OBTAINING ACCURATE CONDUCTIVITY MEASUREMENTS

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Reagecon
Delivering the Correct Result

Conductivity is an extremely common analytical technique. Due to the simplicity of the equipment required, it can be measured quickly and cheaply. However, there are a number of factors that need to be taken into account to ensure that these measurements are accurate and fit for purpose so that decisions made based upon conductivity test results are correct:

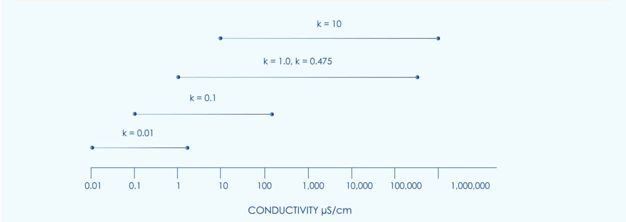
1 INSTRUMENT SELECTION

- Required accuracy of results is the overriding selection factor.
- Take account of the instrument's temperature measuring accuracy – this may be the biggest error source.
- Be aware of specifications stating the accuracy as "% f.s." – this means % of the full scale of the instrument's measuring range and not % of the measured value.

2 SENSOR SELECTION

Conductivity sensor selection is made based upon the conductivity range of the samples being measured. Modern conductivity sensors are capable of giving linear response over several decades; but it is not possible to cover the entire practical conductivity range with a single sensor. Figure 1(1) shows the linear ranges of sensors with different cell constants.

FIGURE 1 : TYPICAL MEASURING RANGES OF SENSORS WITH DIFFERENT CELL CONSTANTS (k)



NB. Ranges are k = 0.01 : 0.01 - µS/cm, k = 0.1: 0.02 - 200µS/cm, k = 1.0, 0.475 : 10.500, 000µS/cm, k = 10 : 1,000 - 1,000,000µS/cm

3 TEMPERATURE EFFECTS

Conductivity is a temperature dependent parameter. Table 1 gives the temperature dependency for a range of solutions.

SOLUTION	TEMPERATURE COEFFICIENT OF VARIATION %/ °C AT 25 °C
Ultrapure Water	5.5
NaOH 5%	2.01
NaOH 30%	4.50
HCl 5%	1.58
HCl 30%	1.52
KCl 5%	2.01
KCl 20%	1.68
Fresh water	~ 2.0

Conductivity instruments are equipped with a temperature compensation function. This has practical benefits, but also limitations:

- Comparisons of measurements made at different temperatures are possible, as the instrument reports an expected conductivity value at a reference temperature (usually 25°C).
- Field measurements are practical, particular with instruments equipped with non-linear temperature compensation specified in ISO 7888(3) (suitable for natural waters, such as groundwater and river water).
- Temperature compensation must be appropriate to the sample type.
- Temperature compensation relies on an assumed temperature effect and so is only an estimate.
- For high accuracy do not use temperature compensation; but ensure all the samples are at the same temperature.
- The Pharmacopoeias stipulate that temperature compensation cannot be used for the laboratory measurement of purified water samples(4,5).

4 SELECTION AND USE OF CALIBRATION STANDARDS

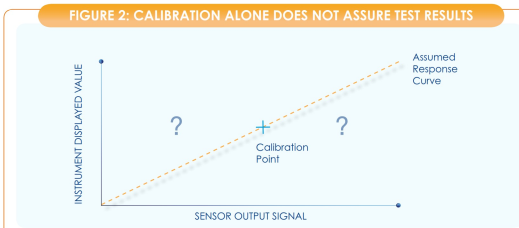
Conductivity instruments multiply the input signal from the sensor by the Cell Constant to give their reported value. The Cell Constant is assigned during calibration by measuring the response to a Calibration Standard. As all of the subsequent sample measurements will be affected by the calibration process, it is essential that the Calibration Standard is suitable and used correctly:

- It should be of high accuracy – your measurements cannot be more accurate than your Calibration Standard.
- It should be traceable to SI units (usually via traceability to primary standards, such as those produced by NIST). If this is not the case then your conductivity measurements are not traceable to SI units and so you are not entitled to quote your readings in SI units.
- Ideally, the manufacturer should hold ISO 17025(6) accreditation – this gives an independent guarantee of the traceability and validity of how its value was assigned.
- To ensure contamination does not occur, rinse the measuring container to drain before filling and rinse the sensor to drain with the Calibration Standard before placing it in the measurement aliquot. The same approach should be used when measuring samples.

5 PROOF OF THE CORRECT RESULT – THE ROLE OF CONTROL STANDARDS

Many analysts cover all of these previous points; but this does not give any proof that their sample measurements are correct. If the only standard used is the Calibration Standard then this assumes that the sensor and instrument give perfectly linear response. Apart from at the calibration value, this gives no knowledge of how your system performs:

FIGURE 2: CALIBRATION ALONE DOES NOT ASSURE TEST RESULTS



To give assurance of results requires the use of Control Standards and also an understanding that the role of the Calibration Standard is merely to accurately assign the Cell Constant. For the Calibration Standard selection:

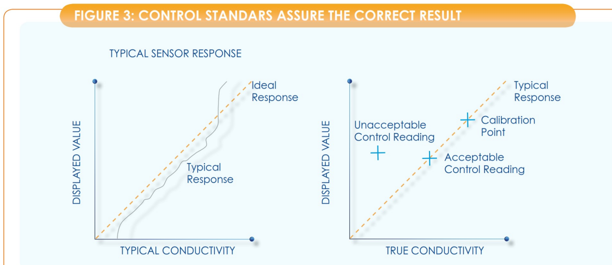
- If the instrument has pre-defined Calibration Standard values then use these values, as this will automate the calibration process.
- When measuring low conductivity then use a Calibration Standard near the upper end of the cell's linear response range (typically 200µS/cm for sensors with a nominal Cell Constant of 0.1cm-1) to limit errors from the instrument's resolution.
- Some instruments have a number of discreet overlapping measurement ranges that each use a separate Cell Constant and so each need a Calibration Standard.

If properly selected, the Control Standard gives full assurance of the correct result(7):

- The Control Standard should have similar properties to the samples – i.e. similar conductivity value and similar matrix (usually aqueous).
- If the samples have a wide range of conductivity values then a number of Control Standards will be required.
- The Control Standard should be handled as described above for Calibration Standards, to ensure contaminations does not occur.
- If an acceptable reading is obtained for the Control Standard then this not only proves that the instrument is functioning correctly; but also that the sensor gives linear response, the calibration process was performed correctly, temperature effects do not give significant errors, the operator has not contributed significant errors and that the entire measurement process yields valid results.

The Use Of Appropriate Control Standards Gives Full Confidence In The Complete Conductivity Measuring System And Method So That There Is Proof That The Conductivity Measurements Are Correct.

FIGURE 3: CONTROL STANDARS ASSURE THE CORRECT RESULT



References

1. John J Barron & Colin Ashton, Reagecon Diagnostics ,"The Selection, Use, Care and Maintenance of Sensors for Accurate Conductivity Measurement" *
2. John J Barron & Colin Ashton, Reagecon Diagnostics, "The Effect of Temperature on Conductivity Measurement" *
3. ISO 7888 "Water Quality – Determination of Electrical Conductivity"
4. United States Pharmacopoeia, Monograph <645>: "Water Conductivity"
5. European Pharmacopoeia Monographs 0008, 0169 & 1927
6. ISO 17025 "General Requirements for the Competence of Testing and Calibration Laboratories"
7. John J Barron & Colin Ashton, Reagecon Diagnostics, "The Application of Good Laboratory Practice in the Selection and Use of Accurate, Traceable Conductivity Standards" *

* These papers form part of a comprehensive series of papers that the authors have written covering all of the practical requirements for accurate conductivity measurement. These papers are available via Reagecon's website at www.reagecon.com.