High Purity Water:
A Technical Guide to Types I, II & III

WHAT IS HIGH PURITY WATER?

High purity water, also known as purified water or laboratory water, is water that has been mechanically filtered or processed to remove impurities and attain uncommonly high purity specifications to make it suitable for use in laboratory settings.

High purity water is typically split into three categories – Type I, Type II, and Type III – each with their own purity specifications depending on the application for which it is required. While Type I is the purest and used for the most sensitive applications, when used in laboratories each type undergoes thorough testing under strict guidelines to maintain industry standards by using specialised water purification systems and equipment. This guide will provide an overview of the different types of high purity water, their specifications and in which applications they are used.

WHY DO WE NEED HIGH PURITY WATER?

High purity water has been used in commercial and industrial laboratories for decades, as well as commonly being used in the pharmaceutical and healthcare industries. In these settings, the use of high purity water is necessary to ensure reliable results from repeatable experiments and processes by eliminating contaminants that can interfere with accuracy and precision.

It is also needed to provide efficiency and in ensuring the safe and effective performance of sensitive laboratory equipment and analytical instruments. In doing so, purified water keeps equipment in operation for longer, helping to keep down costs and reduce laboratory downtime due to maintenance and repair.

As well as maintaining high levels of precision, the correct water type should be used to prevent possible contamination and inaccurate results. In addition, using Type I water, rather than Type II or III, can incur unnecessary costs as the water purification process can be expensive. For these reasons, it's important to identify and use the correct water type to achieve high levels of quality and accuracy.

The Different Types of High Purity Water

Laboratory water is primarily divided into three types. From Type III for general use such as rinsing out beakers, to Type I for sensitive applications. The different types of purified water are used for many procedures within commercial, industrial and research laboratories, such as for scientific experiments, diagnostic testing, and analysis. High purity water is required within these settings to maintain accuracy, control, and effectiveness, by reducing and eliminating contaminants.

DEFINING HIGH PURITY WATER TYPES

There are various requirements and parameters surrounding high purity water, which are used to separate the water into three types, with Type I being the purest. This division serves as a guideline as to what type of water should be used for specific procedures within laboratory settings.

In order to distinguish between the different types of high purity water, specialised tests are carried out to assess the various properties and possible contaminants within the water. These include:

- **Conductivity -** This involves the measurement of ion levels and inorganic impurities within the water, measured in microSiemens per centimeter (QS/cm). Conductivity is typically used when assessing water ranging from 'raw water' to 'drinking water' and provides a valuable, non-specific indication of the level of ions in the water.
- **Resistivity -** The resistivity is measured in Ohms (ff-cm). It is inversely proportional to conductivity and can be used to measure the water's ionic content. By using specific tools, such as a resistivity meter, you can measure how much the water resists the flow of electricity.
- **Organic Compounds -** Typically used for Type I water, you can use the TOC (total organic compounds) to help define the levels of purity. This can offer an indication of organic impurities and involves the process of oxidizing the organic compounds to quantify the oxidation products.

The distinct types of water are produced using different methods and are used for different applications and play varying roles within the laboratory, which is why it's important to identify what type of water is needed for specific procedures and processes.

Here is a closer look at the three types of water and their specific functions and purposes within a laboratory setting:

TYPE III

Type III water is considered primary grade water and has the lowest levels of purity when compared to the other types. For this reason, Type III water is typically used for general and non-critical work and can also serve as the initial stage for Type I and Type II water. This type of water is produced through purification processes such as media filter, carbon filter and reverse osmosis, which is a water purification process that removes approximately 90 – 99% of contaminants.

Despite having lower levels of purity, Type III water is often the basis for basic lab applications and is also suitable for cleaning a range of scientific equipment, including glassware, heating baths and other non-critical applications. In addition, Type III water can be used as feed for autoclaves and in Type I water production.

To meet Type III water requirements, resistivity must be greater than 4 Mff-cm and the conductivity should be less than 0.25 QS/cm. Additionally, the total organic compounds are expected to be less than 200ppb*.

TYPE II

Also known as general laboratory grade water, Type II water has a high level of purity and is often used for standard applications, tests, and procedures.

This type of water can be produced through reverse osmosis and ion exchange which involves the removal of synthetic resins, which are replaced by hydrogen or hydroxyl ions. Type II water can also be produced through electrical ion exchange, which uses active purification technology to combine electrodialysis with ion-exchange, or distillation.

Within a laboratory setting, Type II water can be used for general practices, such as buffer preparations, sample dilution, microbiological analysis, PH-solution preparation, and electrochemistry. Moreover, Type II water provides a good feed for washing machines, SST autoclaves and clinical analysers, as it's able to reduce calcium build-up.
The resistivity requirements for Type II water should be greater than 1 Mff-cm and conductivity less than 1 QS/cm. The total organic compounds are typically required to be less than 50 ppb.

TYPE I

Type I water is the purest form of water and is often referred to as ultrapure water. This water type is used for critical applications and delicate procedures; it is also considered a requirement for analytical labs.

To achieve ultrapure water, it often undergoes ultra-pure polishing which can be carried out using ultra-pure water systems. Due to its pure state, Type I water is ideal for procedures that are highly susceptible to contamination. However, as ultrapure water is far from its natural state, it can be easily contaminated and should not be stored in tanks or carboys as this may lead to organic contamination from the container or surrounding atmosphere.

As Type I has the highest purity levels, it can be used for an extended range of technical applications, and analytical procedures. These include gas chromatography, flow cytometry, molecular biology, liquid chromatography, polymerase chain reaction, atomic absorption spectroscopy and TOC analysis, as well as in cell and tissue culture. In addition, Type I water can also be used as sample dilution and reagent preparation for molecular biology.

To achieve Type I water, it should have a resistivity greater than 18 Mff-cm and conductivity less than 0.056 QS/cm. Type I water should also have less than 50ppb in total organic carbons.

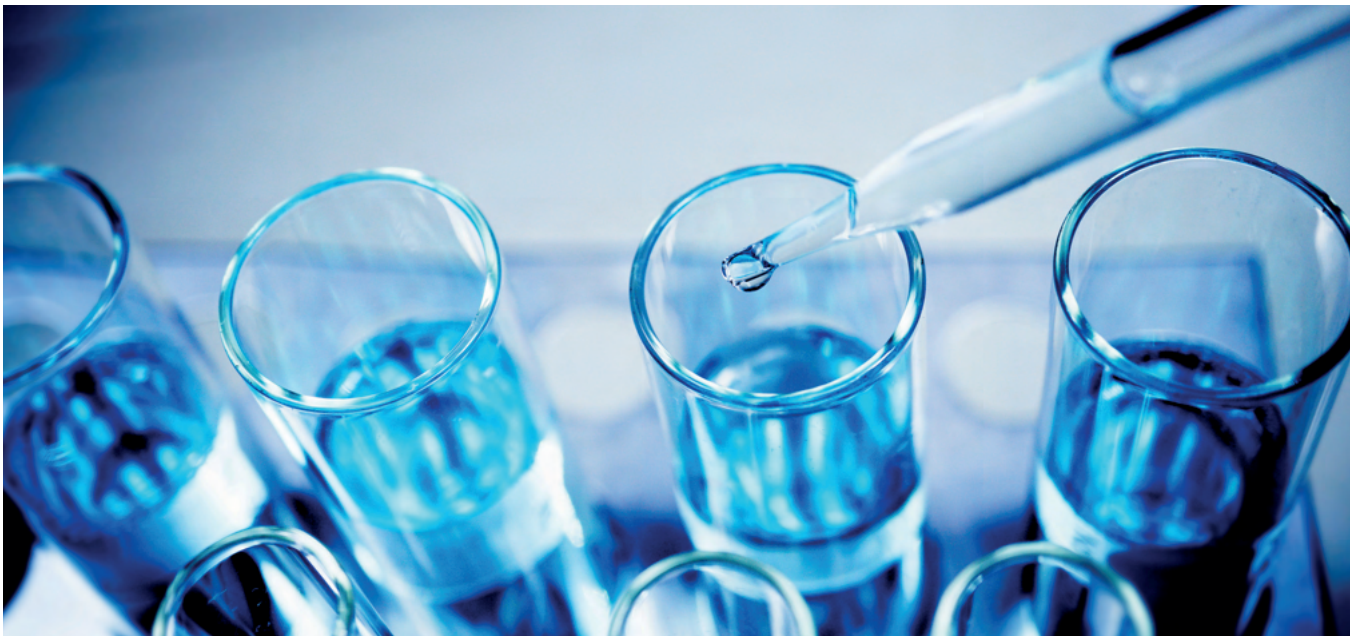
Purification Methods

Water naturally has a variety of solvent properties, which can contain contaminants, such as dissolved gases, bacteria, organic compounds, particles, and colloids. Even in trace levels, these contaminants can impact test results and accuracy. To help attain purified water, several methods can be used, including the use of ultrapure water systems. Here are some of the key processes involved in purifying water.

- **Distillation -** This is a common practice which can help to remove water impurities and contaminants, such as bacteria, organic compounds, and heavy metals. Distillation involves boiling the liquid, allowing it to evaporate into steam and using the cooled vapour to form the distillate. The evaporation process often leaves behind impurities, which can then provide a purified form of the water.

- **Reverse Osmosis -** In summary, reverse osmosis involves deionizing water by pushing it through a semi-permeable Reverse Osmosis Membrane under high pressure. This prevents unwanted contaminants from passing through, such as ions, bacteria, particles, and colloids.

- **Water Deionization -** Otherwise known as DI Water or ion exchange, deionized water refers to the removal of ions, which are extracted as they can often be regarded as impurities. Examples of ions found in municipal water include magnesium, calcium, and chloride. Deionized water is often produced by removing the ions and replacing them with hydrogen and hydroxyl ions, which can combine to produce water. Deionized water and deionizers are typically used to produce Type II water.



Board Standards

To help define and identify water purity levels, many refer to guidelines set by ASTM International, formerly known as the American Society for Testing and Materials. However, there are also alternative organisations which offer their own parameters and standards.

- **ASTM International -** This global organisation develops and provides technical standards for a variety of products and services. Regarding high purity water, ASTM uses parameters, such as conductivity, resistivity, and total organic compounds to define the different levels of purity. As well as the three principal types of water, ASTM also recognises Type IV water, which is typically produced by reverse osmosis and is often used as feed for Type I or Type II water.

- **ISO -** The International Organization for Standardization are responsible for producing international standards relating to technology and manufacturing. Unlike ASTM, ISO categorises pure water into three different grades, with Grade I being the purest. ISO's parameters for water quality include pH value, conductivity, absorbance, and silica content.

- **CLSI -** Formerly the NCCLS, the Clinical and Laboratory Standards Institute is an organisation which develops global laboratory standards. Rather than dividing the water into different types or grades, the CLSI primarily focuses on Clinical Laboratory Reagent Water, which is a single standard which they claim water should meet when being used in a laboratory. Parameters for Clinical Laboratory Reagent Water include a resistivity of 10 Mff.cm, 10 cfu/ml for bacterial contamination, organic impurities at less than 500 ppb and a final filter of a minimum of .22 microns.

Defining and accessing the correct water type can be essential in maintaining high standards within the laboratory and achieving accurate testing and results. Despite the various parameters, standards and complexities surrounding high purity water, there is equipment and expertise available to help simplify the process.

Evoqua Water Purification Systems

Evoqua Water Technologies is a leading provider of water and wastewater treatment solutions for a range of commercial, industrial, and healthcare laboratories around the world.

Leveraging over 50 years of lab water expertise, Evoqua offers a range of world-class water purification systems designed to guarantee the quality of high purity water. With solutions to ensure water meets guidelines needed for critical applications, Evoqua helps customers to obtain the specification of high purity water they require for their unique use-case. Evoqua packaged high purity water systems include multiple unit operations to deliver collective performance with peak efficiency.

See the table below for our high-purity water product range:

Type III Water Systems

Ultra Clear™ System RO Series

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Protegra CS® System RO Series

LEARN MORE

Protegra OF RO Series

LEARN MORE

Type II Water Systems

Labostar® System RO DI Series:

LEARN MORE

Ultra Clear™ System RO DI Series:

LEARN MORE

Ultra Clear™ System RO EDI Series:

LEARN MORE

Protegra System RO EDI Series:

LEARN MORE

Type I Water Systems

Labostar® Polisher System

(Feed water has to be RO or DI water)

LEARN MORE

Labostar® System PRO TWF

(Produces Type I & III)

LEARN MORE

Ultra Clear™ System TP ED Polisher

(Feed water has to be RO or DI water)

LEARN MORE

Ultra Clear™ System TP ED TWF

(Produces Type I & II)

LEARN MORE

Ultra Clear™ System TP ED TWF EDI

(Produces Type I & II)
Produces higher quality Type II water with the use of Ionpure EDI cell.

LEARN MORE

SELECTING THE RIGHT WATER PURITY TYPE

Speak to our team of experts today who can help you select the right purification system for your application. Contact us to learn more!

*American Society for Testing and Materials (ASTM) (2002) Water and Environmental Technology. Annual Book of ASTM Standards, Sec., 11: 11.01 and 11.02, West Conshohocken. The lab water reagent grade water standard is denoted as D1193.