VAISALA / APPLICATION NOTE

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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 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 change 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 a free humidity calculator: 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/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 $LiPF_6$, $LiBF_4$ or $LiClO_4$ in an organic solvent - usually ethylene carbonate (EC), dimethyl carbonate (DMC), or ethyl methyl carbonate (MEC). All of these solvents have the potential to damage a dew point sensor. If the electrolyte is $LiPF_6$, it is present as Li^+ and PF_6- ions. Reaction with H_2O in the environment will create hydrofluoric (HF) acid. This is a strong acid which erodes the isolator film between the cathode and the anode 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 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 offers a chemically resistant, high-polymer dew point sensor that is actively manipulated to achieve long-term reliability with very little measurement drift. This Vaisala DRYCAP® sensor uses auto-calibration to monitor sensor accuracy and make adjustments if necessary. A sensor purge function can be initiated manually or automatically to drive accumulated chemical contaminants off of the sensor.

There is no single dew point sensor technology that 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 as fully configurable field instruments. They are easy to install and use. All Vaisala DRYCAP® dew point instruments have probes with standard ISO or NPT threads. Vaisala sampling cells are available with threaded connections to accept 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 into or removed from a process without process shutdown.

Contact Vaisala for expert guidance on dew point measurement and find out if Vaisala DRYCAP® instruments are right for you.

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For more information, visit www.vaisala.com or contact us at sales@vaisala.com

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