

Top Ten Mistakes When Measuring Conductivity

Conductivity measurements are a useful indicator of the amount of dissolved ions present in a water sample and can serve as a measure of water quality. Conductivity measurements are generally simple and easy to take, so conductivity testing is more convenient than gravimetric total dissolved solids (TDS) measurements, which require a labor-intensive weighing and drying procedure.

Top 10 Mistakes

Although conductivity measurements are generally simple, mistakes can still affect the validity of the data generated. Based on the experience of the customers of Thermo Fischer Scientific (Waltham, Mass.), a list of the top 10 mistakes when measuring conductivity are discussed here, in no particular order.

1. Using an unsuitable conductivity cell

When choosing a conductivity cell (probe), the analyst should consider several factors, including

- the materials that make up the cell,
- the nominal cell constant,
- whether the cell is a two- or four-electrode model, and
- if a flow cell or dip version is appropriate.

Common cell materials include glass with platinum, steel, or epoxy/graphite. The choice of conductivity cell will depend on the composition of the sample to be measured, whether the probe must be durable for field use, and the purity of the water sample. Typical cell constants range from 0.1 to 10 cm⁻¹. The lower the conductivity to be measured, the lower the cell constant desired. A four-electrode conductivity cell has many advantages, such as reduced error arising from polarization, contamination of the electrode surfaces, or cable resistance. However, a two-electrode cell is better for pure-water applications where very low conductivities are measured. Flow cells are useful when making pure-water conductivity readings where the absorption of carbon dioxide from the air can affect the conductivity reading. For wastewater applications, a durable, non-glass four-electrode dip probe cell with a constant in the range of 0.4 to 1 cm⁻¹ is usually a good choice.

2. Not understanding how temperature affects the conductivity measurement

Conductivity measurements are strongly affected by the temperature of the sample. For example, the conductivity reading of a salt solution of sodium chloride typically increases by 2% for every Centigrade degree of temperature change. Therefore, the conductivity value of a salt solution at 15°C can be expected to be about 20% different than the value at 25°C. Depending on the lab's standard operating procedure, conductivity readings may be temperature-compensated or not. It is important to note the temperature reading or the reference temperature with every conductivity reading recorded.

3. Misunderstanding the temperature compensation function

When used correctly, the temperature compensation (TC) function will take the sample conductivity and temperature readings, then calculate and display the conductivity that the sample would be expected to read at the chosen reference temperature, such as 25°C. If the TC function is turned off, the displayed value is the actual conductivity at the measured sample temperature. When not using TC, it is especially important to report the sample temperature reading along with the conductivity reading. When using TC, report the conductivity and the reference temperature.

4. Improper TC settings

When setting up a conductivity measurement system, the lab manager must make appropriate choices relating to TC, such as

- whether TC should be used,
- setting the reference temperature,
- choosing a linear or nonlinear TC, and
- choosing the appropriate TC factor.

For wastewater readings in the United States, it is common to use TC and to choose a reference temperature of 25°C. A linear TC and a factor near 2% are typically chosen as representative of typical potable and wastewater samples. Note that the further the sample temperature is from the chosen reference temperature, the greater the chance for introducing error due to assumptions made when applying TC settings to sample measurements.

5. Taking a conductivity reading before achieving temperature equilibrium

Because conductivity is temperature-dependent, time must be allowed for the conductivity cell to equilibrate to the same temperature as the sample. The lab worker should wait for the temperature reading to stabilize before recording conductivity and temperature readings. This is especially important for non-TC measurements. The most accurate conductivity reading (TC or not) is achieved once the temperature has stabilized.

6. Using elaborate multipoint calibrations

Calibration of the conductivity cell is achieved by determining the cell constant, which the meter then uses to calculate conductivity when measuring a sample. According to Method 2510B in *Standard Methods for the Examination of Water and Wastewater* and ASTM D1125, a one-point calibration of the cell constant at a representative conductivity is sufficient for accurate conductivity readings. A commonly used calibration standard is 0.01M potassium chloride, which gives a conductivity reading near 1410 uS/cm at 25°C. If the samples cover a large range of conductivities, it is appropriate to measure one or more calibration check samples at the levels of interest.

7. Mishandling low-level conductivity samples

In general, it is difficult to collect, store, and properly measure samples that are much lower than ~147 uS/cm (equivalent to 0.001M potassium chloride). These samples are easily affected by small amounts of contamination and by carbon dioxide absorption and degassing. Ideally, the sample container used must be scrupulously clean and exclude the atmosphere. Field testing and flow cells are useful for making low-conductivity level measurements at the point of sampling. The linearity of a good-quality meter and conductivity cell working together is accurate down to very low conductivity levels. (This can be validated using a pure water "standard.") However, the stability and purity of the sample and how it is handled will limit the accuracy of the sample reading.

8. Using calibration standards that are too low

In an attempt to achieve good accuracy at low conductivity levels, users sometimes will attempt low level calibrations. For reasons discussed previously, truly accurate low-level standards are difficult to acquire and use. Low-level standards with tight accuracy claims can be purchased, but studies show that when used, they can be inaccurate. Instead, labs may wish to use low-level standards as calibration checks only. When doing so, they should expect that any tight tolerance interval may have to be expanded past the manufacturer claims. For example, the National Institute of Standards and Technology (NIST) standard reference material (SRM) 3198 at 5 uS/cm standard has a tolerance of ± 0.45 uS/cm. The NIST SRM 3199 at 15 uS/cm has a tolerance of ± 0.54 uS/cm. These types of NIST SRMs sell for more than \$1000 per 500 mL bottle. Commercially available standards selling for a fraction of that price may be expected to have true tolerances that are larger, rather than tighter, than NIST SRMs. Lab managers should establish control charts to determine acceptable limits for low-level standard readings. Alternately, pure water equilibrated by stirring (to incorporate carbon dioxide) and measured near room temperature (~25°C) will read near 1 uS/cm and can serve as a low-level check.

9. Improper storage and maintenance of the conductivity cell

Between measurements, it is acceptable to store the conductivity cell in water or deionized water. However, for overnight and long-term storage, workers should rinse the cell thoroughly with deionized water and store the cell dry. Storing the cell in water — even clean water — can allow fouling of the conductivity electrodes, which changes the surface area and changes the cell constant. Even if no coating of the electrodes is visible to the eye, contaminants can be present and affect the proper function of the cell. If this happens, the electrode should be soaked in a laboratory detergent solution, rinsed well, and soaked briefly.

10. Not understanding the TDS factor

Conductivity readings can be used to determine an estimate of the TDS in a sample by applying a TDS factor manually or automatically through the meter setup. This TDS value is an estimate, since the true TDS is determined by gravimetric testing (weighing the sample before and after drying and calculating the amount of dissolved solids). The TDS factor used is generally in the range of 0.47 to 0.9 and must be determined or validated empirically by comparing conductivity readings of the lab's typical samples to gravimetric TDS results for the same sample. The TDS factor is affected by changes to the soluble components of the water and on the temperature of the measurement.