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Advancement in Conductivity Measurement Technology: A Comprehensive Review

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Abstract

This abstract provide an overview of the development of a state-of-the-art conductivity meter designed for precise measurements in industrial settings. The conductivity meter presented in this study aims to address the growing demand for accurate and reliable measurement of electrical conductivity in various industrial processes

The conductivity meter is equipped with advanced sensor and cutting-edge electronics to ensure precise and real time measurement. It utilizes a multi-frequency measurement approach to account for variations in sample conductivity, temperature and salinity thereby improving measurements accuracy. The device incorporates a user friendly interface and data logging capabilities for ease of operations and data analysis.

Keywords: Introduction,Principle, The conductivity mete,rWorking of conductivity mete,rTypes of conductivity meter,Application, Standard, operating procedureCalibration

Introduction

A conductivity meter measures the amount of electric current or conductance in a solution .Conductivity is useful in determining the overall of a natural water body. Conductivity meters are common in any water treatment or monitoring situation as well as in environment laboratories. A conductivity system measures conductance by means of electronics connected to a sensor immersed in a solution .The analyzer circuitry impress an alternating voltage on the sensor and measures the size of the resulting signal. An integral temperature sensor incorporated into its circuitry adjust the reading to a standard temperature. The units of conductivity are siemens per cm (S/cm). An electric conductivity meter measures the electric conductivity in a solution. It has multiple applications in research and engineering, with common usage in hydroponics,aquaculture , aquaponics, and fresh water system to monitor the amount of nutrients , salts or impurities in the water.

➢ Principle of conductivity meter

The common laboratory conductivity meters employ a potentiometric method and four electrodes. Often the electrodes are cylindrical and arranged parallel. The electrodes current is applied to outer pair of the electrodes. Conductivity could in principle be determined using the distance between the electrodes and their surface area .Generally for accuracy a calibration is employed using electrodes of well- known conductivity

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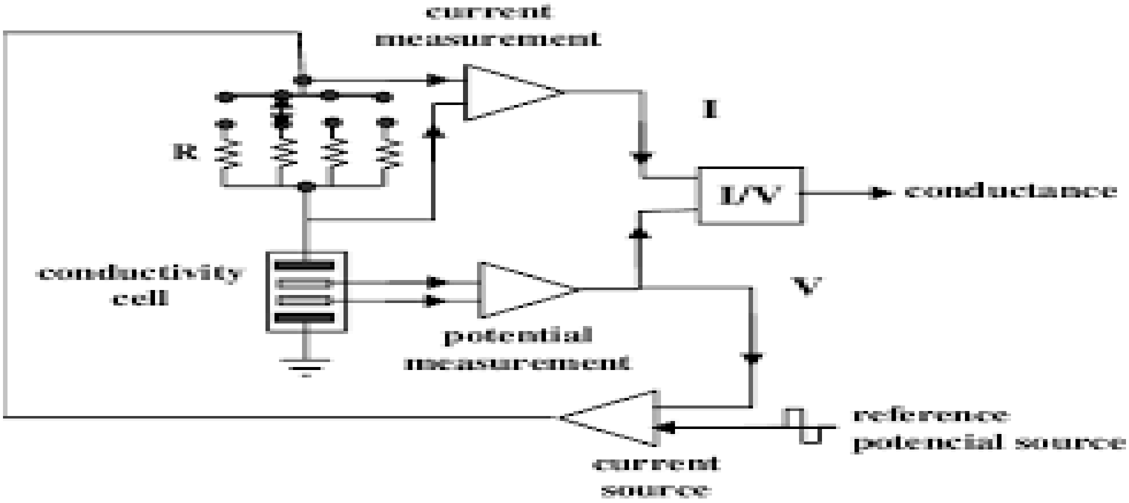
Conductivity is the ability of a material to conduct electric current. The principle by which instruments measure conductivity is simple -two plates are placed in the sample, a potential is applied across the plates (normally a sine wave voltage), and the current that passes through the solution is measured.

The conductivity meter

A typical conductivity meter applies an alternating current at an optimal frequency to two active electrodes and measures the potential (V). Both the current and the potential are used to calculate the conductance (I/V). The conductivity meter then uses the conductance and cell conductance to display the conductivity

Conductivity =cell constant × conductance



Simplified conductivity meter diagram

Working

- Conductivity measurements of solutions can give significant insights into the nature of, and the particles in, a solution.
- Conductivity is the ability of a material to pass or carry electricity or an electric current. It means the existence of charged particles or ions from electrolytes dissolved in it that enable the solution to be conductive.
- If the test solution contains an acceptable concentration of ions, then the conductance of the solution is great.
- Types of ions, the concentration of ions, and the solution's temperature are the factors that affect conductivity.
- The conductivity meter measures conductivity. In this article, we will discuss what a conductivity meter is and how such meters work.
- The device determines the health status of the natural water body. It is beneficial for inspecting the properties of solutions, such as total dissolved solids (TDS) for water quality investigation.
- The meter also checks the correct temperature of the solution and expresses the results on the monitor. The degree of ability to pass electric currents can vary. Substances with conductive solutions are known as electrolytes.

- **TYPES OF CONDUCTIVITY METER**

Two types of conductivity meter use in industry and laboratory.

1. Contacting type conductivity meter.
2. Inductive conductivity meter.

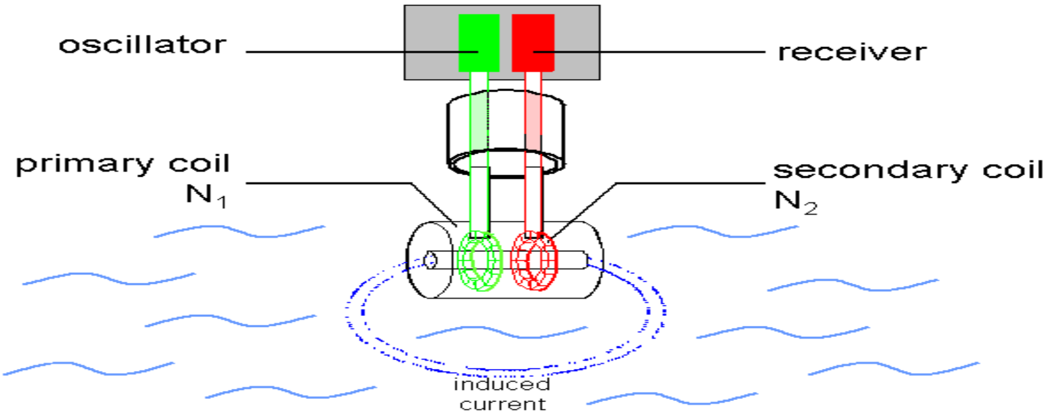
CONTACTING TYPE CONDUCTIVITY METER

Most contacting conductivity sensor consist of two metal electrodes .usually stainless steel or titanium ,in contact with the electrolyte solution. The analyzer applies an alternating voltage to the electrodes. The electric field causes the ions to move back and forth producing a current. The charge carriers are ions, the current is called an ionic currentConductivity measurements of solutions can give significant insights into the nature of, and the particles in, a solution. Conductivity is the ability of a material to **pass or carry electricity** or an electric current. It means the existence of charged particles or ions from electrolytes dissolved in it that enable the solution to be conductive. If the test solution contains an acceptable concentration of ions, then the conductance of the solution is great. **Types** of ions, the **concentration** of ions, and the solution's **temperature** are the factors that affect conductivity. The conductivity meter measures conductivity. In this article, we will discuss what a conductivity meter is and how such meters work.The device determines the health status of the natural water body. It is beneficial for inspecting the properties of solutions, such as **total dissolved solids (TDS)** for water quality investigation. The meter also checks the correct temperature of the solution and expresses the results on the monitor. The degree of ability to pass electric currents can vary. Substances with conductive solutions are known as **electrolytes**.

The ionic current depends on the total concentration of ions in solution and on length and area of the solution. Then multiplying the conductance by the cell constant corrects for the effects of sensor geometry on the measurements. The result is the conductivity which depends only on the concentration of ions .The cell constant is measured at the factory and the user enters the value in the analyzer when the sensor is first put in service. Some contacting sensor have 4 electrodes. In 4 electrodes measurements, the analyzer injects an alternating current through the outer electrodes. Measure the voltage across the inner electrodes. The analyzer calculate the conductance of the electrolyte solution from the current and voltage. Two electrodes sensor are ideal for measuring high purity water in semi-conductor, steam electric power, and pharmaceutical plants.

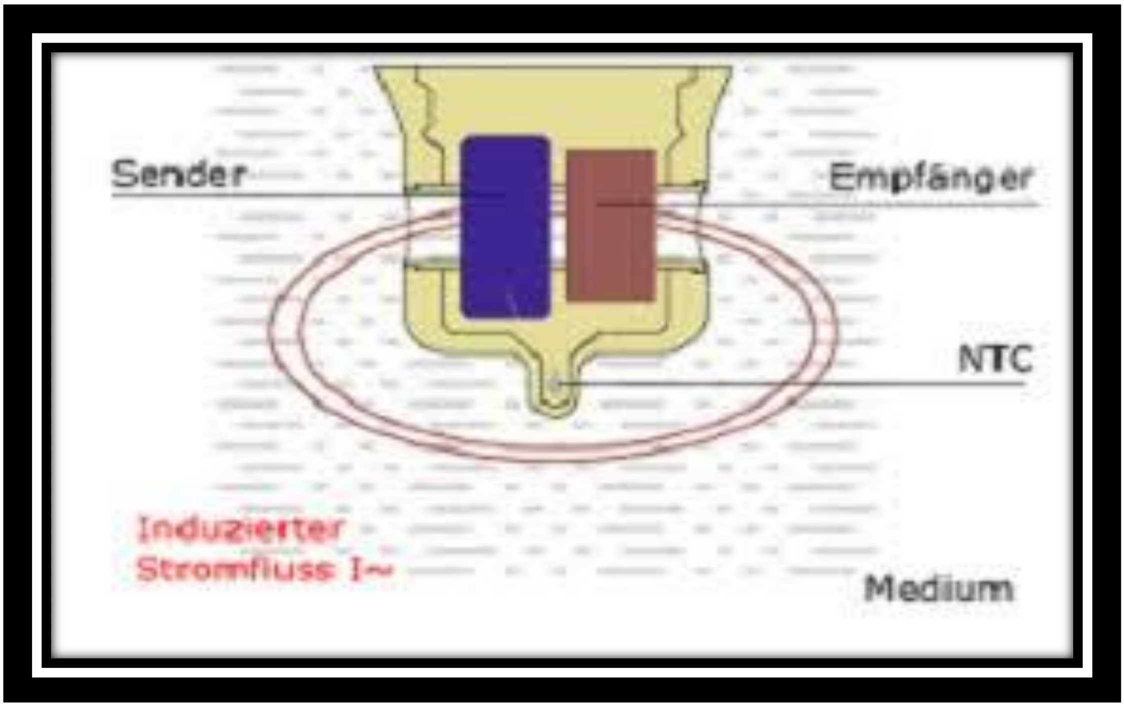
INDUCTIVE CONDUCTIVITY METER

Inductive conductivity is sometimes called toroidal or electrodeless conductivity .An sensor consist of two wire wound toroids encased in a corrosion resistance plastic body. One totroid is the drive coil, the other is the receive coil. The sensor is immersed in the conductive liquid. The analyzer applies an alternating voltage to the drive coil, which induces a voltage in the liquid surrounding the coil.The voltage causes an ionic current to flow proportional to the conductance of the liquid. The current in the receive coil depends on the number of sensor are described by cell constant



Inductive sensors are using two electromagnetic coils usually encased in a polymer ring. An alternating voltage is applied to the driving coil, which induces a voltage in the receiving coil. The induced current is influenced by the conductance of the solution.

Alternating current flowing through a primary coil (emitter) induces an alternating magnetic field, which in turn induces a current in the surrounding medium. The current flow in the medium on its side produces a magnetic field which induces a tension and consequently a flowing current in the secondary coil (receiver). The current which can be measured is the parameter for the conductivity of the medium. As the conductivity of a liquid depends significantly on the temperature, an additional detector in the sensor tip (NTC) continuously measures the temperature of the medium. The influence of the temperature is compensated by the temperature coefficient value (TC value) preset in the electronic device.



A conductivity meter is an essential measuring tool for a range of applications and industries. When the probe (attached to the conductivity meter) is inserted into the solution, an electrical current flows between the electrons inside the probe which reads the electrical current, providing a conductance value.

Electrical Conductivity or (EC) measures the ability of a material to transmit an electrical current over a certain distance, usually measured in Siemens (S) per distance. When the number of dissolved ions (charged particles) in a solution increases, so does the solution's ability to carry an electrical charge. A conductivity meter reads the electrical charge and measures the conductance.

HOW DOES CONDUCTIVITY METER WORKS?

Conductivity is the measurement of the electrical current of a solution, most commonly measured in microsiemens per centimeter (µS/cm).

Conductivity values depend on the ionic strength of the solution, the ions present, and the ion concentration. As the temperature can affect a solution's conductivity, calibration is required before use.

A conductivity meter emits an electrical charge via a conductivity probe, which is dipped into the solution being tested. If there is an increase or decrease in the number of dissolved ions, it will result in an increase or decrease in the electrical charge. A conductivity meter can measure this charge, and provide you with the solution's conductance.

When the probe is inserted into the solution, an electrical current flows between the two electrons inside the probe, set apart at a specific distance. The ion concentration in the solution is what determines if the conductance is high or low. If the ion concentration is high, the higher the conductance will be, which results in a faster current. If the electrical current is slow, the conductance value will be lower because the concentration of ions in the solution is less.

APPLICATION

Despite the difficulty of theoretical interpretation, measured conductivity is a good indicator of the presence or absence of conductive ions in solution, and measurements are used extensively in many industries For example, conductivity measurements are used to monitor quality in public water supplies, in hospitals, in boiler water and industries that depend on water quality such as brewing. This type of measurement is not ion-specific it can sometimes be used to determine the amount of total dissolved solids (TDS) if the composition of the solution and its conductivity behavior are knownConductivity measurements made to determine water purity will not respond to non- conductive contaminants (many organic compounds fall into this category), therefore additional purity tests may be required depending on application.

Applications of TDS measurements are not limited to industrial use; many people use TDS as an indicator of the purity of their drinking water. Additionally, aquarium enthusiasts are concerned with TDS, both for freshwater and salt water aquariums. Many fish and invertebrates require quite narrow parameters for dissolved solids. Especially for successful breeding of some invertebrates normally kept in freshwater aquariums—snails and shrimp primarily—brackish water with higher TDS, specifically higher salinity, water is required. While the adults of a given species may thrive in freshwater, this is not always true for the young and some species will not breed at all in non-brackish water.

Sometimes, conductivity measurements are linked with other methods to increase the sensitivity of detection of specific types of ions. For example, in the boiler water technology, the boiler blowdown is continuously monitored for "cation conductivity", which is the conductivity of the water after it has been passed through a cation exchange resin. This is a sensitive method of monitoring anion impurities in the boiler water in the presence of excess cations (those of the alkalizing agent usually used for water treatment). The sensitivity of this method relies on the high mobility of H+ in comparison with the mobility of other cations or anions. Beyond cation conductivity, there are analytical instruments designed to measure Degas conductivity, where conductivity is measured after dissolved carbon dioxide has been removed from the sample, either through reboiling or dynamic degassing.

Conductivity detectors are commonly used with ion chromatography.

➢ STANDARD OPERATING PROCEDURE

Allow time for the reading to stabilize. Note the reading on the display. TheClear yellow protective probe guard must be attached during measurement.Erroneous results will occur while the probe guard is removed. The conductivity meter will select the optimal range automatically by default.Refer to TABLE 1 for the list of available ranges. For manual ranging, press 'ENTER/RANGE'. MEAS will flash, indicating thatManual ranging is active. To select the next range press 'ENTER/RANGE' again. Select the range that best meets your needs. The reading should show the greatest numberof digits in any given run. Press 'ENTER/RANGE' 5x, automatic ranging is resumed.

CALIBRATION OF CONDUCTIVITY METER

Preparation of 0.001M KClsolution :

Take 74.6 mg of KCl and dissolved into 1000 ml of Milli Q water (this is 0.001M) and record the data as in Annexure-3.

Use Purified water or Milli Q water whose conductivity is less than 2 □ S to prepare the calibration standard solutions.

Always use the freshly prepared KCl solution.

Rinse the conductivity cell with purified water/Milli Q water and remove the excess water using soft tissue paper.

Dip the electrode and RTD sensor in such a way that there is no air bubble in the cell. And ensure that the solution is above the cell tips and below the vent hole.

Use the electrode (Conductivity Cell) having known cell constant e. (K= 0.1), which is to be used for calibration and measurements.

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