This method involves mixing two gases with different flow rates—one completely dry and the other completely saturated—under constant temperature conditions to generate different ranges of relative humidity. The relative humidity value can be calculated from the mass ratio of the two gases and the pressure at each stage before and after mixing. The main advantage of this method is its ability to quickly generate any humidity value; its disadvantage is the difficulty in precisely controlling the ratio of the two gas streams. Commercially available split-flow relative humidity generators are increasingly common, but they are very expensive.
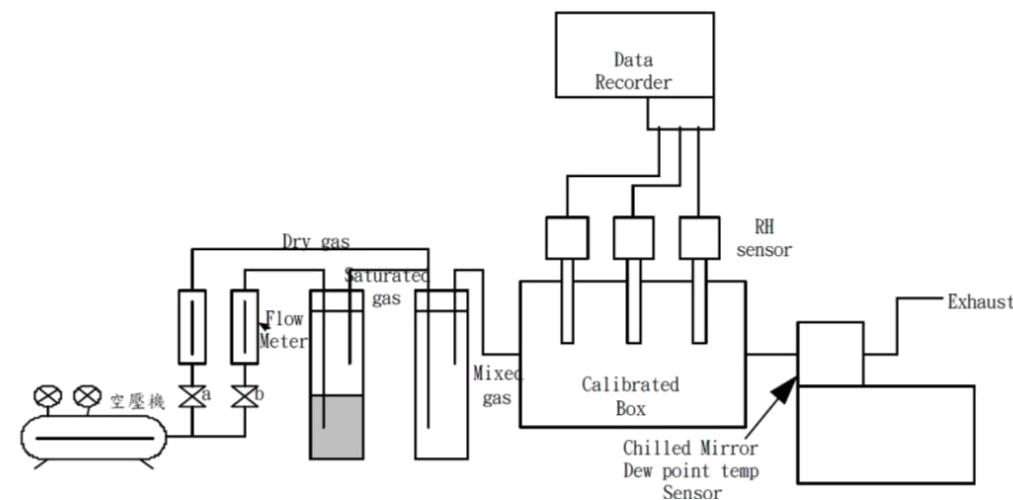
自動化檢測濕度待測區系統設備
Automated humidity detection system equipment for the area to be tested