Ultra-Pure Water Systems

(A General Overview)

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Introduction
Ultra-Pure Water Systems

For many years, the need for and consumption of ultrapure water has been increasing at a dramatic rate. Its use is essential in many industries such as pharmaceutical, laboratory research, food processing, etc. with the semiconductor industry being the most highly visible. Ultra-pure water is simply H_2O without any contaminating materials such as in-organic particles, ionic materials, microorganisms and organic compounds. What follows is by no means an exhaustive or detailed study of all high purity water systems, but instead, a general overview of a system which is intended to provide you, our valued distributor, a familiarization with such systems and where Plast-O-Matic products can be sold.

There are two critical points to deep in mind throughout the following discussions regarding all ultra-pure water systems. One is that velocities, pressures and flows must be precisely controlled to ensure the purity of the delivered water. The other is that every effort must be spent to eliminate “dead legs” (non-flowing areas) within equipment and the piping system.

Material Selection

The choice of materials for use in high purity water systems is constantly expanding. Regardless of the selection, however, the materials used must relate to the designer’s two biggest concerns – finished water quality and overall system cost. Traditionally, PVC (polyvinyl chloride) was considered acceptable from a corrosion aspect and also considered inert. Through advancing analytical technologies and research, it has been determined that materials such as PVC are the cause of chemical contamination due to sub-components leaching into the highly aggressive D.I. water. Significant steps have been taken to identify and fabricate materials that can reduce water quality degradation. Although it is not the intent of the general overview to comment on specifics, the following criteria should be mentioned as important:

- Wetted parts and materials require smooth, non-porous surfaces.
- Jointing methods should minimize crevices and discontinuities.
- Materials should not contain biologically degradable substances that can be nutrient sources.
- Materials should not contain leachable additives such as pigments.
- Jointing methods should minimize or eliminate the use of cements or solvents capable of migration into the water.

Although there are a number of commercially available materials that have properties suitable for use with high purity water systems that include Polypropylene, PVDF, Halar®, Teflon® and electro polished 316L stainless steel, suffice it to say that Plast-O-Matic products are all manufactured from virgin, non-pigmented thermoplastics. Also, mention should be made here of Plast-O-Matic’s unique, clean beadless Plast-O-Pure connector. This joining technique, available with practically all Plast-O-Matic products, provides for an easy to install sanitary like joint for ultra-pure systems.

Glossary Of Terms

Chlorination The process of water treatment whereby a chlorine gas or liquid solution is injected into a water supply for the control of micro-organisms or other treatment of water. The feed, demand and residual of chlorine are expressed as PPM (parts per million).

Deionization The process of water treatment using cation and anion resin beds (either individual or mixed) to attract and hold the dissolved solids in a liquid.

Distillation The evaporation and subsequent condensation of a liquid to remove impurities.

Megohm-cm The term used to express the resistivity ((ability of the water to conduct electricity) of high purity water with 18.3 being the absolute purest. Resistivity is a measure of only ionic impurities and is not affected by particulates, bacteria or other organic contamination.

Ozone A strong oxidizing agent (O_2) which can be generated by an electrical discharge through air or by specifically designed ultraviolet UV) lamps. This is a form of sterilization designed to destroy all micro-organisms in water.

pH An expression of the relative acidity or alkalinity of a substance or solution, 7 being neutral. Above 7 is alkaline or basic, and below 7 is acid.

Resin Bed or Media The material used in a filter, deionized, water conditioner, etc. to remove the dissolved and/or suspended matter present in raw water.

Reverse Osmosis (RO) A purification process in which the solution (feed) is pumped under pressure (25 to 800 PSI) across a membrane, allowing the purified or filtered feed (permeate) to be separated from the flow carrying the dissolved particles (concentrate).

Ultra Filtration (UF) Another purification process similar to reverse osmosis (RO), with the major difference being that UF membranes have larger pores than those utilized in RO, and performs at considerably lower operating pressure requirements.

Ultraviolet Radiation (UV) A form of sterilization that produces energy in the form of wavelengths used to destroy bacteria, mold, virus, algae, etc. Basically an extension of the ozone procedure.

Water Softener A device that removes Calcium (Ca) and Magnesium (Mg) hardness in water and exchanges for Sodium Chloride (NaCl).

Description Of Treatment Components

This is a term commonly used to describe the initial treatment step(s) on the incoming “raw” feed water. The most common source of such raw feed water is from either city water or underground well water, which normally contains considerable amount of dissolved solids and organics. Frequently, the raw feed water is passed through sand and/or carbon filters initially to remove organic constituents. Then a number of corrosive chemicals are utilized for the roughing treatment, such as chlorinization or sodium hypochlorite solution for bacterial contamination, acids to adjust pH and polymers to agglomerate particles so they can be filtered out in the downstream cartridge filters. UV sterilizers (ultraviolet) are frequently utilized at this stage for assuring positive kill of micro-organisms such as bacteria, mold, virus, algae, etc.

Plast-O-Matic products used at this stage include:

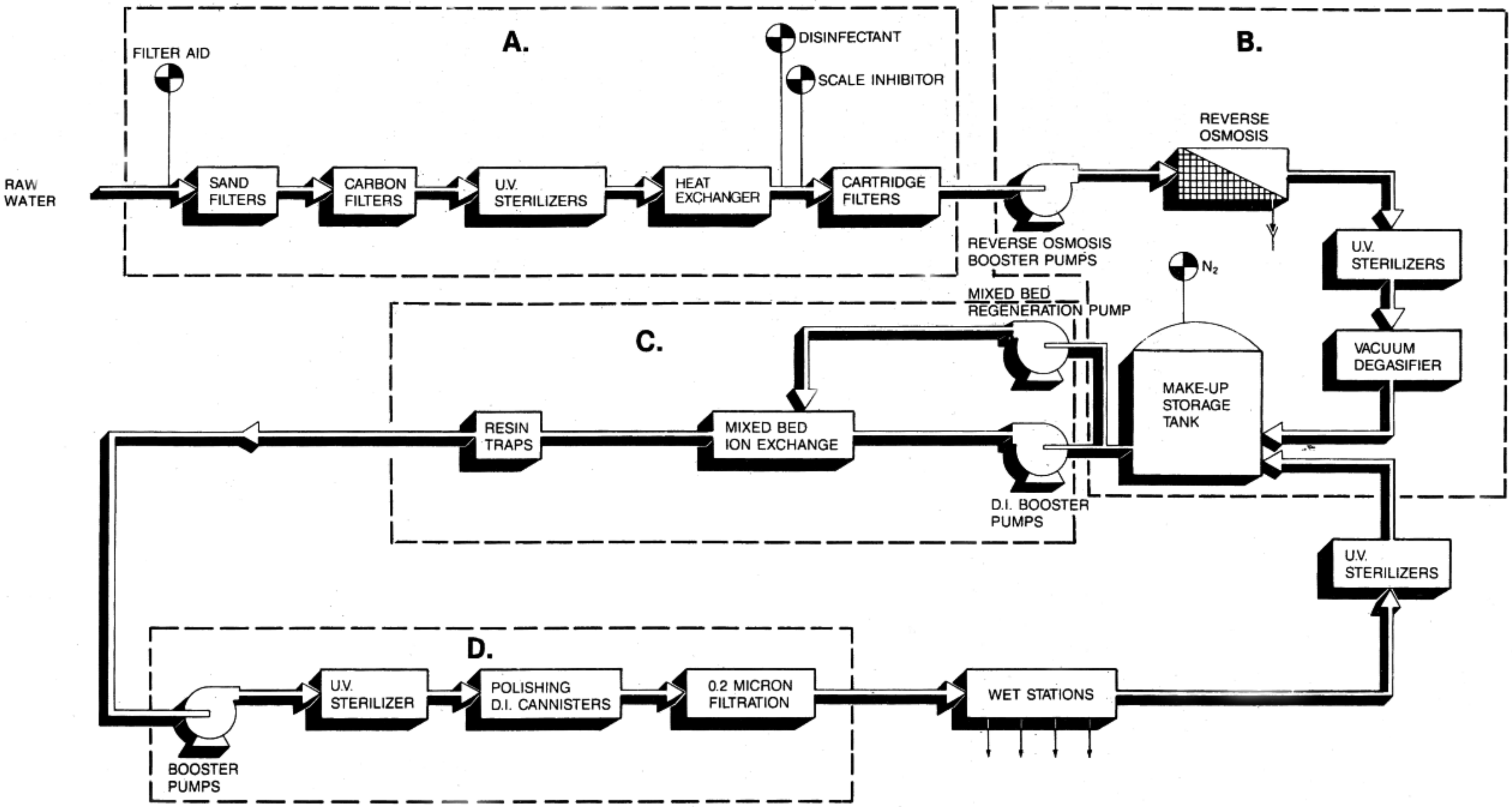
● Solenoid valves for chlorination, sodium hypochlorite feed, and pH balancing.

● Automatic shutoff valves (BSDA or True Blue air-operated ball valves – normally closed) for feed into and backwashing of sand and carbon filters.

● Chemical gauge guards (Series GGS) are always required prior to and following every stage, to monitor line pressures and pressure losses across each component.

● Chemical flow indicators (Series GY) are sometimes used in piping at sand and carbon filters, to visually detect loss of media, particularly during backwash.

● Flow control (Series FC) valves are commonly used to regulate and assure the required flow (GPM) through the UV or ozone sterilization regardless of varying inlet feed pressures. A regulated flow is critical to assure that complete sterilization is accomplished.



HIGH PURITY WATER TREATMENT SYSTEM

PROCESS FLOW SCHEMATIC

CDM

Courtesy of Camp Dresser & McKee Inc.

B. Reverse Osmosis (RO) Treatment

In most typical high purity water systems, the preliminary or roughing stage is followed by the pretreatment stage, which is centered around the reverse osmosis (RO) component. The RO system stage is designed to substantially reduce total dissolved solids, and to filter out some organics and particulates. The RO reject containing the above is then discarded to the drain. RO product water is then passed through a vacuum degasifier (normally made of 316L stainless steel) to remove non-condensable gasses such as carbon dioxide and dissolved oxygen. The degasified water is then collect in a make-up storage tank (normally of fiberglass construction). Chemical additives, such as sodium hypochlorite, are frequently added at this stage to control bacterial growth in the tank(s) while the product water is stored.

Note: Due to the extremely high feed pressures into RO units (normally a minimum of 200 PSI via a booster pump), neither Plast-O-Matic nor any other thermoplastic products are used within the RO unit. However, such products can be used prior to and exiting the RO units. Although the thin film composite membranes are housed in fiberglass, the high pressure manifold piping within the RO units are normally of a 304 stainless steel.

Plast-O-Matic products used prior to and exiting the RO unit include:

● Pressure regulators (PR) preceding the cartridge filters, to assure the cartridge filters are not subjected to over pressure causing damage or lessened filtering efficiencies.

● Pressure differential regulators (PRD) to assure that a maximum ΔP (pressure loss) is not exceeded across the cartridge filters, while ensuring the flow is never stopped.

● Pressure regulator at the suction of the booster pump(s), to assure a constant feed pressure into the pump; thereby ensuring a consistent (versus a variable) discharge pressure into the RO unit.

● Chemical gauge guards (GGS) both prior to and exiting the RO system to monitor pressure.

C. Primary Deionization (Mixed Bed)

The pretreated degasified RO products water is now the feed water for the mixed bed deionizer system, which will remove virtually all ionic impurities. This is accomplished by the feed water flowing through anion (negative) and cation (positive) charged resins, resulting in the dissolved solids being captured by the final water. Deionization is the most efficient process for removing inorganic salts and gases found in water.

Plast-O-Matic products used at this stage include:

● Automatic shut-off valves (BSDA) or True Blue air operated ball valves, on face and interconnecting piping for on/off shut-off or throttling.

● Flow control valves (FC) to ensure proper flow into the vessel(s) for optimum purification.

● Chemical metering pumps (VPA) for acid (sulphuric or hydrochloric acids) and caustic (sodium hydroxide) feed to the resins during the regeneration mode.

● Pressure relief valves (RV) to assure component safety in the event of line blockages.

● Check valves (CKM & CKS) are used throughout this area to assure against reverse flow during its acid and caustic regeneration cycles.

● Chemical flow indicators (sight glasses) are used both within the manifold piping and exiting the deionizer(s), for visual indication of flow and detection of any resins that may be escaping.

D. Polishing Station/Stage

This expression is commonly used to describe the final phase in the ultra-pure water system where the resistivity is raised to 18 megohms or “semiconductor grade” water. Keep in mind that this final “polishing” stage is an optional stage for many industries and users of D.I. water, whose requirements are not as stringent and critical as those in the semiconductor industry.

The components involved at the “polishing” stage are again UV Sterilizers, which will destroy 99%+ of any bacteria present, a dual bed deionizer (in which the feed water passes through the anion and cation resins separately vs. the earlier mixed bed(s) and finally, submicron filters and/or ultra-filters for removing dead bacteria and any other particles remaining. The water at this point should now be of the highest grade possible and ready for use.

Plast-O-Matic products used at this stage are the same used on components earlier in the system with the exception of ultra-pure gauge guards. From this stage through to point of use it is critical that all “dead-legs” be eliminated. “Dead-legs” are non-flowing or non-circulating areas in the piping design hat can harbor and breed contaminates in such high quality water.

E. Summation

The two most important concerns of any ultra-pure water treatment and distribution system are:

1. Delivery to points of use of the highest quality water possible while
2. Maintaining the required critical pressures and flows needed to assure such quality water.

In general, water of less than 1 megohm-cm resistivity may be stored (non-flowing) for hours without significant change in quality, while ultra-pure water of 18 megohm-cm resistivity will begin to demonstrate a drop in resistivity after less than one hour. For this reason, a minimum flow velocity of 5 feet per second is necessary to ensure against high purity water degradation. For these reasons, pressure control and regulation are the most important aspects of the hydraulic system. The three methods most commonly used to regulate pressures and flows are:

1. Pressure Control/Regulating Valves (PR)
2. Orifice Plates/Flow Control Valves (FC)
3. Pressure Relief Valves (RV)

While pressure regulators and flow control valves are commonly used on a continuing basis, pressure relief valves are only used for emergency release situations.

A major design advantage of pressure regulators in high purity systems is the flexibility that they provide. The valves can operate over widely fluctuating user demands, and can be adjusted to meet changing pressure requirement common in such systems due to the variety of treatment components, and their resultant pressure losses. These valves have the ability to fully open and close, as well as assure downstream components are not subjected to pressures above the regulator's set point.

Flow control valves (orifice plates) are found to be the most simple, least expensive devices for regulating pressure and flow. Since they act as a restrictor in the piping system, they provide the ability to maintain back pressure when passing a calculated flow volume. If f a system's pressure requirements and demands are stable, a flow control valve represents a sound, economical choice for pressure regulation. If however, the pressure of flow demands are uncertain or known to fluctuate then the use of a pressure regulator is recommended. Keep in mind that Plast-O-Matic flow control valves (FC) can be used without a pressure regulator since they are pressure compensating (variable orifice) versus the most common "fixed orifice" design, thereby affording more accuracy of flow when feed pressures fluctuate.

As mentioned, pressure relief valves are primarily used to protect equipment and piping from transient hydraulic surges, These surges may occur when multiple outlet points are closed simultaneously, when a pressure control valve malfunction, or during improper sequenced restart following a power failure. By design, relief valves do not respond quickly to the rapid transient hydraulic surges common to water hammer and therefore, serve only a limited purpose in protecting equipment. Their use as a back pressure regulating/control valve is quite frequent in water systems when located at the end of a user loop. When used at this point, it will maintain a constant back pressure thereby providing stabilization over a variety of water demands by restricting return flow until the pressure set point is reached, provided excess flow is available.

One last component that must be stressed in the design of all water distribution systems is the need to monitor the changing pressures inherent throughout these systems, not only at the above mentioned valves to ensure their proper settings and functioning, but at numerous other stages. Such monitoring requires pressure gauges, Keep in mind, however, that ultra-pure water is extremely corrosive, and the use of chemical gauge guards (GGS-Diaphragm Seals) are critical to isolate the metallic gauge from attack while extending the mechanical life expectancy of the gauge, as well as to prevent contaminants from entering the system. Also, as referenced in the introduction every effort must be spent to eliminate "dead legs". This need within the ultra-pure water market prompted the development and introduction of Plast-O-Matic's Ultra-Pure Gauge Guard (Series GGMU) which remains today as the only thermoplastic non "dead leg" gauge guard.

As a supplier of components to the designers and ultimate users of high purity water systems we must always keep our customer's priorities in perspective. As referenced from the beginning, these ultra-pure water systems must be designed and performed to stringent standards of quality and reliability. Don't allow a momentary price inducement to result in sacrificing your customer's deserved expectations of system quality and reliability.

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