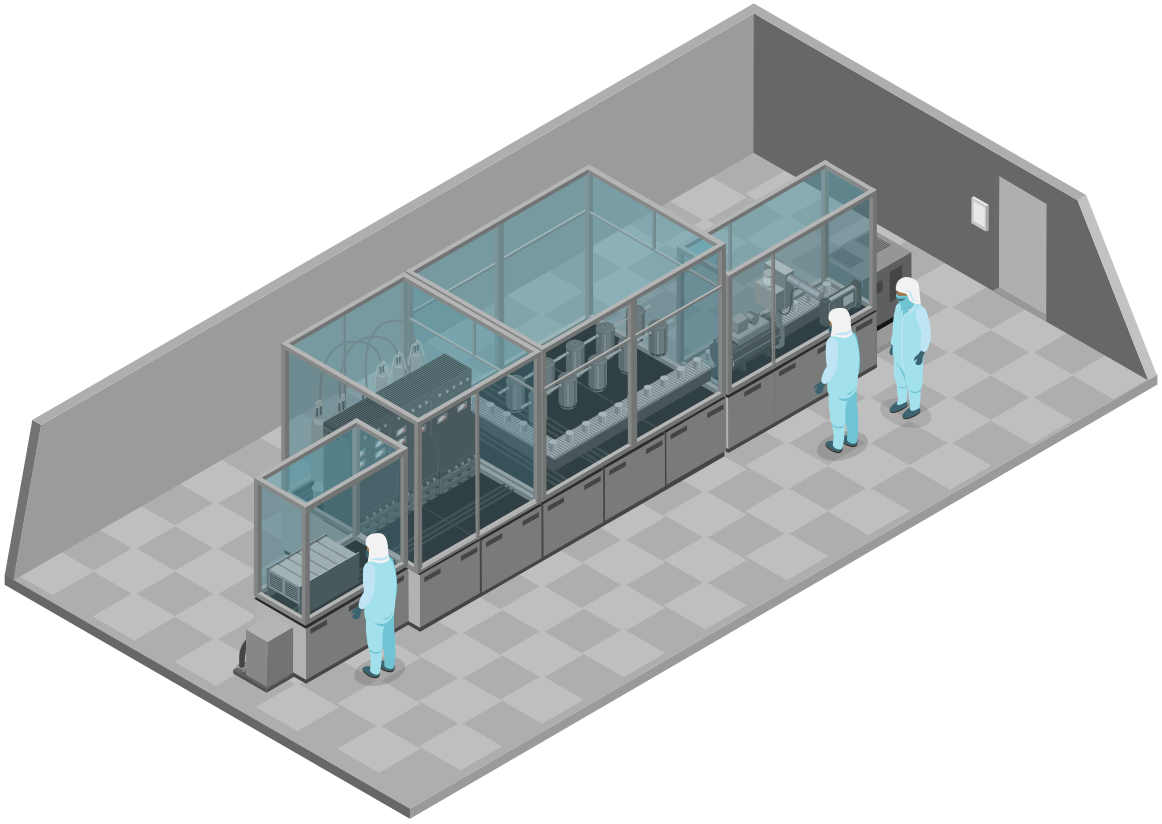
VAISALA / APPLICATION NOTE

Monitoring Water Vapor in the Lithium-ion Battery Manufacturing Process



The lithium-ion battery manufacturing process is sensitive to moisture. This challenging production environment demands a water vapor detection instrument with reliable performance and strong resistance to process byproducts that may be present in the atmosphere.

Dry-air management is essential during the lithium-ion (Li-ion) battery manufacturing process for three reasons: first, to prevent unwanted chemical reactions that can cause hazards such as fires and explosions; second, to prevent product quality problems; third, to understand and control costs associated with drying large volumes of air. Lithium-ion battery manufacturing processes are carried out in dry rooms or glove boxes where the local micro-environment must be controlled to preserve optimum production conditions. The typical dew point temperature range of the processing environment is from -50 °C to -40 °C. Dew point is used to express water vapor concentration at this level because the corresponding relative humidity value is less than 1%. Most instruments used for measuring relative humidity, even if they convert the display and output values to dew point temperature, lack the resolution and accuracy necessary for meaningful measurement at this level. For example, when the dew point temperature is -50 °C, a 5 °C rise to -45 °C represents a corresponding relative humidity change of only 0.1% – a value that is difficult to distinguish from noise. (Visit Vaisala's knowledge center and use or download our free humidity calculator: www.vaisala.com/humiditycalculator).

Optimal location for dew point sensors

Dew point instruments can be used in a variety of ways to achieve the objectives outlined above. The actual air dryer can be monitored and controlled using dew point measurement. In some cases, dryer performance can be improved and energy consumption reduced by implementing dew point demand switching. Dew point instruments can also be installed at the inlet of each process on the supply gas line, either directly or by using a sampling cell or ball valve. These instruments can detect problems quickly and help determine whether the problem is localized or more general. Finally, dew point instruments can be installed in the general work area and used as environmental monitors.

Contamination issues

Dew point sensors can be contaminated in the production environment by chemicals that evaporate from electrolytes used in the process. Liquid electrolytes in a typical lithium-ion battery may consist of lithium salts such as LiPF6, LiBF4, or LiClO4 in an organic solvent – usually ethylene carbonate (EC), dimethyl carbonate (DMC), or Methyl Ethyl Carbonate (MEC). All of these solvents have the potential to damage a dew point sensor. If the electrolyte is LiPF6, it is present as Li+ and PF6- ions. Reaction with H2O in the environment will create hydrofluoric (HF) acid. This is a strong acid that erodes the isolator film between the battery terminals, increasing the risk of short circuit and fire. It can also degrade the dew point sensor. The challenges are similar for different battery formulations.

Solutions for dew point measurement

Common solutions for dew point measurement include chilled mirror hygrometers, oxidized aluminum or silicon sensors, and polymer moisture sensors. Each has strengths and weaknesses.

The chilled mirror hygrometer uses optical reflection to detect the condensation temperature on a reflective surface (the mirror). These devices are very accurate in laboratory conditions, but subject to measurement error known as the Raoult effect when the sample gas contains solvents that go into solution with the condensate on the mirror. Strong acids or bases may also damage the mirror surface.

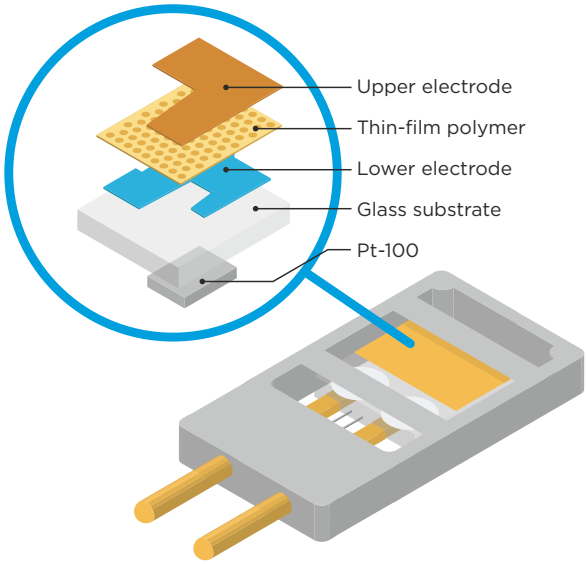
Aluminum oxide and silicon oxide sensors can measure extremely low dew point temperatures. Care should be taken to monitor the calibration of these devices, as any gas that contributes to continuing oxidation of the sensor itself will cause a drift in measurement.

Polymer sensors can be formulated to resist a wide variety of chemical contaminants. Unfortunately, most polymer sensors function exclusively in the percent relative humidity range and are therefore not suitable for use when the relevant dew point values are below -20 °C.

Vaisala solution for dew point measurements in Li-ion battery manufacturing

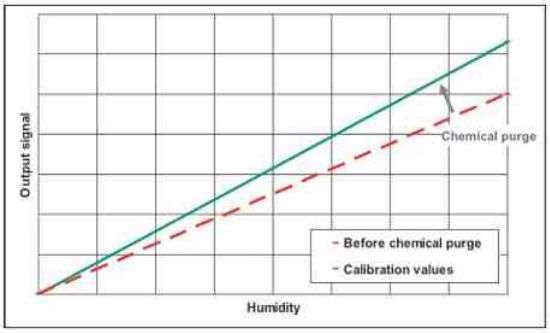
Vaisala offers a chemically resistant, high-polymer dew point sensor that is actively manipulated to achieve long-term reliability with very little measurement drift.

The Vaisala DRYCAP® sensor uses auto-calibration to monitor sensor accuracy and any necessary adjustments. The auto-calibration procedure is based on heating the sensor briefly and observing the change in measured relative humidity, which is physically related to temperature. If the change is not as expected, the algorithm corrects the sensitivity of the sensor, thereby maintaining accuracy in dry measurement conditions, where it is critical.



Another vital feature of the DRYCAP® sensor is the purge function. In Li-ion manufacturing, the demanding chemical conditions cause diffusion of contaminants, mainly hydrocarbons from the used solvents, into the sensor polymer. Sensor contamination may result in an irreversible change in sensitivity, which eventually cannot be compensated for by calibration and leads to sensor malfunction. The purge function briefly heats the sensor in order to remove any volatile contaminants from the polymer. The function can be initiated manually or automatically, and the purge interval can be adjusted to suit the operating environment.

The Vaisala dew point measurement product family includes several options for Li-ion battery manufacturing related measurements, with products ranging from small, compact transmitters perfect for equipment manufacturers to rugged industrial field instruments with various options and accessories, all with different options for output and mounting. Compatibility with handheld devices allows for easy on-site spot-checking and calibration verification.



Contaminants may decrease the sensor sensitivity over time. Vaisala DRYCAP® sensor has automatic purge function which restores the sensor performance by evaporating impurities away from the sensor element.

The purge function briefly heats the sensor in order to remove any volatile contaminants from the polymer.

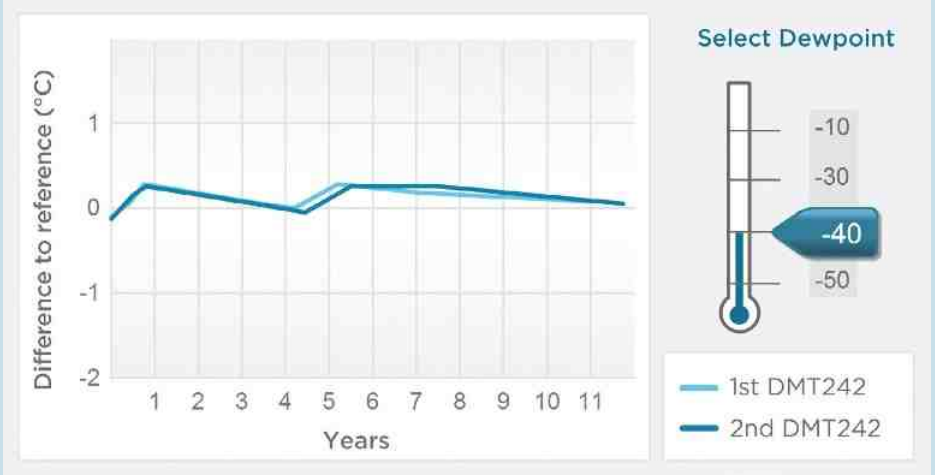
Recommended products

DMT242 Transmitter for Industrial Dryer Applications

-60...+60 °C (-76...+140 °F) T_d with ±2 °C (±3.6 °F) accuracy

- Sensor options for desiccant and refrigeration dryers
- Pressure up to 20 bar
- DRYCAP® sensor technology

Read more or download the datasheet at **www.vaisala.com/DMT242**



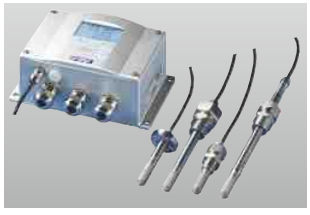
The graphs above are derived from an ongoing test in which two Vaisala DRYCAP® DMT242 dewpoint transmitters were installed in a compressed air line ca 11 years ago and have not been recalibrated or adjusted. The line conditions are representative of instrument air. The x-axis represents years, the y-axis represents difference to the reference value at periodic checks.

Hand-Held DM70 Meter for Spot-Checking and Field Calibration

-60...+60 °C (-76...+140 °F) T_d with ±2 °C (±3.6 °F) accuracy

- Fast response – just minutes
- Easy-to-use
- Multilingual menu (EN, CN, DE, FI, FR, JP, RU, SE, SP)
- Data logging and transfer to a PC via MI70 Link software
- Compatible with DMT132, DPT146, DMT143, DMT242, DMT152, DMT340
- DRYCAP® sensor technology

Read more at **www.vaisala.com/DM70**



Configurable Fixed Mount DMT340 Transmitters

-60...+45 °C (-76...+113 °F) T_d with ±2 °C (±3.6 °F) accuracy

Configurable with various options

- Display/keypad
- Data logging and Relay module
- Multiple probe option

- Integrated data logging with over four years of measured history
- Multilingual menu (EN, CN, DE, FI, FR, JP, RU, SE, SP)
- Pressure up to 50 bar
- DRYCAP® sensor technology

Read more at **www.vaisala.com/DMT340**

DMT143 Miniature Dew Point Transmitter

-60...+60 °C (-76...+140 °F) T_d with ±2 °C (±3.6 °F) accuracy

- Small size for compact industrial dryer applications
- Stable and cost-efficient
- LED alarm for exceeded dew point level
- Pressure up to 50 bar
- DRYCAP® sensor technology

Read more at **www.vaisala.com/DMT143**

No single dew point sensor technology is suitable for all applications. However, Vaisala DRYCAP® technology has been tested and proven in a variety of applications, including dry-room monitoring, for more than ten years. Vaisala DRYCAP® instruments are available as low-cost transmitters or fully configurable field instruments. They are easy to install and use, and all models include probes with standard ISO or NPT threads. Vaisala sampling cells are available with threaded connections compatible with a wide variety of fittings, or with welded compression fittings to accommodate 6 mm or 1/4" tubing. A ball-valve installation allows the dew point probe to be installed in or removed from a process without process shutdown.

Contact Vaisala for expert guidance on dew point measurement and to find out more about Vaisala DRYCAP® instruments.

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Please contact us at
www.vaisala.com/requestinfo

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