Getting to Know Your Electrical Conductivity (EC) / TDS Probe

1. EC, What it is vs. What it is Not

EC, also known as electrical conductivity, electrolytic conductivity, or conductivity, measures the ability of a substance to transmit (conduct) an electrical current over a defined area. This transmittance is done on the atomic or ionic level. EC is a measurement of ion concentration in a sample, however, it is non-specific. Ions are charged particles in solution, and because they are charged, they are able to carry and transmit a current. Electrical conductivity is affected by different factors including temperature, and types of substances (ions) dissolved into solution.

EC is not another method for determining concentrations of ions in complex samples (i.e. salt in food). It is also not a way to differentiate between different types of ions in the solution.

2. Conductivity vs. Resistivity

Conductivity and resistivity are reciprocals of each other. The units can be converted easily between the two. Therefore, resistivity is a substance's ability to inhibit an electrical current. Resistivity measurements are usually used for solutions with low ion (low electrolyte) concentrations, as these substances are less able to transmit an electrical current. An example of a substance where resistivity measurements are common is ultrapure water. As per its name, ultrapure water should have very low ion concentration, and therefore, has extremely low conductivity and high resistivity(>18 MΩ).

3. Measurement Units

Measurement units are written in Siemens/cm (unit per defined distance). S/cm, mS/cm, µS/cm, and dS/m are all common units for EC measurement. For example, ultrapure water has a conductivity of 0.055 µS/cm at 25°C.

Example Conversion:

1000 microSiemens/cm (µS/cm) =
1.0 milliSiemen/cm (mS/cm)

4. TDS

TDS (total dissolved solids), is a method used to determine solid content in a solution. To determine TDS, the solution whose volume is known is evaporated and the residue weighed. A conductivity measurement is commonly used to estimate TDS based on the assumption that the solids are predominantly ionic in nature and the relationship between the dissolved ions and conductivity is known. TDS uses units of mg/L (ppm), or g/L (ppt). On some meters, the user can input the TDS factor for the conversion. On more basic units the factor is fixed.

The TDS factor for strong ionic solutions is 0.5, while for weak ionic solutions (e.g. fertilizers) it is 0.7.

$$TDS = factor \times EC_{25}$$

For example: 100 µS/cm conductivity is a TDS of 50 ppm when the factor is 0.5.

5. Salinity

Conductivity measurements can be used for determining salinity as it relates to general oceanographic use. Three measurement scales are in use and depending on the sophistication of the meter, are available for salinity measurement in seawater. The 3 scales are Practical Salinity Scale (PSU); 1978, Percent Scale (%); and Natural Seawater Scale(g/L); 1966.

6. Types of Probes

Three types of conductivity probes are manufactured by Hanna. The simplest design is a **Two Electrode Probe** that utilizes an amperometric approach to take a measurement; a known AC voltage is applied at a specific frequency between a pair of electrodes in solution. The current produced is measured and reported in conductivity units referenced to a calibrated standard. Electrodes are made of graphite or metal. Fouling due to mineral deposits and polarization at high concentrations are drawbacks of this technology. Two electrode probes are best used in clean water applications when the conductivity remains less than 5 mS/cm.

Four Ring Probe conductivity (four ring conductivity) utilizes a potentiometric approach to taking a measurement; an alternating current is applied to the outer two "drive" electrodes to induce a current in the solution. The voltage is measured between the inner pair of electrodes in solution. The voltage is proportional to the conductivity. Electrodes are made of graphite, stainless steel or platinum. Polarization effects are reduced or negated. A risk of fringe field effect is greater with this type of probe. This happens when the measurement field, the constant current, extends outside of the probe. You only need to worry about the fringe field effect if your probe is too close to the sides of the container or pipe where you are taking an EC measurement. A good rule is to keep the probe at least an inch away from all surfaces. The distance you need to keep the probe varies, reference the manual.

Both two electrode and four ring probes may incorporate an outer sleeve over the cell channel. The sleeve MUST stay in place during the measurement as this defines the volume of solution measured and the cell factor of the probe.

The third type of conductivity probe manufactured by Hanna is often found in industrial processes connected to a controller. An Inductive, **Electrodeless or Toroidal conductivity probe**,uses two or more toroidal transformers which are inductively coupled side by side. These are encased in an inert plastic sheath. By applying a high frequency voltage to the drive toroid, a magnetic field develops that induces a current in the surrounding solution. A receiver toroid on the other side of the sensor measures the strength of the induced current. The strength depends on the conductivity of the solution.

One benefit of this technology is that there are no polarization effects. Another benefit is in the choice of encapsulation material. This can produce chemical resistant and relative immunity to fouling. Also, solutions are not needed for calibration.

Electrical Conductivity Probes: A Comparison		
Probe Type	**Pros**	**Cons**
Two Electrode Probes	Inexpensive. Small sample volume. No fringe field effect.	You need a different meter/ probe for each testing range. Polarization effect.
Four Ring Probes	One probe covers your whole testing range. No polarization effect.	Fringe field effect. Larger sample volume is needed. More of a financial investment.
Toroidal Probes	Higher testing range. Chemically resistant.	Lower accuracy in lower range samples. Most expensive out of the three types of probes.

7. Temperature Compensation

Conductivity changes with ion concentration and with temperature. When a solution is cooled, the ions do not have as much energy, so the conductance drops, and resistivity increases. For example, a standard potassium chloride solution used for the calibration of a cell constant and conductivity bridge, changes conductivity with the temperature. Having both the temperature and ion movement changing would make it near impossible to take useful conductivity measurements. If the temperature was held constant, the conductivity measurement would only have the variable of ion concentration. That is why temperature compensation with a temperature probe is important.

Absolute conductivity is a conductivity measurement without temperature compensation. If the behavior of the conductivity change with the temperature change of a solution is known, the Conductivity measurements can be corrected to a reference temperature (typically 20 or 25°C) by carefully measuring the solution temperature. Fortunately, Hanna EC sensors incorporate an integral temperature sensor to measure solution temperature. Compensation corrects the measured conductivity to a reference temperature by applying a fixed factor β for linear compensation. High end meters allow adjustment of β to compensate for various solutions and permit the adjustment of a reference temperature over a wider range of temperatures. β for neutral salts is typically between 1.5 to 2.2%/°C.

8. Probe Body Type

Polypropylene is an extremely rugged and durable plastic. It is harder, more heat resistant, and chemically resistant than traditional plastics.

Polyetherimide (PEI Plastic) is a stable plastic that is able to resist moderately high temperatures, and it has moderate to high chemical resistance.

PVC acts as a protective sleeve for outdoor environments.

AISI 316 stainless steel is used for durability, and can be used in a wider range of environments.

ABS/Epoxy is used for field measurements in particular due to the high-quality of the plastic.

9. Type of Probe Connector

3.5mm connectors are for digital probes. It is a proprietary connection, where the probe will only fit with a specific meter. Digital probes are smart probes. They store the serial number and GLP (Good Lab Practices Data), and they allow the meter to automatically recognize the individual probe when plugged in.

DIN connectors are also proprietary pin connectors, and may not be interchangeable between meters. Some will have integrated temperature sensors.

Quick Connect DIN connectors are a simple waterproof option with- out any threads. Quick Connect DIN are easier to connect to a meter than traditional DIN connectors. These connectors are commonly used in the Hanna portable meters.

10. USP Conductivity

Conductivity measurements are used for the preparation of pharmaceutical water for injection (WFI) worldwide. Hanna EC probes and meters can permit you to meet USP <645> Water Conductivity Requirements and European Pharmacopoeia 2.2.38. Conductivity Test for USP & EP Purified Water and Water for Injection. USP <645> with three stage compliance uses conductivity as a basis of ionic contaminants. Factors such as accuracy, resolution, cell constant certainty and ability to measure absolute conductivity are required. Stage 1 uses in-line conductivity measurements for compliance and a temperature/conductivity limit for compliance. Water that does not pass the Stage 1 limits must then be tested to Stage 2 requirements. This is a laboratory based technique that is streamlined using our meters with USP application firmware. They offer programmable set points to exceed the minimum meet USP and EP requirements and prompts to guide the technician. Water that does not pass at Stage 2 must be tested for pH.

Using Hanna conductivity will help to meet the goals of the USP Purified Water and EP requirements that include improved water quality, improved equipment reliability and reduction in the number of required tests.

Hanna has put together this guide to serve as a quick reference tool. Always remember to consult the instruction manual or contact us directly for detailed instructions for your specific needs.

Read our blog on "Electrical Conductivity: The Ultimate Guide" at blog.hannainst.com/ec-guide

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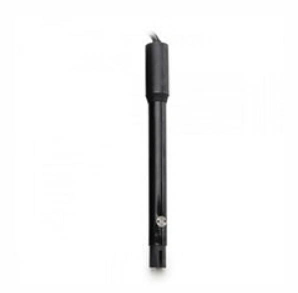

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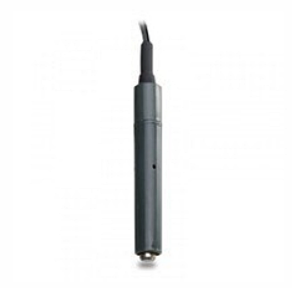

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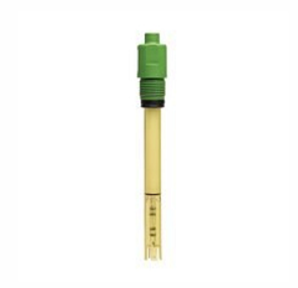

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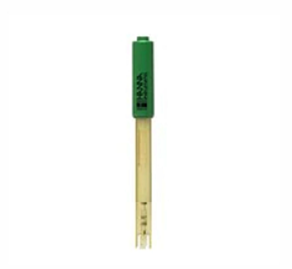

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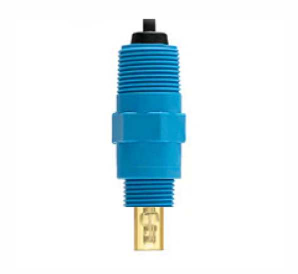

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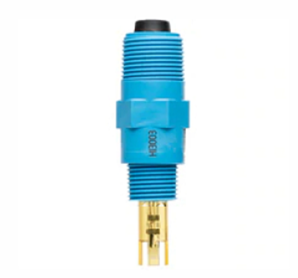

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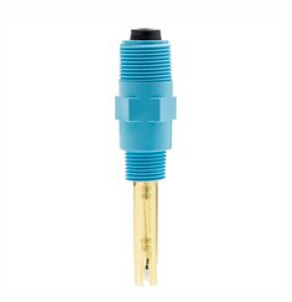

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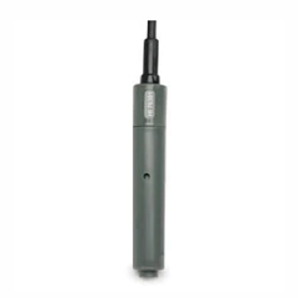

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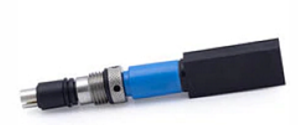

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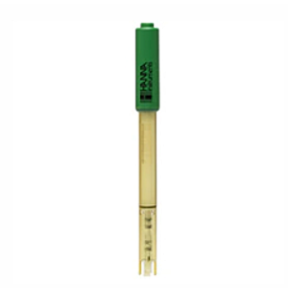

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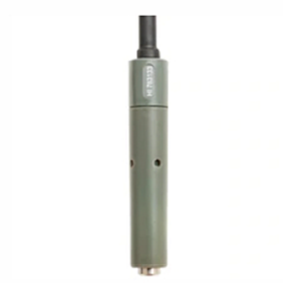

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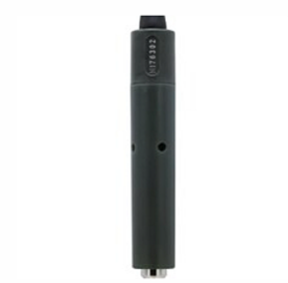

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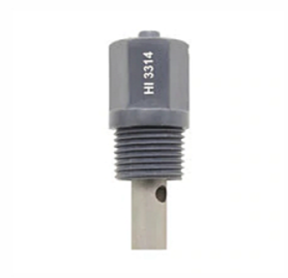

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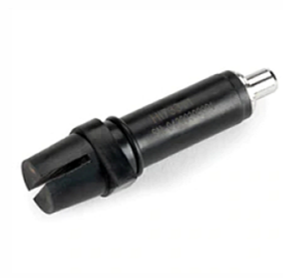

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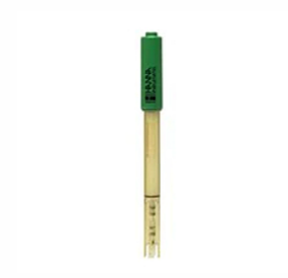

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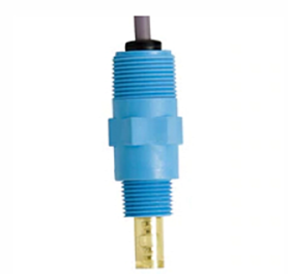

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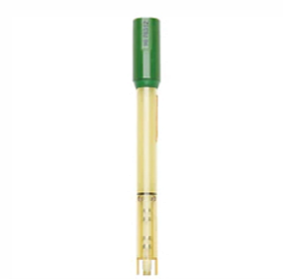

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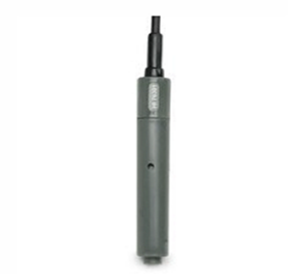

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Benchtop Meters

	EC Range	pH Range	ISE Range	DO Range	Resistivity Range	ORP Range	TDS Range	Salinity Range	Temperature Range(s)	EC Calibration Points	EC Calibration Solutions	ATC (Automatic Temperature Compensation)	Logging	GLP	Capacitive Touch Buttons	Auto End Feature	PC Connectivity	AutoRanging	Benchtop, Portable & Wall-Mount
edge®	•	•*		•*			•	•	°C /°F	1	6	•	•	•	•		•	•	•
edge EC	•						•	•	°C /°F	1	6	•	•	•	•		•	•	•
HI5321	•				•		•	•	°C /°F K	4	†	•	•	•	•	•	•	•	
HI2300	•						•		°C	1	6	•		•			•	•	
HI2315	•									1		•							

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† auto standard recognition, custom calibration
* Using compatible pH or DO probes res

Portable Meters

	EC Range	pH Range	Resistivity Range	ORP Range	TDS Range	Salinity Range	Temperature Range(s)	EC Calibration Points	EC Calibration Solutions	ATC (Automatic Temperature Compensation)	BEPS	Logging	GLP	HOLD Feature	PC Connectivity	AutoRanging	AutoEnd	Waterproof	Flow Cell for WFI Applications
HI98192	•		•		•	•	°C	5	7	•	•	•	•		•	•	•	•	
HI98197	•		•		•	•	°C	5	7	•	•	•	•		•	•	•	•	•
HI9835	•				•	•	°C/°F	1	6	•	•		•			•	•		
HI99300	•				•		°C/°F	1	1	•	•			•				•	
HI99301	•				•		°C/°F	1	1	•	•			•				•	
HI993310	•							1		•	•								
HI9033	•							1		•	•							•	
HI8633	•							1		•								•	
HI8733	•							1		•								•	
HI87314	•		•					1		•									
HI8734					•													•	
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