Agenda

- Group Overview
- Process Analytics Overview
- Application Expertise
- Products & Solutions

Conductivity & Resistivity

- Service & Compliance

Agenda – Conductivity & Resistivity

- Conductivity Measurement Principles
  - Theory
  - 2-Electrode Measurement
  - 4-Electrode Measurement
  - Inductive Measurement
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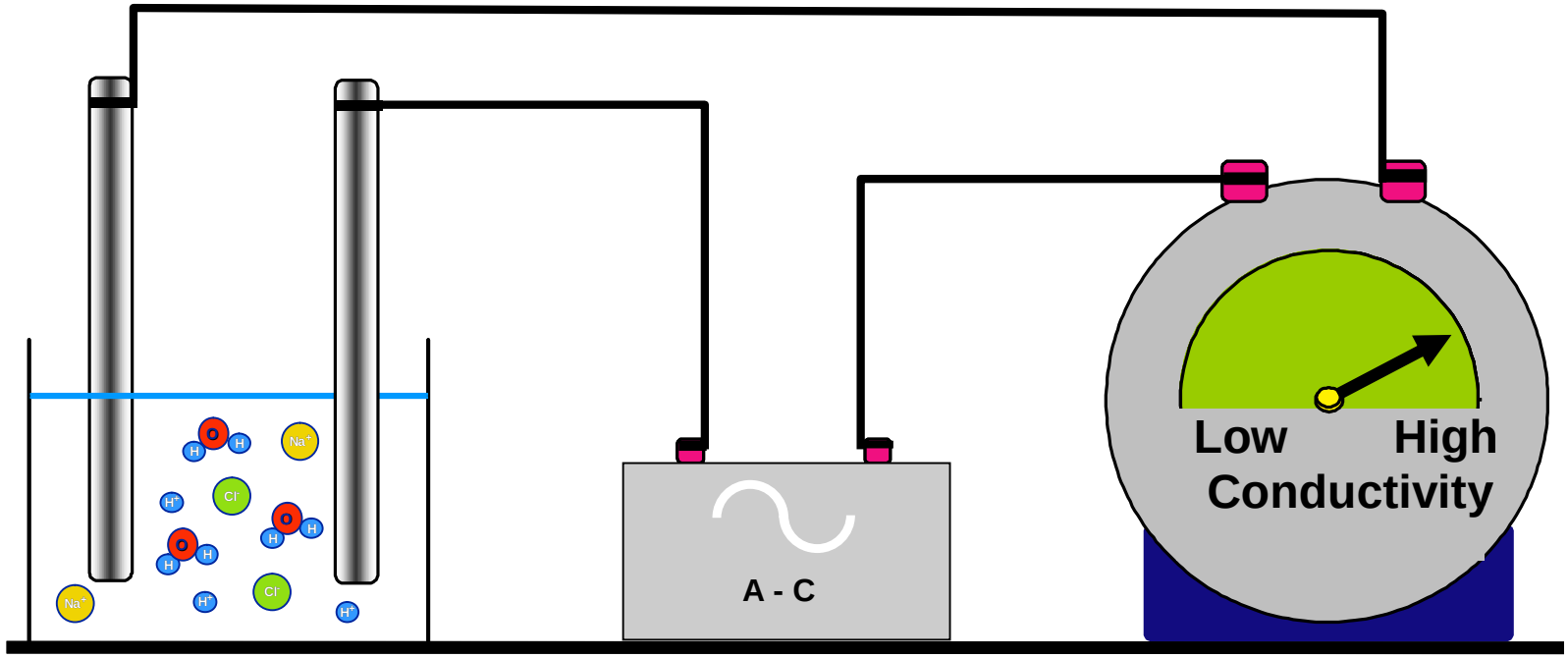
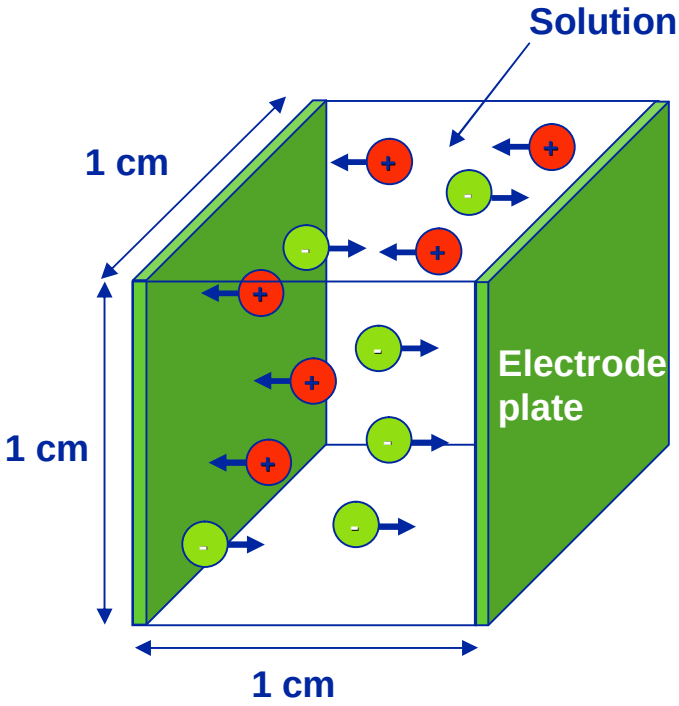
Ionic Conductance

- Used to measure and control the amount of ions in an aqueous solution
- Measures total ionic concentration
- Not ion-specific



The greater the amount of dissolved ions in the water, the higher its conductivity (lower resistivity)

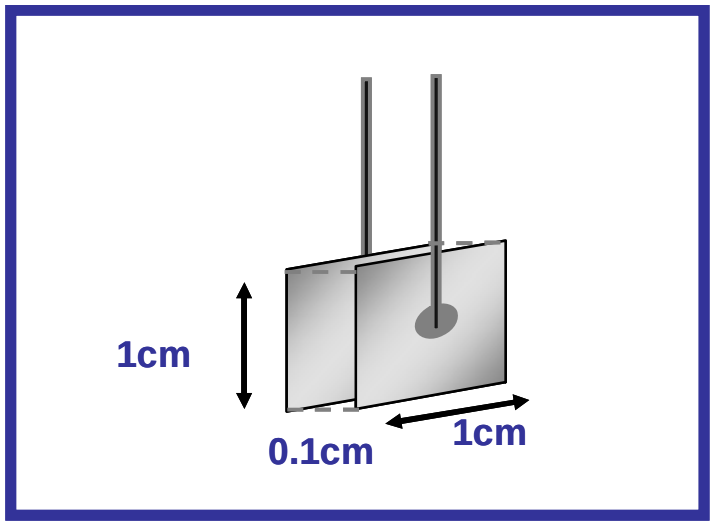
Cell Constant and Units

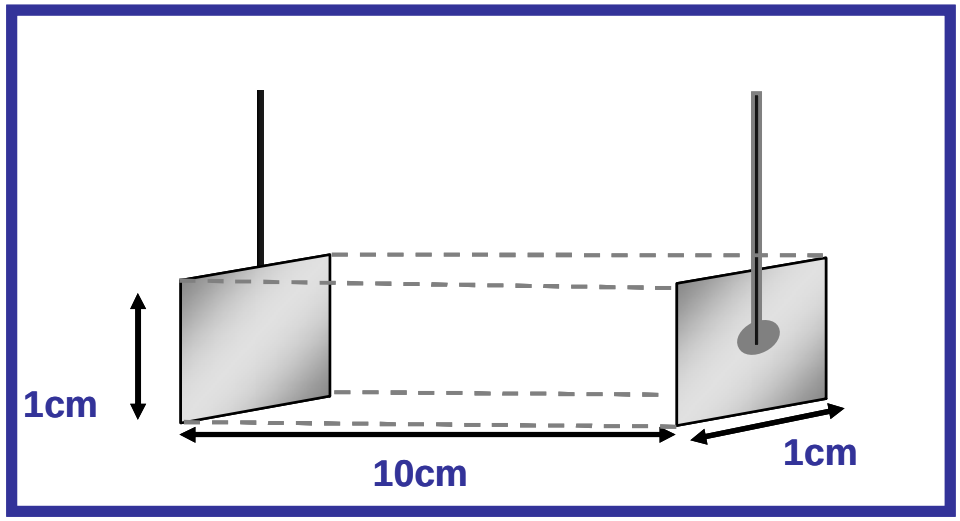


Resistance	ohm
Conductance	siemens = 1/ohm, mho
Resistivity	ohm-cm megohm-cm MΩ-cm
Conductivity	mho/cm µmho/cm siemens/cm microsiemens/cm µS/cm

Conductivity Cell Constant = $\frac{\text{Length}}{\text{Area}} = \frac{1\text{ cm}}{1\text{ cm}^2} = 1\text{ cm}^{-1}$

Other Cell Constants





0.1 constant

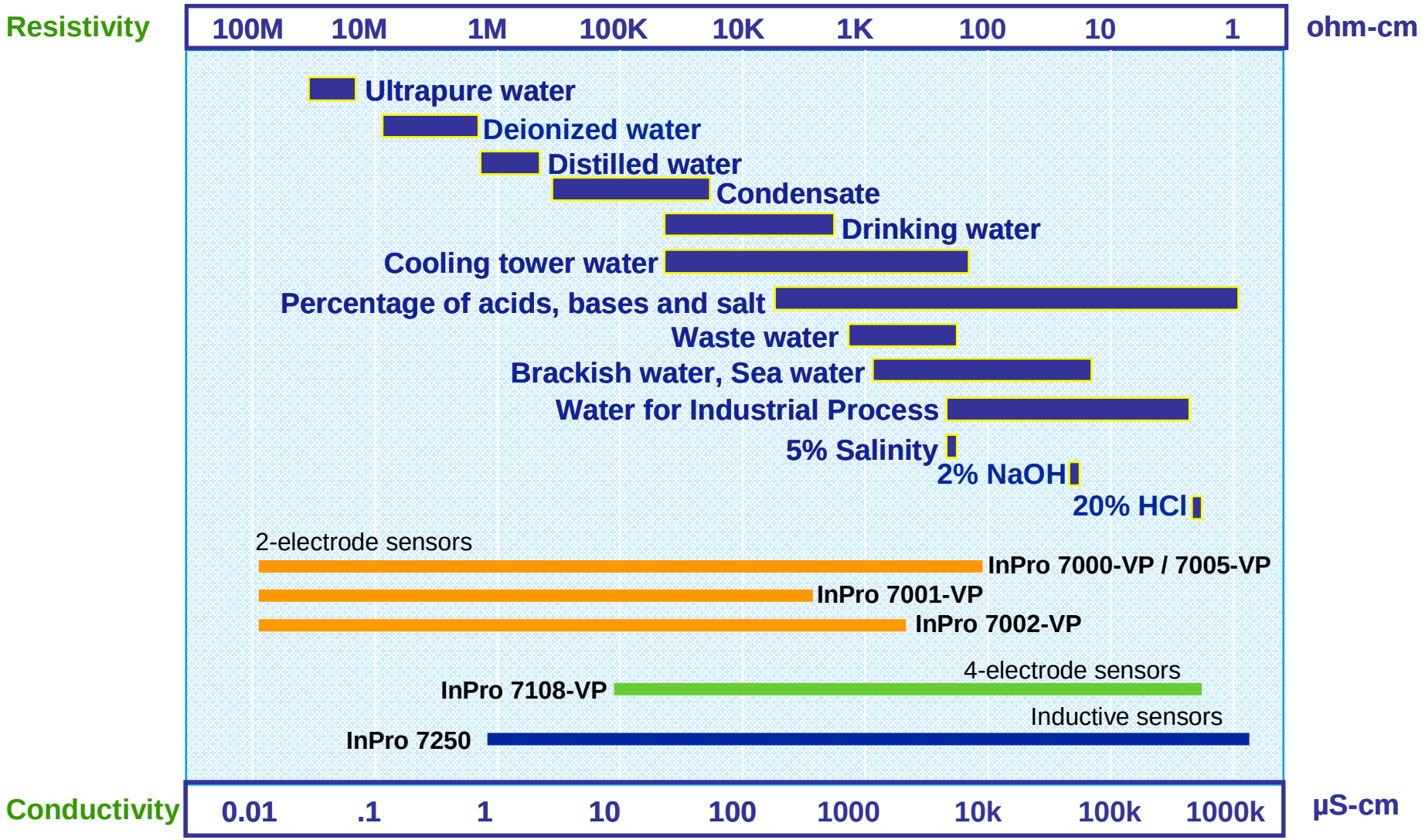
Lower cell constants are needed to provide good signals for low conductivity samples.

10.0 constant

Higher cell constants are needed to measure high conductivity samples.

Cell Constant = Multiplier

Conductivity, Resistivity Ranges

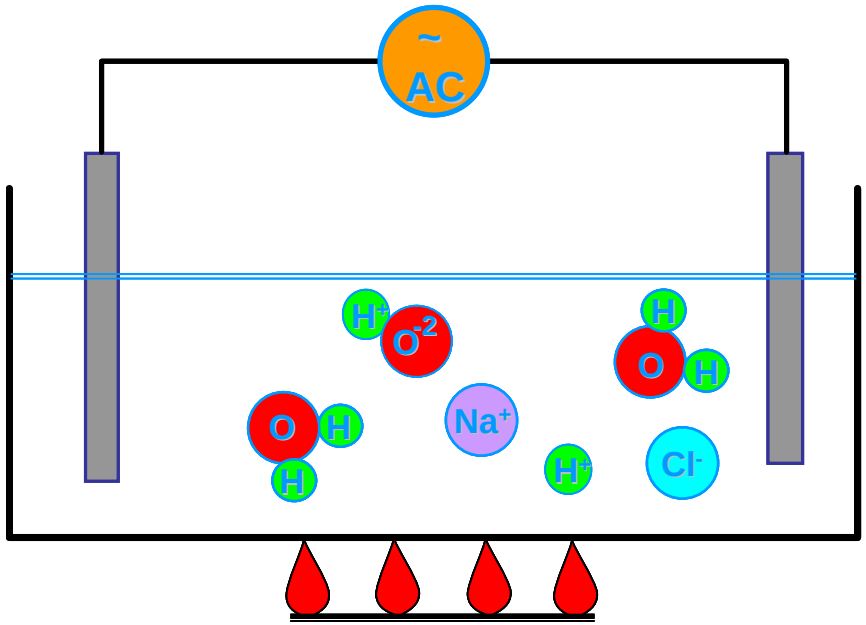


Temperature Compensation

- Conductivity measurements depend on temperature
- The mobility of ions increases at higher temperature
- Resistance of a solution decreases at higher temperature

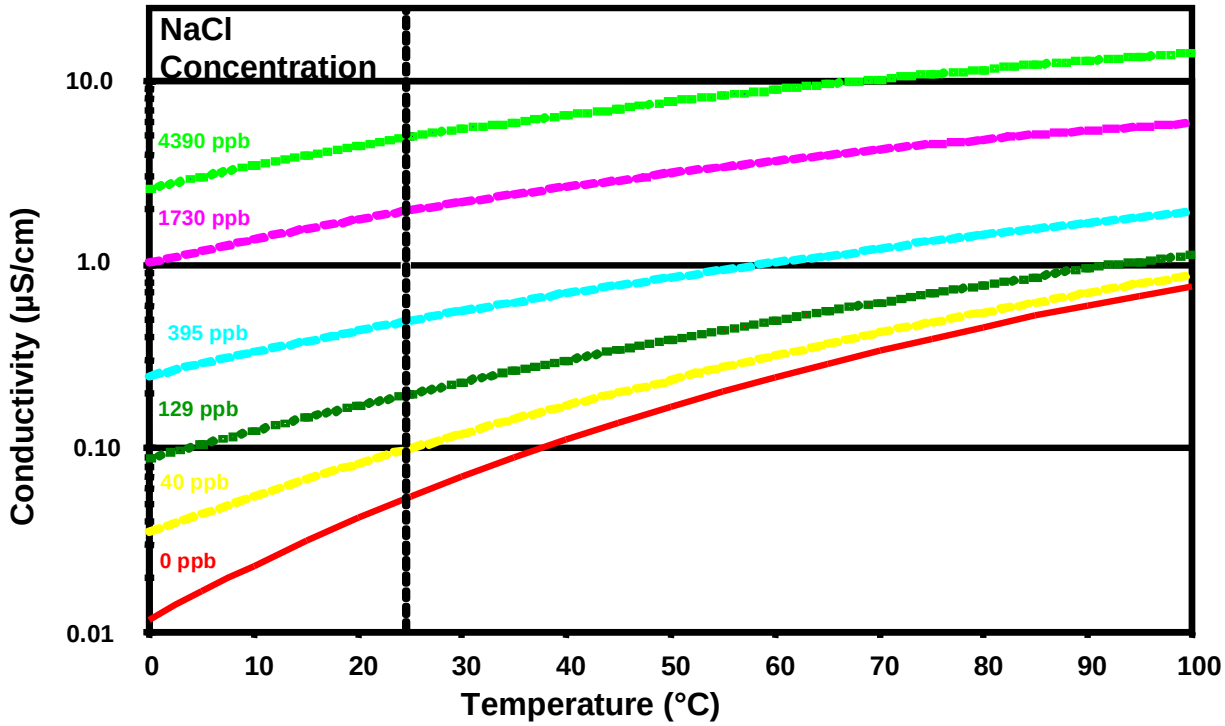
  ➡ Conductivity increases at higher temperature

The change of conductivity per °C is expressed by the temperature coefficient α .



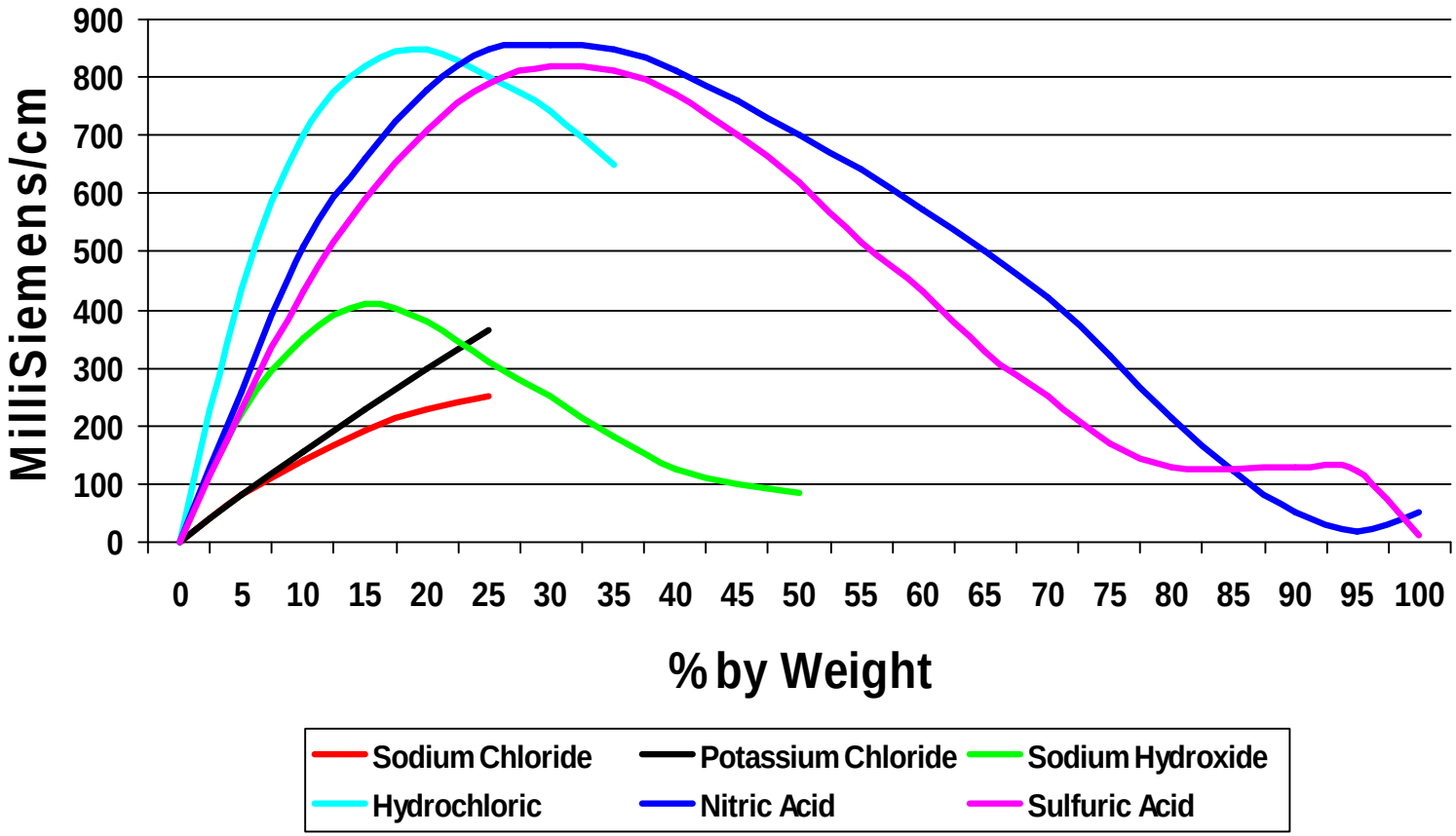
Temperature Compensation

- Most measurements are compensated to 25 °C
- The temperature coefficient α is approx. 2% / °C for many solutions
- Ultra pure water has a much stronger dependency (7 >α> 2.3) and also a non-linear function

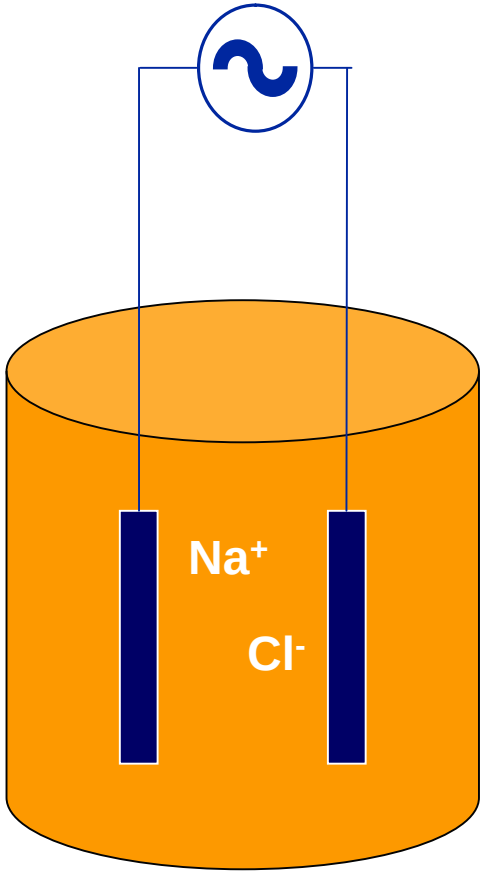


Chemical Concentration Control

§ When expressing the conductivity in units of concentration, the type of solution and its approximative concentration must be known.



2-Electrode Measurements

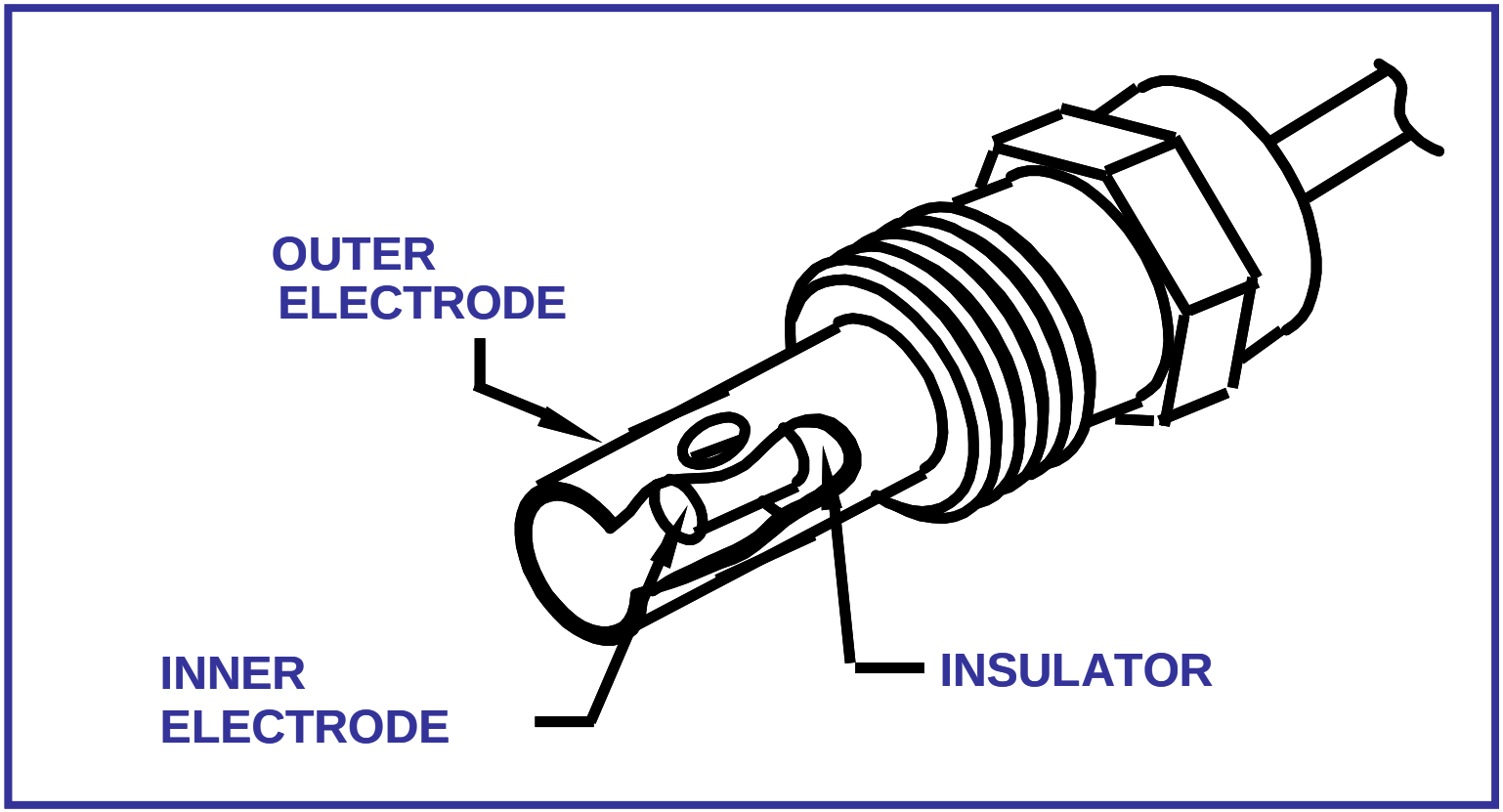


Principle of Measurement:

- Apply an AC voltage to two electrodes of exact dimensions
- Ions dissolved in a solution act as current carriers
- The current flow is directly proportional to the total dissolved solids in solution
- The physical dimensions of a conductivity electrode are referred to as the cell constant

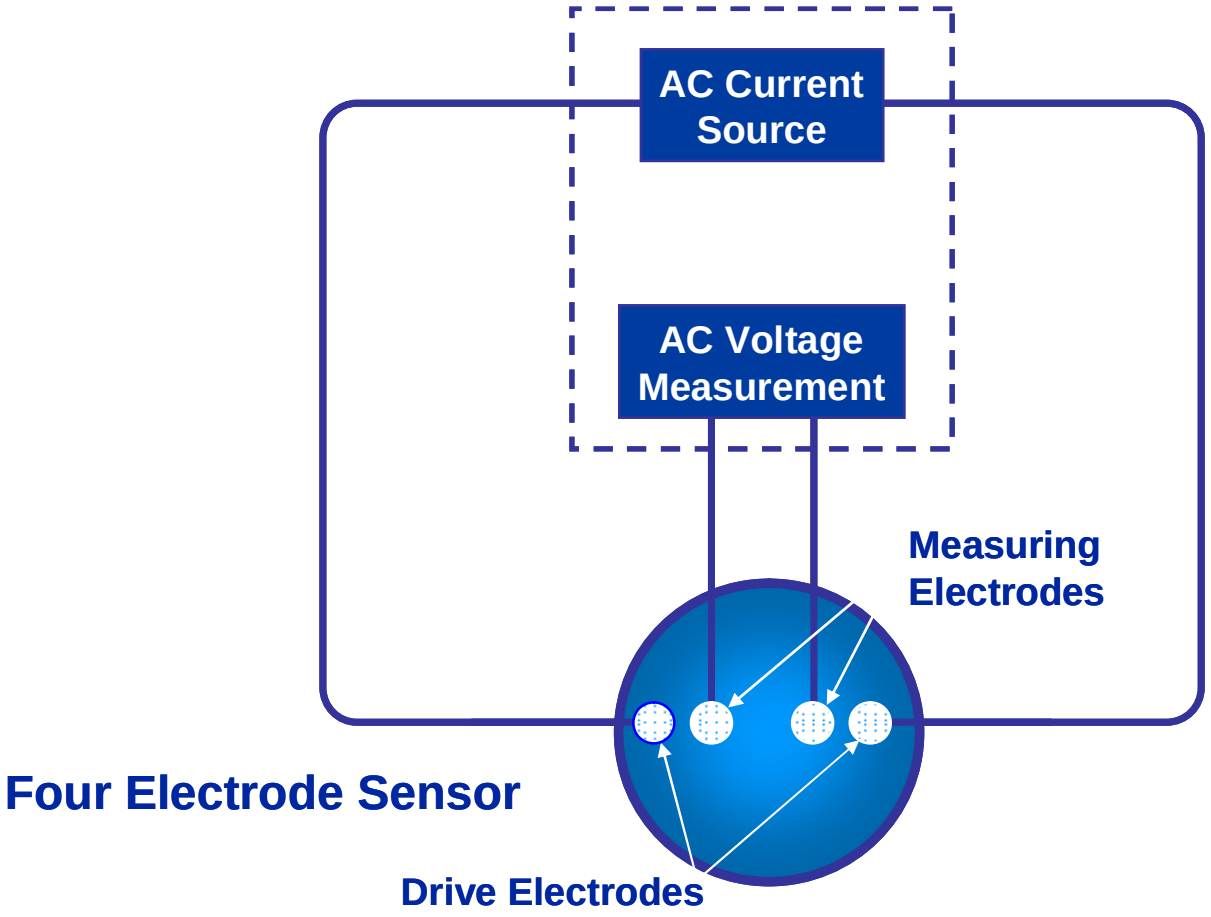
2-Electrode Measurements

Concentric Electrodes



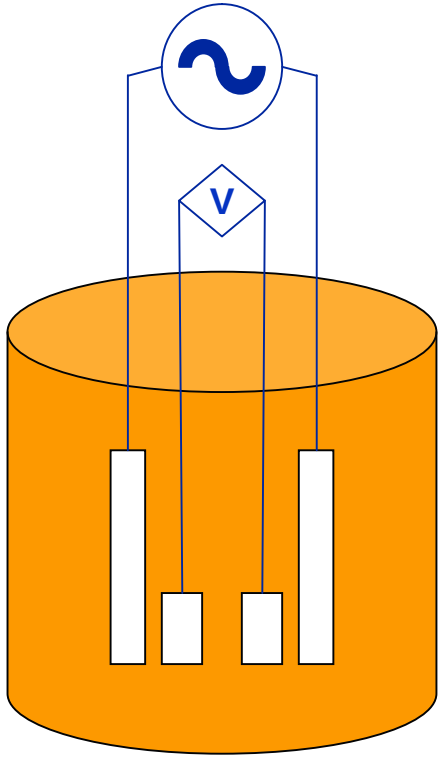
The concentric electrode design allows for a more homogeneous electric field, thereby increasing the signal quality.

4-Electrode Measurements



The 4-electrode (Wheatstone Bridge) arrangement increases the measurement quality in the high conductivity range.

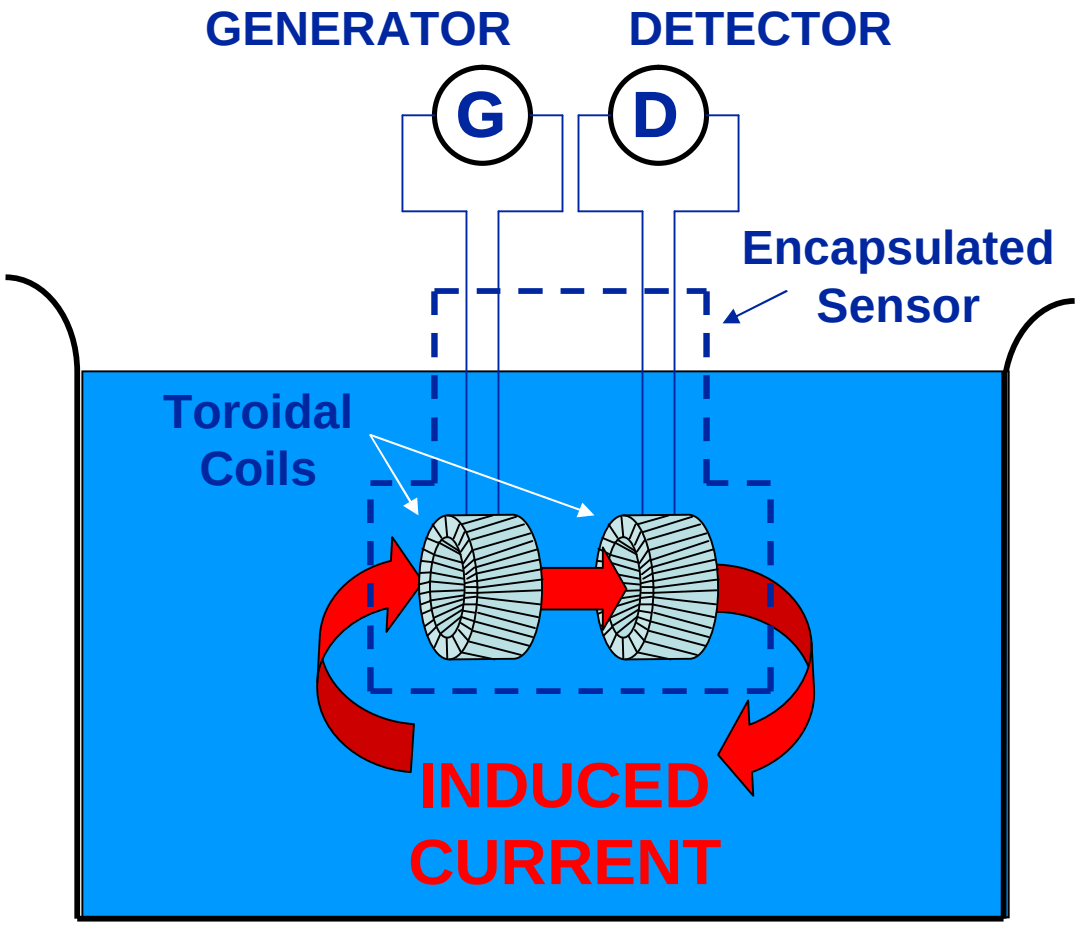
4-Electrode Measurements



Principle of Measurement:

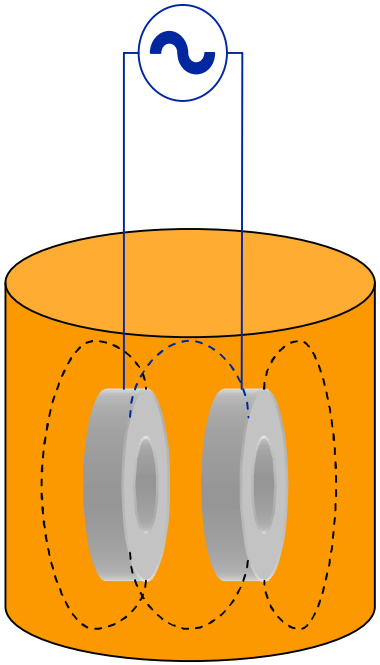
- Measures current and voltage drop
- Current increases with an increase in voltage drop across electrodes
- Compensates for minor coatings on conductivity electrodes
- Used for higher range of conductivity measurement

Inductive Measurements



The current induced by the generator coil in the solution is dependent on its conductivity and is measured by the detector coil.

Inductive Measurements



Principle of Measurement:

- two sealed wire wound coils electrically coupled by solution conductivity
- one transmitting coil, one receiving coil
- principle of a “transformer”

Inductive measurement is also known as toroidal and electrodeless measurements.

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Conductivity Product Overview

	2 Electrode Sensors	4 Electrode Sensors	Inductive Sensors
			
Specific Characteristics	§ very high accuracy § long life time § Simple and cost saving installation § Individually calibrated and certified cell constant § Re-calibration service § Sterilizable sensors § Materials according to FDA guidelines, 3.1B certificates	§ low maintenance § High pressure § Hygienic design § Easy installation in small pipes § Sterilizable up to 140 °C § VP (IP68) water tight connector § FDA compatible PEEK material	§ low maintenance § high pressure § high temperature § Rugged design for use in industrial processes under harsh conditions § Wide linear measuring range § Variety of flanges and adapters § PEEK & PFA versions available
Typical Applications	§ Water Preparation § WFI Water § General Purpose	§ CIP / SIP Processes § Chemical Processes § Waste Water	§ Chemical Processes § Pulp and Paper § Sugar § Waste Water

Sensor Offering

2-electrode sensors	4-electrode sensors	Inductive Sensors
		

The right sensor for your specific application.

Transmitter Offering

State-of-the art conductivity transmitters for the most demanding applications.

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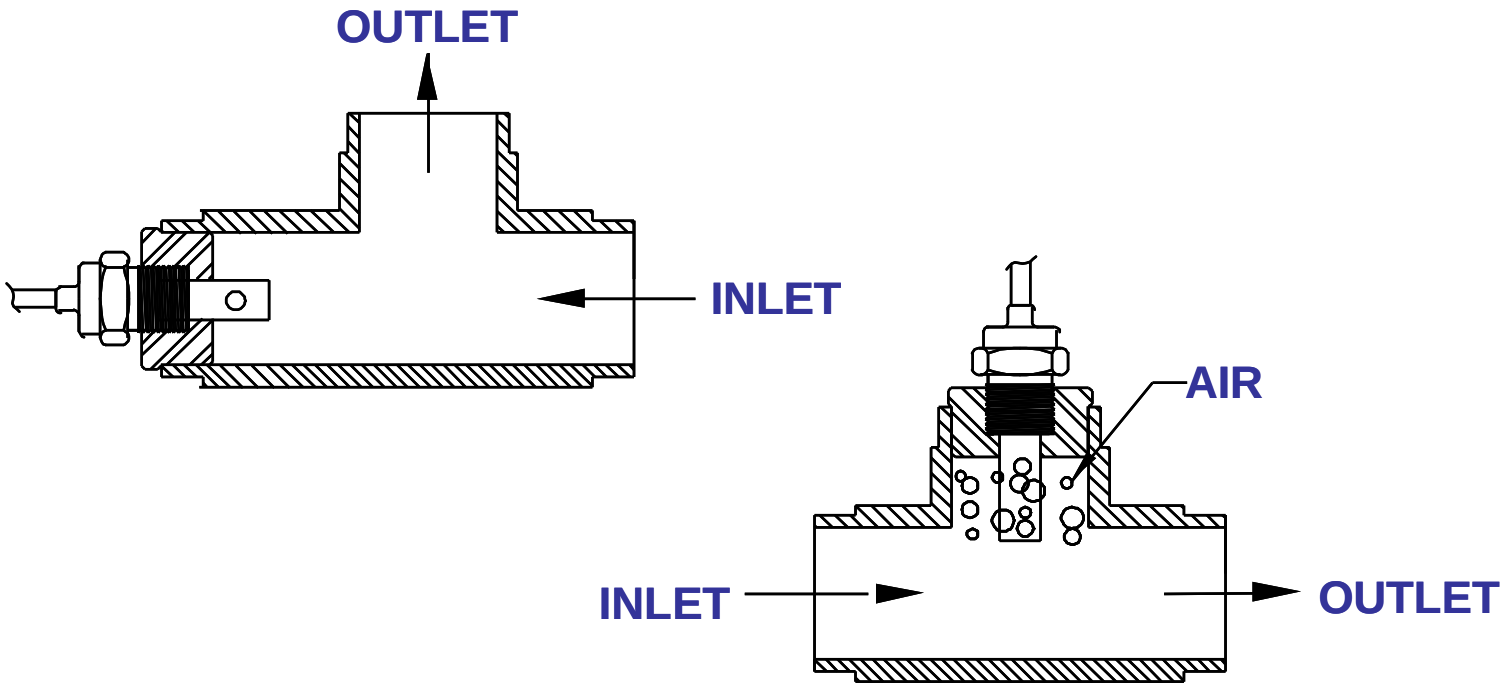
2-Electrode Sensor – Do's and Don'ts

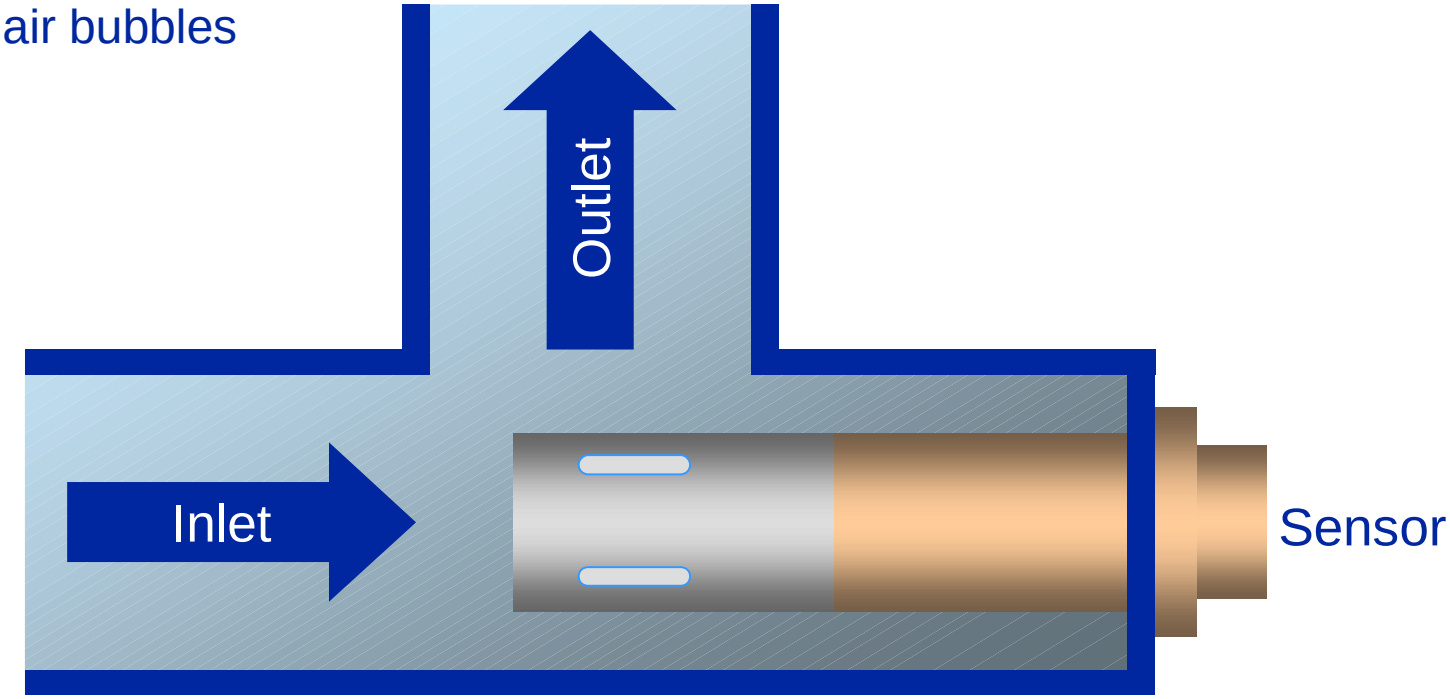
§ NOT recommended installation



Avoid dead legs and air traps !

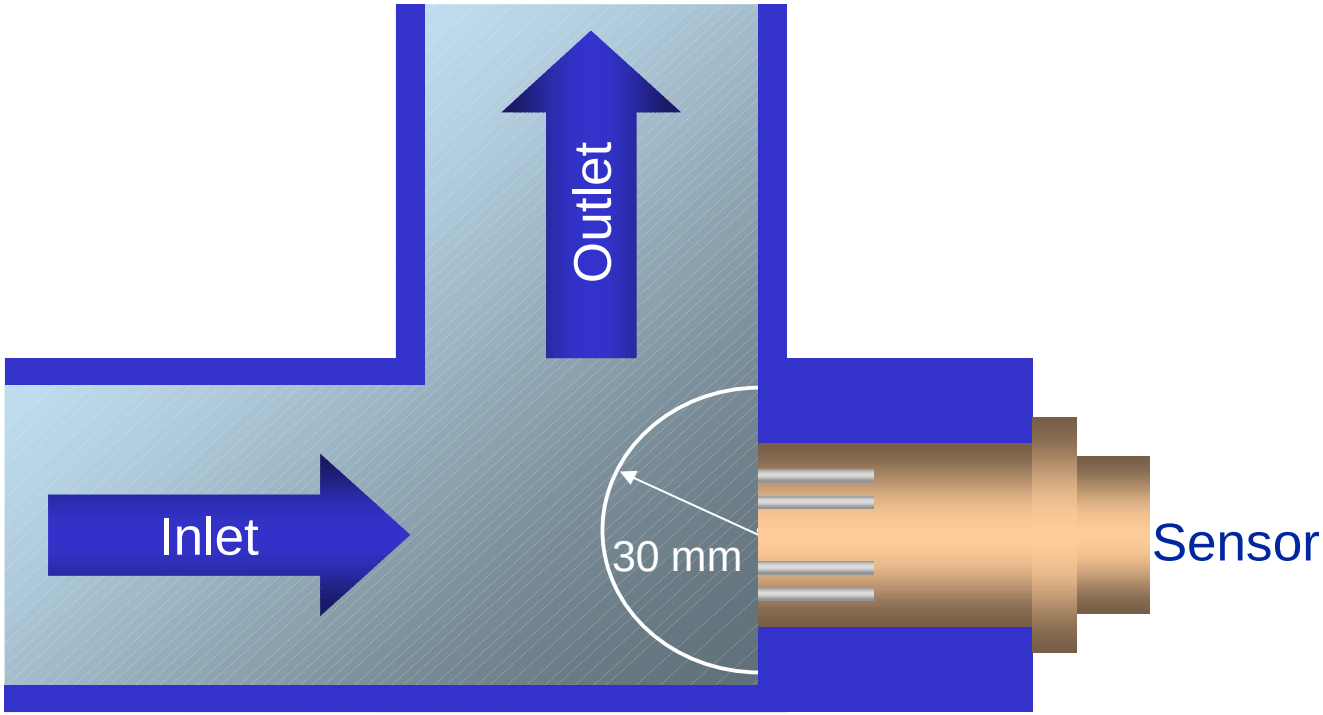
2-Electrode Sensor – Do’s and Don'ts

- Recommended installations
- Assure that the cell is completely immersed
- Avoid air bubbles



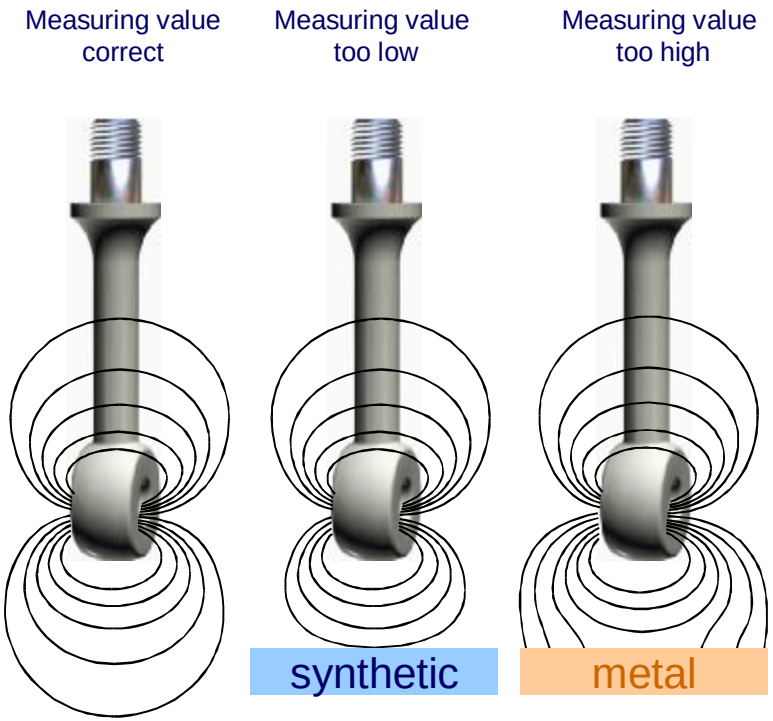
Flow should be directed at the tip of the sensor

4-Electrode Sensor – Do’s and Don'ts



A free zone of approximative 30 cm ahead of the sensor tip should be maintained.

Inductive Sensor – Do’s and Don'ts



- The **minimum distance** from the wall should be approximately **30 mm (1.18”) from the outer side** of the sensor.
- If the distance is smaller, the cell factor will change (re-calibration required).
- If the pipe is conducting (ss), the cell factor will be smaller.
- If the pipe is made of non-conducting material, the cell factor will become larger

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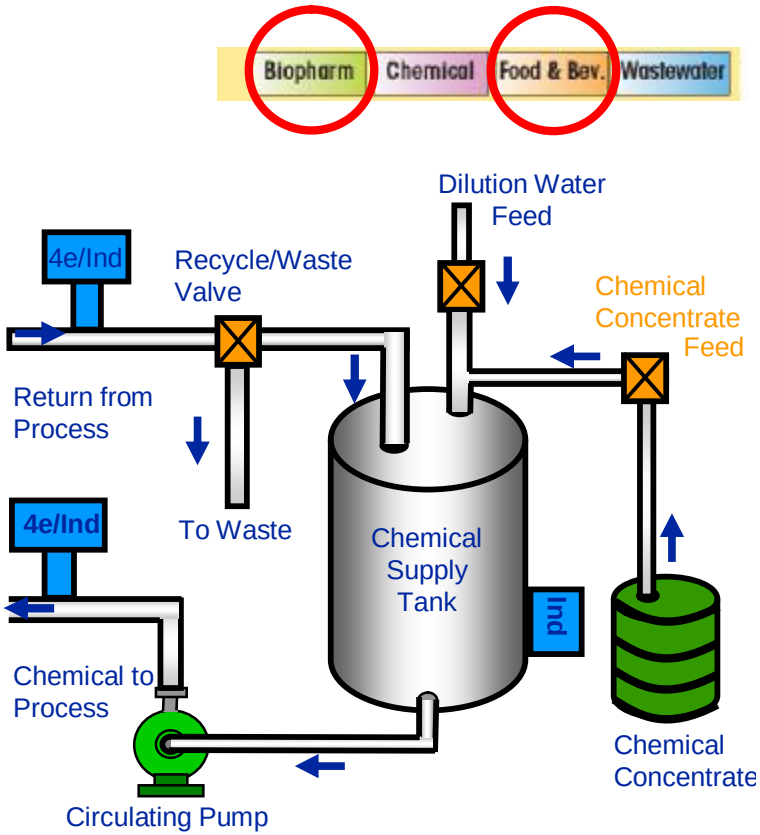
Cleaning-In-Place (CIP) System

Where are CIP systems used?

- In the Pharma and F&B industry, CIP systems are used to clean the reactors, pipes, and so in place.

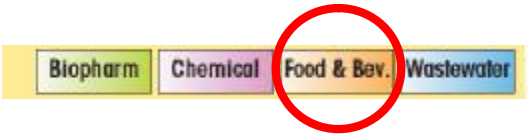
Why conductivity measurement?

- for monitoring concentration levels of the cleansing agent – to indicate the need for replenishment
- for product-water separation in the reverse cleansing flow (phase-separation in the return line)
- for separation of water-foam-water, water-acid-water, and water-disinfectant-water, where only detection of conducting salts is possible
- to determine the end-point of the cleaning process, when the caustic or acid solutions have been totally rinsed away



With conductivity measurement the process efficiency is increasing while the process costs are decreasing.

Lye Peeling of Fruit and Vegetables



Process step

- Many fruits and vegetables are prepared for peeling and canning by exposure to caustic (NaOH).

Why conductivity measurement?

- To ensure adequate and consistent peeling, the concentration of caustic in the treatment bath must be maintained at an effective strength.
- At the same time, if the caustic bath is too strong the fruit or vegetable can be damaged.
- Conductivity as a function of the concentration provides reliable concentration measurement

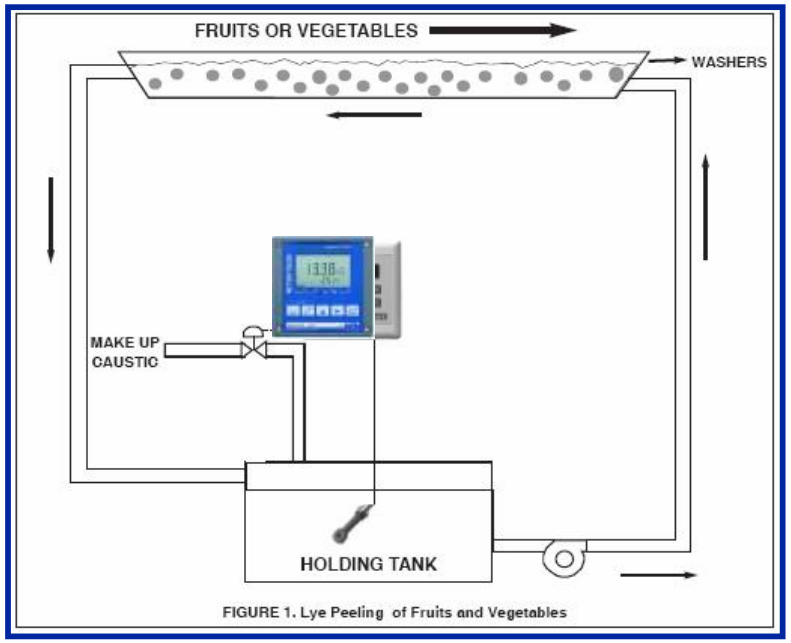
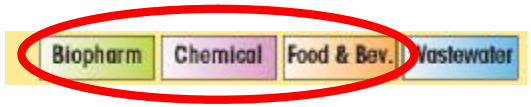


FIGURE 1. Lye Peeling of Fruits and Vegetables

With Conductivity the concentration can be determined accurately, leading to better process control with higher yield.

Phase Separation

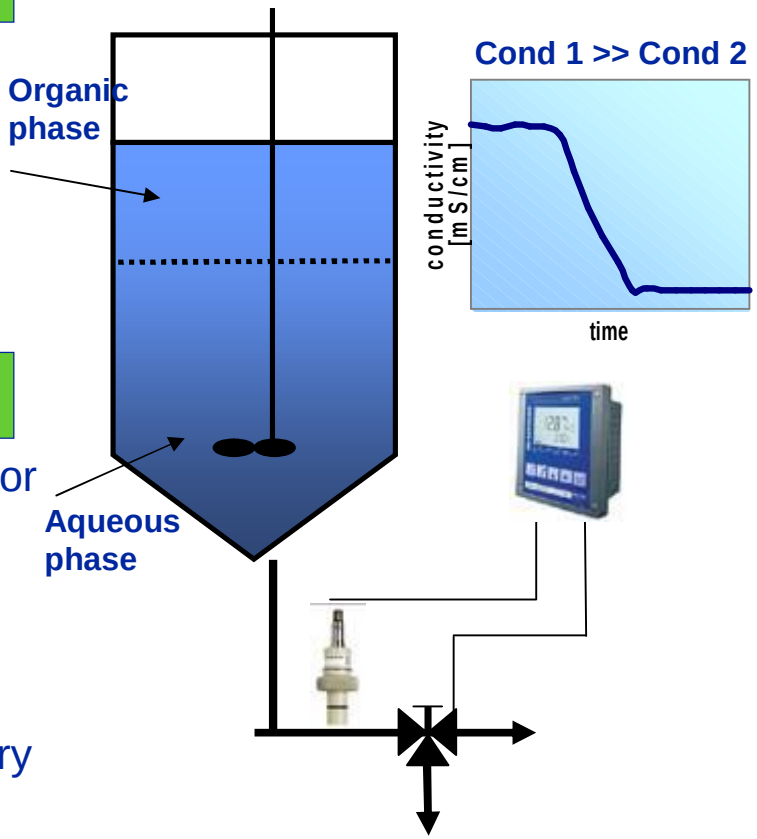


Process steps

- Batch reactions in the pharmaceutical and chemical industry often ends with 2 non-mixable liquid phases
- Separation is required as the product of interest is mainly only in one phase

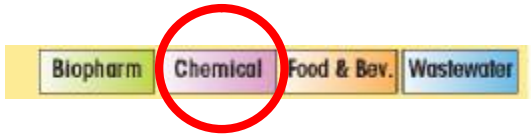
Why conductivity measurement?

- If the two phases cannot be separated completely or within a narrow window, product is lost and yield is reduced.
- The conductivity of these two phases often differ from each other, hence with conductivity measurement a phase change can be detected very fast and reliable



Conductivity measurement leads to high yield, an optimized process and cost reduction in all steps after phase separation.

Chemical Concentration Control

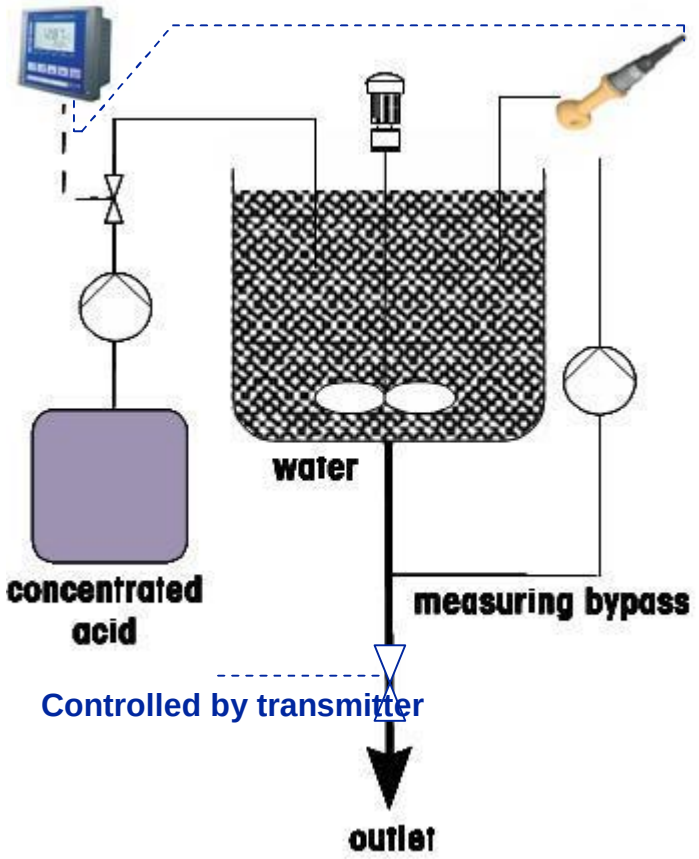


Process steps

- Found in numerous chemical processes
- Chemicals are stored in higher concentrations as required for cost and storage saving
- For further processing, they need to be diluted

Why conductivity measurement?

- A control strategy is necessary for an efficient dilution to save cost
- As conductivity in many cases is a function of solution concentration it is the ideal measurement for concentration control.



Measurement of conductivity allows for proper dosage of expensive chemicals and therefore reduces the operating costs and optimizes the process.

Chemical waste water treatment

Biopharm | Chemical | Food & Bev. | Wastewater

Process step

§ Continuous monitoring of effluents undergoing purification treatment is a critical factor both ecologically and for reasons of economic plant operation.

Why conductivity measurement?

§ For ensuring that the salt content is not to high

§ For ensuring that poisoning agents have been removed

§ Control of ion-level to check the separation effect in any treatment step

§ Quality control of raw waste water and the outflow

With Conductivity measurement, the efficiency of recovery will be optimized leading to a cost saving in the process and helps protecting the environment.

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Your Benefits - Summary

- § Simple installation
- § Universal use
- § Cost efficient through high accuracy and wide measurement range
- § Excellent process safety
- § High cleanability
- § Highest process reliability
- § Supports validation process

Plus:

MT service and consulting close at hand for the highest operational availability