Understanding Conductivity

If you work in a laboratory, or in semi-conductor manufacturing, industrial cleaning, industrial sterilizing or industrial plating operations, conductivity is an important factor in your day-to-day job. Understanding the principles behind conductivity can help you do your job better.

Conductivity, or the measurement of the ability to conduct electricity, is an inherent property of most materials. Materials such as metals are highly conductive . . . they easily carry electricity. Materials like plastic or glass are nonconductive. In other words, an electric charge cannot be transferred from an energized source to plastic or glass. Aqueous solutions can also pass a current and rank between highly conductive metals and nonconductive plastic/glass on the conductivity scale.

Many industries require specific conductivity measurements. The following are examples:

- **Semiconductor Manufacturing:** Conductivity measurements monitor the purity of rinse water which cleans the semiconductors. High conductivity values alert operators to change the rinse water.
- **Boiler Blowdown:** Conductivity is used to monitor the purity of water coming out of the boiler. Low conductivity values indicate a clean boiler.
- **Laboratory Analysis:** Researchers check the conductivity of their lab water. Low conductivity indicates pure water and pure water is less likely to contaminate their experiments.
- **Industrial Cleaning, Sterilizing, and Plating Operations:** These activities use conductivity to monitor their effectiveness in addition to the strength of residue and spent solutions. Depending on their ionic strength readings of the solutions, you may recycle them for further use or replenish them.

How is Conductivity Measured?

Conductivity is determined by the number of charged carriers, how fast they move and how much charge each one carries. In metals, the electrical current is carried by electrons. In aqueous-based solutions, it is carried by charged ions—the more ions present, the easier current will flow.

Conductivity is measured in siemens and ohms. The higher the siemens, the more conductive the liquid is.

Here is the conductivity for some common liquids:

Deionized (distilled) water	0.055 uS/cm
Boiler water	1.0 uS/cm
Drinking water	100.00 uS/cm
Ocean water	53 mS/cm
10% NaOH	355 mS/cm
10% H2S04	432 mS/cm

KEY: 1 /uS= 0.0001 mS   1 ms= 1000 /uS

Types of Measurement Tools

The simplest arrangement for measuring conductivity is a 2-electrode cell. Voltage is applied to two flat plates immersed in a solution and the resulting current is measured. A 3-electrode cell can also be used, but the drawback is polarization. Use of DC voltage would soon deplete the ions near the plates causing polarization and a higher than normal resistance. Deposits can form on the surface of the electrodes which also subtract from the measured conductivity of the sample.

To reduce the effects of polarization and to be able to function in “dirty” solutions the 4-electrode cell offers significant advantages. 4-electrode conductivity cells contain two drive (current) electrodes and two sense (voltage) electrodes. The drive electrodes are powered by an alternating voltage, and the alternating current that flows is measured to determine the conductivity. The amplitude of the alternating voltage is controlled by the voltage measured at the sense electrodes. Since the sense electrodes are positioned in a low current area of the cell, and this voltage is measured using high impedance circuit, it represents the strength of the electric field within the cell with higher accuracy. Using this signal to maintain all field strength at a constant, the current that flows at the drive electrodes is proportional to the conductivity of the sample and the errors due to polarization and contamination are minimal.

Today most conductivity testers, hand held and bench top meters use the 4-electrode cell.

Commonly Asked Questions

Q. How should I store my conductivity cell?

A. Rinse it in tap water when you are finished using it. You can store the electrode either wet or dry. If it is stored dry you will need to recondition the electrode before use.

Q. How do I condition the probe?

A. Place the probe in a standard solution tap water and have power running to the probe. Let it soak for 30 minutes to an hour unless otherwise specified.

Q. How and when should I calibrate the probe?

A. Calibrate using a standard solution in a range of the samples you are testing. Place the probe in standard solution, condition, rinse probe in second sample of standard solution, use a third sample of standard solution to calibrate, and then adjust the cell constant until specified value is displayed. Recalibrate when you change ranges, or if readings seem to be incorrect.