Measurement of Variables Critical to Controlling Processes – Conductivity

Your Objectives:

At the end of this lesson, "Measurement of variables critical to controlling processes – Conductivity" you will be able to appraise the conductivity variable.

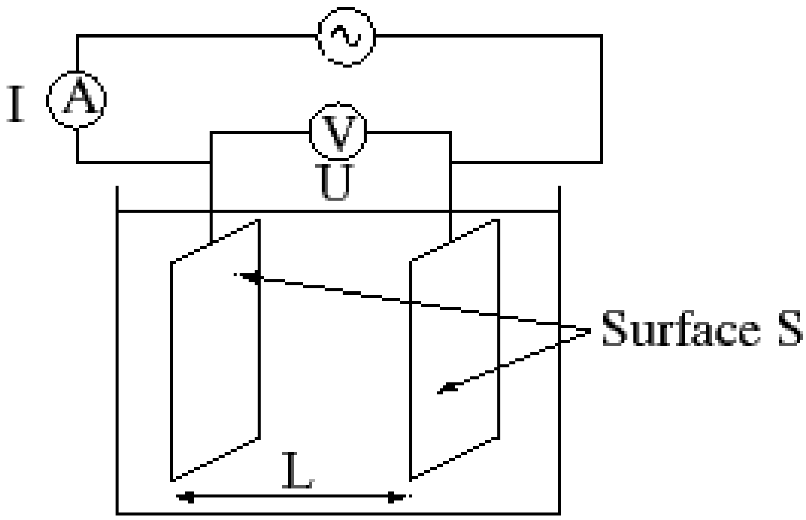
Definition of electrical conductivity

Electrical conductivity, or specific conductance, is the reciprocal of electrical resistivity (see below). It represents a material's ability to conduct electric current. It is commonly represented by the Greek letter σ, while κ (especially in electrical engineering) and γ are sometimes also used. The SI unit of electrical conductivity is siemens per metre (S/m).

Electrical resistivity (also called specific electrical resistance or volume resistivity) and its inverse, electrical conductivity, is a fundamental property of a material that quantifies how strongly it either resists or conducts electric current. A low resistivity indicates a material that readily allows electric current. Resistivity is commonly represented by the Greek letter ρ. The SI unit of electrical resistivity is the ohm-meter (Ω·m). For example, if a 1 m × 1 m × 1 m solid cube of material has sheet contacts on two opposite faces, and the resistance between these contacts is 1 Ω, thereby the resistivity of the material is 1 Ω·m.

Measurement

The electrical conductivity of a solution of an electrolyte is measured by determining the resistance of the solution between two flat or cylindrical electrodes separated by a fixed distance. An alternating voltage is used in order to avoid electrolysis. The resistance is measured by a conductivity meter.



A wide variety of instrumentation is commercially available. There are two types of cells, the classical type with flat or cylindrical electrodes and a second type based on induction. Many commercial systems offer automatic temperature correction.

Here is perhaps a good explanatory video of that:

https://www.youtube.com/watch?v=sVcG65dMZfk

In the highly regulated biotech and pharmaceutical industries, effective analytical measurement is critical for ensuring high production quality and operational efficiency whilst meeting hygienic standards. One key measurement application is conductivity analysis during clean-in-place (CIP) processes, though it is also used for several other processes. Conductivity measurement is so integral to the pharmaceutical manufacturing process that it is easy to take it for granted. However, understanding some basics of its operation and correct application can make a significant difference in the effectiveness and efficiency of CIP.

Conductivity in CIP (Cleaning in Place)

The CIP process ensures that equipment is cleaned and maintained to minimise any possible cross-contamination and improve safety and product quality. Conductivity analysis is a measure of how well a solution conducts electricity. Cleaning solutions are more conductive than water used for flushing the system, thus conductivity measurement enables plants to monitor cleaning steps and final rinsing to ensure completeness.

Optimally, a CIP process will maximise safety while preventing cross-contamination. Hence, increase CIP time and you will minimize production downtime while optimizing thermal efficiency, reduce energy requirements, and avoid excessive heat loss.

The multi-step CIP process includes initial and final drain, pre-rinse, sodium hydroxide wash, and post-rinse. Some processes may also include a sanitizing cycle so as to reduce bacterial contamination, by using strong oxidants such as hydrogen peroxide, ozone, chlorine dioxide, or other chlorine-containing compounds. It is critical that processing plants ensure that these chemicals are thoroughly removed not only to avoid cross-contamination but also to prevent corrosion of equipment.

Effective cleaning is determined by detergent strength, cleaning time, and temperature. Conductivity measurement is used throughout the CIP process to ensure the right detergent concentration and to monitor the completion of each step. By measuring the conductivity of the returning acid and caustic solutions, plants can confirm that the detergent is the right strength, with the correct concentration of acid and caustic, for each CIP circuit. These conductivity measurements are proportional to the concentration or solution strength and are recorded for validation. During the CIP process, since it is common for fluids to be only partially neutralised, conductivity analyses will indicate when additional concentrate should be added.

By measuring conductivity, plants can determine the interface between cleaning solutions and rinse water. When the conductivity drops to the value of rinse water, it indicates that the next step in the cycle may begin. This procedure minimises CIP time while following (standard) regulatory compliance. Conductivity is also an effective way to detect the interface between the cleaning solutions and the product so that valves can be switched at the right time so as to prevent both cross-contamination and product wear and tear.