



Dow  
Water Solutions

DOWEX™  
Ion Exchange Resins

FILMTEC™  
Reverse Osmosis Elements

Producing Ultrapure Water

## The Requirement For Ultrapure Water

Ultrapure water (UPW) is essential to properly fabricate today's integrated circuits. It is the primary cleaning solvent used to rinse all contaminants and remnants of silicon etched away during the production process. The geometry of today's integrated circuits is so minute and complex that even the smallest contaminant can prevent a circuit from functioning properly. These contaminants decrease the production yield of usable circuits.

As the degree of integration becomes increasingly more complex, the semiconductor industry requires higher levels of water purity. The amount of dissolved ionic solids, organics, live bacillus, suspended particulates and silica must approach zero. In fact, the ultrapure water now required by the semiconductor industry typically must have a resistivity of 18.2 MΩ·cm (0.055 μS/cm) at 25°C, while ionic and non-ionic contaminants must approach non-detectable limits.

A single water treatment process cannot efficiently deliver water of such a high purity level. Experience shows that optimum water treatment solutions take advantage of the specific capabilities of reverse osmosis (RO), ion exchange (IX) and other technologies. Dow's Water Solutions business is unique in the industry because it develops, manufactures and offers a comprehensive range of reverse osmosis membrane elements and ion exchange resins.

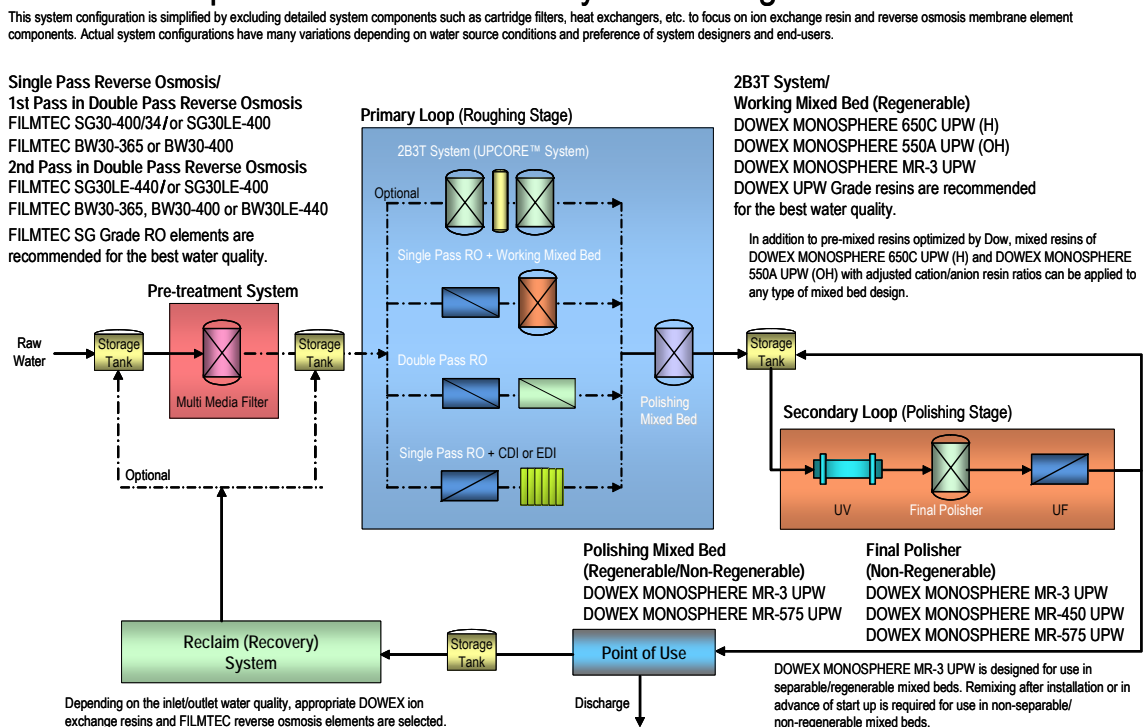
We offer a complete line of FILMTEC™ brackish water and semiconductor grade reverse osmosis elements and DOWEX™ MONOSPHERE™ ultrapure water grade ion exchange resins to meet the most stringent water purity standards required to produce ultrapure water for today's semiconductor devices.

For years, we've been meeting the needs of original equipment manufacturers (OEMs) and end use customers in the semiconductor industry around the world. This experience helps us to continually improve our own technology, manufacturing ion exchange resins and reverse osmosis membrane products with unsurpassed separation performance and low contaminant levels that provide long-lasting, economical service.

## Producing Ultrapure Water

Ultrapure water treatment systems vary depending on the source of the water to be processed and the ultimate purity required by the complexity of the semiconductor device. Regardless of your system design and water source, Dow offers an extensive range of products to meet your specific ultrapure water needs (see Figure 1).

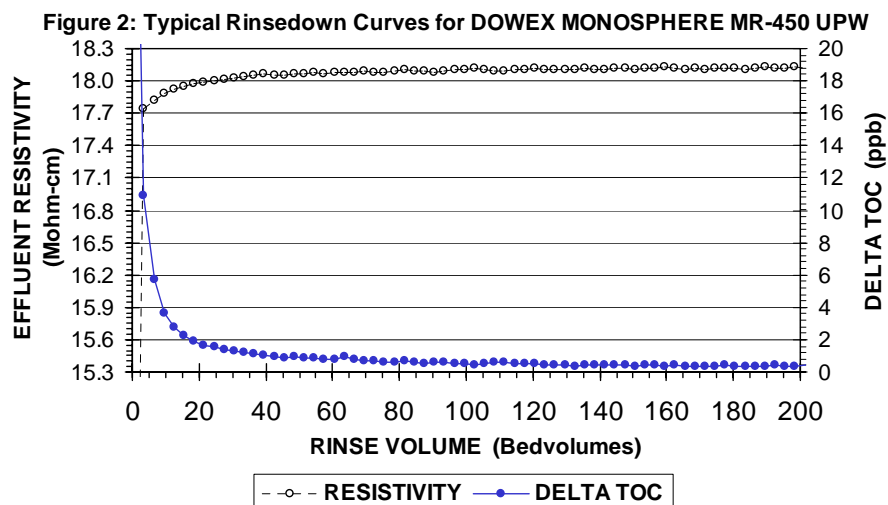
Figure 1. **General Ultrapure Water Production System Configuration**



Dow has cooperated with OEMs and end use customers in the development of UPW recycle systems. Recycling by proper classification of waste water sources and categorization of organic and inorganic impurities has aided in the proper design and operation of waste water recovery systems.

### DOWEX™ MONOSPHERE™ Ultrapure Water Grade Ion Exchange Resins

DOWEX™ MONOSPHERE™ ultrapure water grade ion exchange resins offer significant improvements in lower levels of TOC leakage and rinse profiles to a resistivity of 18.2 MΩ.cm (0.055 μS/cm). Figure 2 shows an example of a rinse profile for DOWEX MONOSPHERE MR-450 UPW mixed resin when rinsed at 30 bed volumes per hour with feed water that has a resistivity of >17 MΩ.cm.



DOWEX™ MONOSPHERE™ resins have a uniform particle size distribution that provides such benefits as faster kinetics, shorter rinse times, better regeneration efficiency and longer resin life. For more detailed information, see [Advantages of UPS Ion Exchange Resins](#).

Our line of ultrapure water grade ion exchange resins are summarized in Table 1.

**Table 1. DOWEX MONOSPHERE UPW Grade Ion Exchange Resins for Ultrapure Water Production**

	Strong Acid Cation	Strong Base Anion	Weak Acid Cation	Mixed Bed	Uniform Particle Size	Regenerable	Non Regenerable
1. DOWEX MONOSPHERE 650C UPW (H)	X				X	X	
2. DOWEX MONOSPHERE 550A UPW (OH)		X			X	X	
3. DOWEX MONOSPHERE MR-3 UPW				X	X	X	
4. DOWEX MONOSPHERE MR-450 UPW				X	X		X
5. DOWEX MONOSPHERE MR-575 UPW				X	X	X	
6. DOWEX MAC-3			X			X	

DOWEX MONOSPHERE 550A UPW (OH) type 1 strong base anion exchange resin ([550A UPW \(OH\)](#)) is used in the roughing stage either in a two bed system followed by a mixed bed or in a working or polishing mixed bed following reverse osmosis or CDI/EDI. This resin is characterized by its light color, superior crush strength, and high conversion of exchange sites to the hydroxide (OH) form.

DOWEX MONOSPHERE 650C UPW (H) strong acid cation exchange resin ([650C UPW \(H\)](#)) is used in the roughing stage either in a two bed system followed by a mixed bed or in a working or polishing mixed bed following reverse osmosis or CDI/EDI. The color difference between DOWEX MONOSPHERE cation and anion resins makes it easy to verify that complete separation has occurred when used in regenerable mixed beds.

DOWEX™ MONOSPHERE™ MR-3 UPW is an anion rich mixed resin ([MR-3 UPW](#)) that is used in primary working or polishing mixed beds following two bed ion exchange, reverse osmosis or CDI/EDI, and in a final polisher. The color and particle size difference allow for the visual confirmation of separation, making it an ideal resin to achieve optimum regeneration in a mixed bed.

DOWEX MONOSPHERE MR-450 UPW is a non-separable homogeneous cation rich mixed resin ([MR-450 UPW](#)). It is used in a point-of-use non-regenerable mixed bed in the polishing stage to achieve low ppb levels of soluble silica, boron, sodium, potassium, sulfate, chloride, zinc, iron and aluminum. It is normally used for two to three years before replacement.

DOWEX MONOSPHERE MR-575 UPW is a high purity cation rich mixed resin ([MR-575 UPW](#)) that is used in both a polishing mixed bed and a final polisher. The higher crosslinkage and smaller bead size of the cation component contributes to faster kinetics. It also has excellent physical and chemical stability.

In addition to these UPW grade ion exchange resins, DOWEX MAC-3 resin is a macroporous weak acid cation exchange resin ([MAC-3](#)). The particle size is specially chosen for use in both co-current and counter-current regeneration systems. This resin efficiently removes hardness associated with alkalinity, and is suitable for ultrapure water systems where hardness removal is necessary to operate the reverse osmosis system at a higher pH.

Additional information about DOWEX MONOSPHERE UPW grade ion exchange resins (including typical physical and chemical properties) is available in technical data sheets at [Ultrapure Water Grade Ion Exchange Resins](#).

### *Boron Selective Resin*

Dow's boron selective resin is a uniform particle size weak base anion exchange resin designed for the selective removal of boron. It is used in a single bed followed by a mixed bed of DOWEX™ MONOSPHERE™ UPW grade resins. Boron levels of <10 ppt can be attained when the boron selective resin is utilized. The delta TOC level in the effluent is less than 2 ppb. Additional information about this product can be found at [Boron Selective Resin](#).

### *UPCORE™ System*

The UPCORE™ process is a packed bed upflow countercurrent regeneration system. Installation of demineralizers incorporating the UPCORE process prior to the first pass RO has proven to be very effective at reducing boron concentrations. For example, the boron content of a solution containing 100-200 ppb boron can be reduced to <0.05 ppb boron when this process is utilized. Additional information on the UPCORE process can be found at [UPCORE System](#).

### *FILMTEC™ Brackish Water Reverse Osmosis Elements*

Dow offers a complete line of FILMTEC™ RO elements to suit specific ultrapure water requirements, based on water chemistry and OEM system design preferences. These elements have several distinguishing features, including an interconnector design that eliminates feed leakage into the permeate. FILMTEC elements are manufactured by FilmTec Corporation using an automated multi-leaf cell (AMEC) construction technique that matches the nominal membrane area within stringent tolerances. The AMEC construction technique allows for a level of accuracy and reproducibility that typically cannot be achieved by the manual or semi-automated techniques common to the construction of most competitive RO elements. FILMTEC elements also have structural integrity of the outer shell through a stable, thoroughly curable epoxy resin and lower leachable roving materials.

All of these FILMTEC elements take advantage of our high active membrane surface area technology to provide greater productivity, higher salt rejection, lower fouling and potentially lower system operating costs. All FILMTEC brackish water elements achieve a stabilized overall rejection of at least 99.5% and have earned a reputation of maintaining structural integrity and performance over several chemical cleaning cycles.

FILMTEC™ BW30-365 element ([BW30-365](#)) has an active membrane area of 365 square feet and an average permeate flow of 9,500 gpd (36 m<sup>3</sup>/d) under standard conditions. It offers high productivity because of its increased surface area, and it has a thicker brine channel spacer that makes it ideal for high fouling situations where frequent cleaning is expected.

FILMTEC BW30-400 element ([BW30-400](#)) is the most cost-effective for new RO systems. The high surface area of this product allows new RO systems to meet productivity targets with fewer elements that could possibly lead to lower system component and installation expenses.

FILMTEC BW30LE-440 element ([BW30LE-440](#)) is used to reduce energy consumption while maintaining reasonably high rejection. It operates at about 150 psi compared to 225 psi for conventional brackish water RO products, resulting in a substantial reduction in operating cost.

Other elements were recently developed to address the need for a consistently high pH feed to achieve higher rejection of boron, silica, TOC and other weak acid anions. They can be used continually at a feed pH of 10.5 without decreasing the life span of the element. Please contact your Dow representative for more information about these products.

### *FILMTEC™ Semiconductor Grade Reverse Osmosis Elements*

Ultrapure water specifications and analytical measurement capabilities have advanced to meet the exacting needs of microprocessor, semiconductor and other silicon based device manufacturers. FILMTEC™ SG30-400/34/ ([SG30-400/34/](#)), which replaces SG30-400 that is now obsolete, and SG30LE-440/ ([SG30LE-440/](#)), which replaces SG30LE-430 that is now obsolete, reverse osmosis elements have been developed to meet the requirements of higher overall rejection, higher rejection of lower molecular weight organic compounds and silica, and an accelerated TOC rinse down profile. These high surface area elements allow for system design with fewer elements and a lower applied operating pressure, thus optimizing amortization of capital costs while lowering operating cost.

Both elements now come with the unique *ILEC*™ interlocking endcaps that reduce system operating costs, reduce the risk of o-ring leaks and the generation of small particles that lead to poor water quality, and eliminate the need for lubricants. Additional information on *ILEC* interlocking endcaps can be found at [ILEC Interlocking Endcaps](#).

SG30-400/34/ is intended primarily for polishing use in traditional UPW systems designed for higher pressure operation. It can be used in either the HERO process or for RO followed by CDI/EDI where the highest hardness, silica and boron rejections are required. It features a 34 mil spacer to lessen the impact of fouling and pressure drop across a vessel, increasing running time between cleaning and enhancing cleaning effectiveness. SG30LE-440/ is a low energy element intended primarily for polishing use in newer UPW equipment where the benefits of lower capital cost and lower energy consumption add value.

The rejection of these reverse osmosis elements for some lower molecular weight organic compounds can be found in Table 2.

**Table 2. Typical Organic Compounds Rejection**

Organic compound	MW	Rejection (%) SG30-400/34/ <sup>1</sup>	Rejection (%) SG30LE-440/ <sup>2</sup>
Methanol	32	14	13
Ethanol	46	50	40
Acetone	58	68	48
Isopropanol	60	95	92

Test conditions: 1. Feed concentration 10 ppm, 214 psi (1.47 MPa), 25°C, pH 7 and 15% recovery.  
 2. Feed concentration 10 ppm, 107 psi (0.74 MPa), 25°C, pH 7 and 15% recovery.

FILMTEC™ SG30LE-400 ([SG30LE-400](#)) is a low energy element with high overall rejection and high rejection of lower molecular weight organic compounds and silica. It operates at low pressure to deliver energy savings. This element is intended for use in the roughing stage of UPW systems in both new equipment and replacement situations where lower energy cost is desired.

Additional information about FILMTEC Semiconductor Grade RO elements (including typical physical and chemical properties) is available in technical data sheets at [Semiconductor Grade Reverse Osmosis Elements](#).

### *Dow Products, Technology and Support*

Dow Water Solutions is a global organization serving the ultrapure water needs of the semiconductor manufacturing industry in North America, Europe, Japan and southeast Asia. In addition to our line of ultrapure water products, we provide complete application assistance. We'll help you select the exact combination of reverse osmosis elements and ion exchange resins for your water quality needs. We can also help you determine the best time to clean or replace your reverse osmosis elements and ion exchange resins, and even provide you with your own testing and monitoring program.

#### **ROSA**

The ROSA Reverse Osmosis System Analysis program lets system designers and specifiers quickly and easily predict the performance and operating economics of FILMTEC™ elements in specific systems. To ensure that designers and specifiers have the most complete and accurate information possible, ROSA includes an interactive library of technical data. Also included is an Internet access to link users to the Dow Liquid Separations home page on the World Wide Web where they can obtain updated information about FILMTEC elements. ROSA can be downloaded from [our ROSA webpage](#).

#### **CADIX**

The CADIX Computer Assisted Design for Ion eXchange systems program is intended to assist engineering companies and plant operators to obtain design projections for ion exchange plants. In addition to new plant designs, the performance of existing and retrofitted softening, dealkalization, demineralization, and condensate polishing plants can be evaluated. An economic comparison of before and after scenarios can be completed. CADIX can be downloaded from [our CADIX webpage](#).

Other Dow support services include plant trials, system optimization, operator training programs and the industry's most up-to-date and comprehensive technical literature. Please refer to technical data sheets for additional information, or contact the ultrapure water experts at Dow. For the location nearest you, please see the back cover of this brochure.

### *References*

1. [ASTM D5127-99 Standard Guide for UPW Used in the Electronics and Semiconductor Industry](#)
2. [Balazs Analytical Services 2000 UPW Monitoring Guidelines](#)
3. [Balazs Analytical Services 2004 UPW Monitoring Guidelines](#)
4. Case Histories:
  - a. [Practical Application of Equilibrium Theory to Improve UPW Quality by Minimizing Ionic Leakage](#)
  - b. [LED Manufacturer Combines UPCORE™ Packed Beds and FILMTEC™ RO Systems for Reliable Ultrapure Water Production](#)
  - c. [UPCORE System Reduces Boron to Undetectable Levels In Ultrapure Water](#)
  - d. [Ultrapure Water in the Microelectronics Industry](#)
  - e. [ILEC™ Interlocking Endcaps Solve Leakage Problems and Improve Energy Efficiency in Semiconductor Plant](#)

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† Toll-free telephone number for the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom

Notice: Oxidizing agents such as nitric acid attack organic ion exchange resins under certain conditions. This could lead to anything from slight resin degradation to a violent exothermic reaction (explosion). Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

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