



Pure Water: The Basics

Common Water Impurities

Suspended Particles

Sand, silt, clay and other suspended particles cause water to be turbid. These particles are measured with a turbidity meter which passes a beam of light through water and measures the amount of light scattered by the suspended particles. Suspended particles can plug valves and foul reverse osmosis membranes. They are typically removed by filters with pore sizes of 1 to 20 microns.

Colloids

Colloidal particles range in size from 0.01 - 1.0 micron and can be either organic or inorganic. They are quantified by measuring the rate that water blocks a submicron filter. Colloids clog filters, foul reverse osmosis membranes and lower resistivity in deionized water systems. They are removed by macrorreticular anion exchange resin, filtration, ultrafiltration, reverse osmosis, and distillation.

Dissolved Inorganic (Ionized) Solids

Impurities such as silicates, chlorides, fluorides, bicarbonates, sulfates, phosphates, nitrates and ferrous compounds are present as cations (positively charged ions) and anions (negatively charged ions). In water, ions are measured with a conductivity/resistivity meter which transmits an electrical current between two electrodes. Water with higher concentrations of ions conducts electricity more easily than water with lower concentrations of ions. Ions affect the results of inorganic analyses such as IC, AAS, ICP/MS, and may retard cell and tissue growth in biological research. They are removed by cation and anion exchange resins or distillation, and reduced by up to 98% by reverse osmosis.

Dissolved Organics

Organic solids are present from plant and animal decay and from human activity. They may include proteins, alcohols, chloramines, and residues of pesticides, herbicides and detergents. Their presence is indicated by the potassium permanganate color retention test and measured by a Total Organic Carbon Analyzer. They foul ion exchange resins, interfere with organic analyses including HPLC, gas chromatography and fluoroscopy, and hinder electrophoresis, tissue and cell culture. Dissolved organics may be removed by activated carbon, macrorreticular resin, reverse osmosis and ultrafiltration, and oxidized by ultraviolet light.

Dissolved Gases

CO₂ dissolves in water to form weakly acidic carbonic acid (H₂CO₃). This gas can be measured with a conductivity/resistivity meter. CO₂ is only removed by strong base anion exchange resins. Oxygen is the most common non-ionized gas and is monitored with oxygen sensing electrodes. Oxygen may cause corrosion of metal surfaces and is removed by anion exchange resins in the sulfite form.

Microorganisms

Bacteria, fungi and algae are found in most surface waters. Bacteria are measured by culturing a sample and counting the colony forming units per milliliter (CFU/ml). City water treatment facilities commonly add chlorine to kill microorganisms. This chlorine is removed in the first step of most water purification systems which allows bacteria to multiply in the system. Distillation effectively kills microorganisms, reverse osmosis removes them and UV light can control their growth. All ultrapure water systems must have a 0.2 micron or smaller absolute filter on the outlet to prevent bacteria from contaminating the ultrapure product water. In addition, all water pathways in the system should be regularly sanitized.

Pyrogens and Viruses

Pyrogens or bacterial endotoxins are lipopolysaccharide molecules and are incorporated in the cell membrane of gram negative bacteria. Viruses are considered to be non-living nucleic acids. Pyrogens are detected by injecting a sample into test rabbits and monitoring their body temperature rise, or measured with the more sensitive LAL (Limulus Amoebocyte Lysate) test. Pyrogens cause fever when injected into mammals and hinder cell and tissue growth in culture. Pyrogens and viruses can be removed or reduced by distillation, ultrafiltration, reverse osmosis, and carbon adsorption.

Nucleases & DNA

RNase and DNase are naturally occurring enzymes that are instrumental in regulating bodily functions. DNA is the building block of life itself. As important as these are to the life process, they can be devastating to life science applications. If these contaminants are present in the pure water used, the ability to amplify DNA molecules will be severely limited. They can be removed by a combination of adsorption, ultrafiltration and ultraviolet oxidation.

	Deionization	Distillation	Reverse Osmosis	
DISSOLVED INORGANIC SOLIDS	●	●	●	
DISSOLVED GASES	●	●	●	
DISSOLVED ORGANICS	●	●	●	● Excellent
PARTICULATES	●	●	●	● Good
BACTERIA	●	●	●	● Poor
PYROGENS	●	●	●	