METTLER TOLEDO APPLICATION NOTE

Continuous Conductivity Measurement in HPW

BACKGROUND

The subject of purest water is not only of academic interest, but is also highly relevant in the manufacturing area. Salt-free water is needed for the most varied of applications. Typical examples include the manufacture of semi-conductor devices and printed-circuit boards, pharmaceutical manufacturing, and water supplies for boilers. The purest water is obtained only by a full desalting process. One method of doing this is by distillation (usually double-distillation). Ion exchangers and reverse osmosis plants are also used for obtaining fully desalted water. Depending upon the exact method of preparation, the water has a dissolved solids content from a few mg/liter (ppm) down to trace impurities. The quality of the water is quickly and easily monitored using in-line continuous conductivity measurement.

THE PROCESS

The measurement of distillate or deionisate from water purification plants is carried out using two-electrode conductivity sensors. The two electrodes are arranged concentrically, the outer electrode screening the inner one. The current flowing in the measurement circuit is proportional to the conductivity of the solution relative to the voltage applied to the electrodes. By applying an AC voltage, electrode polarization is prevented. The conductivity of the medium being measured depends upon the number, valence and mobility of all the ions in the solution, i.e., is non-specific.

Temperature parameter:
The electrolytic conductivity is greatly dependent upon temperature. The measurement must always be referred to a defined reference temperature, usually 25 °C. Modern measurement equipment provides this temperature compensation function. From the electrolytic conductivity at the process temperature, the transmitter calculates the conductivity at the reference temperature. The precondition is that the transmitter must know the temperature behavior of the water. However, the temperature behavior of water is complicated, particularly for the highest purity water. Recently published work has thrown doubt on the efficacy of some conversion algorithms in commercial use (Gray, D.M. and Bevilacqua, A.C. "Cation Conductivity Temperature Compensation," International Water Conference, Paper IWC-97-48, Engineers' Society of Western Pennsylvania, Pittsburgh, PA, Nov 1997).

Requirements for the measuring system
Since even small quantities of impurities or carbon dioxide from the air will appreciably affect the measured value, measurements are always taken in-line. The cell constant should be as small as possible, preferably lying between K = 0.01 cm^{-1} and K = 0.1 cm^{-1}. It is important to use two-electrode measuring cells with a homogeneous field and a low capacitance of the electrodes and cables via the insulating material to the medium whose conductivity is being measured. Stainless steel is especially suitable as an electrode material since steel sensors are robust and have a good response behavior. By using seals made only from materials on the FDA positive list on the sensor and housing, the measuring system fulfills all the requirements for the pharmaceutical industry.

General inspection of measuring systems
Potassium chloride (KCl) solutions of different concentrations are used to monitor test equipment. Normal commercial conductivity standards are 0.1 mol/liter KCl solution (reference value at 25 °C = 12.88 mS/cm) and 0.01 mol/liter KCl (reference value at 25 °C = 1413 µS/cm). Carefully dried potassium chloride of the highest purity should be used in the preparation of solutions. A reference temperature of 25 °C must be set for testing the measurement transducer and the KCl solutions must also be maintained at 25 °C. Temperatures must be measured with a calibrated precision thermometer. Any deviations of a new measuring cell from the reference value of the KCl solution require the cell constant value to be adjusted via the transmitter's software. For the

most critical work, attention should also be paid to the cell equivalent effect, which relates to the impedance dependant capacitive coupling of the cell at the measurement frequency.

Inspection of the measuring system when used in ultra-pure water

Unfortunately, no stable solutions with a defined low conductivity (e.g., 1 µS/cm) are known. To determine the lower limit of the permitted range of measurement, METTLER TOLEDO calibrates its sensors according to the ASTM standard test method D1125-91 using NIST-traceable equipment. A relevant certificate stating the cell constants and temperature constants is enclosed with each sensor supplied. These constants, which are also printed on the sensor, can be directly entered into the transmitter, thus eliminating falsification of measurements which could occur due to unstable sensors with unsuitable cell constants. Furthermore, METTLER TOLEDO transmitters used for high purity water measurement, together with their associated cables, can be validated by means of NIST-traceable calibrators (resistors).

Conclusion

The precise measurement of conductivity for ultra-pure water requires sensors calibrated by the Standard Test Method (ASTM/ NIST). Where measurements for pharmaceutical purposes are required (e.g., water for injection) the use of seals incorporating FDA positive listed materials ensures that the system fulfills the required preconditions for pharmaceutical manufacture.